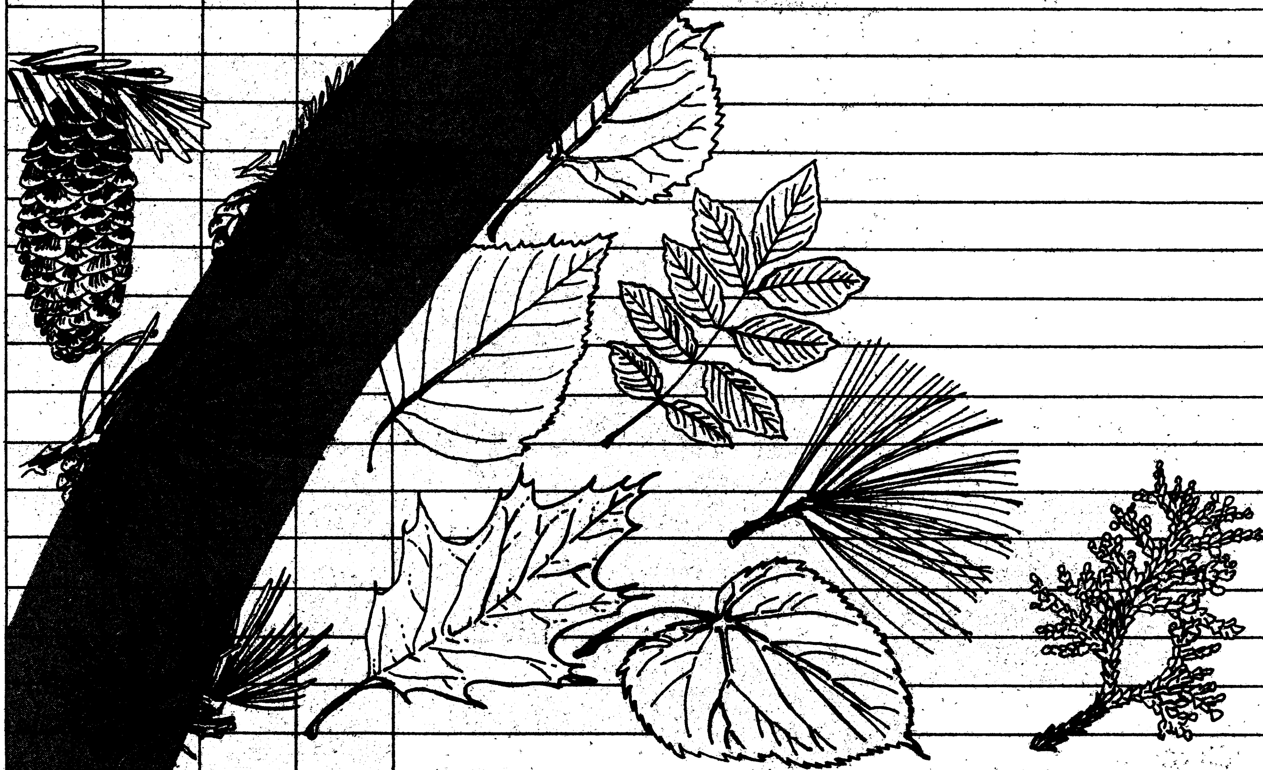
NC-65
RP

TM
FEGR

USDA
FOREST SERVICE
RESEARCH PAPER NC-65
1971

Site-Index COMPARISONS for TREE SPECIES in N[redacted]ERN MIN[redacted]A

[redacted]ARD H. CARMEAN
ALEXANDER VASILEVSKY



NORTH CENTRAL FOREST EXPERIMENT STATION · FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

CONTENTS

Willard H. Carmean and Alexander Vasilevsky are Principal Soil Scientist and Associate Mensurationist, respectively, at the Station's Headquarters Laboratory in St. Paul, Minnesota.

North Central Forest Experiment Station
D. B. King, Director
Forest Service — U.S. Department of Agriculture
Folwell Avenue
St. Paul, Minnesota 55101

(Maintained in cooperation with the University of Minnesota)

Manuscript approved for publication May 11, 1971.

SITE-INDEX COMPARISONS FOR TREE SPECIES IN NORTHERN MINNESOTA

Willard H. Carmean and Alexander Vasilevsky

Forest trees in northern Minnesota grow on a large variety of soils having great differences in tree-site quality. Faced with this profusion of species, soils, and sites, a forest manager often has difficulty deciding which tree species to favor on a given type of land. The problem of fitting the proper tree species to the proper site is frequently encountered in tree planting, stand conversion, thinning, and timber stand improvement.

