A TECHNIQUE FOR PREDICTING MERCHANTABLE TREE HEIGHTS FOR USE IN CONJUNCTION WITH FOREST INVENTORIES

by

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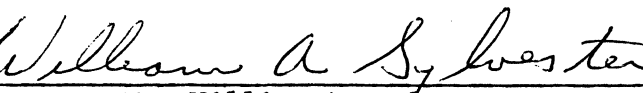

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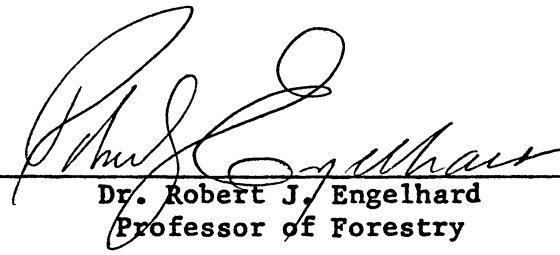

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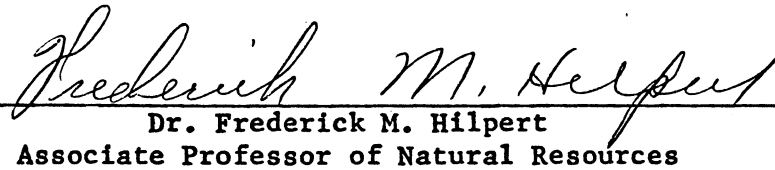

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ABSTRACT

A TECHNIQUE FOR PREDICTING
MERCHANTABLE TREE HEIGHTS FOR USE
IN CONJUNCTION WITH FOREST INVENTORIES

Charles H. Ouimette

A merchantable tree height regression model has been developed which can predict heights and compute resultant volumes for the northern hardwood species group.

Test data was comprised of successional continuous forest inventory files supplied by a northern Wisconsin paper manufacturing company. Percent comparisons between actual (measured) and predicted heights and computed volumes were within acceptable accuracy limits.

Model flexibility can accomodate multiple silvicultural considerations including major regional soil groups, stocking levels, and site classifications.

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Chapter 1

INTRODUCTION

The primary objective of this study is to develop a basic regression model which can predict acceptable northern hardwood tree height values by diameter class, thus eliminating most of the need for costly height measurement incurred during C.F.I. (Continuous Forest Inventory) measurements and remeasurements. Measured tree diameters from subsequent remeasurements and predicted heights could then be utilized to compute tree volumes with a reasonable and practical degree of reliability.

Historically, C.F.I. has been a method of determining timber inventory, land value classes, current forest growing conditions, and is a basis for developing in-company accounting data for volume and land values. Woodlands management interprets C.F.I. data for determining growth, allowable cut, and to obtain better insight to developing forest problems.

Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin, utilizes a series of permanent one-seventh acre plots on which all merchantable trees are individually identified and measured. C.F.I. measurements (new plots) and remeasurements (all other plots) are completed once every five years.

Collectable on-plot individual tree data includes species identification, d.b.h. (diameter breast height), and merchantable tree height to a four (4) inch top outside bark.

Tree height measurement utilizes approximately forty percent of on-plot remeasurement time. This high cost factor precipitated the need for a tree height prediction model, the main objective of this study.

A secondary objective is to verify model applicability to Owens-Illinois' Northern Woodlands "hardwood" species group which is comprised of the greatest variety of individual species, soil types, and silvicultural systems of all company controlled woodlands.

A final goal is to incorporate enough flexibility within the model to encompass a diversity of species/species groups, silvicultural considerations, and regional differences of other Owens-Illinois' woodlands located in Virginia, Georgia, Florida, Texas, Louisiana and Tomahawk.

In summary, if the model could be shown to yield acceptable inventory and growth information, and provide a usable accounting data base for the northern hardwood species group, then model flexibility and applicability should accommodate other company C.F.I. remeasurement system data.

Chapter 2

METHODS AND MATERIALS

The regression model was developed using SPSS (Statistical Package for the Social Sciences, Nie, Norman, Hadlai, Hull, Jenkins, Steinbrenner, and Bent, 1975). Modifications include transformations of some input data to accommodate silvicultural growth characteristics of the northern hardwood species group.

Data utilized in this study consists of individual hardwood tree measurements taken from the 1964, 1969 and 1974 C.F.I. remeasurement tape files from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

In-company definition of "dense hardwoods" is "....comprises more than fifty percent of the dominant stand," and consists of hard maple (Acer saccharum Marsh.), red maple (Acer rubrum L.), basswood (Tilia americana L.), yellow birch (Betula alleghaniensis Britton), ashes (Fraxinus, spp.), elms (Ulmus spp.), oaks (Quercus spp.), cherry (Prunus serotina Ehrh.), ironwood (Ostrya virginiana (Mill.), and bitternut hickory (Carya cordiformis (Wangenh.) K Koch.).

Initial analysis includes separation of individual species files into basal area classes and site categories.

Final analysis combines northern hardwood species into one group file, but is further subdivided into major regional soil types. Analysis of variance (ANOVA) was utilized to test significance between soil types.

Height prediction curves were generated from the 1964 and 1969 C.F.I. files to predict 1969 (from 1964) and 1974 (from 1964 and 1969) merchantable tree heights with subsequent computation of percentage comparisons between actual (measured) and predicted heights and

calculated volumes.

Initially, actual "old" diameter (d.b.h, diameter breast height in tenths of inches) and "old" height (merchantable height in feet from a one foot stump to a four inch top diameter outside bark) were analyzed using regressions, resulting in first order equations of the form $Y = a + bX$. Diameters from a subsequent C.F.I. remeasurement year were then substituted into the prediction equation, resulting in "new" predicted heights by diameter class.

"New" predicted heights and actual heights from the same C.F.I. remeasurement year were submitted to a basic volume formula to standardize final volume comparisons.

Percentage difference calculations were completed for height and volume using form: (Actual - Predicted/Actual) x 100, for hardwood group categories (soil, basal area, and site), and individual plot comparisons.

Final diameter vs. height prediction tables were developed for tested remeasurement periods and compared for possible trends.

Chapter 3

THE MODEL

Individual stem analysis

Height (feet) vs. diameter (breast height - tenths of inches) regression equations were developed for individual northern hardwood species (Northern Woodlands' hardwood group) from C.F.I. remeasurement years 1969 and 1974. Owens-Illinois' management believes that two years data analysis would be sufficient to identify trends.

Initially, species were identified by percent of occurrence within the hardwood group (Figure 1). Increase of maple and decrease of yellow birch, elms, oaks, and cherry over time are a direct result of species discrimination due to in-company silvicultural management techniques of the hardwood species group.

Height was plotted against the square root of the diameter. This diameter transformation tended to "flatten" first order prediction curves and is an acceptable, statistically sound modification of independent variables (Ryan, Joiner, and Ryan, 1976).

Species were further segregated based on stem occurrence within C.F.I. plots differentiated by basal area (square feet) stocking classes and site (measured base 50) categories (Figure 2).

Existing company hardwood management guidelines assigned stocking levels at: low = 1-60, medium = 61-90, and high = 91+.

Site quality was measured on all C.F.I. plots identified as "dense hardwood" by species specific site curves (Figure 3 - 11, Carmean, 1978). Established in-company management guidelines for hardwood group site categories are: low = 1-45, medium = 46-65, and high = 66+.

Regression parameters developed for each hardwood species and for the total hardwood group from C.F.I. remeasurement years 1969 and 1974 (Appendix A).

In general, 1974 statistical parameters were less accurate than those of 1969 due to different tree characteristics on land acquired during the five year interim period during which a fifteen percent increase occurred. Existing overall hardwood stem quality on company owned woodlands was better than that of the acquired data base due to a higher degree of management proficiency which resulted in periodic removal of poor quality, off-site, and diseased stems.

At this point, Owens-Illinois' management evaluated obtained regression parameters and elected to regard northern hardwoods as a single species group. The data obtained supported unitizing the hardwoods which agreed with existing woodlands' management policies.

Company interest was expressed concerning additional segregation of the hardwood data by soil types (Figure 13). Delineation lines were established by coordinating maps of major regional soil types (Hole, 1974) and company controlled woodlands (Figure 14).

Description of major regional soil types

Company hardwood lands and corresponding C.F.I. plots occurred within four major soil types (Table 1).

Soil 1 or "wet" soils (Pella, Poygan, Newton, Houghton, Arenzville) were lowland soils found in stream bottoms and floodplains. These soils are periodically enriched through rainfall with humus, soluble salts and colloids. Increased movement of water accelerates local soil dynamics, greatly influencing annual changes in soil morphology.

The hardwood forest cover type consists of hydrophytic species. Associated tree growth rate is dependent upon the degree of ground water oxygenation and periodic fluctuation of the ground water table.

Relative influence of soil 1 on this study is decreased because only four percent of hardwood group C.F.I. plots occur on "wet" soils.

"Loams" (soil 2 - Iron River, Gogebic, Kennan) are acid soils of northern uplands and plains, and are stony, sandy or loamy.

Hard maple dominates the forest cover, with common "hardwood group" associates consisting of red maple, basswood, yellow birch, ashes, elms, oaks, black cherry, ironwood, and bitternut hickory.

Soil 2 provides an unusually stable environment for hardwoods, but due to an almost neutral reaction in the humus layer, most jack pine (Pinus banksiana Lamb.) and red pine (Pinus resinosa Ait.) reproduction can be destroyed by damping off fungus.

"Loams" provide an ideal seed bed for hardwoods. After stand interruptions such as fires and logging, prolific reproduction of hardwood species is generated through stump sprouts and seedlings.

Fifty-seven percent of all hardwood group C.F.I. plots occurred within soil group 2.

Soil 3, or "sands" (Omega, Hiawatha, Vilas) are found on northern sandy uplands and plains of outwash sands. They tend to be of low fertility, droughty, acid, and subject to wind erosion.

Hardwood cover type consists of red maple, some oaks, white birch (Betula papyrifera Marsh.), aspens (Populus, spp.) and some willows (Salix, spp.). These soils are generally characterized by low hardwood occurrence and productivity, and have only a twelve percent incidence of hardwood group C.F.I. plots.

"Silts" (Withee, Santiago, Amery, Antigo) generally describe soil 4 as those of northern silty uplands on plains of outwash sand and gravel. Due to higher fertility and superior development of the soil surface layer (6 - 8 inches deep), the rate of hardwood growth is superior to other soils considered in this study. Conversion of hardwood fiber production to agriculture generally occurs whenever the land exhibits gently rolling relief, and a relative lack of stones (Wilde, 1976).

Hardwood group cover type species are similar to soil 2 ("Loams") but exhibit somewhat better growth. Hard maple is dominant, associated with red maple, basswood, yellow birch, ashes, elms, oaks, black cherry, ironwood, and bitternut hickory. White pine (Pinus strobus L.) occurs in small numbers, but can add substantially to total stand merchantable volume.

Thirty-seven percent of hardwood group C.F.I. plots occur on this soil.

Statistical validation of soil categorization

Hardwood species group basal area classes and site category guidelines were viewed by Owens-Illinois to be silviculturally different. Inclusion of soil type segregation was not based on systematic management routine, therefore, statistical techniques were implemented to verify any differences between soil types.

Initially, mean heights of stems occurring within each soil type (Tables 2 - 4) were compared using "one-way" ANOVA. All soil group descriptive data is displayed in conjunction with the ANOVA summary table.

"ONEWAY" analysis of variance identifies existing total statistical significance between soil groups, but does not indicate which individual group(s) are significantly different from others. Therefore, "T"-Tests

were used to evaluate differences between soil groups (Tables 5 - 7).

Individual soil group descriptive data including soil group, Count (N). Mean (Feet), standard deviation, and standard error (standard deviation/ count) by C.F.I. remeasurement year for Tables 5 - 7 are identical to those of Tables 2 - 4 respectively.

Generally, all soil group tree height means were significantly different in 1964 except for group 2 (loams) versus 4 (silts). This is understandable since eighty-four percent (57 & 27 respectively) of all hardwood group C.F.I. plots occur on these soils. However, the 1969 analysis showed some equality between soil groups at different probability levels for all combinations of soil group 1. This may not be of great concern due to a small occurrence of C.F.I. plots within the "wet" (soil 1) group (4 percent). 1974 data analysis displayed similar trends as did the 1969 example. 1964 soil 1 analysis was not relevant as "count" (N) was zero.

Therefore, segregation of C.F.I. hardwood group plots by major regional soil group was an appropriate action, and should be incorporated into Owens-Illinois' forest management guidelines.

Description of model base data.

Table 8 summarizes the 1974 hardwood data base, and exemplifies the basal area, site, and soil classification system used to complete model analyses. Soil group productivity observations were accurately delineated by number of trees/plot sub-table summarizations.

Increases in basal area and site resulted in concurrent increases of number of trees/plot.

Sub-table soil group 1 (29 trees/plot) and 3 (30 trees/plot) are considered "off-site" for productive hardwood growth while groups 2

(34 trees/plot) and 4 (37 trees/plot) include a large majority of existing hardwood group stems, and are capable of vigorous sustained hardwood growth rates. Soil 4 (silts) are regarded as most productive of all regional groups.

Development of model regression coefficients

Concern was expressed regarding occurrence of non-hardwood species groups within northern hardwood cover type C.F.I. plots. Table 9 describes plot distribution and major species group stem count by percent by site.

In aggregate, hardwood plots contained eighty-four percent hardwood group species. Owens-Illinois' management acknowledged that some inter-species influence between hardwood and non-hardwood stems existed, but concurred that within-plot occurrence levels were acceptable for management and therefore, model purposes.

Since the data did not fit the assumption of linearity, transformations of independent variables were required.

To verify model procedures, comparisons of height in feet and diameter, breast height in tenths of inches; and height versus square root of diameter (transformation) were completed using the 1974 "all soil" data base (Appendix B versus Appendix G, respectively). In all basal area and site category analyses, transformation of input data generated higher R^2 values and corresponding lower standard error of estimate figures.

Therefore, transformation of the independent variable, square root of the diameter, was incorporated into developmental model procedures.

A total of 257 equations were developed by soil group, basal area class, and site category from the 1964, 1969 and 1974 remeasurement year data files (Appendices C - S). Statistical inference for soil groups 1

through 4 and "all soils" by hardwood cover type were developed from analysis of individual hardwood group stem data from hardwood cover type C.F.I. plots only, while "all land use - all soil types" incorporated all hardwood group stems from any C.F.I. plots regardless of cover type (Tables 10 - 26).

Inconclusive difference existed between "all soils" and "all land use - all soils" regression curve analyses, probably due to small incremental differences between C.F.I. file data which displayed ten to fifteen percent more stems per remeasurement year (1964, 1969, 1974) for the "all land use - all soils" data base.

Tables 10 - 12 were compiled to present differences between soil group regression coefficients, and related statistical parameters.

To recap, regression equations were generated from all applicable silvicultural categories (soil, basal area, site) from three C.F.I. remeasurement years (1964, 1969, 1974). Subsequent model development required testing of the prediction equations.

Methodology of actual versus predicted data comparisons

C.F.I. equations developed from 1964 and 1969 data were then applied to 1969 and 1974 hardwood stem diameters, respectively, resulting in predicted heights. A ten year interval utilizing 1964 equations to predict 1974 diameters was completed to determine effects of a prolonged period (more than five years) between remeasurement years.

Calculated volume comparisons between measured and predicted heights were standardized by use of a gross cord volume table (Appendix T). Subsequently, computed differences of height and resultant volume between actual and predicted data was analyzed by means of the formula: % = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$.

Percentage differences were calculated for stems occurring in northern hardwood cover type plots as well as hardwood group stems from all plots regardless of cover type (Tables 13 - 25).

Construction of height tables by diameter class were developed by remeasurement year (Tables 27 - 29).

Before model validation procedures were implemented, all procedures were reviewed and approved by Owens-Illinois' Northern Woodlands' management. General concensus regarding C.F.I. remeasurements was a concern that excessive time was being allocated to measuring the height variable, which could be predicted within an acceptable degree of accuracy. Recommended percentage difference limits between actual and predicted height and calculated volume was $\pm$ five percent.

Consequently, management personnel supported use of a height prediction model based on individual tree remeasurement data.

Chapter 4

VALIDATION of the MODEL

Source of error

Differences in standard error (Appendices A - S and Tables 10 - 12) ranged from ± 2.8 to ± 11.7 feet (ninety-five percent of all stem heights should occur within the stated ± value). Average standard error for all remeasurement years ranged from ± 6.1 to ± 7.1 feet.

