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Studies in Site Evaluation for Southern Hardwoods

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SOUTHERN HARDWOODS, which supply more than half of the nation's hardwood lumber, are a complex and varied mixture of nearly 40 commercial species. On a good share of the 112 million acres of southern hardwood types the hardwoods are mixed with or have replaced southern pines. Faced with this profusion of species, the silviculturist's first problem is to know what species to grow on a given type of land. Superficially, this would appear to require only a knowledge of the market value of different species. But actually it requires a basic knowledge of the comparative growth rate and quality of different species if grown on the same land, or of a particular species if grown on different types of land. This paper discusses current studies designed to evaluate southern hardwood sites. Such information is needed in stand improvement operations, in type conversion work, and particularly in seeding and planting where there may be no existing trees from which to estimate future growth rate.

Ideally, the choice between species should be made on the basis of their volume and value production. Unfor-

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tunately this cannot be done in one jump for all 40 species. It has therefore been necessary to start with studies of comparative height growth of different species as expressed by site index and with studies of the specific soil and site requirements of each species. As fast as yield tables become available for the different species, yield comparisons can be made from the site index data.

Conventional site indices for southern hardwoods are expressed as the height attained by dominant trees at 50 years of age. Complications in its application to southern hardwoods are caused by: (1) the deliquescent stem habits of these species, (2) the prevalence of uneven-aged stands, (3) the number of stands too young, abused and depleted, suppressed or lacking the species to be indexed, and (4) the inability of site index to directly evaluate log or tree quality potential, an important factor in hardwood production.

Several methods can be used to get around the difficulties encountered in applying conventional site indices to southern hardwoods. One method consists of obtaining a number of site determinations for several species growing on the same plots and comparing their site indices. These comparative or relative site indices for a given species can then be indirectly obtained if another species on the site fulfills the requirements for conventional site indexing. Of course, if there are no trees available for conventional site indexing, soil and topographic features can be measured. Then site index can be obtained through prediction equations derived from sites that meet the criteria for site indexing.

A study by the Southeastern Forest Experiment Station in the Piedmont, involves the comparative site index method. Another by the Southern Forest Experiment Station on productive hardwood sites from Alabama to Texas approaches the problem through soil-site relationships of individual species.[3]

In both of these investigations, sample trees were chosen from well-stocked, even-aged stands or small groups within specified age limits. They were free from disturbing influences which might alter their height-age relationship. Detection of a history of suppression or top breakage disqualified many prospective sample trees. Increment core examination and frequent stem analyses were necessary for accurate age determination.

Piedmont Studies

Over 130 plots have been located in the Georgia Piedmont, each containing at least two species, one of which is prevalent enough on various sites to be used in common comparisons. Height and age data were obtained.

Conventional site index curves were then tested for Georgia Piedmont conditions. Fortunately, the pine site index curves by Coile (*2*) included plots from the Piedmont in his original data, and agreed with curves derived from field data in this study. Our curves for yellow-poplar, upland oak, and sweetgum, did not differ from published curves for these species (*3, 5, 6*).

[3] An important study in site evaluation of Appalachian hardwoods is not reported here.

Inasmuch as yellow-poplar and sweetgum were the two most abundant hardwood species, a regression analysis was made of the site index of yellow-poplar to that of sweetgum growing on the same plots. This analysis revealed no significant difference, so both were used as comparison species in this study. The site index of each other species was then compared by regression analysis with the site index of yellow-poplar or sweetgum or both. Thus, comparative or relative site indices were obtained for the ranges of sites encountered in the field plots. Preliminary results are shown in Figure 1.

On all sites below loblolly pine site index 90, other tested species showed a lower rate of height growth than loblolly pine. On sites above site index 90, yellow-poplar and sweetgum have greater height growth and a higher site index than other species, including loblolly pine. No difference was found between the site indices of black oak, southern red oak, and scarlet oak, so all were grouped for comparison with the index species. Site indices for the oaks were below those for loblolly pine and below those of yellow-poplar and sweetgum except at the lower extremes. White oak bears a relationship to sweetgum similar to that of loblolly pine, as shown by its gradual slope on the comparative site index chart. However, a site index more favorable for sweetgum occurs above site index 66. Indications are that shortleaf pine (not shown) has a site index below that of sweetgum, yellow-poplar, loblolly pine, and northern red oak.

The estimate of comparative site index can be used in conjunction with yield tables to obtain comparative yields for desired rotation ages. For example, for fully stocked yellow-poplar stands of site index 80, board foot volume production (International 1/8" rule) should equal 17,620 board feet at 50 years. Under the same conditions, white oak should yield only 10,470 board feet.

