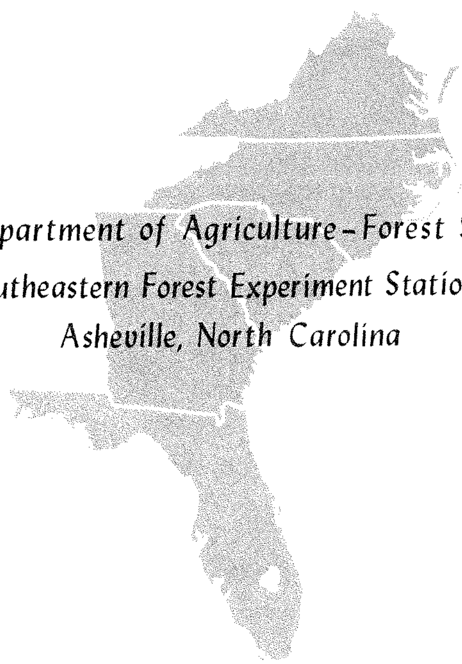
Station Paper No. 104

October 195

Site Index Comparisons for Several Tree Species in the Virginia-Carolina Piedmont

by

David F. Olson, Jr. and Lino Della-Bianca



U.S. Department of Agriculture-Forest Service
Southeastern Forest Experiment Station
Asheville, North Carolina

ACKNOWLEDGMENT

The research described in this Station Paper was the result of efforts by the Furniture, Plywood and Veneer Council of the North Carolina Forestry Association cooperating with the Southeastern Forest Experiment Station. Grateful acknowledgment is made to Council Forester Howard J. Doyle, who gave valuable assistance in the field work. Special thanks are due to Duke Power Company, Clemson College, and Duke University for providing study areas.

Site Index Comparisons for Several Tree Species in the Virginia-Carolina Piedmont

by

David F. Olson, Jr. and **Lino Della-Bianca**

INTRODUCTION

The Piedmont of southern Virginia and the Carolinas contains thousands of acres of pine-hardwood forests. The most widespread commercial timber type of the region is the shortleaf pine-hardwood type. The less extensive Virginia pine-hardwood type lies along the western edge of the Piedmont, but reaches its peak development in the adjacent Appalachian Mountain region (fig. 1). The natural forest succession in the Piedmont proceeds from pure pine to mixed pine-hardwood to nearly pure stands of the more tolerant hardwoods (6), and hardwood species gradually crowd out pine and dominate the mixed forests. The tendency of hardwoods to encroach on pine is helped out by man through heavier cutting of pine than of hardwood, and by efficient and widespread forest fire protection.

Forest managers in the Piedmont (primarily farmers with small woodland holdings) are faced with the problem of profitably managing stands of timber with a gradually increasing hardwood component. This job is formidable because hardwoods generally do not have wood properties desirable in mass-demand products, such as house framing and kraft paper. These multiplying hardwoods, added to an already over-abundant supply of low-grade trees throughout the eastern United States, constitute a major problem in forest management and utilization.

There are a variety of marketing outlets in the Piedmont for both pine and hardwood species. The presence of these diversified markets creates an immediate need for knowledge about the relative productivity of forest land for different tree species. Unlike many parts of the South, where pine completely dominates the marketplace, the Virginia- Carolina Piedmont challenges the forest manager to choose whether he will grow various oaks, yellow-poplar, pine, or mixtures of these with other special-use species, such as walnut and ash.

