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SOIL-SITE CLASSIFICATION FOR BOTTOMLAND HARDWOODS

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Foresters have always needed a means of predicting tree growth. Of the many indexes of potential growth, site index is the most widely used. Site index may be defined as the height of dominant trees in a stand at a reference age (usually 50 years). Site index is, in theory, a true reflection of growth potential of the site because height growth is generally unaffected by stand density, except at extremes. If no suitable trees of the desired species are present, our estimates must be based on other indicators of potential growth. The environmental factors, the sum of which are known as site, are an interesting and powerful means of estimating site index.

Estimates of Site Index Based on Trees and Vegetation

The simplest approach is to determine site index estimates directly from trees on the site to be evaluated. Often this cannot be done reliably. The species of interest may not be present or, if present, may be very young, damaged by storms, or suppressed at an early age. Also, suitable site index curves are not available for all species. Species for which site index curves are available are listed in Table 1.

The site indexes of some species are correlated with those of another species. At present, comparative site index curves are available only for green ash, cottonwood, cherrybark oak, water oak, willow oak, and Nuttall oak as based on the site index of sweetgum (Broadfoot 1970). At times, the site index of one species can be assumed to approximate the site index of another species. The site indexes of sugarberry and hackberry, and willow oak and water oak, were estimated by the same system (Baker and Broadfoot 1979).

Site indexes could conceivably be predicted from the presence and size of plant indicator species. Most foresters are aware of and use plant indicators in making judgments about sites. For example, an attempt to establish cherrybark oak on a site presently harboring buttonbush and swamp-privet would surely fail. I know of no quantitative site evaluation system for the bottomlands that is based on indicator species.

Table 1. Site index curves available for bottomland hardwood species

Species	Source area	Author	
Cottonwood	IL, IN, KY, MO	Neebe and Boyce	1959
	LA, MS	Alexander	1976
	AR, KY, LA, MS, TN	Broadfoot	1960
Sweetgum	AL	Lyle and others	1975
	AR, LA, MS, TN	Broadfoot and Krinard	1959
Sycamore	LA	Briscoe and Ferrill	1958
Cherrybark oak	AR, AL, LA, MS, TN	Broadfoot	1961
Water oak	AR, AL, LA, MS, TN	Broadfoot	1963
Nuttall oak	AR, AL, LA, MS, TN	Broadfoot	1969
Green ash	AR, AL, LA, MS, TN	Broadfoot	1969
Swamp blackgum	GA	Applequist	1959
Tupelo-gum	GA	Applequist	1959

Estimates of Site Quality Based on Species Trials

The lack of suitable trees to measure raises the possibility of evaluating a site by planting a species or a number of species and observing their growth. This approach offers the ultimate "ground truth" for the potential of plantations but has a few drawbacks. It is costly, takes many years to produce answers, and relates only to the site on which the trial is conducted. Also, the results may not apply well to natural stands. A number of species-site trials are in progress around the country. Information on them is available mostly on a local basis.

Experience and Judgment

Some foresters accumulate a host of cues about site quality almost automatically: the height and straightness of trees in the stand, species present, topographic position, swampiness underfoot, color and general texture of the soil, and many others. The experience and judgment necessary to recognize indicators and make good estimates of site quality are not easily acquired. A career hobby of asking, "How good is this site?" and "Why?" could do much to build one's judgment. For most, a more systematic approach to evaluating a site is obviously desirable. Even with the "systems" now available, however, experience and judgment are invaluable aids in site assessment.

Site Index Prediction with Soil-Site Equations

Soil-site equations rely on observed correlations between height growth and environmental variables, particularly soil variables, to predict site index. Some equations have been developed for hardwoods on bottomland sites. Broadfoot (1969) presents equations for sweetgum, water oak, willow oak, Nuttall oak, green ash, and cottonwood. Other authors present equations for sweetgum (Phillips and Markley 1963, Phillips 1966); yellow-poplar, cherrybark oak, and sweetgum (Hebb 1962); swamp blackgum and tupelo (Applequist 1959); and willow oak (Beaufait 1956). Of the above equations, only Broadfoot's (except for cottonwood) were tested against new data. No equation was able to account for more than 67% of the variation in site index.

Broadfoot (1969) admits that "the relationships between [bottomland] soil characters and height growth seem to defy quantification." He cites a host of difficulties, including extreme variability of alluvial soils and absence of unabused stands to work with. Other difficulties mentioned are lack of "measurable variables that faithfully express soil moisture and nutrient availability during the growing season, physical condition including root growing space, and soil aeration."

Site Indexes Associated with Soil Series

An elaborate system of soil classification has been developed under the leadership of the Soil Conservation Service. What could be more natural than to document the site index range of each soil series? The difficulty that arises is that soil series are not necessarily based on features associated with yield, even agricultural yield (Coile 1959). Consequently, considerable range in site index is possible within a soil series. It is imperative that a person using soil series-site association systems be able to identify soil series correctly and judiciously interpolate the site index within the range given for that particular soil series.