The comparative site indices shown in the figure do not fully integrate the answer as to which species or species group is best suited for an individual site. Nor are they without error. In this series of comparisons,

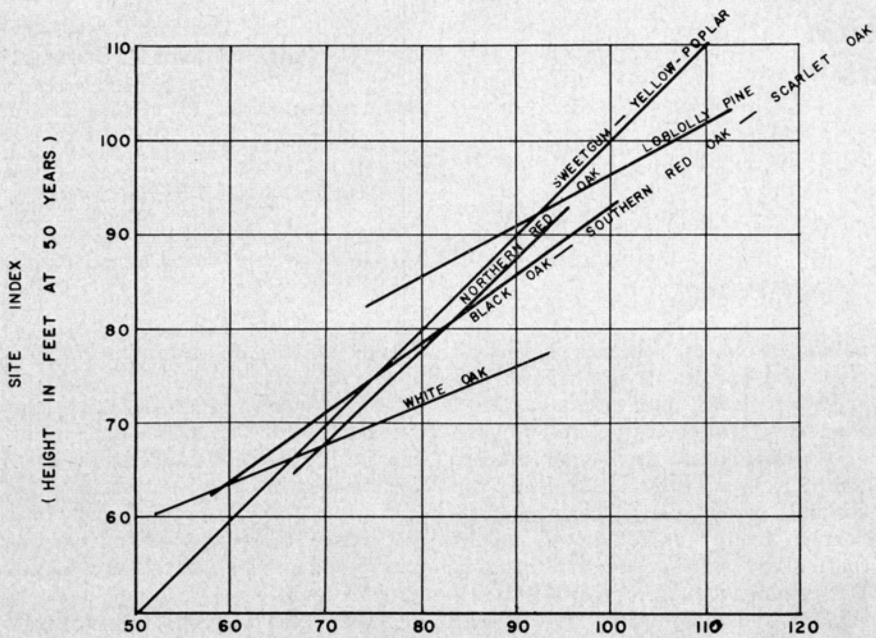

FIG. 1.—Preliminary comparison of site indices for several different species on the same land in the Georgia Piedmont.

for example, the slopes of the regression equations differ significantly from the sweetgum-yellow-poplar slope except in the case of northern red oak. The data are not precise enough so that differences between regression means are statistically valid. Of course, the reliability of each additional estimation such as yield table and stumpage values must be weighted in the decision among species.

These data, backed by other field observations, indicate that the breakpoint between loblolly pine and the most common soft-textured hardwoods in the Georgia Piedmont in respect to height growth is in the vicinity of site index 90 for loblolly pine. That is to say, in terms of height growth, sweetgum and yellow-poplar will outgrow loblolly pine only on above-average sites (Figure 1).

Data are currently being gathered in an attempt to relate soil and topographic characteristics to site quality where a comparative site index cannot be obtained.

Other Southern Hardwood Sites

In contrast to the approach taken in the Piedmont, work at the Southern Forest Experiment Station is concentrating on the site requirements of one species at a time. When the sites of all southern hardwood species have been evaluated, then yields and site indices will be compared.

To serve as a basis for further work, the first species to be studied had to be found on a wide variety of alluvial sites. Willow oak was chosen for this characteristic as well as for its commercial importance.

Hardwoods in the South are rarely in pure, fully stocked, even-aged stands. With the exception of the tupelos, eastern cottonwood, black willow, and some old-field sweetgum, southern hardwoods are currently being treated on a single-tree selection basis which maintains uneven-aged stand conditions. As a result, the very few existing site index curves and yield tables based on even-aged stands are not generally applicable. As yield data become available for hardwood types, the species-site relationships shown by this study will serve as useful refinements in site identification.

The alluvial floodplains of the South, where most of the productive hardwood sites are found, are noted for their flat appearance. Despite this apparent flatness, differences in elevation as small as 2 feet cause differences in species occurrence and growth (*4*). This is partly because topographic classification of bottomland sites is a measure of surface water relationships, and extended periods of flooding can cause concentration of some soil elements and reduced activity of soil fauna. Figure 2 illustrates site differentiation during a period of receding high water. Definitions of these topographic classes are as follows:

High ridge or front: The highest land found in alluvial bottoms. These are the banks of former channels or presently active main watercourses where seasonal overflows have deposited most of the large sediment particles. Built up as natural levees, they are rarely inundated. Surface drainage is superior to that in other topographic classes.

Low ridge: Topographic map inspection is often necessary to distinguish these from high ridges. Only a few feet lower than the preceding class, they are more numerous, formed as banks of older, smaller, sluggish or less permanent watercourses. Also included here are sites located on the gently sloping sides of the high ridges.

High and low flats: "Flat" well describes the broad area between ridges. It is easily recognized by its poor surface drainage and wide dimensions. It tends to have a higher proportion of clay in its make-up. The difference between high and low flats is one of degree. A logical line of demarcation may be drawn by the rate of drainage after flooding or heavy rainfall. Those flats which are free of water within a few days after the river or stream is again between banks, or after the heaviest seasonal rains, may be classified as high. Low flats often retain a cover of water for several weeks longer or even into the early growing season.

