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A PRACTICAL FIELD METHOD OF

SITE EVALUATION FOR EIGHT IMPORTANT SOUTHERN HARDWOODS

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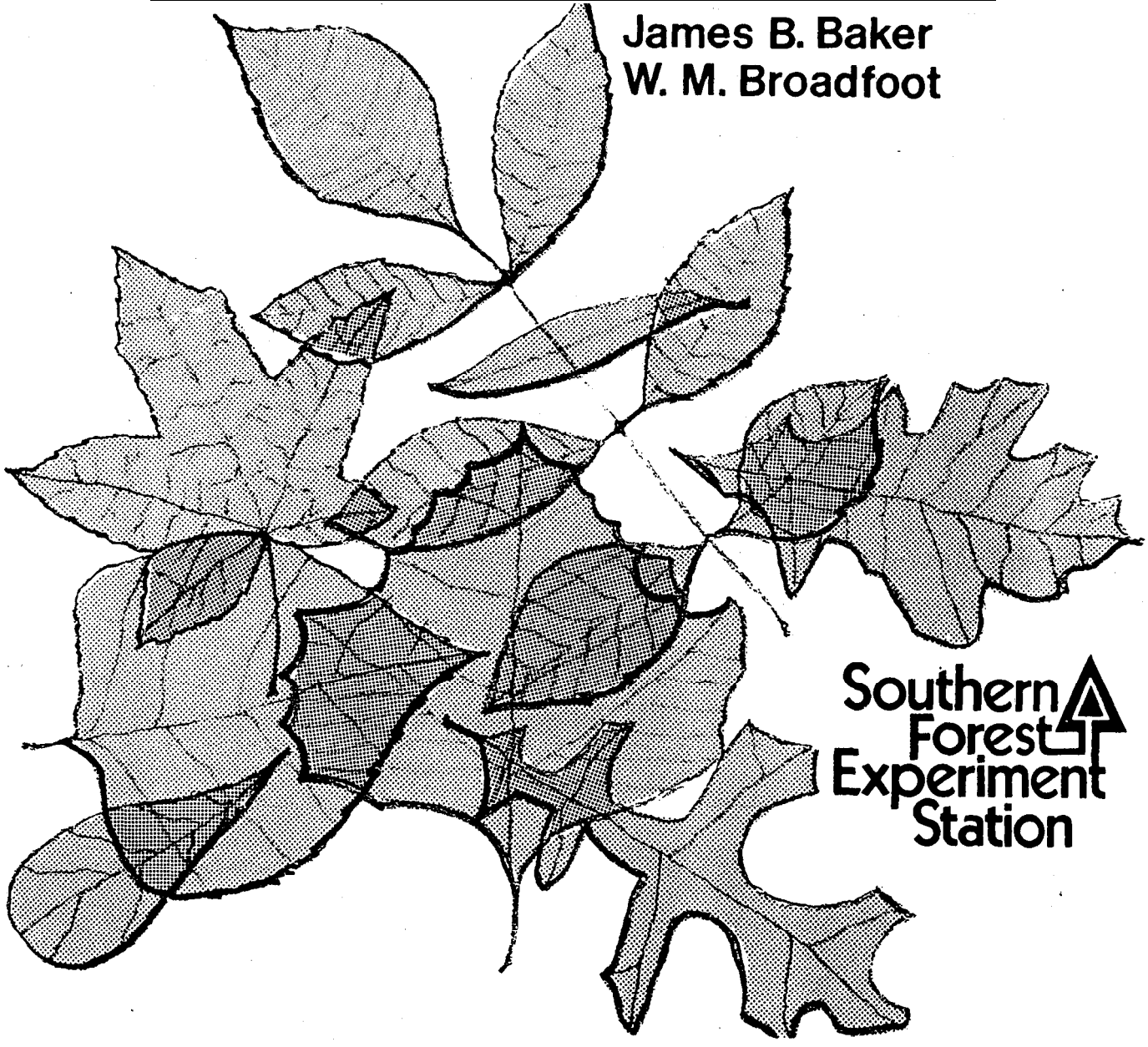

Southern Forest Experiment Station

SUMMARY

This paper presents a new method of site evaluation for cottonwood, sweetgum, sycamore, green ash, and Nuttall, water, willow, and cherrybark oaks. The method incorporates an evaluation of the physical, moisture, nutrient, and aeration properties of a soil into a site quality rating. Field tests have demonstrated the accuracy of the technique. The site evaluation technique also provides a basis for possible soil improvement treatments for the eight hardwood species and estimates of potential productivity for cottonwood plantations.