A word of caution about using soil survey maps to identify soil series on forest tracts: the older soil surveys used many series that are now defunct or that have been modified. Forested areas often were not mapped or were mapped in such an extensive way that inclusions of sizable areas of contrasting soil types were missed or ignored.

Broadfoot (1976) prepared a guide on 40 important Midsouth soils that gives site index ranges, recommended species for planting and management, and important soil properties. This is the guide I use most often in my soil-site work. Because of the particular soils cited, the guide is probably not very useful in the Southeast. The Soil Conservation Service has published "Soil Survey Interpretations for Woodlands" for each physiographic provenance, giving site index averages and ranges, recommended species for planting, and management hazards for each soil series covered. However, Broadfoot was the source of most of the information on bottomland hardwoods in these publications.

An Empirical System

Not being tied to mathematical functions, the only requirement of an empirical system is that it work. The only effective system for bottomlands that I am aware of was developed by Jim Baker and Walter Broadfoot (1979). Fourteen species are covered: sycamore, swamp chestnut oak, yellow-poplar, cherrybark oak, pecan, green ash, sugarberry, hackberry, sweetgum, Nuttall oak, willow oak, Shumard oak, cottonwood, and water oak.

Tree growth is dependent on four soil factors: (1) physical condition, (2) available moisture, (3) nutrient availability, and (4) aeration. It is assumed that each factor is responsible for a certain portion of site index. For example, the assigned percentages of potential height growth for cottonwood are soil physical condition, 35%; available moisture, 35%; nutrient availability, 20%; and aeration, 10% (Figure 1). Each of these factors is split into several subfactors. During its development process, the system was repeatedly compared with and adjusted to soil-site data on file.

The user assigns each subfactor a score according to choices given in the guide. The sum of the scores equals estimated site index. Used correctly, the system will provide estimates within 5 feet of true site index 95% of the time, according to the authors.

The system is straightforward and easy to understand. With a little training, the practicing forester can use it. However, one difficulty is noticeable; the user is called upon to make fairly sophisticated determinations of some soil properties--or guess at them. Of particular concern are texture, compaction, water table depth, organic matter content, and pH. An error in measuring or estimating a single factor will not result in a large error in site index.

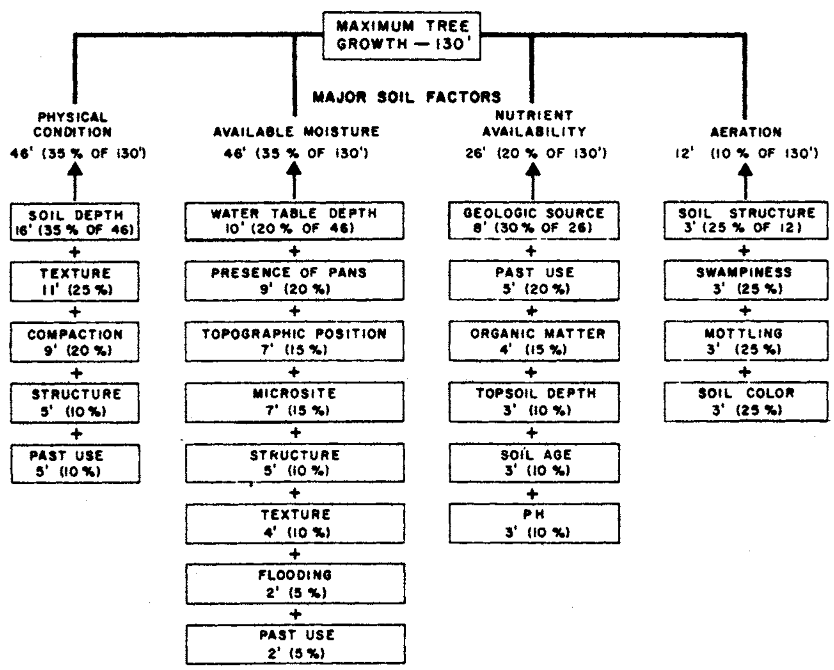

Figure 1. Contribution of various soil-site properties to the four major soil factors and to cottonwood growth (maximum growth expected on an ideal site at age 30).

Where Do We Go from Here?

Though it does appear possible to create simpler and more accurate soil-site prediction tools, the Baker-Broadfoot system seems adequate for the species covered in most circumstances in the South and Southeast. The need now is for greater understanding of the underlying relationships between tree growth and soil properties. For example, we have very little quantitative information about soil aeration, which, according to one author (Patrick 1981), "plays the dominant role in determining species distribution." For all our efforts with fertilization, we cannot quantitatively relate nutrient levels in bottomland soils to tree growth. Likewise, soil moisture relationships of the various species are poorly understood. The need for semibasic research becomes more apparent as time goes on. Site index curves for additional species are also needed. A little work is now underway, such as my own work with the upper pH tolerances of oaks, but much more on many subjects is needed. After developing a greater understanding of soil-tree growth interactions, we shall be able to create soil-site prediction systems that are more accurate and descriptive of site-related limitations to growth.

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