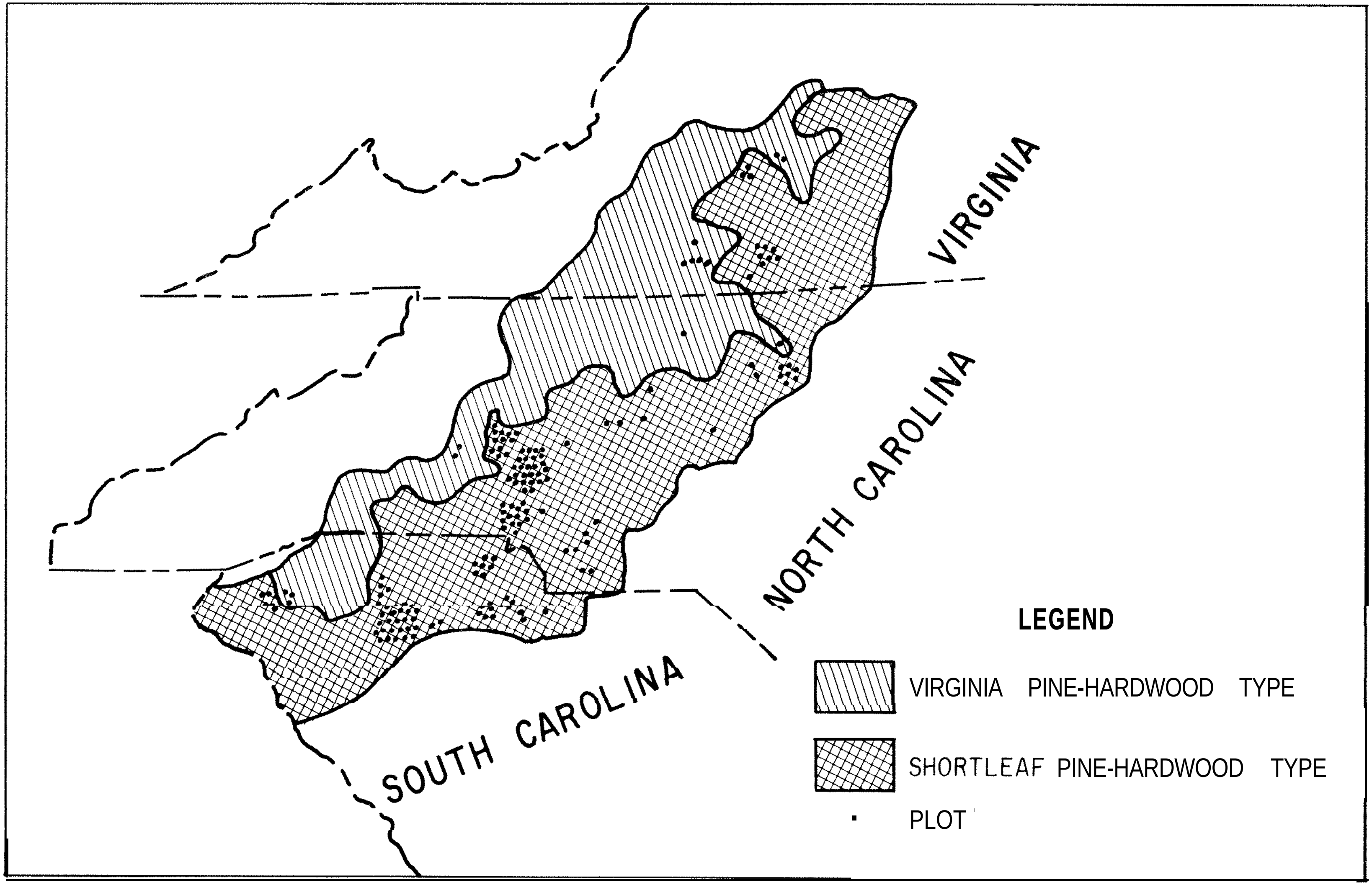


Figure l.--Plot location map for the site index comparison study in the Virginia-Carolina Piedmont region.

This study compares the site index of several commercial timber species growing on comparable soils. It is a step toward determining relative productivity, and when added to knowledge about timber quality, yield per acre, and marketability, will aid landowners in deciding what kind of forests to grow.