Errors within the C.F.I. remeasurement data files are due to a variety of height measurement techniques, variance between crews, and lack of uniform instrumentation.

Previous individual stem remeasurement data included measured tree height to a four inch diameter outside bark. However, calibrated height poles could only accurately measure to approximately twenty-eight feet. All other merchantable heights were estimated to a point on the tree by the crew leader and measured with a variety of instruments. Due to in-company uniform training in basic forest measurement skills, variation was probably reduced.

Error associated with measured plot site values are attributable to two sources.

First, within stand variance of environmental influences including genetic, biological, and soil related factors (McQuiken, and Rogers, 1978). Soil relationship to existing vegetation depends to some degree on soil area size and surrounding forest cover (Wilde, 1958). Collection of site data with one tree representing one plot may not capture all significant qualities of environmental influences.

Second, site tree selection techniques coupled with credibility

of existing site curves can account for significant error possibilities.

Site curves are based on even-aged stands. Company-owned hardwood stands are usually under management transition from two-storied residual stands, from old high-grade logging activities, to an all-aged regulated forest. Site tree selection of a residual stem from an area of old logging activity is undesirable because height is modified due to the "open-grown" condition.

Older site curves were unreliable because original hardwood stands in the Lake States were un-even, or all-aged. Selection of dominant or co-dominant stems from old-growth stands was undesirable because of periods of earlier stagnation due to suppression. Total height is more difficult to measure, and "frequently is not a particularly meaningful figure" (Davis, 1966).

Owens-Illinois has generally used site equations developed by the United States Forest Service (Figures 3 - 11, Carmean, 1978).

Some variation in average silvicultural category stem count characteristics used to develop regression equations can be attributed to the dynamic condition of the forest. Ingrowth, accretion, mortality, harvest, and growth on harvest all contribute to a changing data base by remeasurement year.

Company purchase of new lands add to the raw data base, but individual stem quality on procured lands is different from that of fee ownership which is under some degree of management. This problem is compounded when company-owned lands are traded or sold, resulting in depletion of "managed quality" stems from the original data base. This activity tends to increase the standard error of estimate.

Justification for model development

Tables 2 - 8 support the need for soil group differentiation into practical forest management silvicultural guidelines. Historically, site classifications were considered adequate for management purposes; however, differences in dominant and co-dominant tree growth on different soils and different climates has been closely studied with resultant loss of confidence in site differentiation only (Youngberg, 1963).

Due to the uncommonly large data pool (9200+ stems in 1974), no inferential statistical procedures were considered necessary to complete model analyses.

The basic concept of height prediction by diameter class is not new. Bonner (1974) estimated tree heights (in conjunction with measured sample trees) and found that total volume estimates were not significantly affected. On-plot remeasurement time was reduced forty percent which resulted in more sample plots measured during a given time frame. Owens-Illinois reported similar results in 1979.

Some samplers (Schreuder, 1978) have attempted to estimate basal area, sums of diameters, and numbers of trees without stem measurement by tallying trees on point samples and fixed radius plots. Schreuder does not recommend this technique as a practical field procedure.

Dimitrou (1978) has developed height versus diameter regression equations for spruce trees. Height was correlated with diameter by age class and experimental data utilization levels. The most desirable formula format which best explained all experimental conditions was $\log Y = a + b/X$, where Y = height, and X = diameter.

Results of analysis

A regression equation of the form $Y = -a + bX$ was used where: Y = merchantable height in feet, and X = the square root of the diameter, breast height in tenths of inches.

If the regression equation is observed in the positive quadrant of the system, and since "a" is negative, then the predictive line intersects the X axis, and since "b" is positive, the line will descend to the left (Loetsch & Haller, 1964).

C.F.I. involves periodically measuring individual tree growth, observing changing forest conditions, and providing an accounting data base (Husch, Miller, and Beers, 1972). Implementation of height estimation destroys the concept of individual tree measurement records.

Owens-Illinois' management feels that cost savings incurred during remeasurement more than compensated for maintenance of individual tree records. Most relevant growth trends had been observed during past remeasurements.

R^2 (Tables 10 - 12) were uniformly high for "wet" soils (1) and low for "sands" soils (3). Soil 1 supports hydrophytic hardwoods (elms and some ash) which are inherently "limby." Multiple branching provided more distinct four inch top d.o.b. height estimation points due to forking, resulting in lower variances.

Soil 3 hardwood cover type consists of red maple and red oak, both considered "pioneer" or "sub-climax" species. Both species develop relatively tall columnar boles (Fowells, 1965) which result in more difficult estimation of a four inch top.

Stems occurring on soils 2 and 4 approximated each other in variability due to an increased data base, and inclusion of some soil 1 and 3 species

stems within the data base.

Tables 13 - 25 represent percent differences in height and resultant calculated volume of all possible combinations of silvicultural categories that exist within the C.F.I. data files (1964, 1969, 1974) of the Owens-Illinois' forest management silvicultural guideline structure. Most differences are explained by "source of error" already discussed, and, inherent differences within the silvicultural categories of the hardwood group.

Table 26 broadly summarizes the results of Tables 13 - 25. General differences are a decrease in percent difference of height and volume for "All" versus "Northern Hardwood" land uses. Greater species variation occurs within hardwood land use plots. Hardwood species occurring on aspen and conifer land use plots generally consist of paper birch, red maple, and oak which exhibit similar form and taper, and occur between the height range limits of the hardwood species group. Therefore, differences could be due to an increased data base which provides a positive compensating effect on variability.

Soil 3 percentage difference analysis reflects greater variances than soils 2 and 4 by remeasurement year, probably due to inherent increased standard error of prediction input data.

Company management recommended a $\pm$ five percent limit on percent difference between actual and predicted total volume per comparison year. Results were well within model goals; 1964 to 1969 resulted in 1.2 and .5 percent difference, 1969 to 1974 reported 2.3 and 1.4 percent variation, while the ten year study (1964 to 1974) indicated 4.6 and 3.7 percent dissimilarity for "All soils" by "Northern Hardwood" and "All" land uses, respectively.

"All soils" results displayed a compensating effect of all individual soils, and should be utilized for woodlands' total hardwood volume accounting data base requirements. In contrast, finer delineation of data analysis is desirable for land management needs.

Height tables by diameter class (Tables 27 - 29) were developed to compare model predictions to actual mean heights by comparison years (1964 to 1969, 1969 to 1974, and 1964 to 1974).

The actual (measured) height by diameter relationship is represented by an "S" shaped curve while the model predictive curve is linear, which could be cause for concern. Upon closer scrutiny of the "number of trees" distribution data, several compensating actions occur. Stem distribution is bell-shaped, peaking at the six inch diameter class. Approximately ninety-five percent of the tree tally occurs within the five to twelve inch diameter class. The linear regression expression crosses and re-crosses the actual "S" shaped height curve twice between the five and twelve inch diameter classes, which produces a "compensating" effect for approximately ninety-five percent of comparable tree heights. Throughout succeeding diameter classes, both curves display increasing divergence. This is due to the inflexible quality of the predictive curve, and the tendency of the upper end of the "normal" (in nature) "S" shaped curve to "increase at an increasing rate" and finally, to decrease at an increasing rate."

Model limits required five feet variance for mean predicted height for all hardwood group stems.

Average height increased from twenty-five to twenty-seven feet from 1964 to 1974. Percent difference between actual and predicted mean height was approximately four percent for both years, which resulted in

underestimating actual mean height by approximately one foot.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

A regression model which predicts tree heights and calculates acceptable volumes has been developed and implemented. Percent difference results of actual versus predicted data is well within predetermined model accuracy limits and can be used to provide acceptable accounting data as well as usable land management information.

The model can readily accomodate variability of the northern hardwood species group which has the greatest diversity of species and related silvicultural qualities of any group within company-controlled woodlands. Due to intrinsic model flexibility, usage in other Owens-Illinois' forests can be readily incorporated.

Recommendations

Include all other Northern Woodlands species groups within the height prediction model system which will result in analysis of total company C.F.I. data by remeasurement year. If total model results are within predetermined accuracy limits, then heights should be predicted and resultant volumes calculated for the next C.F.I. remeasurement.

In conjunction, a systematic sub-sample of some measured tree heights should be considered as a monitoring device.

Prediction curves were developed from all stems on previous C.F.I. data files. When the height prediction model is used on subsequent remeasurements, tree heights from new plots and ingrowth should be measured. In addition, improved instrumentation such as the "Spiegel Relaskop" should be used to accurately determine merchantable height.

Initially, the main objective of this study was to investigate potential reduction of on-plot remeasurement time, but due to the ten year (1964-1974) study results, extension of time periods between remeasurements should be strongly considered.

Model height prediction capabilities should be applied to company-controlled southern pine stands which are generally even-aged and monotypic. Due to the nature of this forest, percent differences between predicted heights and calculated volumes should be significantly smaller than results determined in this study.

Future research opportunities include adapting the height prediction model to the regional silvicultural requirements of other Woodlands, prediction of tree volumes directly from stem diameters, and reducing the number of plots measured during C.F.I.

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TABLES

TABLE 1

Major Regional Soil Type Descriptions Used to Develop Regression Curves for Northern Hardwood Cover Type from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Number	Soil Series	Occurrence of N. Hardwood Plots in %	Soil Description
1	Pella, Poygan, Newton, Houghton, Arenzville	4	Soils of stream bottoms and major wetlands occur in depressions and drainage ways.
2	Iron River, Gogebic, Kennan	57	Soils of northern uplands and plains. Acid, stoney, sandy loam and loams
3	Omega, Vilas Hiawatha	12	Soils of northern sandy uplands and plains. Droughty, acid, low fertility and highly subject to wind erosion. Areas contain numerous lakes and bogs.
4	Withee, Santiago, Amery, Antigo	27	Soils of northern silty uplands on plains of outwash sand and gravel.

Soils 1 through 4 and "All Soils" refer to northern hardwood cover type.

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

TABLE 2

"Analysis of Variance" of Mean Tree Heights between Major Regional Soil Groups from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Group	Count (N)	Mean (Feet)	Standard Deviation	Standard Error	Minimum (Feet)	Maximum (Feet)	95 Percent Confidence Interval for Mean (Feet)
1	0	0.0	0.0	.0	0	0	0.0 to 0.0
2	2094	23.53	10.29	.23	4	59	23.09 to 23.97
3	334	20.34	9.33	.51	4	48	19.34 to 21.35
4	1152	23.80	10.18	.30	5	65	23.22 to 24.39
Total	3580	23.32	10.21	.17	5	65	22.98 to 23.65

Summary Table

	Degree of Freedom	Sums of Squares	Mean Squares	F Ratio	"S" Statistic
Between Soils	2	3322.18	1661.09	16.07	0
Error	3577	367764.81	103.37		***
Total	3579	373086.98			

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

Significance Levels: * - .10
** - .05
*** - .01

TABLE 3

"Analysis of Variance" of Mean Tree Heights between Major Regional Soil Groups from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Group	Count (N)	Mean (Feet)	Standard Deviation	Standard Error	Minimum (Feet)	Maximum (Feet)	95 Percent Confidence Interval for Mean (Feet)
1	200	23.87	10.68	.76	7	58	22.38 to 25.3
2	3256	25.74	10.58	.19	4	62	25.37 to 26.1
3	593	22.35	9.15	.38	6	54	25.61 to 23.0
4	1326	24.60	9.99	.27	4	65	24.07 to 25.1
Total	5375	25.01	10.35	.14	4	65	24.74 to 25.2

Summary Table

	Degree of Freedom	Sums of Squares	Mean Squares	F Ratio	"S" Statistic
Between Soils	3	6497.51	2135.84	20.16	0
Error	5371	568965.43	108.93		***
Total	5374	57372.93			

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

Significance Level: * - .10
** - .05
*** - .01

TABLE 4

"Analysis of Variance" of Mean Tree Heights between Major Regional Soil Groups from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Group	Count (N)	Mean (Feet)	Standard Deviation	Standard Error	Minimum (Feet)	Maximum (Feet)	95 Percent Confidence Interval for Mean (Feet)
1	246	26.17	11.36	.72	5	65	24.75 to 27.60
2	3828	27.27	11.39	.18	4	75	26.91 to 27.63
3	701	24.36	10.88	.41	5	62	23.55 to 25.17
4	1679	28.11	10.79	.26	5	76	27.59 to 28.62
Total	6454	27.13	11.23	.14	4	76	26.86 to 27.40

Summary Table

	Degree of Freedom	Sums of Squares	Mean Squares	F Ratio	"S" Statistic
Between Soils	3	7279.72	2426.57	19.41	0
Error	6450	806363.70	125.02		***
Total	6453	813643.41			

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

Significance Level: * - .10
** - .05
*** - .01

TABLE 5

"T" Tests of Mean Tree Heights between Major Regional Soil Groups from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Group	Count (N)	Mean (Feet)	Standard Deviation	Standard Error
1	0	0.0	0.0	.0
2	2094	23.53	10.29	.23
3	334	20.34	9.33	.51
4	1152	23.80	10.18	.30
Total	3580	23.32	10.21	.17

Soil Groups	"S" Statistic
2 vs 3	***
2 vs 4	
3 vs 4	***

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

Significance Level: * - .10
** - .05
*** - .01

TABLE 6

"T" Tests of Mean Tree Heights between Major Regional Soil Groups from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Group	Count (N)	Mean (Feet)	Standard Deviation	Standard Error
1	200	23.87	10.68	.76
2	3256	25.74	10.58	.19
3	593	22.35	9.15	.38
4	1326	24.60	9.99	.27
Total	5375	25.01	10.35	.14

Soil Groups	"S" Statistic
1 vs 2	**
1 vs 3	*
1 vs 4	
2 vs 3	***
2 vs 4	***
3 vs 4	***

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

Significance Level: * - .10
** - .05
*** - .01

TABLE 7

"T" Tests of Mean Tree Heights between Major Regional Soil Groups from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc. Tomahawk, Wisconsin.

Soil Group	Count (N)	Mean (Feet)	Standard Deviation	Standard Error
1	246	26.17	11.36	.72
2	3828	27.27	11.39	.18
3	701	24.36	10.88	.41
4	1679	28.11	10.79	.26
Total	6454	27.13	11.23	.14

Soil Group	"S" Statistic
1 vs 2	
1 vs 3	**
1 vs 4	***
2 vs 3	***
2 vs 4	***
3 vs 4	***

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

Significance Level: * - .10
** - .05
*** - .01

TABLE 8

1974 Continuous Forest Inventory Plot and Stem Distribution for the Northern Hardwood Species Group from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Soil	Number of Plots	Number of Trees	Number of Trees/Plot
Low	Low	1	1	22	22
Low	Low	2	12	237	20
Low	Low	3	8	160	20
Low	Low	4	6	206	35
			Sums 27	625	24
Low	Med	1	1	6	6
Low	Med	2	27	585	22
Low	Med	3	11	316	29
Low	Med	4	12	320	27
			Sums 51	1227	24
Low	High	2	8	246	31
Low	High	3	3	69	23
Low	High	4	5	162	33
			Sums 16	477	30
Med	Low	1	2	62	31
Med	Low	2	7	214	31
Med	Low	3	1	31	31
Med	Low	4	1	47	47
			Sums 11	354	33
Med	Med	1	4	121	31
Med	Med	2	35	1208	35
Med	Med	3	5	164	33
Med	Med	4	23	862	38
			Sums 67	2355	36
Med	High	2	15	516	35
Med	High	3	3	107	36
Med	High	4	10	347	35
			Sums 28	970	35
High	Low	2	7	263	38
High	Low	4	1	44	44
			Sums 8	307	39

TABLE 8 CONTINUED

Basal Area	Site	Soil	Number of Plots	Number of Trees	Number of Trees/Plot
High	Med	1	2	64	32
High	Med	2	32	1302	41
High	Med	3	4	171	43
High	Med	4	7	290	42
		Sums	45	1827	41
High	High	1	1	37	37
High	High	2	15	667	45
High	High	4	9	403	45
		Sums	25	1107	45

Basal Area Plot Summary

Basal Area	Number of Plots	Number of Trees	Number of Trees/Plot
Low	94	2329	25
Med	106	3679	35
High	78	3241	43
All	278	9249	34

Site Plot Summary

Site Category	Number of Plots	Number of Trees	Number of Trees/Plot
Low	46	1286	28
Med	163	5409	34
High	69	2554	38
All	278	9249	34

Soil Plot Group Summary

Soil Group	Number of Plots	Number of Trees	Number of Trees/Plot
1	11	312	29
2	158	5238	34
3	35	1018	30
4	74	2681	37
All	278	9249	34

Basal Area (Square Feet): Low 1-90, Medium 91-120, High 121+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

Soil: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

TABLE 9

Distribution of Major Species Group Stems within the Continuous Forest Inventory Northern Hardwood Cover Type by Site Category from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

NORTHERN HARDWOOD

Site	Number of C.F.I. Plots	%	Northern Hardwood %	Aspen %	Conifer %
Low	46	16	76	5	19
Medium	163	58	85	8	7
High	69	26	86	8	6
All	278	100	84	8	8

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

TABLE 10

Summary of Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Soil Type from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Type	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
1	-	-	-	-	-	-
2	1938	.80	.64	-32.56	21.18	6.3
3	230	.77	.59	-33.13	20.21	5.6
4	1090	.82	.68	-34.08	21.64	5.8
All Soils	3258	.80	.64	-33.53	21.45	6.1
All Land Use All Soils	3765	.80	.64	-34.06	21.56	6.1

Soils 1 through 4 and "All Soils" refer to northern hardwood cover type.