Selecting the proper tree for the site requires detailed knowledge of the relative productivity of the site for several alternative tree species. Methods must be available for estimating site quality for the different tree species. In addition, yield information is needed for various species growing on lands of differing site qualities, and knowledge is needed about present and future market values for the variety of forest products that might be produced. Thus the first step in choosing among alternative tree species is to estimate the site quality of the land for each of these species. This information can then be used to determine and compare the volume and value of products the land is capable of producing when stocked with these alternative tree species.

The most commonly used method for estimating site quality is based on tree age and height measurements taken from dominant and codominant trees growing in fully stocked, undisturbed, even-aged stands. These measurements are used with site-index curves to estimate how tall trees will be at an index age – usually 50 years for eastern hardwoods and conifers (Carmean 1970). However, many stands suitable for site-index estimation do not contain the species of tree for which site information is desired. In these stands, we can estimate site index from the tree species that are present, then use species-comparison graphs to convert site index of the measured species to site index of the desired species. Species-comparison graphs have been published for the Southern Appalachians (Doolittle 1958), the Piedmont (Nelson and Beaufait 1957, Olson and Della-Bianca 1959), Vermont (Curtis and Post 1962), Connecticut and Massachusetts (Foster 1959), Idaho (Deitschman and Green 1965), and California (Wiant and Porter 1966). In this study, similar methods were used for developing species-comparison graphs for several tree species found in northern Minnesota.

THE DATA

We examined forest survey[1] and soil-site[2] plot records for 20 counties in northern and northeastern Minnesota. On each of these plots site index estimates were available based upon age and height measurements of dominant and codominant trees; very often site-index estimates were available for several tree species growing on a single plot. All plots having site estimates for two or more tree species were selected for study.

We next carefully screened all data for suitability in estimating site index. Many forest survey plots were discarded because records revealed the stands were poorly stocked, uneven aged, or too young for dependable site-index estimation. Most of the forest survey plots retained for further analysis had age and height measurements based on only one or two trees of each species, but in some cases measurements were taken from three or four dominant and codominant trees.

Site-index estimates for each tree species were made using standard harmonized site-index curves (table 1). Site curves for basswood and

[1] *Appreciation is extended to the Minnesota Department of Iron Range Resources and Rehabilitation for assistance in collecting and compiling field data.*

[2] *Appreciation is extended to the USDA Soil Conservation Service, St. Paul, Minnesota, for the use of data from their soil-site plots.*

Table 1.–Species studied and curves used for estimating site index in northern Minnesota

Species	Standard site index curves (reference)
Quaking aspen (Populus tremuloides Michx.)	(Gevorkiantz 1956b)
Paper birch (Betula papyrifera Marsh.)	(Cooley 1958)
Red oak (Quercus rubra L.)	(Gevorkiantz 1957f)
Basswood (Tilia americana L.)	(Gevorkiantz 1957f)
Black ash (Fraxinus nigra Marsh.)	(Gevorkiantz 1957f)
Jack pine (Pinus banksiana Lamb.)	(Gevorkiantz 1956a)
Red pine (Pinus resinosa Ait.)	(Gevorkiantz 1957e)
White pine (Pinus strobus L.)	(Gevorkiantz 1957d)
White spruce (Picea glauca (Moench) Voss)	(Gevorkiantz 1957c)
Black spruce (Picea mariana (Mill.) B.S.P.)	(Gevorkiantz 1957b)
Balsam fir (Abies balsamea (L.) Mill.)	(Gevorkiantz 1956c)
White-cedar (Thuja occidentalis L.)	(Gevorkiantz 1957a)
Tamarack (Larix laricina (Du Roi) K. Koch)	(Gevorkiantz 1957g)

black ash do not exist, so the site index curves for red oak were used for these species. All of the site curves are based on total tree age except the white spruce and balsam fir curves, which are based on breast-height age. Thus, in the case of white spruce and balsam fir we added 10 years to d.b.h. age for good sites (S.I. 50 and greater), and 15 years for poorer sites (S.I. less than 50). This procedure insured that comparable site index values based on total tree age were used for all tree species.

ANALYSIS AND RESULTS

Our first step was to record site index values for all possible paired species combinations. Then scatter diagrams were prepared relating site indices of the two paired species. In many cases, we found there were only a few paired observations, the range of site index was limited, or the data were erratic with little relationship between the site indices of the paired species. However, in many cases site index relationships were evident and so these species combinations were selected for further analysis.