These site index comparisons have been developed as one part of a larger effort to determine the site indices of several species in relation to permanent features of the soil and physiography. The comprehensive soil-site work will be published in the future, based on the identical tree data used in this study. Relating the site indices of several species to one another will furnish estimates of site index for a large number of species conveniently and quickly, if site index for one species can be determined by conventional means

FIELD METHODS

Plots from 1/5 to 1/2 acre in size were established in 155 upland **Virginia-**Carolina Piedmont forest stands. Study areas were located so that the plot would be homogeneous with respect to soil type, topography, aspect, and degree of slope. Only second-growth stands older than 20years were sampled; stands older than 120 years were avoided. The location of plots was confined to the shortleaf pine- hardwood and Virginia pine- hardwood types. On each plot an aggregate of four dominant and codominant trees of as many species as pos sible were selected and numbered. Some plots had as many as seven species and others only two. Four or five species on a plot was the most common occurrence. The tree species measured were: Yellow- poplar (Liriodendron tulipifera L.), white oak (Quercus alba L.), black oak (Q. velutina Lam.), scarlet oak (Q. coccinea Muenchh.), southern red oak (Q. falcata Michx.), northern red oak (Q. rubra L.), sweetgum (Liquidambar styraciflua L.), shortleaf pine (Pinus echinata Mill.), Virginia pine (P. virginiana Mill.), loblolly pine (P. taeda L.), and eastern white pine (P. strobus L.). Each plot was selected to contain yellow- poplar, white oak,-or shortleaf pine, as index species with which to compare all others.

For each selected tree the total height, age, and diameter breast high was determined. Four years were added to the age from a boring at breast height to determine total age for all species except yellow-poplar and sweetgum. Three years were added to yellow-poplar breast high age, and nothing was added to sweetgum because the site curves were based on breast high age.

Ages and heights for the four trees of each species were averaged, and a single site index value was obtained for each species. These were then grouped in a plot-by-plot tally so that prediction equations could be computed.

ANALYSIS OF DATA

General

The field tabulations were sorted to see if data on all eleven species could be used. Since loblolly and eastern white pine were found on less than ten plots, they were not considered in further analysis of the data. Insufficient data were tabulated for sweetgum and Virginia pine to make strong comparisons of site index with other species, but the mean and range of site indices encountered for these two species are included (table 1), and their position in upland Piedmont forests is discussed later. As a result of these limitations, the seven major species retained for comparative analysis were the four in the red oak group, white oak, yellow-poplar, and shortleaf pine.

Table 1. --Site index of important Piedmont species: Mean, range, and associated species

Species	Code number	Plots	Mean site index	Highest site index	Lowest site index	Associated species: Plot with highest site index	Associated species: Plot with lowest site index
		Number	Feet	Feet	Feet	Code Number	Code Number
Yellow-poplar	1	97	83	122	55	2,9	5,7,8
White oak	2	99	69	90	49	1,9	3
Black oak	3	59	73	98	50	1,4,7	2
Scarlet oak	4	55	76	96	56	1,2,3,6,7	1,2,3,7
Southern red oak	5	36	69	88	52	1,2,3,4,6	1,8
Northern red oak	6	23	83	102	72	1,4	1,2,7,8
Shortleaf pine	7	103	64	88	44	1,6,9	2
Virginia pine	8	28	72	93	57	7	2,3,4,5,7
Sweetgum	9	12	90	112	69	1	1,7

Site Classification

Classification of site index at age 50 for oak, yellow-poplar, and shortleaf pine growing in mixed stands on the Piedmont presented certain difficulties. Oak curves developed by Schnur (7), yellow-poplar by McCarthy (3), and shortleaf pine from USDA Miscellaneous Publication 50 (9) and Coile and Schumacher (1) were not entirely applicable. The study plots were located in mixed stands, whereas data for existing curves came from nearly pure stands. Also, the geographic range of the data for existing oak and yellow-poplar curves did not include the Piedmont region.