A Practical Field Method of Site Evaluation For Eight Important Southern Hardwoods

JAMES B. BAKER
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This report is a field guide to be used in estimating the suitability of sites for eight important hardwood species. In establishing hardwood plantations, the forest manager must know whether a site is suitable for a particular species, and for investment planning he should have some idea of the potential productivity of the site.

Tables l-7 are the guides for applying the site-evaluation method; instructions on their use are given beginning on page 2. For cottonwood, a table (table 8) that gives expected ranges in tree growth and volume production is presented. A glossary of terms that may be unfamiliar to many readers is included as an appendix.

BACKGROUND

Many acres of hardwood plantations are established each year throughout the eastern United States. Johnson and Kerr (1976) reported that by 1981 cottonwood plantations could total about 70,000 acres, a 30,000-acre increase in 5 years. Other species, such as sycamore, sweetgum, and green ash, are also being planted at accelerated rates throughout the South.

The techniques now available to aid in site selection and evaluation for hardwoods involve either objective or subjective approaches which have inherent shortcomings that limit their usefulness. The problems of objectively selecting and quantifying measurable soil variables that consistently reflect the growth potential of hardwoods over wide geographic areas appear to be insurmountable (Broadfoot 1969). On the other hand, subjective approaches provide only broad classes of soil suitability or productivity for hardwoods (Broadfoot 1964, Broadfoot et al. 1972, Maisenhelder 1960, McKnight 1970, and Smith 1957).

James B. Baker is Principal Soil Scientist and W. M. Broadfoot, now retired, was Principal Soil Scientist at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station, Forest Service—USDA, in cooperation with the Mississippi Agricultural and Forestry Experiment Station and the Southern Hardwood Forest Research Group.

We propose a new technique of site evaluation that combines the best features of objective and subjective approaches. The technique is based on our experience and is not the result of formal experimentation but should provide foresters with an accurate way of evaluating a site's suitability for any of eight hardwood species. The method can also be used to obtain estimates of potential volume production of cottonwood at various ages.

The advantages of the technique are: **(1)** it provides accurate estimates of site index under any soil or site condition; (2) it can be applied throughout the southern hardwood region except in those mountainous areas where aspect is important; (3) it does not require identification of soil series; and (4) it provides guidelines for soil ameliorative treatments. In the future, the method could possibly be modified to include species of trees from throughout the world if allowance is made for differences in climate, soils, and topography.

With field-plot data for hardwoods (Broadfoot 1976), the technique was field tested for each species for a variety of soils and physiographic areas. Site index values estimated for a particular site by the new method were compared to measured site index values obtained by Broadfoot. These comparisons were subjected to correlation analysis and to the chi-square test of accuracy (Freese 1960). On the average, 20 sites were tested for each species; correlation coefficients ranged from 0.93 for sweetgum to 0.99 for cottonwood. The chi-square test of accuracy indicated that the new evaluation technique should provide estimates of site index that are within 5 feet of measured site index values 99 percent of the time.

BASIS FOR AND DEVELOPMENT OF THE TECHNIQUE

Growth of hardwoods is dependent primarily on four major soil factors (Broadfoot 1969, Broadfoot et al. 1972, Kaszkurewicz 1973, Schreiner 1959, Waring 1961). These factors are:

(1) Soil physical condition.
(2) Moisture availability during the growing season.
(3) Nutrient availability.
(4) Aeration.

Each major factor consists of many soil and site properties that affect tree growth. The interaction of these properties within and among the major soil factors makes evaluation of a site a complex task.

The basis of our approach is the assumption that each of the major factors is responsible for a certain percentage of tree growth. The proportion of growth accounted for by each major factor is composed of the contributions made by each of its soil-site properties.