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

TABLE 11

Summary of Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Soil Type from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Type	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
1	200	.87	.75	-36.68	22.66	5.4
2	2914	.79	.63	-30.06	20.87	6.5
3	445	.74	.55	-25.44	18.00	5.8
4	1242	.82	.68	-31.96	20.96	5.7
All Soils	4801	.80	.64	-30.81	20.86	6.3
All Land Use All Soils	5409	.79	.63	-31.18	20.89	6.3

Soils 1 through 4 and "All Soils" refer to northern hardwood cover type.

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

TABLE 12

Summary of Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Soil Type from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Soil Type	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
1	246	.85	.73	-36.68	23.13	5.9
2	3411	.79	.63	-32.28	21.96	6.9
3	521	.62	.38	-25.46	18.99	8.7
4	1570	.79	.63	-28.56	20.75	6.6
All Soils	5758	.78	.61	-31.25	21.58	7.0
All Land Use All Soils	6490	.78	.60	-32.28	21.79	7.1

Soils 1 through 4 and "All Soils" refer to northern hardwood cover type.

Soils: 1 - Wet
2 - Loams
3 - Sands
4 - Silts

TABLE 13

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1969 Remeasurement Data for Soil 2 (Loams) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE: Northern Hardwood Number of Cases	Northern Hardwood HT. %	Northern Hardwood Vol. %	All Number of Cases	All HT. %	All Vol. %
Low	Low	94	0.0	-.5	155	0.0	-.6
Low	Med	395	4.6	2.6	455	4.6	1.2
Low	High	111	4.2	-1.7	122	0.0	-2.7
Low	All	600	4.6	1.9	732	4.6	.5
Med	Low	205	4.0	.2	246	4.0	.2
Med	Med	796	7.7	4.7	834	8.0	4.3
Med	High	387	0.0	-2.6	409	-4.0	-3.3
Med	All	1348	7.7	3.4	1489	8.0	2.9
High	Low	75	9.1	2.3	132	3.5	.4
High	Med	545	6.7	0.0	546	6.7	0.0
High	High	346	3.3	-.8	357	0.0	-1.2
High	All	966	3.3	1.1	1035	3.5	.7
All	Low	304	3.9	-.1	533	0.0	-.3
All	Med	1696	3.9	2.3	1835	7.7	1.7
All	High	844	0.0	-.8	8888	0.0	-1.5
All	All	2914	3.9	2.4	3256	7.7	1.6

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

% = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100.$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values

TABLE 14

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1969 Remeasurement Data for Soil 3 (Sands) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	44	36.8	28.6	74	36.5	29.8
Low	Med	109	5.6	-1.2	124	5.6	-1.9
Low	High	17	9.4	4.7	21	6.7	2.6
Low	All	170	5.0	.3	219	0.0	-1.9
Med	Low	20	-18.2	-10.4	38	-10.0	-8.5
Med	Med	53	-21.1	-20.9	72	-15.0	-13.9
Med	High	76	22.2	14.2	78	19.2	14.0
Med	All	149	0.0	-.4	188	0.0	.4
High	Low	0	0.0	0.0	23	15.4	15.4
High	Med	126	100.0	100.0	146	100.0	100.0
High	High	0	0.0	0.0	17	100.0	100.0
High	All	126	8.0	8.7	186	11.5	10.7
All	Low	64	0.0	-4.0	135	5.0	1.1
All	Med	288	4.8	-2.8	342	4.5	-.8
All	High	93	14.3	5.8	116	11.1	4.5
All	All	445	4.6	3.0	593	9.1	4.0

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

% = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}}$ X 100.

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 15

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1969 Remeasurement Data for Soil 4 (Silts) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE: Northern Hardwood Number of Cases	Northern Hardwood HT. %	Northern Hardwood Vol. %	All Number of Cases	All HT. %	All Vol. %
Low	Low	12	-5.9	-8.0	28	-17.7	-17.9
Low	Med	279	13.6	6.9	306	9.1	5.8
Low	High	68	4.4	6.4	71	4.4	6.5
Low	All	359	9.1	5.6	405	9.1	4.2
Med	Low	40	-4.2	-5.1	42	-8.7	-5.5
Med	Med	232	-4.6	-3.6	252	0.0	-4.9
Med	High	170	8.7	2.9	170	8.7	2.9
Med	All	442	0.0	-3.0	464	0.0	-3.9
High	Low	2	100.0	100.0	8	100.0	100.0
High	Med	216	-3.6	-2.0	226	0.0	-2.2
High	High	223	0.0	-.5	223	0.0	-.5
High	All	441	0.0	-1.5	457	-3.5	-1.9
All	Low	54	-4.4	-6.2	78	-14.3	-13.7
All	Med	727	0.0	-.5	784	0.0	-1.4
All	High	461	3.7	.5	464	3.7	.4
All	All	1242	0.0	-.6	1326	0.0	-1.6

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual} - \text{Predicted}}{\text{Actual}} \times 100.$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 16

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1969 Remeasurement Data for All Soils by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	183	0.0	.8	290	0.0	-1.3
Low	Med	870	9.1	3.1	972	4.8	2.0
Low	High	196	4.2	1.7	214	4.2	.9
Low	All	1249	4.6	2.4	1476	0.0	.9
Med	Low	278	0.0	-1.9	339	0.0	-.2
Med	Med	1110	8.0	3.0	1227	8.0	2.4
Med	High	665	4.0	-1.1	689	4.0	-1.5
Med	All	2053	4.0	1.9	2255	8.0	1.4
High	Low	77	9.1	2.9	163	3.6	1.0
High	Med	887	3.5	-1.4	918	3.5	-1.2
High	High	569	0.0	-.5	597	0.0	-1.0
High	All	1533	0.0	-.1	1678	0.0	-.4
All	Low	538	0.0	-1.3	792	0.0	-1.9
All	Med	2867	4.0	1.2	3117	4.0	.7
All	High	1430	3.7	.1	1500	3.7	-.4
All	All	4835	7.7	1.2	5409	4.0	.5

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

% = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 17

Prediction Equations Developed from 1969 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 1 (Wet) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use from Northern Woodlands, Owens-Illinois., Tomahawk, Wisconsin

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	22	0.0	2.4	22	0.0	2.4
Low	Med	1	-22.0	-12.9	1	-22.0	-12.9
Low	High	0	0.0	0.0	0	0.0	0.0
Low	All	23	-4.0	-1.2	23	-4.0	-1.0
Med	Low	43	0.0	1.1	43	0.0	1.1
Med	Med	100	-3.9	-2.9	100	-3.9	-2.9
Med	High	0	0.0	0.0	0	0.0	0.0
Med	All	143	7.7	5.3	143	7.7	5.3
High	Low	0	0.0	0.0	0	0.0	0.0
High	Med	43	100.0	100.0	43	100.0	100.0
High	High	37	100.0	100.0	37	100.0	100.0
High	All	80	100.0	100.0	80	100.0	100.0
All	Low	65	7.7	2.9	65	7.7	2.9
All	Med	144	7.1	2.4	144	7.1	2.4
All	High	37	9.1	4.9	37	9.9	4.9
All	All	246	3.9	2.0	246	3.9	2.0

All Height in Feet

All Volume in Cords

Basal Area (Square Feet);: Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 18

Prediction Equations Developed from 1969 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 2 (Loams) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	131	4.8	.3	224	0.0	-3.0
Low	Med	305	-4.6	-4.7	371	-9.5	-6.8
Low	High	119	11.5	7.7	133	12.0	6.7
Low	All	555	-4.6	-1.4	728	-4.8	-4.3
Med	Low	143	0.0	-3.7	156	0.0	-3.8
Med	Med	822	0.0	.8	940	3.9	.3
Med	High	354	3.5	.1	382	0.0	-.8
Med	All	1319	0.0	.3	1478	0.0	-.4
High	Low	145	3.0	2.5	184	0.0	-.7
High	Med	899	0.0	-1.3	925	0.0	-1.4
High	High	493	6.5	2.7	513	6.5	2.3
High	All	1537	0.0	.4	1622	3.2	0.0
All	Low	419	3.7	1.0	564	0.0	-.8
All	Med	2026	3.6	-.1	2235	0.0	.7
All	High	966	6.8	2.4	1028	3.5	1.7
All	All	3411	3.6	.7	3828	0.0	-.2

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 19

Prediction Equations Developed from 1969 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 3 (Sands) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	56	5.3	4.2	108	0.0	2.3
Low	Med	107	5.3	5.3	133	5.3	3.6
Low	High	41	11.1	7.1	46	8.8	4.8
Low	All	204	13.0	9.4	287	4.8	5.3
Med	Low	19	11.5	6.2	38	13.6	7.7
Med	Med	76	13.0	3.9	88	9.1	3.5
Med	High	79	12.9	7.9	86	6.9	6.6
Med	All	174	11.1	4.9	212	8.0	3.7
High	Low	0	0.0	0.0	0	0.0	0.0
High	Med	143	3.7	2.2	181	10.3	5.7
High	High	0	0.0	0.0	21	100.0	100.0
High	All	143	3.7	2.2	202	7.1	4.4
All	Low	75	9.5	5.5	146	5.3	3.3
All	Med	326	8.3	3.4	402	8.3	5.2
All	High	120	15.2	8.7	153	6.7	5.2
All	All	521	8.0	5.3	701	4.2	4.3

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

% = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 20

Prediction Equations Developed from 1969 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 4 (Silts) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	47	10.0	7.1	71	0.0	1.3
Low	Med	162	0.0	-3.6	187	0.0	-4.0
Low	High	67	7.7	3.7	72	11.5	4.0
Low	All	276	0.0	-1.0	330	0.0	-2.5
Med	Low	23	7.4	5.3	24	11.1	5.8
Med	Med	517	17.9	9.8	544	11.1	8.7
Med	High	260	16.1	9.1	260	16.1	9.1
Med	All	800	17.2	9.1	828	10.7	8.4
High	Low	28	100.0	100.0	34	100.0	100.0
High	Med	175	3.3	1.8	196	3.5	1.1
High	High	291	8.8	3.5	291	8.8	3.5
High	All	494	6.3	3.1	521	9.4	2.6
All	Low	98	4.4	1.2	129	0.0	-3.0
All	Med	854	11.1	4.9	927	11.1	3.9
All	High	618	12.5	5.1	623	12.5	5.0
All	All	1570	10.3	4.9	1679	7.1	4.0

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 21

Prediction Equations Developed from 1969 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for All Soils by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE: Northern Hardwood Number of Cases	Northern Hardwood HT. %	Northern Hardwood Vol. %	All Number of Cases	All HT. %	All Vol. %
Low	Low	256	4.8	1.3	425	0.0	-2.7
Low	Med	575	-4.8	-3.8	692	-4.8	-5.4
Low	High	227	100.0	100.0	251	100.0	100.0
Low	All	1058	0.0	.2	1368	-4.8	-2.5
Med	Low	228	0.0	-.8	261	0.0	-1.0
Med	Med	1515	7.4	2.3	1672	3.9	1.6
Med	High	693	10.0	4.6	728	6.9	4.0
Med	All	2436	7.1	2.8	2661	3.7	2.1
High	Low	173	100.0	100.0	218	100.0	100.0
High	Med	1295	100.0	100.0	1380	100.0	100.0
High	High	821	100.0	100.0	862	100.0	100.0
High	All	2289	3.2	1.3	2460	3.2	1.0
All	Low	657	4.0	1.6	902	0.0	-.6
All	Med	3385	3.7	1.5	3744	3.7	.9
All	High	1741	6.7	3.7	1841	6.7	3.1
All	All	5783	7.1	2.3	6489	3.7	1.4

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, 45-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 22

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 2 (Loams) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	131	4.8	.6	224	0.0	-2.6
Low	Med	305	0.0	-1.0	371	-4.8	-3.1
Low	High	119	11.5	7.6	133	12.0	6.7
Low	All	555	0.0	1.7	728	0.0	-1.1
Med	Low	143	3.9	-2.2	156	3.9	-2.1
Med	Med	822	7.7	6.5	940	11.5	6.0
Med	High	354	0.0	-1.7	382	-3.6	-2.6
Med	All	1319	7.4	4.9	1478	7.7	4.4
High	Low	145	12.1	7.1	184	9.7	5.7
High	Med	899	3.2	-.2	925	3.2	-.4
High	High	493	6.5	3.1	513	6.5	2.7
High	All	1537	6.5	2.8	1622	6.5	2.5
All	Low	419	7.4	2.6	564	4.0	1.0
All	Med	2026	7.1	3.3	2236	7.4	2.7
All	High	966	6.7	2.6	1028	3.5	2.0
All	All	3411	7.1	4.3	3828	7.4	3.5

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

% = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 23

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 3 (Sands) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	56	36.8	32.2	108	33.3	31.1
Low	Med	107	10.5	6.0	133	10.5	4.5
Low	High	41	19.4	12.2	46	17.7	10.2
Low	All	204	17.4	10.4	287	9.5	6.4
Med	Low	19	0.0	-2.2	38	0.0	-1.3
Med	Med	76	-13.0	-19.6	88	-13.6	-19.4
Med	High	79	32.3	22.3	86	27.6	21.4
Med	All	174	14.8	5.1	212	8.0	4.2
High	Low	0	0.0	0.0	0	0.0	0.0
High	Med	143	100.0	100.0	181	100.0	100.0
High	High	0	0.0	0.0	21	100.0	100.0
High	All	143	14.8	11.8	202	17.9	14.0
All	Low	75	4.8	2.4	146	0.0	.6
All	Med	326	12.5	1.2	402	12.5	3.0
All	High	120	24.2	14.9	153	20.0	11.9
All	All	521	16.0	9.4	701	12.5	8.5

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 24

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for Soil 4 (Silts) by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	47	0.0	-1.5	71	-5.3	-8.2
Low	Med	162	9.5	4.7	187	9.5	4.4
Low	High	67	15.4	11.0	72	15.4	11.1
Low	All	276	9.1	5.6	330	9.1	4.2
Med	Low	23	3.7	1.5	24	3.7	2.1
Med	Med	517	14.3	7.0	544	11.1	5.9
Med	High	260	19.4	11.1	260	19.4	11.1
Med	All	800	13.8	6.8	828	10.7	6.1
High	Low	28	100.0	100.0	34	100.0	100.0
High	Med	175	3.3	.5	196	0.0	-.3
High	High	291	8.8	3.8	291	8.8	3.8
High	All	494	6.3	2.5	521	6.3	2.1
All	Low	98	0.0	-3.9	129	-9.1	-8.3
All	Med	854	11.1	5.0	927	11.1	4.1
All	High	618	12.5	6.3	623	15.6	6.3
All	All	1570	13.8	5.1	1679	10.7	4.3

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 25

Prediction Equations Developed from 1964 Continuous Forest Inventory, and Applied to 1974 Remeasurement Data for All Soils by Basal Area Classes and Site Categories, with Resultant Height and Volume Percentage Differences between Actual (Measured) and Predicted Values by Land Use, from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	LAND USE					
		Northern Hardwood			All		
		Number of Cases	HT. %	Vol. %	Number of Cases	HT. %	Vol. %
Low	Low	256	4.8	2.8	425	5.0	-1.1
Low	Med	575	4.8	.6	692	4.8	-.9
Low	High	227	17.9	10.2	251	14.8	9.2
Low	All	1058	4.6	3.6	1368	0.0	1.0
Med	Low	228	3.9	-1.4	261	0.0	-1.5
Med	Med	1515	11.1	6.2	1672	7.7	5.5
Med	High	693	10.0	3.7	728	6.9	3.2
Med	All	2436	10.7	5.7	2661	11.1	5.1
High	Low	173	9.7	7.0	218	10.0	5.5
High	Med	1295	6.5	.5	1380	3.3	.5
High	High	821	6.3	2.6	862	3.2	2.1
High	All	2289	6.5	2.5	2460	6.5	2.2
All	Low	657	4.0	1.8	904	4.2	-.3
All	Med	3385	7.4	3.8	3744	7.4	3.2
All	High	1741	10.0	4.8	1841	10.0	4.2
All	All	5783	10.7	4.6	6489	7.4	3.7

All Height in Feet

All Volume in Cords

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

$$\% = \text{Percent Difference} = \frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$$

"Northern Hardwood" Land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

TABLE 26

Regression Equation Development and Application to Continuous Forest Inventory Remeasurement Years with Resultant Percentage Differences between Actual (Measured) and Predicted Height and Volume Data between Land Uses and Major Regional Soil Types from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Year Regress. Curves Developed From	Year Regress. Curves Applied To	Land Use	All Soils		Northern Hardwood by Major Regional Soil Type							
					1 (Wet)		2 (Loams)		3 (Sands)		4 (Silt	
			Ht %	Vol %	Ht %	Vol %	Ht %	Vol %	Ht %	Vol %	Ht %	Vol %
1964	1969	N. Hardwood	7.7	1.8	0.0	0.0	3.9	3.4	4.6	4.1	0.0	-
		All	4.0	.5	0.0	0.0	7.7	1.6	9.1	4.0	0.0	-1
1969	1974	N. Hardwood	7.1	4.0	3.9	3.9	3.6	1.0	8.0	8.3	10.3	7
		All	3.7	1.4	3.9	2.0	0.0	-.2	4.3	4.2	7.1	4
1964	1974	N. Hardwood	10.7	6.8	0.0	0.0	7.1	6.6	16.0	12.9	13.8	7
		All	7.4	3.7	0.0	0.0	7.4	3.5	12.5	8.5	10.7	4

All Ht. (Height) in Feet

All Vol. (Volume) in Cords.