No curvilinear trends were apparent, so linear regression equations were computed using site index of one species as the dependent variable, and site index of the associated species as the independent variable (table 2). Because either of the paired species can be considered as the dependent variable, two separate equations were computed for each of the species comparisons. These equations accounted for 40 to 65 percent (r^2) of the site index variation associated with the various species comparisons.

The regression equations (table 2) could be used for directly calculating site index of one species based on measured site index of the associated species. However, when such calculations are made, the equation used should be the one in which measured site index is the independent variable. That is, these equations should only be solved forward and not backward. For example, one might measure site index in a paper birch stand and then wish to estimate site index for quaking aspen. In this case the first equation (table 2) should be used because site index for quaking aspen is the value to be estimated (dependent variable).

The objective of our study was to derive site-index ratios or species-comparison graphs that can be used for estimating site index for tree species based upon measured site index of species actually present in the stand. However, site-index ratios or species-comparison graphs imply that the regressions on which they are based can be solved forward or backward. Such a procedure

Table 2.—Regression equations and statistics for site-index comparisons of northern Minnesota forest species. Also shown are equations that average the trends portrayed by the two equations listed for each paired species combination

Species: Dependent variable (Y)	Species: Independent variable (X)	Site index range: Y (feet)	Site index range: X (feet)	Number of paired observations	Equations	Coefficient of determination (r^2)	Standard error of estimate (feet)
Quaking aspen	Paper birch	43-90	37-82	106	Y=24.36 + 0.67(X)	0.51	6.2
Paper birch	Quaking aspen	37-82	43-90	106	Y= 9.87 + .75(X)	.51	6.6
					SI QA= 8.50 + .95(SI PB)		
Quaking aspen	Basswood	40-80	37-80	16	Y=22.41 + .75(X)	.45	8.1
Basswood	Quaking aspen	37-80	40-80	16	Y=20.44 + .59(X)	.45	7.2
					SI QA= 0.60 + 1.11(SI Ba)		
Paper birch	Red oak	40-85	40-76	32	Y=29.01 + .58(X)	.44	7.0
Red oak	Paper birch	40-76	40-85	32	Y=10.43 + .76(X)	.44	8.0
					SI PB=11.20 + .98(SI RO)		
Jack pine	Red pine	43-72	40-75	66	Y=23.85 + .63(X)	.40	5.7
Red pine	Jack pine	40-75	43-72	66	Y=19.38 + .64(X)	.40	5.8
					SI JP= 2.80 + .995(SI RP)		
Red pine	White pine	37-72	41-70	58	Y=18.84 + .68(X)	.47	4.8
White pine	Red pine	41-70	37-72	58	Y=15.90 + .69(X)	.47	4.8
					SI RP= 3.57 + .95(SI WP)		
White pine	White spruce	31-67	32-68	23	Y=20.06 + .60(X)	.62	5.0
White spruce	White pine	32-68	31-67	23	Y=-1.30 + 1.03(X)	.62	6.6
					SI WP=10.90 + .78(SI WS)		
Red pine	White spruce	43-70	36-67	15	Y=26.58 + .56(X)	.65	4.0
White spruce	Red pine	36-67	43-70	15	Y=-11.87 + 1.17(X)	.65	5.8
					SI RP=18.90 + .70(SI WS)		
Balsam fir	White cedar	32-68	21-38	19	Y=24.47 + .92(X)	.43	6.4
White cedar	Balsam fir	21-38	32-68	19	Y= 4.87 + .47(X)	.43	4.6
					SI BF=11.80 + 1.36(SI WC)		
Balsam fir	Black ash	34-68	25-62	21	Y=18.69 + .81(X)	.53	7.0
Black ash	Balsam fir	25-62	34-68	21	Y= 7.04 + .65(X)	.53	6.3
					SI BF= 6.60 + 1.11(SI BA)		
Tamarack	Black spruce	10-67	10-49	67	Y= 7.48 + .95(X)	.52	8.1
Black spruce	Tamarack	10-49	10-67	67	Y=11.56 + .54(X)	.52	6.1
					SI Ta=-3.70 + 1.30(SI BS)		

is not statistically acceptable, thus we looked for other means to derive these ratios and graphs.

First we calculated trend graphs using each of the two equations available for each species combination (table 2). These trend graphs confirmed that somewhat different site-index trends are obtained depending upon which species is used as the dependent variable. The two trend graphs coincide at the average site index for each species, thus both equations will show the same site-index relationships at average site index. But the trend graphs diverge with increased distance from average site index, until markedly different site-index predictions are obtained at very good or very poor sites. Thus, considerable error in site prediction might result if the wrong equation is used for very good or very poor sites. But which equation should be used?