Tables 1-7 list the major soil factors and soil-site properties for the eight species. The tables also present a range of soil-site conditions, from best to poor, that are likely to occur for each soil property. The soil-site conditions for each property are assigned numerical site-quality ratings

(SQR), which are given in brackets. The SQR values were first estimated for the best site conditions (see fig. 1) and were then assigned to medium and poor sites by estimating height reductions caused by less than optimal conditions.

FIELD USE OF THE EVALUATION TECHNIQUE

To obtain an SQR value for a particular species, match the soil-site conditions of your area as closely as possible to the range of conditions listed for each soil-site property in the appropriate table. A 30-year site index for cottonwood or a 50-year site index for the other species is obtained by adding the SQR's for each soil-site property. If a total SQR for any site does not exceed 80 feet for cottonwood, 75 feet for sweetgum and Nuttall oak, 70 feet for sycamore and water, willow, and cherrybark oaks, and 65 feet for green ash the area should be considered unsuitable for that species unless soil amelioration is used to alleviate adverse soil-site conditions.

If an exact match is not possible, interpolate between conditions listed in the tables. If you are unable to determine a specific soil-site condition, do not hesitate to make an educated guess; a few poor estimations probably will not cause serious errors in the final site quality rating. A few hours of instruction from a soil scientist should enable people who are unfamiliar with various soil-site conditions to make accurate estimates.

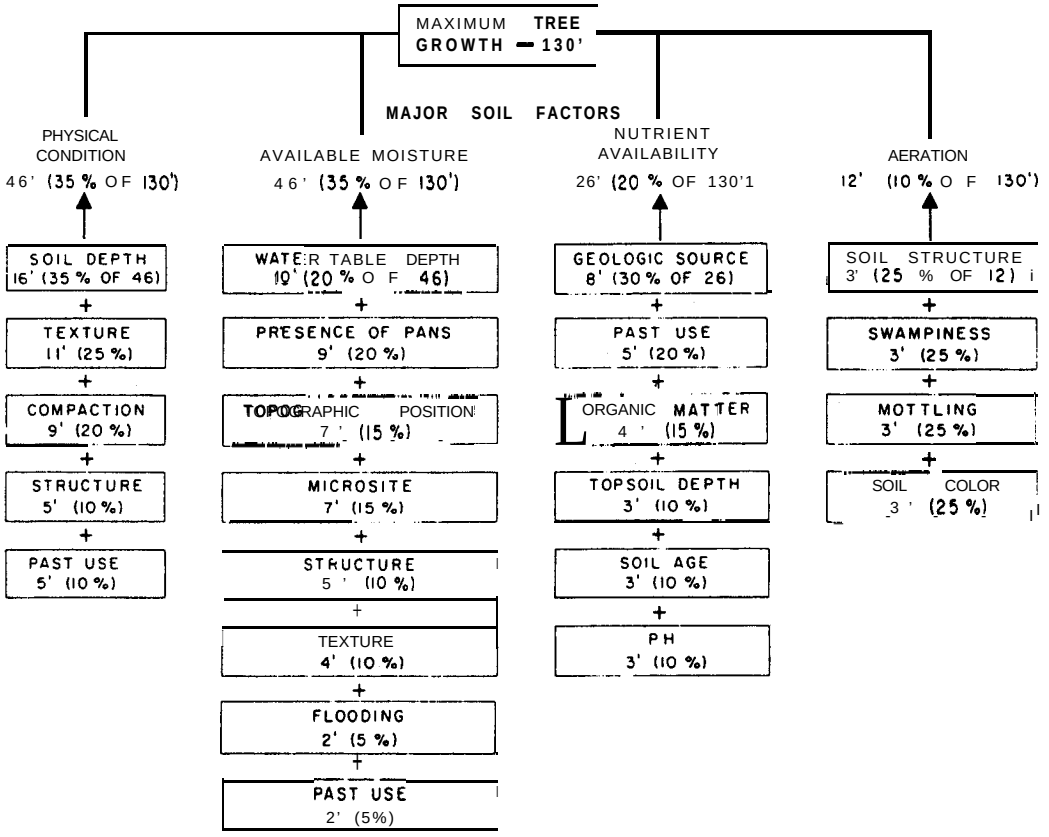

Figure *l.-Contribution of various soil-site properties to the four major soil factors and to cottonwood growth (maximum growth expected on an ideal site at age 30).*

As an example of how the technique is applied, let us assume that the location to be evaluated is a recently abandoned old field in the Mississippi River floodplain that had been under intensive agronomic cropping for 25 years. The area is level and not subject to flooding. The soil is a loam with no profile development; it is granular in structure but is moderately compacted and has a plowpan at 10 inches. It is brown and mottled at 36 inches. A water table occurs at 5 feet during the growing season, pH is 6.5, and there is less than 1 percent organic matter in the A-horizon.