% = Percent Difference = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

"Northern Hardwood" land use was selection of all hardwood (except aspen and paper birch) stems from plots designated "Northern Hardwood" only.

"All" Land use was selection of all hardwood (except aspen and paper birch) stems from any plot.

All negative values indicate predicted values were higher than actual values.

"Northern Hardwood by Major Regional Soil Type" from: "Soil Regions of Wisconsin" by Francis D. Hole, 1974, University of Wisconsin Extension, Madison, Wisconsin.

TABLE 27

Hardwood Species Group Height (Feet) by Diameter (Inches) Summary for 1964 to 1969 Continuous Forest Inventory Comparisons from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

D.B.H. (Inches)	Number of Trees	Mean Actual Height (Feet)	Mean Predicted Height (Feet)	Percent Difference between Actual & Predicted Height (%)
5	969	13.9	14.4	-3.7
6	1665	19.1	19.0	.6
7	1091	24.8	23.2	6.4
8	729	29.0	27.1	6.6
9	521	32.5	30.8	5.3
10	328	35.4	34.3	3.0
11	247	37.6	37.6	0.0
12	144	38.0	40.8	-7.3
13	100	40.3	43.8	-8.6
14	63	42.1	46.7	-11.0
15	36	43.5	49.6	-13.9
16	35	44.8	52.3	-16.8
17	25	48.2	54.9	-13.8
18	11	45.6	57.5	-26.0
19	8	49.5	60.0	-21.2
20	5	47.0	62.4	-32.8
21	2	56.0	64.8	-15.7
22	3	54.3	67.1	-23.5
23	3	58.0	69.3	-19.6
24	0	0.0	71.6	0.0
25	2	56.5	73.7	-30.5
26	1	59.0	75.9	-28.6
27	2	53.0	77.9	-47.0

Total Trees..... 5990

Mean Actual Height (Feet).....25.0

Mean Predicted Height (Feet).....24.0

Percent Difference between Actual and Predicted Mean Height (%).....4.0

Percent Difference between Actual and Predicted = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

TABLE 28

Hardwood Species Group Height (Feet) by Diameter (Inches) Summary for 1969 to 1974 Continuous Forest Inventory Comparisons from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

D.B.H (Inches)	Number of Trees	Mean Actual Height (Feet)	Mean Predicted Height (Feet)	Percent Difference between Actual & Predicted Height (%)
5	981	14.9	15.8	-6.2
6	1808	20.0	20.3	-1.4
7	1378	26.0	24.4	6.1
8	872	30.4	28.2	7.2
9	672	34.3	31.8	7.3
10	466	37.5	35.2	6.2
11	290	39.3	38.4	2.2
12	242	41.5	41.5	.1
13	120	42.2	44.4	-5.2
14	92	44.4	47.3	-6.4
15	63	45.9	50.0	-8.8
16	25	46.7	52.6	-12.8
17	38	49.6	55.2	-11.4
18	18	52.7	57.7	-9.6
19	8	41.8	60.1	-44.0
20	7	51.6	62.5	-21.2
21	3	56.7	64.8	14.4
22	0	0.0	67.1	0.0
23	2	60.5	69.3	-14.5
24	2	56.5	71.4	-26.4
25	2	58.0	73.5	-26.7
26	0	0.0	75.6	0.0
27	2	62.5	77.6	-24.2
28	0	0.0	79.6	0.0
29	0	0.0	81.5	0.0
30	1	41.0	83.5	-103.6

Total Trees.....7092

Mean Actual Height (Feet).....27.1

Mean Predicted Height (Feet).....26.0

Percent Difference between Actual and Predicted Mean Height (%).....4.2

Percent Difference between Actual and Predicted = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

TABLE 29

Hardwood Species Group Height (Feet) by Diameter (Inches) Summary for 1964 to 1974 Continuous Forest Inventory Comparisons from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

D.B.H. (Inches)	Number of Trees	Mean Actual Height (Feet)	Mean Predicted Height (Feet)	Percent Difference between Actual & Predicted Height (%)
5	981	14.9	14.4	3.2
6	1808	20.0	19.0	5.0
7	1378	26.0	23.2	10.6
8	872	30.4	27.1	10.6
9	672	34.3	30.8	10.1
10	466	37.5	34.3	8.5
11	290	39.3	37.6	4.2
12	242	41.5	40.8	1.8
13	120	42.2	43.8	-3.8
14	92	44.4	46.7	-5.2
15	63	45.9	49.6	-7.9
16	25	46.7	52.3	-12.0
17	38	49.6	54.9	-10.8
18	18	52.7	57.5	-9.1
19	8	41.8	60.0	-43.7
20	7	51.6	62.4	-21.0
21	3	56.7	64.8	-14.3
22	0	0.0	67.1	0.0
23	2	60.5	69.3	-14.6
24	2	56.5	71.6	-26.7
25	2	58.0	73.7	-27.1
26	0	0.0	75.9	0.0
27	2	62.5	77.9	-24.7
28	0	0.0	80.0	0.0
29	0	0.0	82.0	0.0
30	1	41.0	84.0	-104.8

Total Trees.....7092

Mean Actual Height (Feet).....27.1

Mean Predicted Height (Feet).....25.0

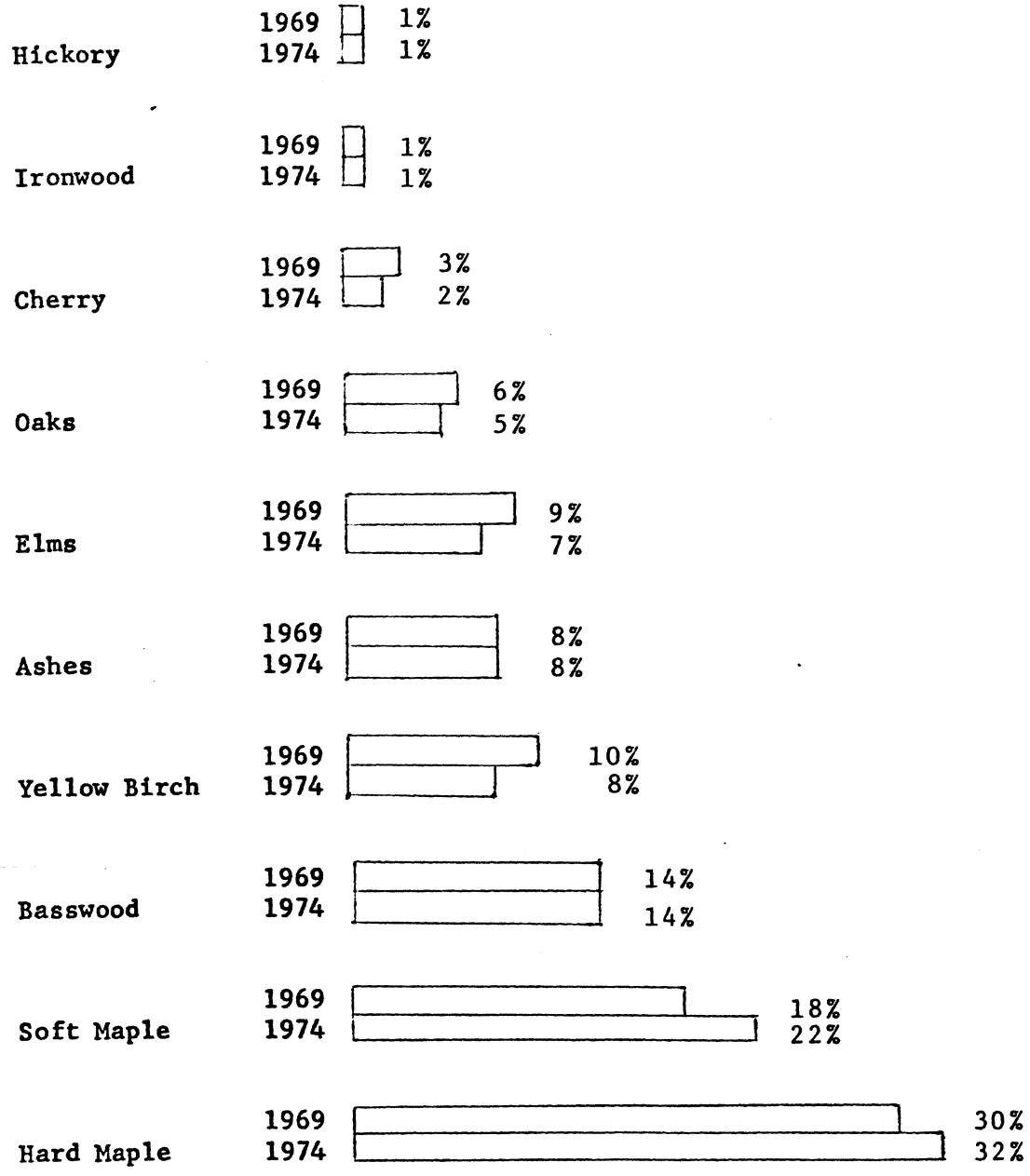
Percent Difference between Actual and Predicted Mean Height (%)....7.9

Percent Difference between Actual and Predicted = $\frac{\text{Actual - Predicted}}{\text{Actual}} \times 100$

FIGURES

FIGURE 1

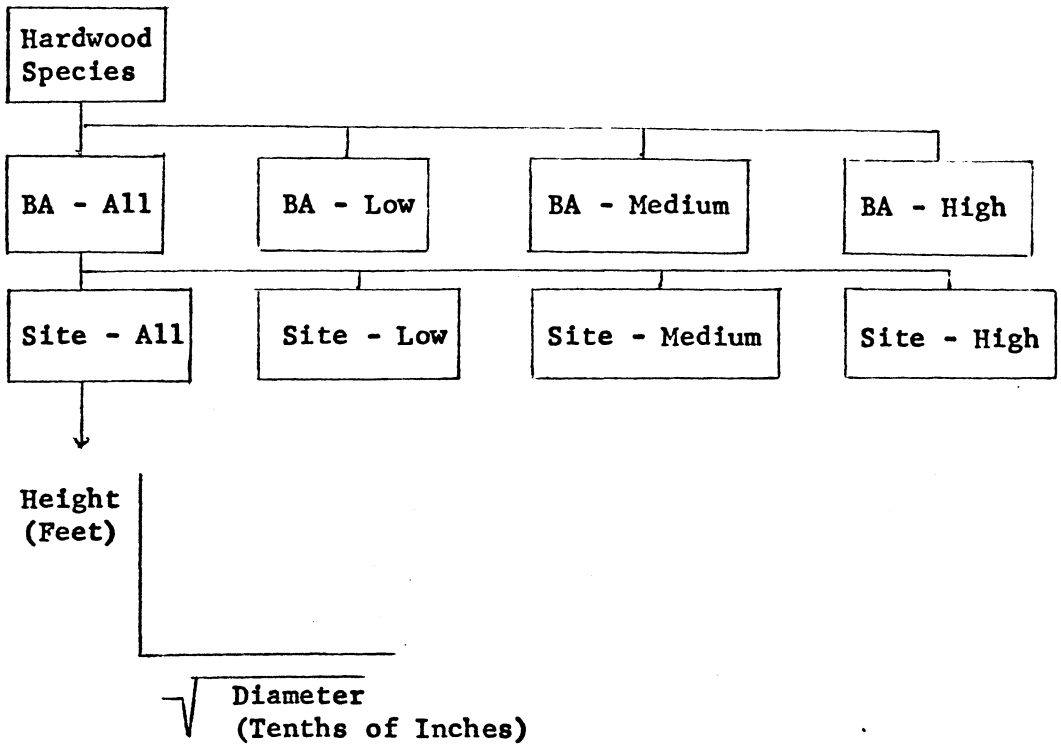
Hardwood Species Group Percentage Composition by Different Continuous Forest Inventory Year Stem Counts from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.



Scale: 1 inch = 10 percent.

FIGURE 2

Initial Individual Hardwood Species Data Classification into Basal Area Classes, Site Categories, and Final Height vs. Diameter (Square Root) Regression Curves.