There are no reasons to favor one equation over the other. Accordingly, we calculated new equations that averaged the trends shown by the two equations in each paired species combination. These graphically determined average equations (table 2) can be solved forward or backward and thus are suitable for calculating site-index ratios or species-comparison graphs.

Species-comparison graphs for each species combination were next prepared using these average equations. All of these graphs showed definite site-index differences between the compared species. In some cases site-index differences were relatively consistent regardless of site quality (fig. 1); in other cases site-index differences varied with site quality (fig. 2). These observed site-index relations also are expressed

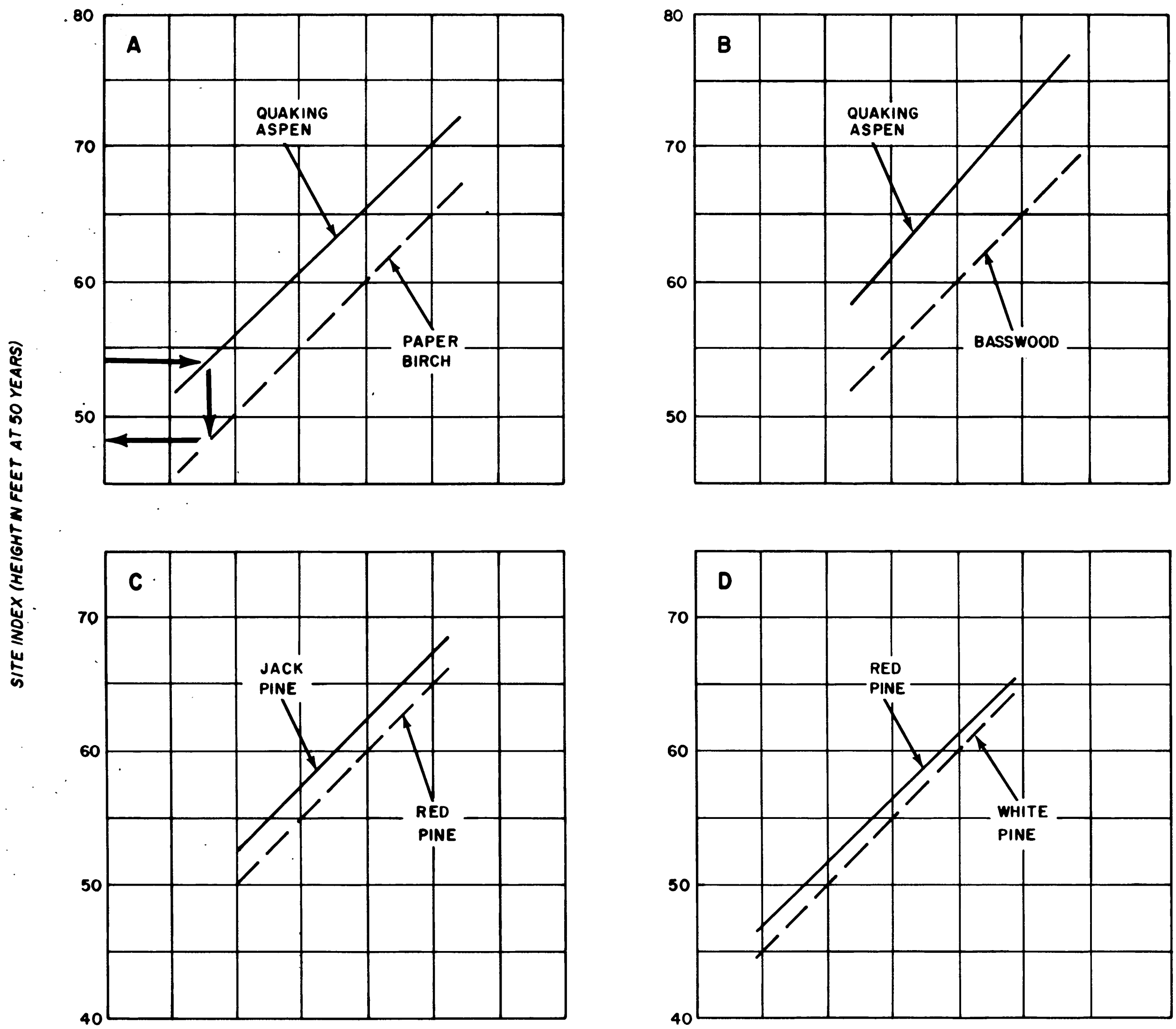


Figure 1.—Species-comparison graphs for hardwood and conifer species of northern Minnesota that have relatively consistent site-index differences at all site qualities. These graphs can be used to estimate site index for certain tree species based on site-index measurements of other tree species present in the forest stand. For example: Suppose you would like to know the site index for paper birch on a certain area, but there are no paper birch trees available for the required tree height and age measurements. However, there are suitable quaking aspen trees present and height and age measurements indicate that their site index is 54. So, on graph A start at 54 on the site-index scale and read right to the quaking aspen line, then read straight down to the paper birch line; then read left to the site-index scale where estimated site index for paper birch is found to be 48. The reverse of this procedure also can be used; for example, site index 48 for paper birch indicates a site index of 54 for quaking aspen.