The SQR's for each soil-site characteristic of the hypothetical area, taken from table 1, are summed and produce the following site evaluation for cottonwood:

MAJOR SOIL FACTORS							
(1) Physical condition		(2) Moisture availability		(3) Nutrient availability		(4) Aeration	
Soil depth and pans	11	Water table	10	Geologic source	8		
Texture	11	Pans	6	Past use	-3		
Compaction	6	Position	7	% organic matter	-3	Structure	3
Structure	5	Microsite	5	Topsoil	3	Swampiness	3
Past use	-2	Structure	5	Soilage	3	Mottling	3
		Texture	4	pH	3	Color	3
		Flooding	-1				
		Past use	-1				
Total	31 ft		35 ft		11 ft		12 ft
(Total possible)	(46 ft)		(46 ft)		(26 ft)		(12 ft)
TOTAL SQR OR SITE INDEX = 89 ft							

This evaluation indicates that the site index for cottonwood on this particular area is 89 feet at 30 years.

By comparing the values obtained for each major factor with the maximum values possible for an ideal site, we can determine which major factor limits growth. In the example, physical condition received 31 of the 46 (67 percent) points possible; moisture availability and aeration received 76 and 100 percent, respectively, of the total possible points. Nutrient availability, however, received only 42 percent of its total possible points. Thus, a lack of sufficient nutrients would probably limit growth on this site, and fertilization might be used to improve the growth of cottonwood.

ESTIMATES OF COTTONWOOD VOLUME AND DRY MATTER PRODUCTION BY SITE CLASSES

Once a forest manager has calculated the SQR for cottonwood for an area, he can obtain from table 8 an estimate of cottonwood productivity for various stages of development. These production estimates were obtained from measured yields in cottonwood plantations through age 15 and from natural stand data for ages 20 through 30 years. At present, plantation data are not adequate to prepare productivity tables for the

other species. Derivation of the estimates for cottonwood was based on the following assumptions:

(1) Site preparation and plantation culture through the first growing season as described by McKnight (1970).

(2) Planting density of approximately 430 trees per acre; 20% planting mortality and 1% natural mortality per year after establishment.

(3) Proper thinning to maintain adequate growing space for crop trees. These thinnings included:

a. One-half of the trees (1/2 of the basal area) removed per acre as row thinnings on the Class I and II sites at age 5.

b. One-half of the trees (1/2 of the BA) removed as row thinnings on the Class III sites and one-third of the BA (38% of the trees from the lower half of the diameter range) removed by selection on the Class I and II sites at age 10.

c. One-third of the BA (38% of the trees from the lower half of the diameter range) removed by selection on all site classes at age 15.

d. One-third of the BA (38% of the trees from the lower half of the diameter range) removed by selection on the Class I sites at age 20.

Production estimates presented at each age are for standing trees at that time and do not include previous thinnings, but net production (final harvest cut + previous thinnings) is given for age 30. Net production for ages other than 30 years can be calculated by summing the volume of standing trees at the intermediate age and the volume obtained from previous thinnings. For example, net production in cords for the Class I sites at age 15 is 50 + (1/3 of 46) or 15.3 + (1/2 of 17) or 8.5, giving a total of 73.8 cords per acre (Table 8).

It should be noted that values for cu. ft., cords, M bd. ft., and dry matter represent the total production for a single product. For example, at age 30 the Class I sites would produce 11,170 cu. ft. or 124 cords or 39 and 49 M bd. ft. (Doyle and Int.) or 130 tons of stem per acre (Table 8). Estimates are not provided for multiple products.