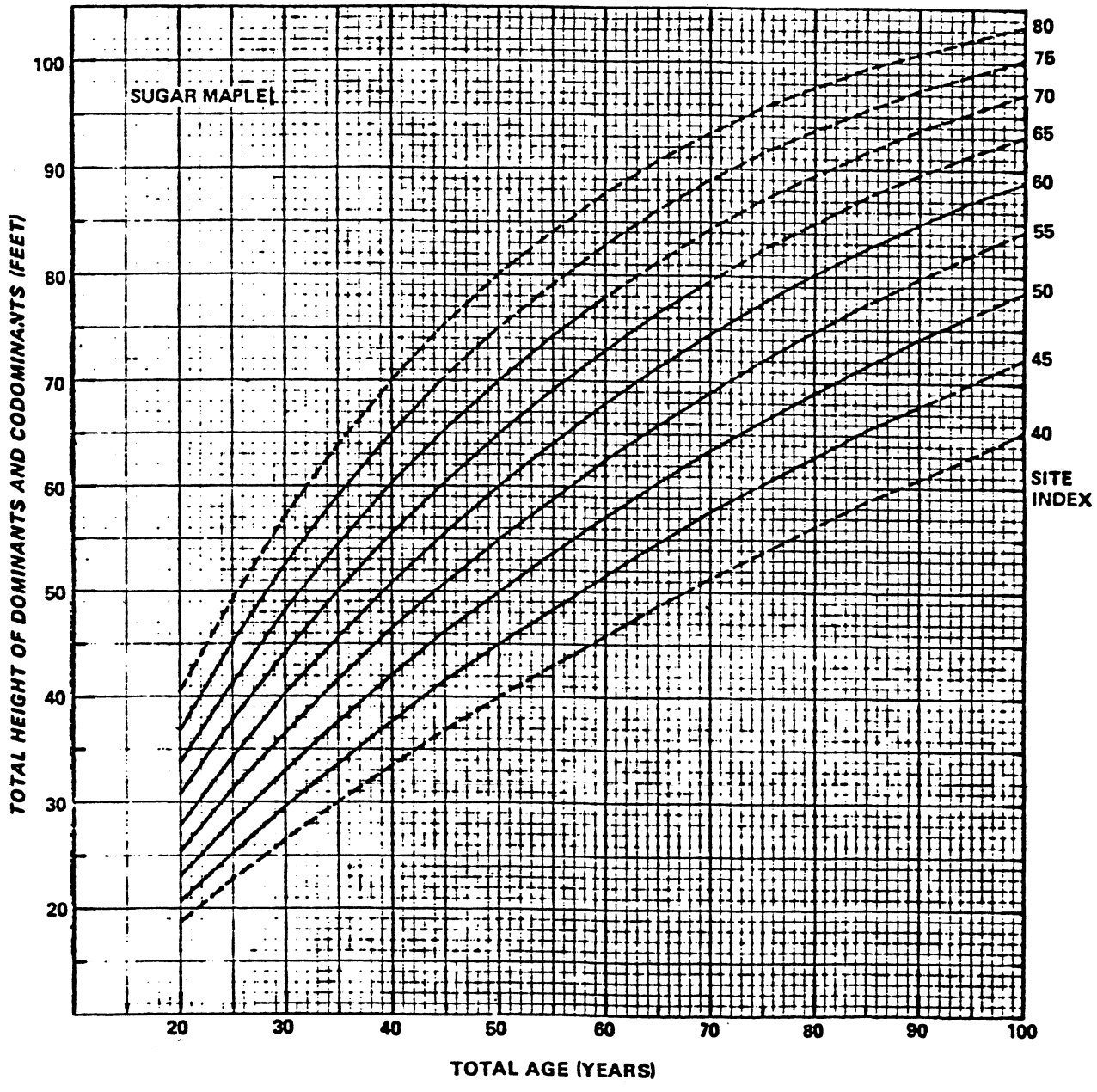
Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured - Base 50): Low 1-45, Medium 46-65, High 66+

FIGURE 3

Site index curves for sugar maple in northern Wisconsin and Upper Michigan

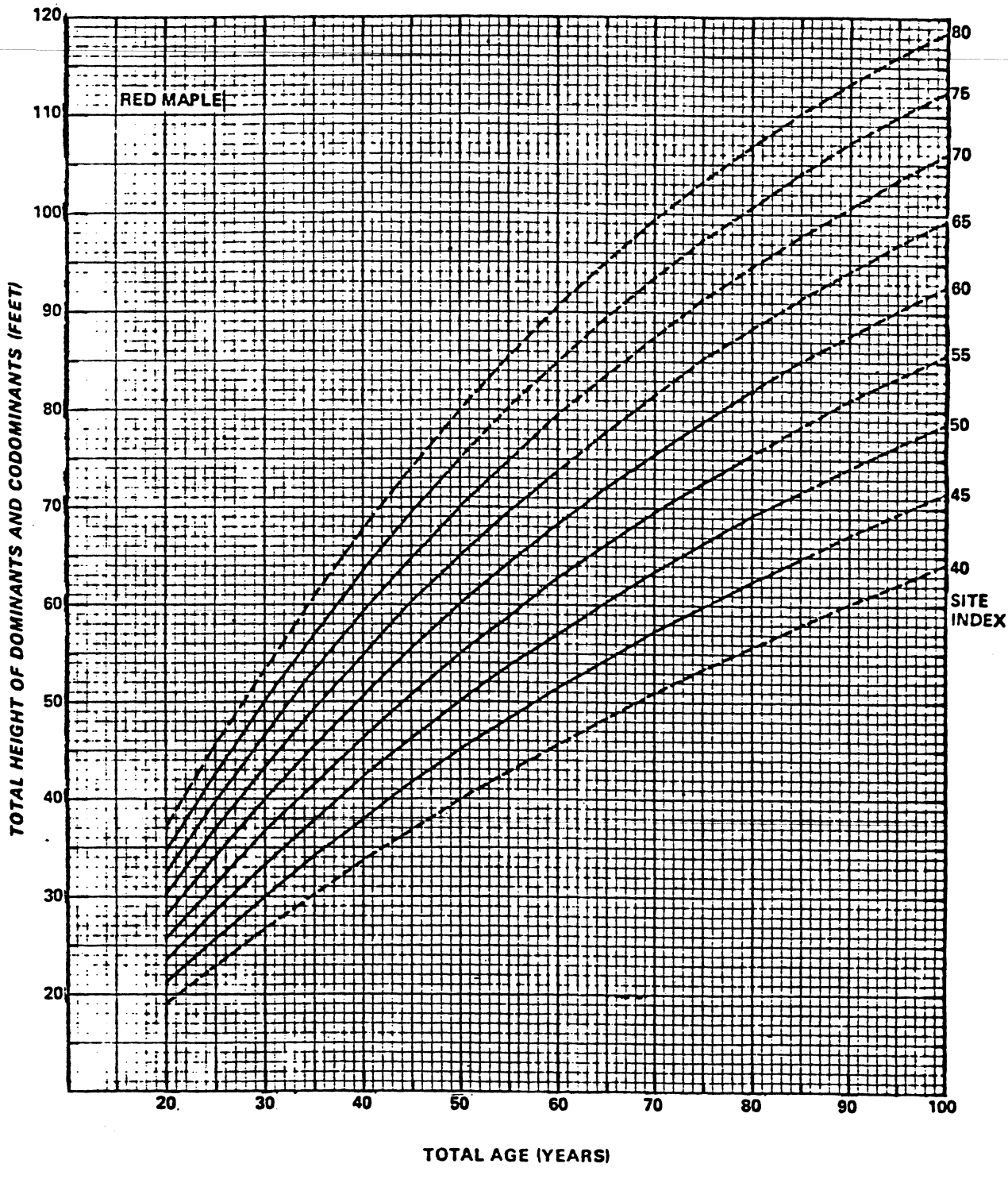
(Carmean, 1978)



These curves are based on stem analyses of 721 dominant and codominant trees growing in 177 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 4

Site index curves for red maple in northern Wisconsin and Upper Michigan
(Carmean, 1978)

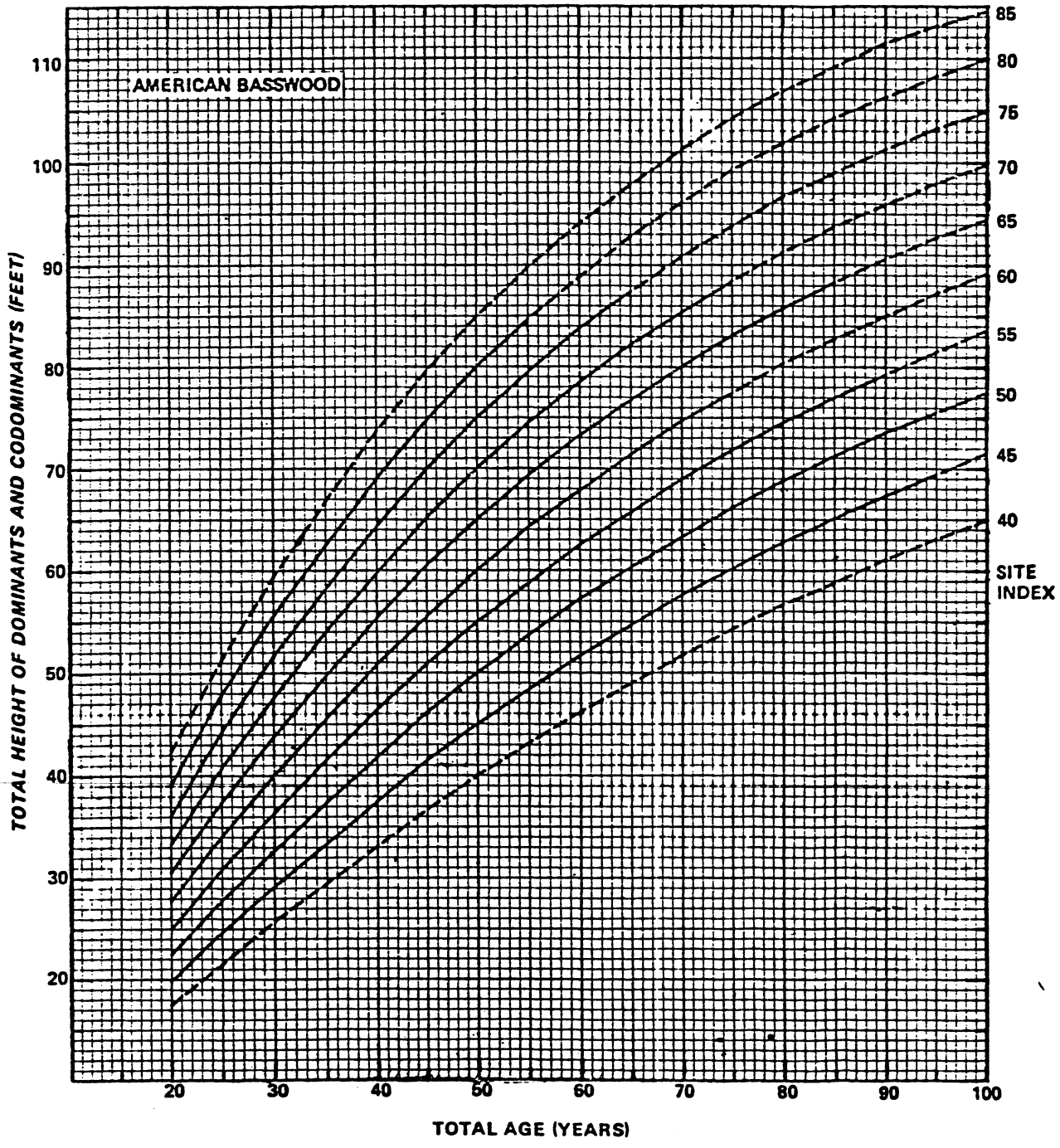


These curves are based on stem analyses of 438 dominant and codominant trees growing in 114 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 5

Site index curves for American basswood in northern Wisconsin and Upper Michigan

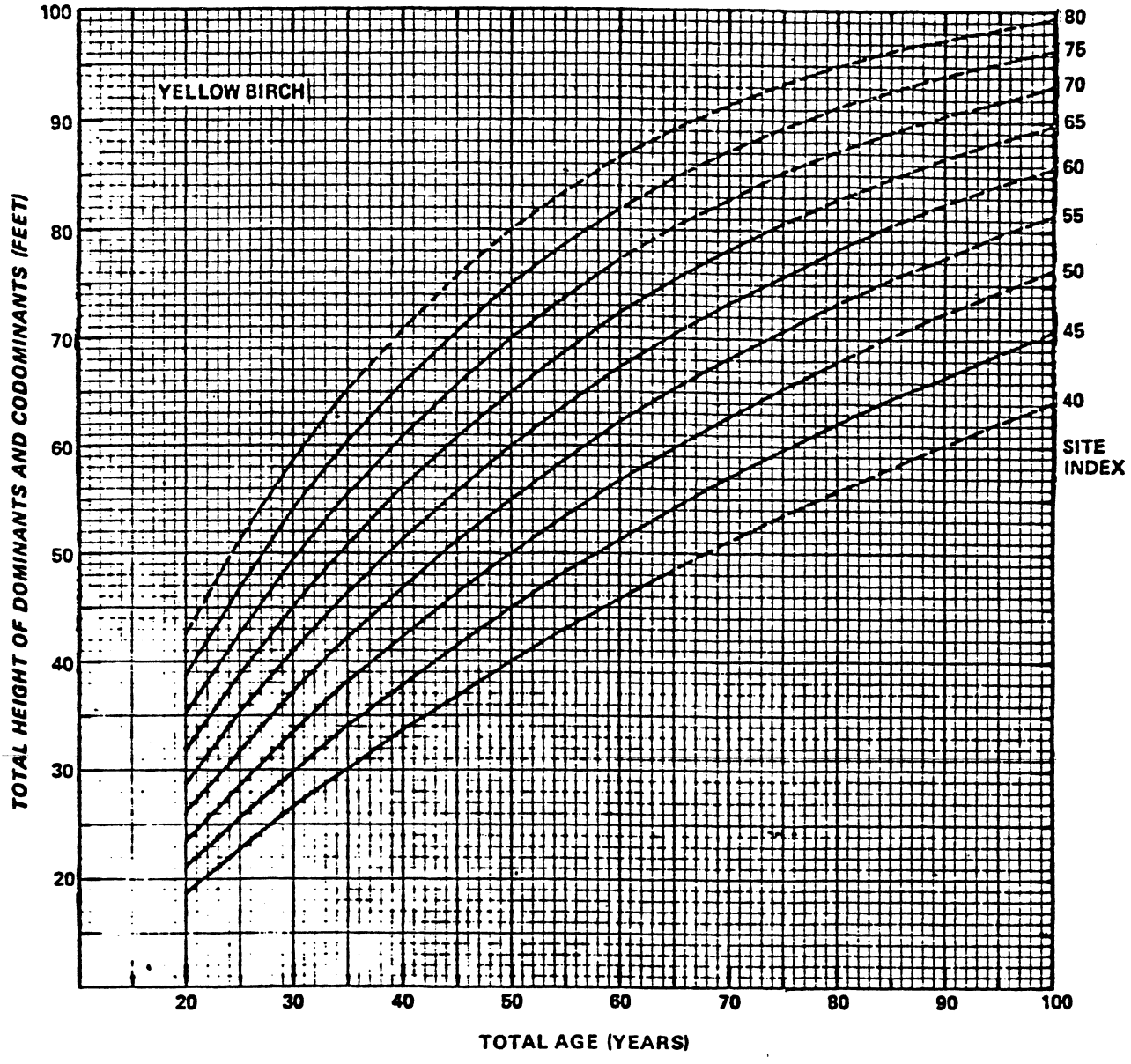
(Carmean, 1978)



These curves are based on stem analyses of 483 dominant and codominant trees growing in 122 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 6.

Site index curves for yellow birch in northern Wisconsin and Upper Michigan (Carmean, 1978)

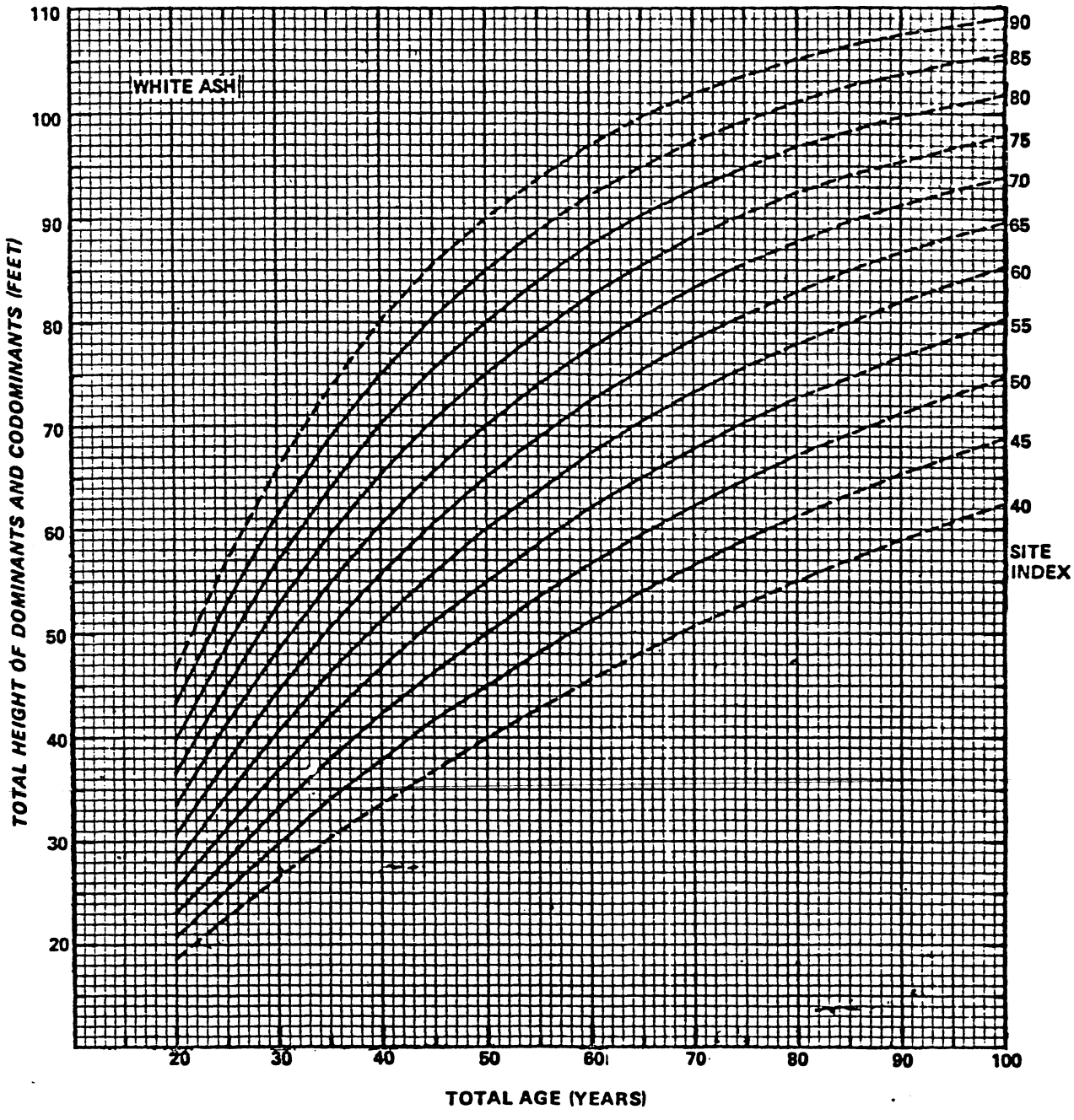


These curves are based on stem analyses of 459 dominant and codominant trees growing in 119 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 7