Site classification for this study was based on equations of the form, Logarithm of Total Height = a + b $\frac{1}{(\text{Total age})}$, using the height and age data obtained on the comparative site index plots. For oak, the basic relationship was identical for oak in the Piedmont and Southern Appalachian mountains (5). The equations for derivation of a family of site index curves are as follows:

(1) Oak. Because statistical tests showed no significant difference in the rate of height growth relationship by species and no differences between Piedmont and mountain oaks, a single equation is sufficient for all oak species under study.

$$\text{Log H} = 2.028 - 9.5639 \left(\frac{1}{A}\right)$$, based on 697 observations, i. e., plot;

(2) Yellow- poplar

$$\text{Log H} = 2.046 - 6.5788 \left(\frac{1}{A}\right)$$, based on 98 observations.

(3) Shortleaf pine

$$\text{Log H} = 2.027 - 10.9081 \left(\frac{1}{A}\right)$$, based on 103 observations.

The major species were classified according to these three equations. Site index for sweetgum was determined from Winters and Osborne (10), and for Virginia pine from Slocum and Miller (8). Site index was recorded to the nearest foot.

Comparative Site Index

All possible paired species combinations were analyzed to determine regression equations which would define in general terms the relationship in site index between species. The analysis revealed that the only reliable independent variable (index species) to use in formulating prediction equations was yellow- poplar. It was also discovered that white and southern red oak and scarlet and northern red oak could be grouped for analysis. Neither shortleaf pine nor white oak was entirely satisfactory as an index species because of the limited range of site index values encountered (table 1). Yellow-poplar, on the other hand, exhibited a range from near the lowest shortleaf pine and white oal value to over 30 feet greater than the highest of these two species. This show! that yellow-poplar is highly sensitive to the various site factors found on the Virginia-Carolina Piedmont, and this fact can be put to use predicting site inde for numerous other species. Doolittle (2) discovered a similar relationship in the Southern Appalachians.

A tabulation of the regression equations using yellow-poplar as the independent variable (x) is made in table 2. Statistical tests revealed no significant differences between slope of the comparative regressions. They differed only in level and are parallel. Figure 2 presents the equations in a chart for easy use. This graphic comparison and the equations must be used with cautic because both the x and y terms contain experimental error. The presence of experimental error in site index curves and the comparative equations is unde1 further study. Results of this work will be released later. Nevertheless, the

curves do indicate valid trends, and make it possible to estimate the site index of any of the seven major species if the site index of yellow-poplar can be determined by conventional means.

Table 2. --Comparison equations using yellow-poplar as the index species

Species comparison	Comparisons	Regression equation-1/	Level of significance
	Number		Percent
Yellow-poplar Shortleaf pine	62	$Y_{slp} = 31.5 + 0.45x_{yp}$	1
Yellow-poplar White-Southern red oak	67	$Y_{wo} = 36.7 + 0.45x_{yp}$	1
Yellow- poplar Black oak	42	$Y_{bo} = 39.7 + 0.45x_{yp}$	1
Yellow-poplar Scarlet-Northern red oak	44	$Y_{so} = 44.5 + 0.45x_{yp}$	1

1/ Y_{slp} denotes site index of shortleaf pine; Y_{wo}, white and southern red oak; Y_{bo}, black oak; Y_{so}, scarlet and northern red oak. X_{yp} denotes site index of yellow-poplar.