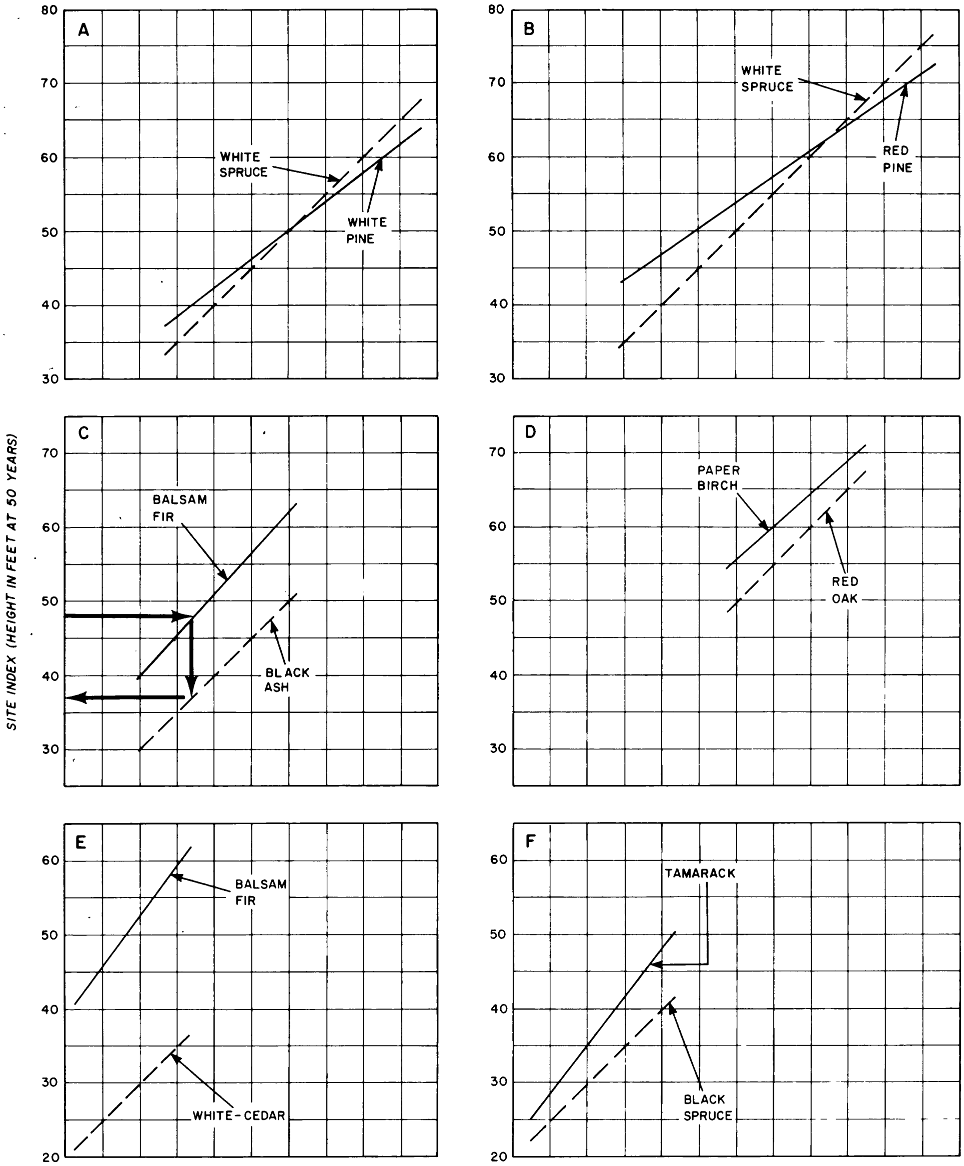


Figure 2.—Species-comparison graphs for hardwood and conifer species of northern Minnesota having site-index differences that vary with site quality. These graphs can be used to estimate site index for certain tree species based on site-index measurements of other tree species present in the forest stand. For example: Suppose you would like to know the site index for black ash on a certain area, but there are no black ash trees available for the required tree height and age measurements. However, there are suitable balsam fir trees present and height and age measurements indicate that their site index is 48. So, on graph C start at 48 on the site-index scale and read right to the balsam fir line, then read straight down to the black ash line; then read left to the site-index scale where estimated site index for black ash is found to be 37. The reverse of this procedure also can be used; for example, site index 37 for black ash indicates a site index of 48 for balsam fir.