Site index curves for white ash in northern Wisconsin and Upper Michigan

(Carmean, 1978)

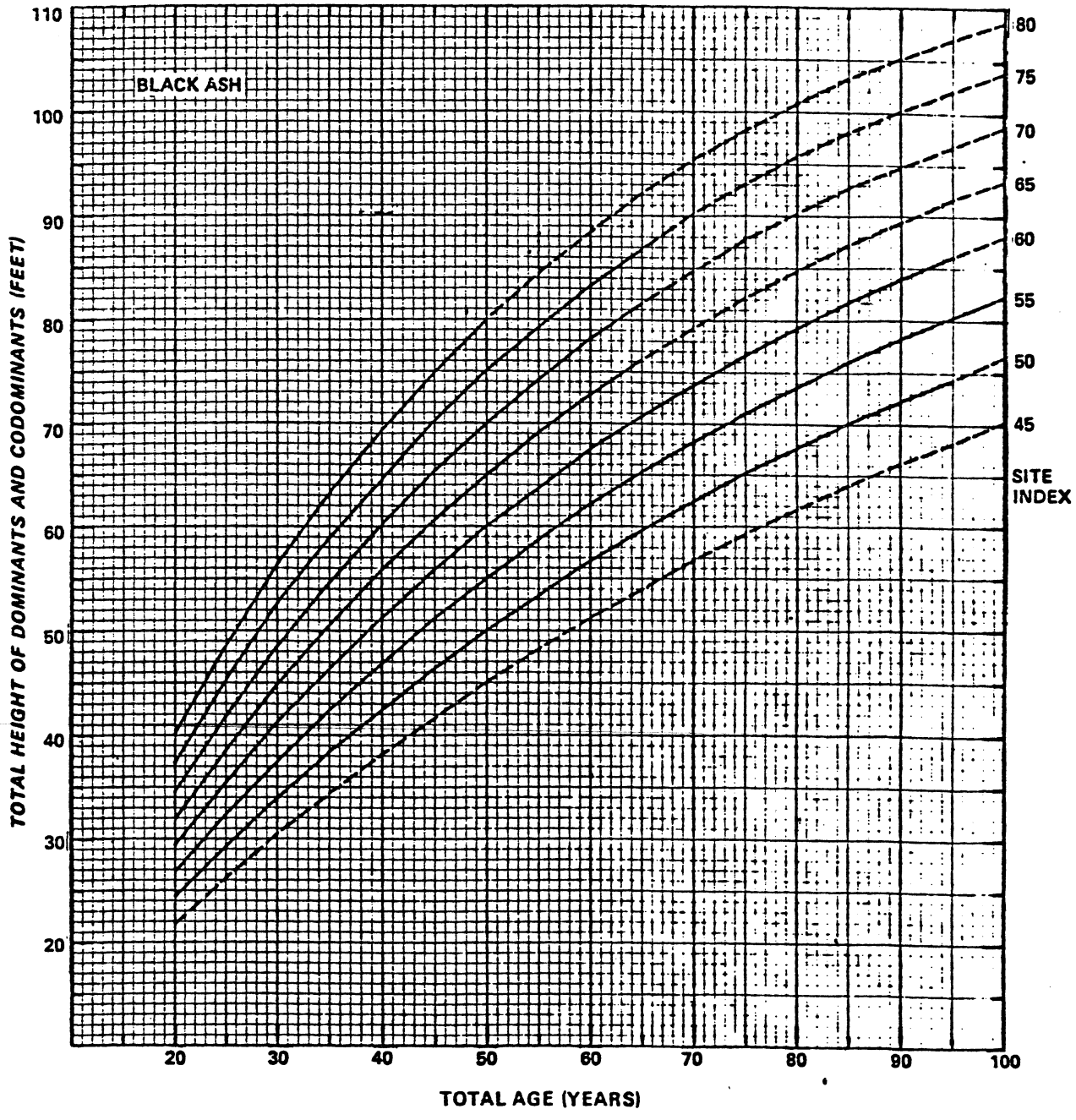


These curves are based on stem analyses of 275 dominant and codominant trees growing in 73 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 8

Site index curves for black ash in northern Wisconsin and Upper Michigan

(Carmean, 1978)

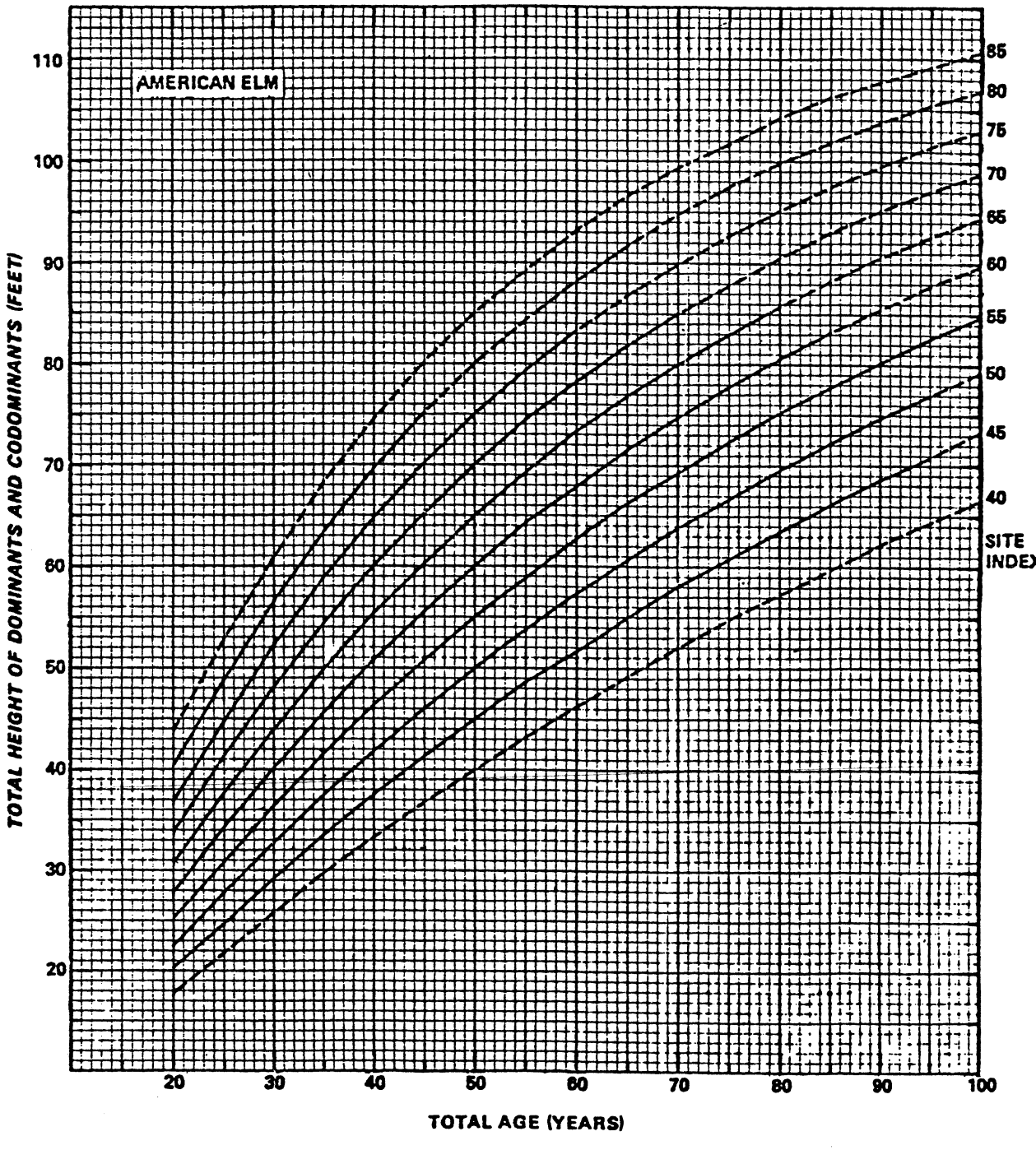


These curves are based on stem analyses of 143 dominant and codominant trees growing in 39 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 9

Site index curves for American elm in northern Wisconsin and Upper Michigan

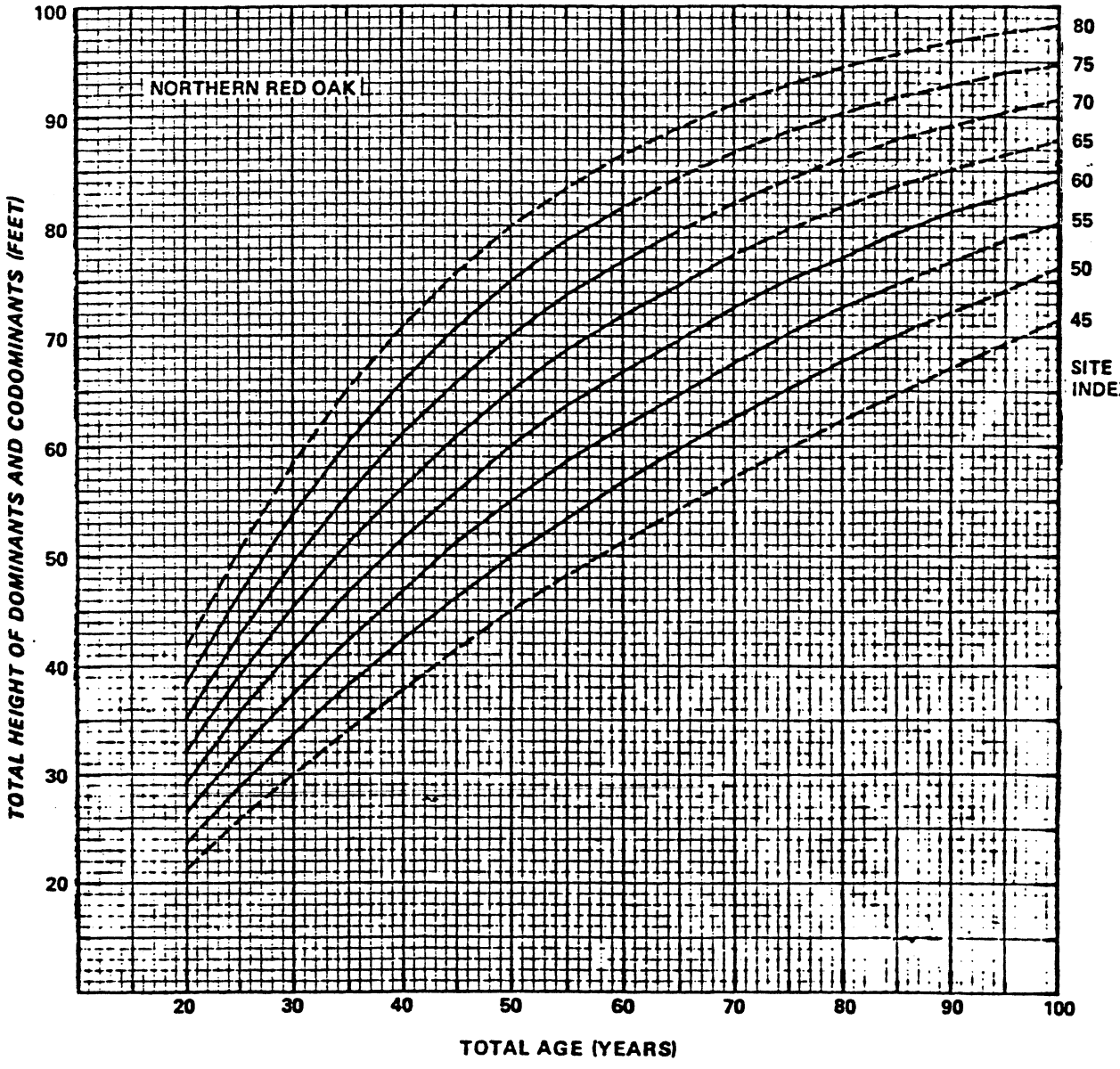
(Carmean, 1978)



These curves are based on stem analyses of 416 dominant and codominant trees growing in 109 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 10

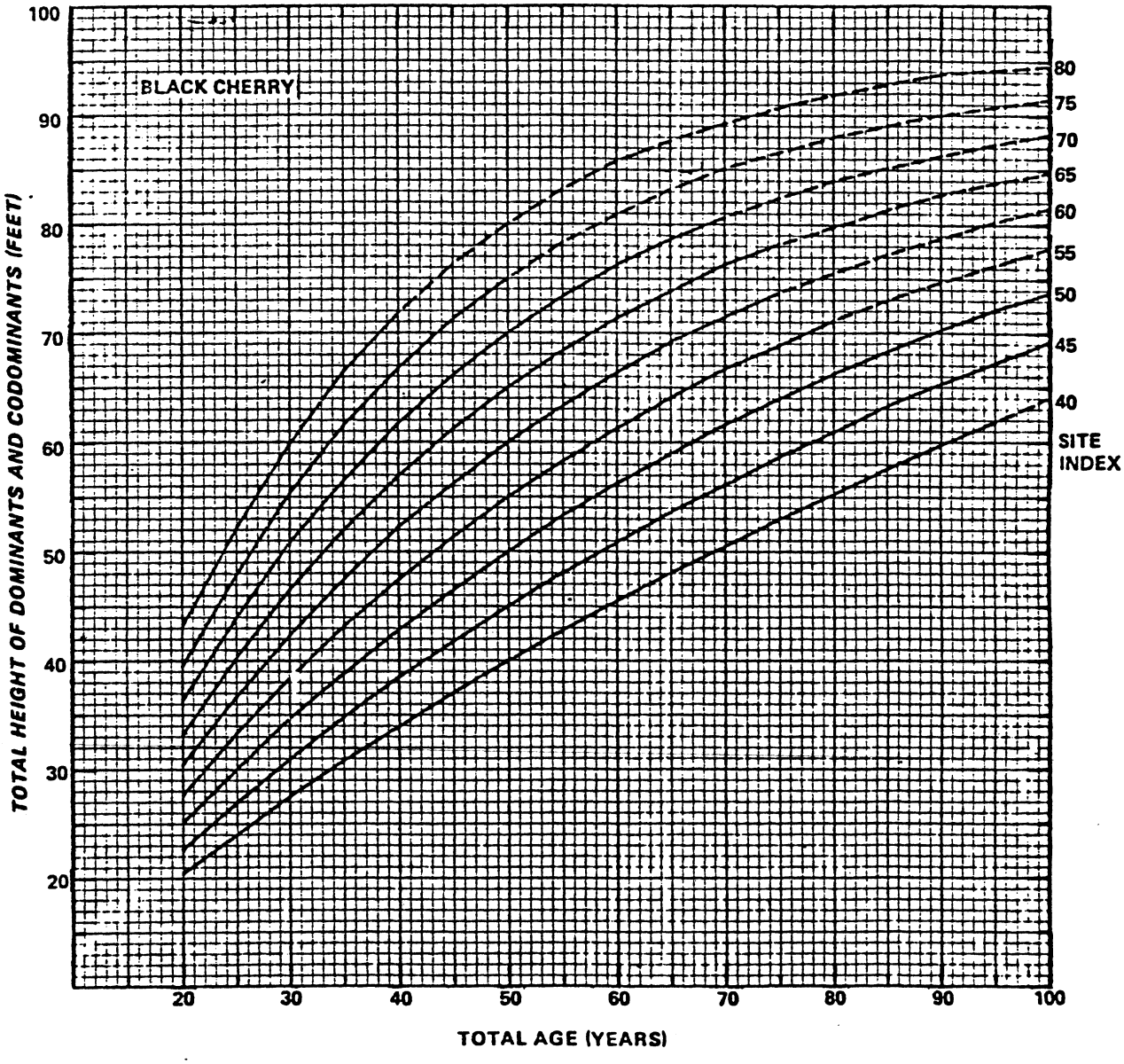
Site index curves for northern red oak in northern Wisconsin and Upper Michigan (Carmean, 1978)