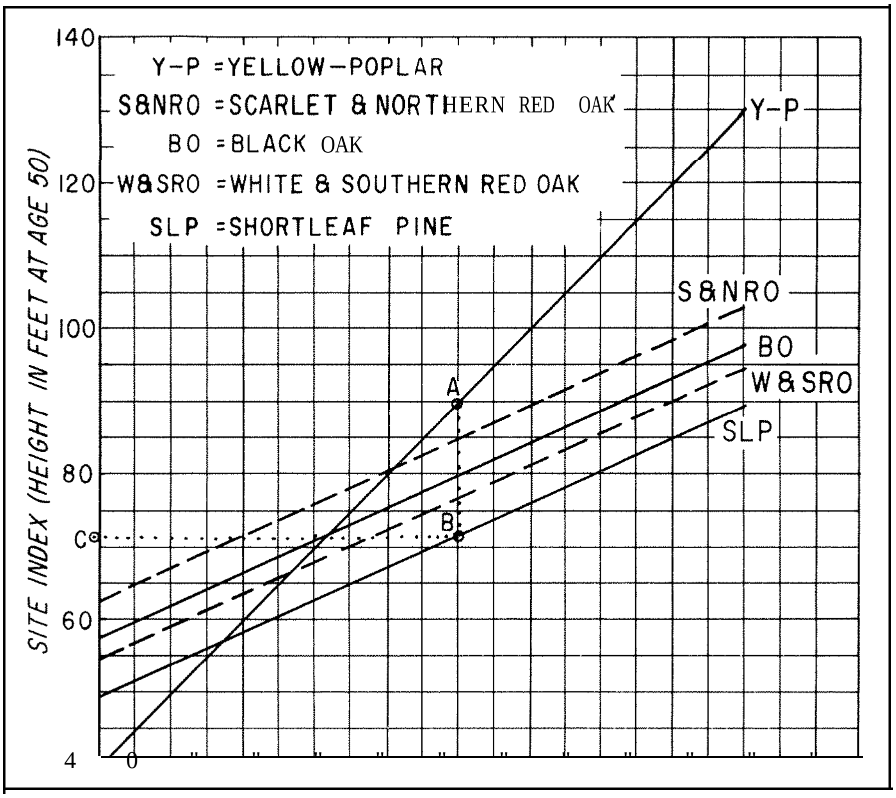


Figure 2. --A site index comparison study for important timber species in the Virginia-Carolina Piedmont. For example, on land that is site index 90 (A), for yellow-poplar, read down (B) and across (C)to find that this same land averages about 72 feet for short-leaf pine.

RESULTS AND DISCUSSION

The comparisons among species reveal that for yellow-poplar site index of 81 feet or more, yellow-poplar has the highest site index value of any Piedmont species. However, data on the few plots on which sweetgum occurred with yellow-poplar indicate that sweetgum has a site index about equal to yellow-poplar where the two grow together on upland, residual soils. Associations of yellow-poplar and sweetgum on upland sites in the northern Piedmont are infrequent. Nelson and Beaufait (4) report that yellow-poplar and sweetgum on the Georgia Piedmont can be grouped as a single independent variable for formulating prediction equations in that region, but their field plots included many bottomland sites.

When the yellow-poplar site index falls below 81 feet, down toward the minimum, scarlet and northern red oak, black oak, white and southern red oak, and finally, shortleaf pine exceed yellow-poplar in site productivity based on height at age 50. For yellow-poplar site index of 57 feet and below, yellow poplar has the lowest site index of any Piedmont species.

Virginia pine is the one major species of the northern Piedmont upland forests which cannot be directly compared in this study using yellow-poplar as an index. The two occurred together on only 13 plots, and no satisfactory prediction equation could be formulated from so few observations. Virginia pine was present on a total of only 28 out of 155 established plots (table 1). This reflects a marked tendency on the part of Virginia pine to occur in pure stands, and the species can be found on many of the shallowest soils and drier, exposed situations in the Piedmont. Examination of the available data indicate: that Virginia pine exceeds white oak in site index throughout the range covere in figure 2, and would be intermediate in site index between the white and blac oaks. Virginia pine consistently has a higher site index than shortleaf pine wh the two are associated.

In general, the findings of Doolittle (2) in the Southern Appalachians, an of Nelson and Beaufait (4) in the Georgia Piedmont agree closely with the resu of this study regarding species which are common to the three regions. Yello poplar exceeds all oak species and shortleaf pine for above-average sites and gets progressively poorer in relation to the other species on the low index site In this study, shortleaf pine is lower than all other associated species except (the very poor sites, while in the Southern Appalachians, white oak, shortleaf, a pitch pine share the lowest relative position.