by site-index ratios between each of the paired species at different site qualities (table 3). Ratios are listed only for the range of site index well represented by plot data. In addition, ratios and species-comparison graphs were restricted to the range of site index in which trend graphs, calculated by the two species-comparison equations, differed no more than 5 feet.

Four of the species combinations have similar site-index ratios for all levels of site quality (table 3). For these combinations the average site index ratios can be used at all levels of site quality for determining site index from the associated species. The species-comparison graph showing the site-quality relationships of these four species combinations (fig. 1) also can be used for convenience in estimating site indices.

Six of the species combinations have different site-index ratios for different levels of site quality (table 3). For example, the white pine - white spruce combination has an average site-index ratio of 1.00, but ratios of 0.93 and 1.05 were obtained for poorer and better sites, respectively. Thus these species have similar site indices for the average sites in our study. However, we can expect white pine to have a higher site index than white spruce on poorer sites, while white spruce will have a higher site index than white pine on better sites. The site-index ratios listed for the different site qualities can be used for direct calculations of site index when site index of the associated species is known. Also the species-comparison graphs (fig. 2) can be used to estimate site index based on measured site index of other tree species present in the stand.

DISCUSSION

Our results show that much unexplained variation remains in the site-index correlations between the various tree species (table 2). The various regressions account for 40 to 65 percent (r^2) of the total variation of site index about the computed trend lines. Also the standard errors of estimate are rather large (4.0 to 8.1 feet); thus we cannot place too much confidence in the actual position of the trend lines shown in figures 1 and 2.

Several reasons may account for this unexplained variation. Although we rejected plots that were obviously poorly stocked or uneven-aged in our initial data screening, some of the

Table 3.—Site-index ratios for paired species combinations at different site qualities

Species comparisons: Species 1	Species 2	Average site index (feet): Sp 1	Sp 2	Site-index ratios (Sp 1: Sp 2) at Sp 1 site index of: 30	40	50	60	70	80	Average site-index ratio at Sp 1-Sp 2 average site indices
Quaking aspen	Paper birch	62.8	57.2	--	--	0.88	0.90	0.93	--	1/ 0.91
Quaking aspen	Basswood	68.5	61.1	--	--	--	.89	.89	0.89	1/ .89
Paper birch	Red oak	62.2	57.5	--	--	.87	.92	.95	--	2/ .92
Jack pine	Red pine	60.3	58.0	--	--	.95	.96	.97	--	1/ .96
Red pine	White pine	55.5	54.1	--	--	.96	.98	.99	--	1/ .97
White pine	White spruce	50.5	50.7	--	0.93	1.00	1.05	--	--	2/ 1.00
Red pine	White spruce	57.7	55.7	--	.76	.89	.98	1.05	--	2/ .97
Balsam fir	White cedar	50.7	28.7	--	.52	.56	.59	--	--	2/ .57
Balsam fir	Black ash	51.6	40.8	--	.75	.78	.80	--	--	2/ .79
Tamarack	Black spruce	38.0	32.2	0.87	.84	.83	--	--	--	2/ .85

1/ Site-index ratios are relatively consistent at all site qualities. Therefore, use the average site-index ratios to estimate site index when the site index of the associated species is known. The species-comparison graph (fig. 1) also can be used for convenience in estimating site indices.

2/ Site-index ratios are different for different site qualities. Therefore, use the listed Sp 1 site-index ratios, or use the species comparison graphs (fig. 2) to estimate site index when the site index of the associated species is known.

survey plots used might still have been in stands that were not completely satisfactory for site-index determination. Also, some of the trees measured for site index may have had early suppression or past injuries, and errors may have occurred in ring counting of diffuse porous hardwoods or in measuring tree heights. In addition, on most of the plots only one or two trees were measured for site index. This is a small number of trees for site-index estimation even on carefully selected research plots, because much variation often occurs among trees measured for site index. It is also possible that the harmonized site index curves used in this study (table 1) may not be suitable for application in northern Minnesota; trees growing on certain northern Minnesota soils may have height-growth patterns different from those portrayed in the standard site-index curves. Estimating site index for basswood and black ash from red oak site-index curves certainly is not advisable, and we need new site curves for these species. Finally, unexplained variation in site index may be associated with genetic differences in tree-height growth (and site index) among clones of aspen (Zahner and Crawford 1963).