These curves are based on stem analyses of 136 dominant and codominant trees growing in 37 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 11

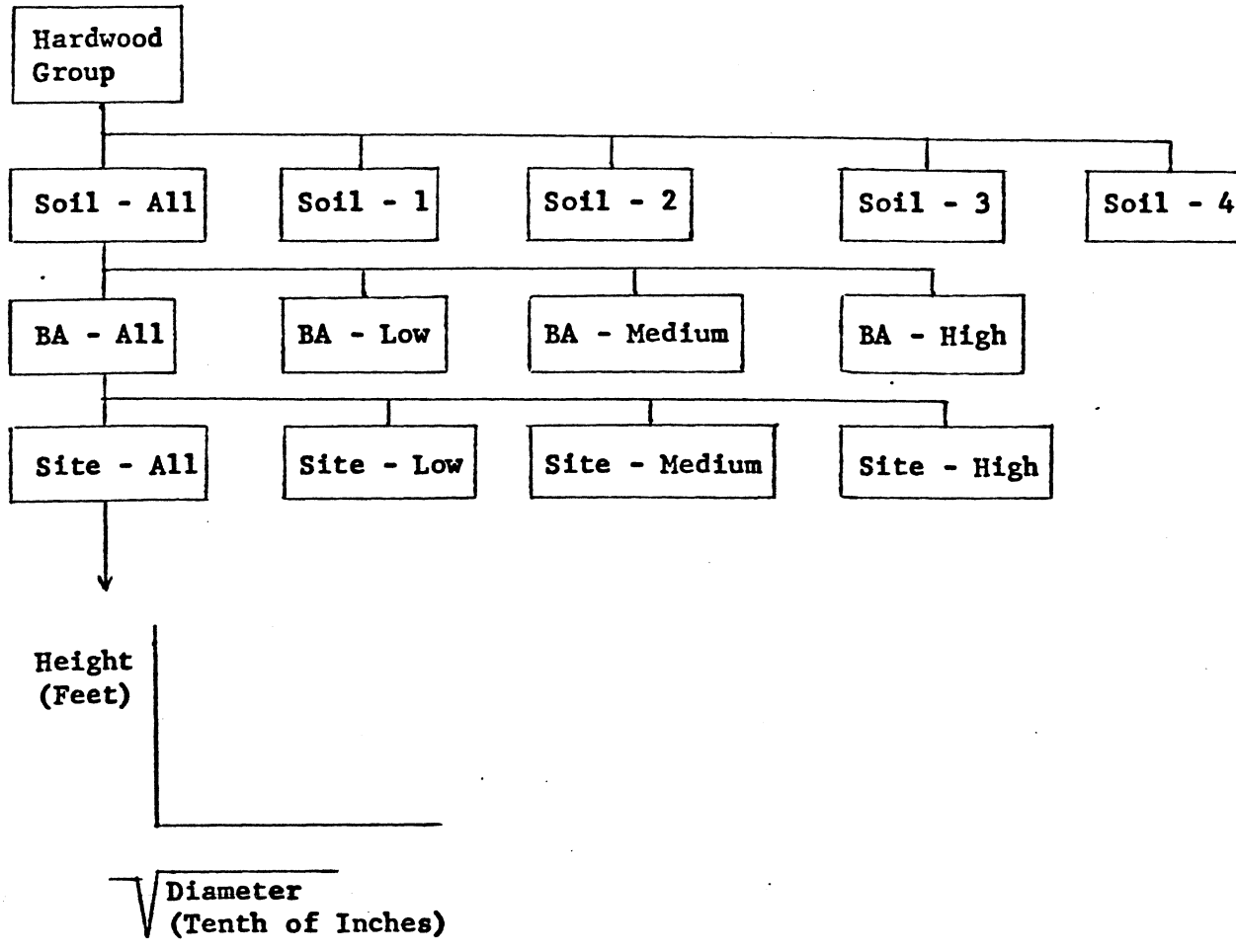
Site index curves for black cherry in northern Wisconsin and Upper Michigan (Carmean, 1978)



These curves are based on stem analyses of 126 dominant and codominant trees growing in 42 plots. Add 4 years to breast-height age to obtain total age. Dashed lines indicate extrapolations beyond actual observed data.

FIGURE 12

Hardwood Species Group (from Plots Designated Hardwood Cover Type) Data Classification into Major Regional Soil Groups, Basal Area Classes, Site Categories, and Final Height vs. Diameter (Square Root) Regression Curves.



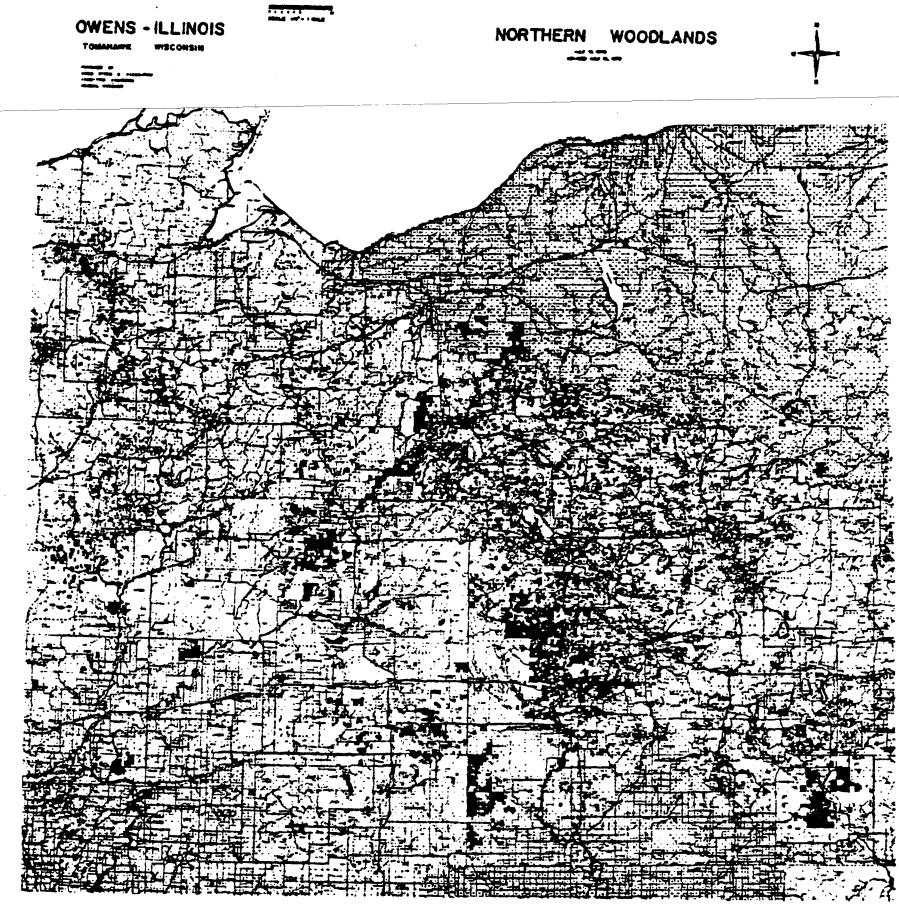
Soil (From "Soil Regions of Wisconsin" by Francis D. Hole, 1974, University of Wisconsin Extension, Madison, Wisconsin) : Soil 1 - wet, Soil 2 - loams, Soil 3 - sands, Soil 4 - silts.

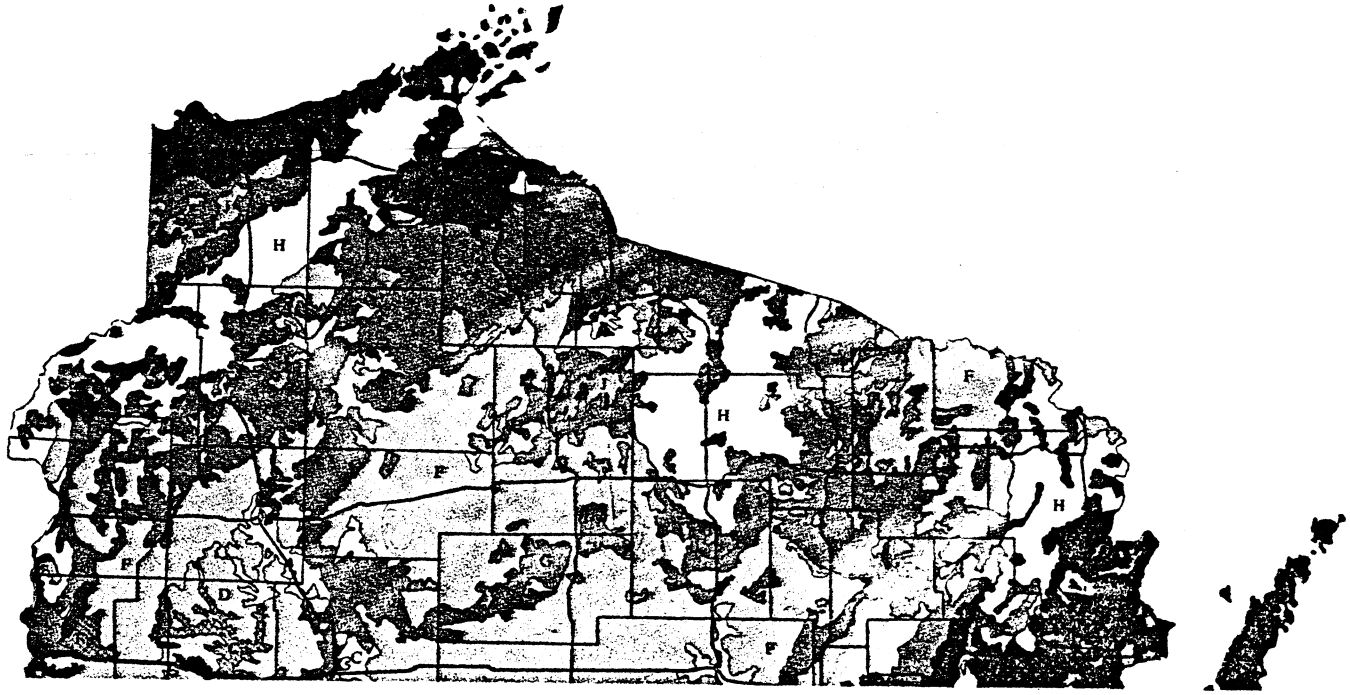
Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured - Base 50): Low 1-45, Medium 46-65, High 66+

FIGURE 13

Owens-Illinois fee ownership map with corresponding major regional soil type delineation from Northern Woodlands, Owens-Illinois Inc., Tomahawk, Wisconsin.





Soil Map Legend

Major Soils (from "Soil Regions of Wisconsin" - Hole, F.D. 1974)

F - Withee, Santiago, Amery, Antigo.

G - Iron River, Gogebic, Kennan.

H - Omega, Vilas, Hiawatha

APPENDICES

APPENDIX A

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regressions between 1969 and 1974 Continuous Forest Inventories for Hardwood Species from Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Species	Number of Plotted Values		r		r^2		Intercept		Slope		Standar Error o Estimat	
	69	74	69	74	69	74	69	74	69	74	69	74
Hard Maple	1877	2395	.79	.76	.63	.58	-25.94	-26.78	18.75	19.55	5.8	6.6
Red Maple	1150	1413	.82	.76	.66	.58	-29.92	-28.32	19.89	19.93	5.5	6.7
Basswood	825	939	.80	.81	.65	.66	-40.60	-40.49	25.30	25.57	6.7	7.2
Yellow Birch	586	597	.79	.75	.62	.56	-25.49	-21.94	17.48	16.73	7.5	8.2
Ashes	477	598	.81	.78	.65	.61	-37.19	-37.52	23.44	24.07	6.0	7.2
Elms	454	518	.85	.84	.72	.70	-36.94	-40.39	22.18	23.85	6.1	6.8
Oaks	385	384	.75	.74	.56	.54	-24.65	-25.91	19.71	20.92	7.3	8.4
Cherry	158	162	.81	.83	.66	.70	-31.23	-34.82	20.80	22.53	6.0	6.4
Ironwood	63	60	.78	.76	.61	.57	-43.09	-31.91	24.79	20.60	5.2	5.3
Hickory	20	21	.71	.71	.51	.51	-23.52	-31.82	16.24	20.25	4.7	5.7
All Hardwoods	5995	7087	.80	.78	.64	.61	-30.81	-31.25	20.86	21.58	6.3	7.0

APPENDIX B

Height (Feet) vs. Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	3765	.78	.60	-2.44	3.56	6.4
Low	All	1260	.77	.59	-4.72	3.56	5.5
Med	All	1395	.78	.61	-1.49	3.39	6.0
High	All	1110	.76	.58	2.99	3.25	6.9
All	Low	1142	.74	.55	-1.07	3.26	6.6
All	Med	1777	.79	.62	-3.56	3.70	6.2
All	High	846	.79	.63	-1.47	3.62	6.5
Low	Low	304	.74	.55	-2.80	3.16	5.5
Med	Low	582	.76	.58	-1.56	3.33	6.3
High	Low	256	.70	.49	5.52	2.77	7.0
Low	Med	671	.78	.60	-5.08	3.61	5.2
Med	Med	606	.80	.64	-.85	3.29	5.6
High	Med	500	.78	.61	-.61	3.64	6.9
Low	High	285	.78	.61	-6.01	3.90	5.9
Med	High	207	.82	.68	-3.54	3.90	5.5
High	High	354	.78	.62	5.23	3.06	6.5

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX C

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 2 (Loams) from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	1938	.80	.64	-32.56	21.18	6.3
Low	All	585	.83	.68	-36.90	22.27	5.1
Med	All	717	.80	.64	-30.00	19.96	6.0
High	All	636	.77	.60	-27.75	20.22	6.8
All	Low	735	.78	.61	-30.81	20.13	6.2
All	Med	880	.81	.65	-32.85	21.31	6.2
All	High	323	.82	.68	-34.09	22.58	6.0
Low	Low	185	.84	.71	-39.28	22.79	4.7
Med	Low	334	.79	.62	-30.70	19.85	6.1
High	Low	216	.74	.55	-21.15	17.45	6.8
Low	Med	311	.81	.66	-33.14	20.94	5.2
Med	Med	280	.81	.66	-26.22	18.48	5.5
High	Med	289	.80	.64	-34.77	22.84	6.9
Low	High	89	.85	.72	-43.42	25.15	5.5
Med	High	103	.86	.74	-35.77	23.46	4.9
High	High	131	.79	.63	-25.14	19.73	6.4

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX D

Height (Feet) vs Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 3 (Sands) from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	230	.77	.59	-33.13	20.21	5.6
Low	All	116	.72	.52	-36.42	20.99	5.9
Med	All	104	.81	.65	-29.84	19.48	5.0
High	All	10	.86	.74	-5.60	10.76	3.0
All	Low	82	.76	.58	-26.56	17.45	5.9
All	Med	93	.76	.57	-47.69	26.03	4.9
All	High	55	.79	.62	-35.72	21.69	5.8
Low	Low	16	.51	.26	-6.47	7.11	4.5
Med	Low	56	.86	.73	-30.95	19.66	4.8
High	Low	10	.86	.74	-5.60	10.76	3.0
Low	Med	61	.74	.54	-35.52	20.29	4.0
Med	Med	32	.87	.76	-56.43	30.94	3.8
High	Med	-	-	-	-	-	-
Low	High	39	.83	.70	-43.43	25.09	5.7
Med	High	16	.78	.61	-25.47	16.89	4.9
High	High	-	-	-	-	-	-