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Table 1. — ***Soil-site properties influencing the four major soil factors and thus cottonwood growth***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 1. Physical condition			
Soil depth and presence of artificial or inherent pan	Deep soil (> 4 feet); without pan [16][1]	Medium depth (2-4 feet), or a soil with a plowpan [11]	Shallow soil (< 2 feet), or a soil with an inherent pan I-111
Texture (in rooting zone)	Medium-textured; silty or loamy [11]	Coarse-textured; sandy [8]	Fine-textured: clayey l-41
Compaction (in surface foot)	No compaction: loose, porous, friable, bulk density < 1.4 g/cc [9]	Moderately compacted; firm, moderately tight, bulk density 1.4-1.7 g/cc [6]	Strongly compacted; tight, bulk density > 1.7 g/cc i-31
Structure (in rooting zone)	Granular; single-grained; massive (if sandy, loamy, or silty) - [5]	Prismatic; blocky [3]	Massive (if clayey); platy l-31
Past use and present cover	Undisturbed; near-virgin forest cover [5]	Moderate cultivation; cultivated < 20 years, or open with grass [2]	Intensive cultivation; cultivated > 20 years, or open and bare [-2]

Continued

Table 1. — ***Soil-site properties influencing the four major soil factors and thus cottonwood growth (continued)***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6' [10]	1-2'; 7-10' 171	< 1' I unsuitable] ; > 10' [0][2]
Artificial or inherent pans	No pans [9]	Plowpan [6]	Inherent pan [-6]
Topographic position	Floodplain or stream bottom [7]	Stream terraces or lower slopes [5]	Upland I-51
Microsite	Concave; depression, pocket, trough [7]	Level; flat [5]	Convex; ridge, mound I-21
Structure (in rooting zone1	Granular; massive (if silty, loamy, or clayey); stratified [5]	Prismatic; blocky [3]	Massive (if sandy); platy; single-grained [-3]
Texture (in rooting zone)	Silty or loamy (or stratified) [4]	Clayey [2]	Sandy i-21
Flooding	Winter through spring [2]	Winter only [1]	None I-l]; continuous [unsuitable]
Past use and present cover	Undisturbed; near-virgin forest cover [2]	Moderate cultivation; cultivated < 10 years [1]	Intensive cultivation; cultivated > 10 years [-1]

Continued

Table 1. — ***Soil-site properties influencing the four major soil factors and thus cottonwood growth (continued)***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River, Loess, Blackland [8]	Mixed Coastal Plain and other [5]	Coastal Plain [-5]
Past use and present cover	Undisturbed; near-virgin, forest cover, cultivated < 5 years [5]	Moderate cultivation; cultivated 5-10 years, or open with grass [3][3]	Intensive cultivation; cultivated > 10 years, or open and bare [-3][3]
Organic matter (A-horizon)	> 2% [4]	1-2% [3]	< 1% 1-31
Depth of topsoil (A-horizon)	> 6" or no profile development [3]	3-6" [2]	< 3" [-2]
Soil age	Young, no profile development (Entisols) [3]	Medium. moderate profile development (Inceptisols) [2]	Old, well-developed profile, leached (Alfisols) [-2]
pH (in rooting zone	5.5-7.5 [3]	4.5-5.5 or 7.6-8.5 [2]	< 4.5 or > 8.5 i-21
Factor 4. Aeration			
Soil structure (in rooting zone)	Granular, porous; single-grrined; or massive (if sandy, loamy, or silty) [3]	Prismatic; blocky [2]	Massive (if clayey); platy i-21
Swampiness	Wet in winter only [3]	Wet January-July [2]	Waterlogged all year [Unsuitable]
Mottling	None to 18" depth [3]	None to 8" depth [2]	Mottled to surface [-2]
Soil ccior (A-horizon)	Black, brown, red [3]	Yellow, brownish-gray [2]	Gray I-21

[1] Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

[2] If the soil is a sand or loamy sand, then [-20].

[3] If cultural practices included annual fertilization, then [4].