Despite these limitations we have found significant site-index relations among various tree species in northern Minnesota. These results are helpful guides in selecting the most suitable tree species for various sites. Accordingly, the relative positions of the trend lines in figures 1 and 2 are more important than the actual predicted differences in site index.

We can generalize that on all sites quaking aspen has a higher site index than paper birch (fig. 1-A) and basswood (fig. 1-B); jack pine has a site index slightly higher than red pine (fig. 1-C); and red pine may have a site index slightly higher than white pine (fig. 1-D). These relations are only predicted for the listed range of sites that we observed in northern Minnesota, and better or poorer sites elsewhere may show different relations. For example, site index for basswood on very good sites might exceed site index for quaking aspen.

We also can generalize that on poor sites both white pine (fig. 2-A) and red pine (fig. 2-B) will have higher site indices than white spruce. However, on better sites white spruce site index apparently exceeds that of white and red pine. On all sites observed balsam fir site index is much higher than black ash (fig. 2-C); however, the sites we observed are relatively poor, and black ash might grow faster on better sites. On all sites paper birch site index exceeds that for red oak; however, differences apparently are not as great on better sites (fig. 2-D), and possibly red oak also will grow faster on better sites. Balsam fir has a much higher site index than white-cedar on all sites (fig. 2-E); tamarack also has a much higher site index than black spruce on all sites (fig. 2-F), and possibly these differences are even more pronounced on better sites.

Site-index comparisons are a necessary first step in choosing the best species for a given site. The comparisons we have made (figs. 1 and 2) will help foresters to select the most productive tree on various portions of their forest lands in northern Minnesota. However, tree species in addition to those presented here also might be considered for management in northern Minnesota – for example, certain northern hardwood species on the better sites.

Other factors that should be considered in choosing among alternative tree species include tree height growth before and after index age (50 years), total yield produced, and the value of this yield. For example, on good sites quaking aspen might have a somewhat higher site index than basswood or red oak. However, aspen is a short-lived tree and thus height and volume growth may slow markedly after 50 years of age. In contrast, the longer-lived basswood and red oak maintain height, diameter, and volume growth well after 50 years, and thus may ultimately produce more volume than aspen. Finally, red oak and basswood are often valuable for high-quality veneer and saw logs, while aspen is chiefly used for pulp and fiber. Even though all three species might produce similar total volume on certain sites, we might still favor red oak and basswood because they can produce a greater total value of yield.

LITERATURE CITED

Carmean, Willard H. 1970. Site quality for eastern hardwoods. *In* The silviculture of oaks and associated species. USDA Forest Serv. Res. Pap. NE-144, p. 36-56. Northeast. Forest Exp. Sta., Upper Darby, Pa.

Cooley, J. H. 1958. Site index curves for paper birch in northern Wisconsin. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 541, 2 p., illus.
Curtis, R. O., and Post, B. W. 1962. Comparative site indices for northern hardwoods in the Green Mountains of Vermont. USDA Forest Serv., Northeast. Forest Exp. Sta., Sta. Pap. 171, 6 p., illus.
Deitschman, G. H., and Green, A. W. 1965. Relations between western white pine site index and tree height of several associated species. USDA Forest Serv. Res. Paper INT-22, 28 p., illus. Intermountain Forest & Range Exp. Sta., Ogden, Utah.
Doolittle, W. T. 1958. Site index comparisons for several forest species in the southern Appalachians. Soil Sci. Soc. Amer. Proc. 22: 455-458, illus.
Foster, R. W. 1959. Relation between site indices of eastern white pine and red maple. Forest Sci. 5: 279-291, illus.
Gevorkiantz, S. R. 1956a. Site index curves for jack pine in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 465, 2 p., illus.
Gevorkiantz, S. R. 1956b. Site index curves for aspen in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 464, 2 p., illus.
Gevorkiantz, S. R. 1956c. Site index curves for balsam fir in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 465, 2 p., illus.
Gevorkiantz, S. R. 1957a. Site index curves for white-cedar in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 472, 2 p., illus.
Gevorkiantz, S. R. 1957b. Site index curves for black spruce in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 473, 2 p., illus.
Gevorkiantz, S. R. 1957c. Site index curves for white spruce in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 474, 2 p., illus.
Gevorkiantz, S. R. 1957d. Site index curves for white pine in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 483, 2 p., illus.
Gevorkiantz, S. R. 1957e. Site index curves for red pine in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 484, 2 p., illus.
Gevorkiantz, S. R. 1957f. Site index curves for red oak in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 485, 2 p., illus.
Gevorkiantz, S. R. 1957g. Site index curves for tamarack in the Lake States. USDA Forest Serv., Lake States Forest Exp. Sta. Tech. Note 498, 2 p., illus.
Nelson, T. C., and Beaufait, W. R. 1957. Studies in site evaluation for southern hardwoods. Soc. Amer. Forest Proc. 1956: 67-70, illus.
Olson, D. F., Jr., and Della-Bianca, L. 1959. Site index comparisons for several tree species in the Virginia-Carolina Piedmont. USDA Forest Serv., Southeast. Forest Exp. Sta. Paper 104, 9 p., illus.
Wiant, H. V., Jr., and Porter, D. R. 1966. Site index comparisons for redwood, Douglas-fir, and some associated hardwoods. J. Forest. 64: 541-543.
Zahner, R., and Crawford, N. A. 1963. The clonal concept in aspen site relations. *In* Forest-soil relationships in North America. Second N. Amer. Forest Soils Conf. Proc. Oreg. State Univ. Press, p. 229-243, illus.