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX E

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 4 (Silts) from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	1090	.82	.68	-34.08	21.64	5.8
Low	All	297	.74	.54	-29.07	18.61	5.2
Med	All	448	.83	.68	-34.19	21.62	5.3
High	All	345	.83	.69	-24.46	19.18	5.7
All	Low	146	.80	.65	-33.70	21.88	5.7
All	Med	570	.84	.71	-36.73	22.25	5.5
All	High	374	.82	.67	-30.65	20.81	6.1
Low	Low	13	.86	.73	-39.89	23.18	5.1
Med	Low	132	.80	.64	-32.66	21.59	5.7
High	Low	1	-	-	-	-	-
Low	Med	169	.80	.64	-35.74	20.88	4.8
Med	Med	255	.85	.72	-35.04	21.71	5.2
High	Med	146	.84	.71	-27.47	19.87	5.5
Low	High	115	.64	.41	-18.84	15.02	5.5
Med	High	61	.77	.59	-32.61	20.75	4.3
High	High	198	.83	.69	-22.28	18.70	5.7

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX F

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for all Soils from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	3297	.80	.64	-33.53	21.45	6.1
Low	All	998	.79	.62	-35.32	21.35	5.4
Med	All	1269	.81	.65	-31.34	20.46	5.7
High	All	1030	.79	.63	-26.64	19.89	6.5
All	Low	963	.78	.61	-30.64	20.07	6.2
All	Med	1582	.81	.66	-35.29	22.01	6.0
All	High	752	.82	.66	-32.50	21.64	6.1
Low	Low	214	.80	.64	-36.25	21.40	5.2
Med	Low	522	.79	.62	-31.01	20.19	6.0
High	Low	227	.74	.54	-20.35	17.11	6.7
Low	Med	541	.80	.64	-35.34	21.29	5.2
Med	Med	567	.82	.68	-30.19	19.96	5.4
High	Med	474	.80	.64	-32.01	21.80	6.5
Low	High	243	.77	.60	-34.06	21.30	5.8
Med	High	180	.83	.69	-37.79	23.49	5.3
High	High	329	.82	.67	-23.32	19.06	6.0

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX G

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for All Land Uses with All Soils from the 1964 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	3765	.80	.64	-34.06	21.56	6.1
Low	All	1260	.78	.61	-34.03	20.71	5.3
Med	All	1395	.81	.66	-31.74	20.57	5.6
High	All	1110	.79	.63	-27.58	20.24	6.5
All	Low	1142	.77	.60	-30.78	20.04	6.2
All	Med	1777	.81	.65	-35.51	22.03	6.0
All	High	846	.82	.67	-34.20	22.11	6.1
Low	Low	304	.77	.59	-30.82	19.17	5.2
Med	Low	582	.79	.62	-31.60	20.34	6.0
High	Low	256	.74	.54	-21.03	17.46	6.6
Low	Med	671	.79	.62	-33.77	20.58	5.1
Med	Med	606	.82	.68	-30.40	20.04	5.3
High	Med	500	.80	.65	-32.79	22.13	6.6
Low	High	285	.79	.63	-37.55	22.44	5.7
Med	High	207	.84	.71	-35.84	22.68	5.2
High	High	354	.82	.67	-24.79	19.51	6.0

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX H

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 1 (Wet) from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	200	.87	.75	-36.68	22.66	5.4
Low	All	120	.88	.77	-35.08	22.14	4.5
Med	All	80	.85	.73	-39.14	23.43	6.5
High	All	-	-	-	-	-	-
All	Low	46	.87	.76	-38.49	23.07	5.8
All	Med	122	.92	.84	-39.91	24.46	4.3
All	High	32	.79	.62	-17.10	13.45	3.9
Low	Low	33	.88	.78	-41.73	24.10	5.0
Med	Low	13	.84	.70	-30.45	20.70	7.7
High	Low	-	-	-	-	-	-
Low	Med	87	.89	.79	-32.91	21.52	4.2
Med	Med	35	.97	.94	-47.91	27.97	3.4
High	Med	-	-	-	-	-	-
Low	High	-	-	-	-	-	-
Med	High	32	.79	.62	-17.10	13.45	3.9
High	High	-	-	-	-	-	-

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX I

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 2 (Loams) from the 1969 Continuous Forest Inventory Hardwood Species Group Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	2914	.79	.63	-30.02	20.87	6.5
Low	All	600	.82	.67	-37.63	22.90	5.7
Med	All	1348	.80	.64	-27.83	19.90	6.1
High	All	966	.77	.59	-24.66	19.61	6.8
All	Low	374	.80	.64	-29.32	19.87	7.1
All	Med	1696	.80	.64	-31.13	21.25	6.5
All	High	844	.80	.64	-29.80	21.13	5.9
Low	Low	94	.84	.70	-40.02	23.12	5.1
Med	Low	205	.80	.64	-25.78	18.48	6.6
Med	Low	75	.73	.53	-18.38	17.40	8.9
Low	Med	395	.82	.67	-37.38	22.93	5.9
Med	Med	756	.82	.67	-29.28	20.38	5.9
High	Med	545	.76	.57	-25.14	19.82	7.0
Low	High	111	.82	.66	-36.54	22.61	5.4
Med	High	387	.79	.62	-29.70	21.11	5.9
High	High	346	.80	.65	-26.37	20.20	5.9

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX J

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 3 (Sands) from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	445	.74	.55	-25.44	18.00	5.8
Low	All	170	.71	.51	-27.17	17.83	5.8
Med	All	149	.78	.60	-24.38	17.65	5.3
High	All	126	.80	.64	-23.08	18.17	5.1
All	Low	64	.79	.63	-22.17	15.60	4.6
All	Med	288	.72	.52	-23.96	17.30	5.5
All	High	93	.78	.61	-25.01	19.03	5.8
Low	Low	44	.58	.34	-14.80	12.84	5.0
Med	Low	20	.94	.88	-29.50	17.98	3.5
High	Low	-	-	-	-	-	-
Low	Med	109	.68	.46	-19.45	14.49	5.0
Med	Med	53	.82	.67	-21.75	15.75	2.8
High	Med	126	.80	.64	-23.08	18.17	5.1
Low	High	17	.87	.76	-35.63	23.47	5.9
Med	High	76	.74	.55	-20.29	17.13	5.6
High	High	-	-	-	-	-	-

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX K

Height (Feet) vs Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 4 (Silts) from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	1242	.82	.68	-31.96	20.96	5.7
Low	All	359	.82	.67	-37.32	22.33	5.6
Med	All	442	.77	.59	-27.54	19.00	5.3
High	All	441	.85	.72	-25.23	19.34	5.5
All	Low	54	.76	.58	-30.33	20.03	5.6
All	Med	727	.84	.70	-33.56	21.20	5.4
All	High	461	.82	.68	-29.14	20.51	5.9
Low	Low	12	.85	.72	-22.86	15.96	3.3
Med	Low	42	.72	.52	-29.80	20.06	6.1
High	Low	-	-	-	-	-	-
Low	Med	279	.83	.68	-38.18	22.67	5.4
Med	Med	232	.78	.61	-29.00	19.20	5.3
High	Med	216	.87	.76	-28.00	19.83	5.1
Low	High	68	.79	.63	-35.31	21.66	6.8
Med	High	170	.79	.62	-27.12	19.22	4.8
High	High	223	.84	.70	-22.77	18.95	5.6

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX L

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for All Soils from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	4835	.80	.64	-30.81	20.86	6.3
Low	All	1249	.81	.65	-35.92	21.99	5.7
Med	All	2053	.79	.63	-28.73	19.99	6.0
High	All	1533	.79	.63	-24.85	19.48	6.4
All	Low	538	.80	.64	-30.18	19.96	6.8
All	Med	2867	.80	.64	-32.05	21.24	6.2
All	High	1430	.80	.64	-28.98	20.62	6.2
Low	Low	183	.81	.66	-35.89	21.45	5.2
Med	Low	278	.80	.64	-26.14	18.52	6.5
High	Low	77	.76	.58	-26.81	19.72	7.7
Low	Med	870	.80	.64	-35.30	21.79	5.7
Med	Med	1110	.81	.66	-31.27	20.90	5.9
High	Med	887	.78	.61	-25.97	19.76	6.5
Low	High	192	.81	.66	-36.58	22.47	6.0
Med	High	665	.77	.59	-27.59	19.88	5.8
High	High	573	.81	.65	-25.08	19.66	6.0

Basal Area (Square Feet): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX M

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for All Land Uses with All Soils from the 1969 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	5409	.79	.63	-31.18	20.89	6.3
Low	All	1476	.79	.63	-34.95	21.47	5.8
Med	All	2255	.79	.63	-28.93	19.99	6.0
High	All	1678	.79	.62	-25.79	19.74	6.4
All	Low	792	.78	.61	-29.76	19.73	6.6
All	Med	3117	.80	.64	-32.26	21.24	6.3
All	High	1500	.80	.64	-29.66	20.78	6.1
Low	Low	290	.79	.62	-32.29	19.97	5.5
Med	Low	339	.79	.63	-25.68	18.32	6.3
High	Low	163	.76	.58	-26.81	19.72	7.7
Low	Med	972	.79	.63	-34.96	21.52	5.7
Med	Med	1227	.81	.66	-31.03	20.73	5.9
High	Med	918	.78	.61	-25.97	19.76	6.5
Low	High	214	.81	.66	-36.58	22.47	6.0
Med	High	689	.77	.59	-28.69	20.21	5.9
High	High	597	.81	.65	-25.08	19.66	6.0

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX N

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 1 (Wet) from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	246	.85	.73	-36.68	23.13	5.9
Low	All	23	.94	.88	-44.88	25.23	4.6
Med	All	143	.86	.74	-36.39	23.38	5.6
High	All	80	.84	.70	-37.12	22.92	6.5
All	Low	65	.88	.78	-38.60	23.69	5.8
All	Med	144	.90	.81	-40.94	25.28	5.2
All	High	37	.78	.60	-15.53	13.53	4.2
Low	Low	22	.96	.92	-52.43	28.18	3.8
Med	Low	43	.85	.73	-32.53	21.75	6.3
High	Low	-	-	-	-	-	-
Low	Med	-	-	-	-	-	-
Med	Med	100	.86	.75	-39.29	24.56	5.3
High	Med	43	.96	.91	-46.24	27.55	4.2
Low	High	-	-	-	-	-	-
Med	High	-	-	-	-	-	-
High	High	37	.78	.60	-15.53	13.53	4.2

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX O

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 2 (Loams) from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	3411	.79	.63	-32.28	21.96	6.9
Low	All	555	.77	.60	-37.80	22.96	6.3
Med	All	1319	.80	.64	-30.02	20.90	6.5
High	All	1537	.79	.62	-28.69	21.26	7.1
All	Low	419	.82	.68	-32.78	21.43	6.9
All	Med	2026	.80	.64	-33.52	22.25	7.0
All	High	966	.79	.62	-30.00	21.79	6.5
Low	Low	131	.85	.72	-42.38	24.12	5.3
Med	Low	143	.77	.59	-20.84	16.65	6.6
High	Low	145	.87	.76	-29.56	21.65	6.4
Low	Med	305	.80	.64	-37.14	22.38	5.8
Med	Med	822	.81	.66	-33.85	22.24	6.4
High	Med	899	.77	.60	-27.91	20.78	7.4
Low	High	119	.69	.47	-33.33	22.74	7.1
Med	High	354	.82	.66	-26.90	20.35	5.9
High	High	493	.79	.62	-31.50	22.63	6.7

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX P

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 3 (Sands) from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	521	.62	.38	-25.46	18.99	8.7
Low	All	204	.59	.35	-36.30	22.53	10.5
Med	All	174	.60	.36	-16.24	15.81	8.0
High	All	143	.75	.56	-20.96	17.87	5.5
All	Low	75	.77	.60	-25.27	17.43	5.8
All	Med	326	.52	.27	-16.76	15.38	8.7
All	High	120	.74	.55	-34.03	23.79	7.7
Low	Low	56	.62	.39	-23.78	16.71	6.2
Med	Low	19	.90	.82	-22.60	16.89	4.7
High	Low	-	-	-	-	-	-
Low	Med	107	.32	.10	-13.13	12.98	11.7
Med	Med	76	.49	.24	-5.98	10.98	7.3
High	Med	143	.75	.56	-20.96	17.87	5.5
Low	High	41	.86	.74	-42.96	27.46	6.6
Med	High	79	.64	.41	-24.40	19.99	7.9
High	High	-	-	-	-	-	-

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX Q

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for Soil 4 (Silts) from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	1570	.79	.63	-28.56	20.75	6.6
Low	All	276	.77	.60	-29.37	19.48	5.5
Med	All	800	.80	.64	-28.72	20.96	6.3
High	All	494	.79	.63	-22.06	19.05	6.7
All	Low	98	.71	.50	-24.26	18.10	5.8
All	Med	854	.82	.66	-31.31	21.28	6.1
All	High	618	.78	.61	-22.49	19.38	6.8
Low	Low	47	.71	.51	-26.87	18.32	5.6
Med	Low	23	.81	.65	-26.87	19.85	5.3
High	Low	28	.59	.35	-8.77	12.75	5.4
Low	Med	162	.80	.64	-30.93	19.75	5.1
Med	Med	517	.81	.66	-31.22	21.58	6.0
High	Med	175	.84	.71	-25.41	19.44	5.8
Low	High	67	.73	.53	-21.59	17.52	5.9
Med	High	260	.78	.61	-23.46	19.66	6.5
High	High	291	.79	.62	-19.67	18.78	6.8

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX R

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for All Soils from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	5783	.78	.61	-31.25	21.58	7.0
Low	All	1058	.73	.53	-35.51	22.03	7.1
Med	All	2436	.79	.62	-29.12	20.75	6.5
High	All	2289	.79	.62	-27.56	20.83	7.0
All	Low	657	.82	.67	-32.40	21.16	6.6
All	Med	3385	.79	.62	-32.58	21.85	7.0
All	High	1741	.77	.60	-27.08	20.81	6.8
Low	Low	256	.81	.66	-38.64	22.71	5.5
Med	Low	228	.79	.62	-22.62	17.41	6.4
High	Low	173	.86	.74	-29.42	21.47	6.4
Low	Med	575	.69	.48	-31.43	20.10	7.1
Med	Med	1515	.80	.64	-32.20	21.71	6.3
High	Med	1295	.79	.62	-28.20	20.84	7.0
Low	High	227	.75	.56	-34.50	23.17	7.1
Med	High	693	.78	.61	-25.31	20.04	6.4
High	High	821	.77	.60	-26.34	20.74	7.0

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX S

Height (Feet) vs. Square Root of Diameter (Tenths of Inches) Regression Equation Analysis by Basal Area Classes and Site Categories for All Land Uses with All Soils from the 1974 Continuous Forest Inventory Hardwood Species Group, Northern Woodlands, Owens-Illinois, Inc., Tomahawk, Wisconsin.

Basal Area	Site	Number of Cases	r	r^2	Intercept	Slope	Standard Error of the Estimate
All	All	6490	.78	.60	-32.28	21.79	7.1
Low	All	1369	.72	.52	-34.59	21.38	7.0
Med	All	2661	.79	.62	-29.89	20.91	6.5
High	All	2460	.78	.61	-27.96	20.92	7.1
All	Low	904	.80	.64	-33.11	21.10	6.6
All	Med	3745	.78	.61	-33.04	21.92	7.0
All	High	1841	.77	.60	-28.55	21.20	6.9
Low	Low	425	.77	.59	-33.69	20.49	5.8
Med	Low	261	.79	.63	-23.65	17.78	6.1
High	Low	218	.83	.70	-30.88	21.68	6.8
Low	Med	693	.69	.48	-31.42	19.91	6.9
Med	Med	1672	.80	.64	-32.31	21.65	6.3
High	Med	1380	.78	.61	-28.16	20.85	7.2
Low	High	251	.75	.57	-37.46	24.04	7.2
Med	High	728	.78	.61	-26.92	20.49	6.5
High	High	862	.78	.59	-27.02	20.89	7.1

Basal Area (Square Root): Low 1-60, Medium 61-90, High 91+

Site (Measured Base 50): Low 1-45, Medium 46-65, High 66+

APPENDIX T

FORMULA FOR COMPUTING THE GROSS CORD VOLUME OF HARDWOOD TREES UTILIZED FOR PULPWOOD.

THE FORMULA

$$Vc = (0.001D^2) \quad (1.9 + 0.01D) \quad (0.026H - 0.000156H^2 + \frac{0.32}{H})$$

IN WHICH

Vc = Volume Cords

D^2 = DBH Squared

D = DBH

H = Usable Length

H^2 = Usable Length Squared

For converting VC to Cu. Ft. multiply by 79.

Formula developed by Lake States F.E.S., U.S.F.S.

BASIS: BULLETIN 1104. Composite Volume Tables for Timber and Their Application in the Lake States. S. R. Gevorkiantz and L. P. Olsen, L.S.F.E.S. - Forest Service.