Swamps and sloughs: Swamps are low, land-locked topographic classes which are dry only during the latter portion of the growing season. Sometimes these tupelo and cypress sites remain inundated yearlong.

Sloughs are the remaining channels of former water courses. They collect water from surrounding areas. Surface drainage is slow, but usually complete at some time during the growing season.

To date, the mensurational phases and soil sampling have been completed for willow oak, and site index may be predicted for this species when topographic position and certain soils values are known. Butt log grade shows a direct relationship to site index (*1*). The site requirements of eastern cottonwood, sweetgum, green ash, cherrybark oak, water oak, Nuttall oak, and swamp chestnut oak are currently being studied.

Due to the nature of alluvial deposition, soil texture and structure also are related to topographic position. These variables reflect internal drainage relationships and, in doing so, extend our knowledge of the sites under study. Figure 3 presents the observed relationship of topography, percent clay, and site index for willow oak on Mississippi Delta soils. The lower-lying sites are less productive for willow oak. On any site, there tends to be an inverse relationship between site index and the percentage of clay 12 to 18 inches under the soil surface.

FIG. 2.—Aerial photograph illustrating topographic classes in an alluvial flood plain. This photograph was taken during a period of receding high water.

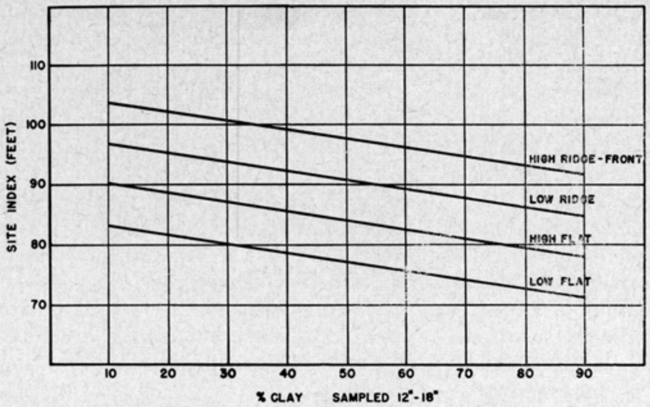

FIG. 3.—The observed relationship of topography, percent clay, and site index for willow oak on Mississippi Delta soils.

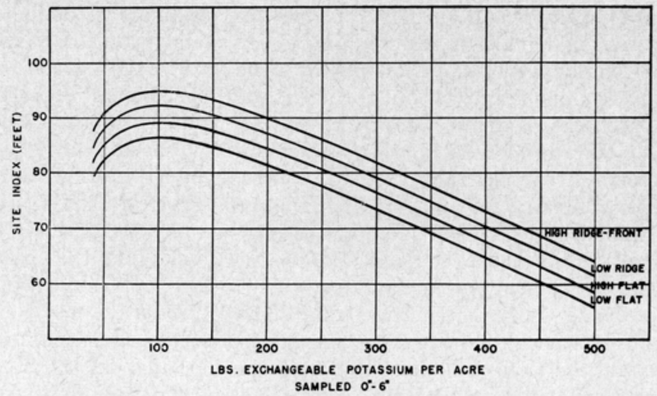

FIG. 4.—The observed relationship of topography, amount of exchangeable potassium in the top 6 inches of soil, and site index for willow oak on non-Delta river bottoms.

Figure 4 shows how the amount of available potassium in the top 6 inches of soil may be used as the soil variable in other river and stream bottoms of the South. Again, lower topographic classes and larger amounts of potassium reduce site index. Both clay and potassium are probably secondary indicators rather than true causative factors in site-quality determination.

After many interrelated and reliable soil variables had been tested, these two criteria were chosen because the soil tests required can readily be made by appropriate State agencies or by practicing foresters.

Unfortunately, a large porportion of the soils typical of approximately 2 million acres of excellent hardwood sites unprotected from Mississippi River overflow are not so easily described. Every combination of soil texture and depth may be found there, as well as in other overflow bottoms of the South. To adequately analyze the effects of centuries of differential alluviation has been the largest obstacle in bottomland hardwood site prediction. As a result, variables other than topography and percent clay may prove more reliable for other commercially important species. For example, cottonwood on the complex layered or stratified soils of the Mississippi River batture does well on wet heavy clays.

When the sites of many southern hardwoods were first described, sweetgum, cherrybark oak, swamp chestnut oak, and water oak were identified with well drained ridges. Green ash, sugarberry, Nuttall oak, overcup oak, and water hickory were found in the poorly drained flats. Cottonwood, black willow, sycamore, and pecan are usually associated with new accretion land along the banks of major rivers (*4*). These broad site differences permit assignment of hardwood species to relatively useful associations. As management intensifies in southern hardwoods, however, the differences in site adaptation and productivity within these groups must be recognized and defined on a more fundamental basis. The completion of the work described in this paper will ultimately provide means to assign the right tree to the right place in the southern hardwood region.

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