SUMMARY

Total height and total age were obtained for dominant and codominant tre of as many species as possible in 155 upland, northern Piedmont forest stand From two to seven species were found associated on each of the plots. Site inc equations were developed for oak, yellow-poplar, and shortleaf pine growing i these mixed forests of the Virginia-Carolina Piedmont. The site index of othe species was determined with the use of published curves.

The site indices of all species were compared, and yellow-poplar was the only widely occurring species with a sufficient range of site index to serve as an index species. Using yellow-poplar as the independent variable, equations were computed for estimating the site index of scarlet and northern red oak, black oak, white and southern red oak, and shortleaf pine. These were presented in chart form (fig. 2) and make it possible to estimate the site index of any of these seven major species if the site index of yellow-poplar can be determined by conventional means.

Though direct comparisons with yellow-poplar could not be made for sweetgum and Virginia pine, the role of these two species in upland, northern Piedmont forests is discussed.

The most significant results of these site index comparisons are: (1) yellow-poplar exceeds all other Piedmont species in site index on sites which are 81 feet or more for poplar; (2) as the site index for yellow-poplar falls below 81 feet, the oaks, shortleaf, and Virginia pine begin to exceed yellow-poplar in site productivity, and yellow-poplar becomes the poorest of the seven species at site index 57 and under; and (3) throughout the range of yellow-poplar site index from 58 to 130 feet, shortleaf pine has a lower indicated site index than any of the commonly associated Piedmont species.

LITERATURE CITED

(1) Coile, T. S., and Schumacher, F. X.
1953. SITE INDEX OF YOUNG STANDS OF LOBLOLLY AND SHORTLEAF PINES IN THE PIEDMONT PLATEAU REGION. Jour. Forestry 51: 432-435.

(2) Doolittle, Warren 'I'.
1958. FOREST SOIL-SITE RELATIONSHIPS AND SPECIES COMPARISONS IN THE SOUTHERN APPALACHIANS. Soil Sci. Soc. Amer. Proc. 22: 455-458.

(3) McCarthy, E. F.
1933. YELLOW-POPLAR CHARACTERISTICS, GROWTH, AND MANAGEMENT. U. S. Dept. Agr. Tech. Bul. 356, 58 pp.

(4) Nelson, T. C., and Beaufait, W. R.
1957. STUDIES IN SITE EVALUATION FOR SOUTHERN HARDWOODS. Soc. Amer. Foresters Proc. 57: 67-70.

(5) Olson, D. F., Jr.
1959. SITE INDEX CURVES FOR UPLAND OAK IN THE SOUTHEAST, U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 125, 2 pp.

(6) Oosting, H. J.
1942. AN ECOLOGICAL ANALYSIS OF THE PLANT COMMUNITIES OF PIEDMONT, NORTH CAROLINA. Amer. Midland Nat. 28: 1-126.

(7) Schnur, G. Luther
1937. YIELD, STAND, AND VOLUME TABLES FOR EVEN-AGED UPLAND OAK FORESTS. U. S. Dept. Agr. Tech. Bul 560, 88 pp.

(8) Slocum, G. K., and Miller, W. D.
1953. VIRGINIA PINE. N. C. Agr. Expt. Sta. Tech. Bul. 100, 52 pp.

(9) U. S. Forest Service
1929. VOLUME, YIELD, AND STAND TABLES FOR SECOND-GROWTH SOUTHERN PINES. U. S. Dept. Agr. Misc. Pub. 50, 202 pp.

(10) Winters, R. K., and Osborne, J. G.
1935. GROWTH AND YIELD OF SECOND-GROWTH RED GUM IN FULLY STOCKED STANDS ON ALLUVIAL LANDS IN THE SOUTH. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 54, 35 pp.