SOME RECENT RESEARCH PAPERS OF THE NORTH CENTRAL FOREST EXPERIMENT STATION

Wilderness Ecology: A Method of Sampling and Summarizing Data for Plant Community Classification, by Lewis F. Ohmann and Robert R. Ream. USDA Forest Serv. Res. Pap. NC-49, 14 p., illus. 1971.

Predicting Lumber Grade Yields for Standing Hardwood Trees, by Charles L. Stayton, Richard M. Marden, and Glenn L. Gammon. USDA Forest Serv. Res. Pap. NC-50, 8 p. 1971.

Tables of Compound-Discount Interest Rate Multipliers for Evaluating Forestry Investments, by Allen L. Lundgren. USDA Forest Serv. Res. Pap. NC-51, 142 p. 1971.

Ecological Studies of the Timber Wolf in Northeastern Minnesota, by L. David Mech and L. D. Frenzel, Jr. (Editors). USDA Forest Serv. Res. Pap. NC-52, 62 p., illus. 1971.

Pest Susceptibility Variation in Lake States Jack-Pine Seed Sources, by James P. King. USDA Forest Serv. Res. Pap. NC-53, 10 p., illus. 1971.

Influence of Stand Density on Stem Quality in Pole-Size Northern Hardwoods, by Richard M. Godman and David J. Books. USDA Forest Serv. Res. Pap. NC-54, 7 p., illus. 1971.

The Dynamic Forces and Moments Required in Handling Tree-Length Logs, by John A. Sturos. USDA Forest Serv. Res. Pap NC-55, 8 p., illus. 1971.

Growth and Yield of Black Spruce on Organic Soils in Minnesota, by Donald A. Perala. USDA Forest Serv. Res. Pap. NC-56, 16 p., illus. 1971.

Impact of Insects on Multiple-Use Values of North-Central Forests: An Experimental Rating Scheme, by Norton D. Addy, Harold O. Batzer, William J. Mattson and William E. Miller. USDA Forest Serv. Res. Pap. NC-57, 8 p., illus. 1971.

Growth and Yield of Quaking Aspen in North-Central Minnesota, by Bryce E. Schlaegel. USDA Forest Serv. Res. Pap. NC-58, 11 p., illus. 1971.

ABOUT THE FOREST SERVICE . . .

As our Nation grows, people expect and need more from their forests — more wood; more water, fish, and wildlife; more recreation and natural beauty; more special forest products and forage. The Forest Service of the U.S. Department of Agriculture helps to fulfill these expectations and needs through three major activities:

- Conducting forest and range research at over 75 locations ranging from Puerto Rico to Alaska to Hawaii.
- Participating with all State forestry agencies in cooperative programs to protect, improve, and wisely use our Country's 395 million acres of State, local, and private forest lands.
- Managing and protecting the 187-million acre National Forest System.

The Forest Service does this by encouraging use of the new knowledge that research scientists develop; by setting an example in managing, under sustained yield, the National Forests and Grasslands for multiple use purposes; and by cooperating with all States and with private citizens in their efforts to achieve better management, protection, and use of forest resources.

Traditionally, Forest Service people have been active members of the communities and towns in which they live and work. They strive to secure for all, continuous benefits from the Country's forest resources.

For more than 60 years, the Forest Service has been serving the Nation as a leading natural resource conservation agency.

☆U.S. GOVERNMENT PRINTING OFFICE, 1971-760-124