Table 2. — ***Soil-site properties influencing the four major soil factors and thus sweetgum growth***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
	Factor 1. Physical condition		
Soil depth and presence of artificial or inherent pan	Deep soil (> 4 feet); without pan [6][1]	Medium depth (2-4 feet), or a soil with a plowpan 141	Shallow soil (< 2 feet), or a soil with an inherent pan [-2]
Texture (in rooting zone)	Medium-textured; silty or loamy [4]	Coarse-textured; sandy [2]	Fine-textured; clayey [1]
Compaction (in surface foot)	No compaction; loose, porous, friable, bulk density < 1.4 g/cc [6]	Moderately compacted; firm, mode-ately tight, bulk density 1.4-1.7 g/cc [4]	Strongly compacted; tight, bulk density > 1.7 g/cc [-2]
Structure (in rooting zone)	Granular; blocky single grained; massive (if sandy loamy, or silty, [3]	Prismatic; platy [4]	Massive (if clayey) [0]
Past use and present cover	Undisturbed; near-virgin forest cover [0]	Moderate cultivation; cultivated < 20 years, or open with grass [-1]	Intensive cultivation; cultivated > 20 years, or open and bare [-2]

Continued

Table 2. — ***Soil-site properties influencing the four major soil factors and thus sweetgum growth (continued)***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6' [6]	1-2'; 7-10' [3]	<1' [unsuitable]; > 10' [-12]
Artificial or inherent pans	No pans [6]	Plowpan [3]	Inherent pan [-12]
Topographic position	Floodplain or stream bottom [5]	Stream terraces or lower slopes [3]	Upland [-2]
Microsite	Concave; depression, pocket, trough [2]	Level; flat [1]	Convex; ridge, mound [-2]
Structure (in rooting zone)	Granular; blocky; massive (if silty, loamy, or clayey); stratified [5]	Prismatic; platy [3]	Massive (if sandy); single-grained [-1]
Texture (in rooting zone)	Silty or loamy, (or stratified) [5]	Clayey [2]	Sandy [0]
Flooding	Winter through spring [5]	Winter only [3]	None [0]; Continuous [Unsuitable]
Past use and present cover	Undisturbed; near-virgin, forest cover [2]	Moderate cultivation; cultivated < 10 years [1]	Intensive cultivation; cultivated > 10 years [0]

Continued

Table 2. — ***Soil-site properties influencing the four major soil factors and thus sweetgum growth (continued)***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River, Loess, Blackland [5]	Mixed Coastal Plain and other [4]	Coastal Plain [2]
Past use and present cover	Undisturbed; near-virgin, forest cover, cultivated < 5 years [5]	Moderate cultivation; cultivated 5-10 years, or open with grass [3][3]	Intensive cultivation; cultivated > 10 years, or open and bare [1][3]
Organic matter (A-horizon)	> 2% [4]	1-2% [2]	< 1% [-2]
Depth of topsoil (A-horizon)	> 6" or no profile development [5]	3-6" [2]	< 3" i-31
Soil age	Young, no profile development (Entisols) [4]	Medium, moderate profile development (Inceptisols) [2]	Old, well-developed profile, leached (Alfisols) [0]
pH (in rooting zone)	5.5-7.5 [1]	4.5-5.5 or 7.6-8.5 [0]	< 4.5 or > 8.5 [-1]
Factor 4. Aeration			
Soii structure (in rooting zone)	Granular, porous; single-grained; or massive (if sandy, loamy, or silty); blocky [8]	Prismatic; platy [4]	Massive (if clayey) [-2]
Swampiness	Wet in winter only [8]	Wet January-July [4]	Waterlogged all year [Unsuitable]
Mottling	None to 18" depth 171	None to 8" depth [5]	Mottled to surface I-21
Soil color (A-horizon)	Black, brown, red 171	Yellow, brownish-gray [4]	Gray L-21

[1] Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

[2] If the soil is a sand or loamy sand, then [-10].

[3] If cultural practices included annual fertilization, then [4].

Table 3. — ***Soil-site properties influencing the four major soil factors and thus sycamore growth***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
	Factor 1. Physical condition		
Soil depth and presence of artificial or inherent pan	Deep soil (> **4** feet); without pan [10][1]	Medium depth (**2-4** feet), or a soil with a plowpan [5]	Shallow soil (< **2** feet), or a soil with an inherent pan [-5]
Texture (in rooting zone)	Medium-textured; silty or loamy [8]	Coarse-textured; sandy [4]	Fine-textured; clayey [0]
Compaction (in surface foot)	No compaction : loose, porous, friable, bulk density < 1.4 ***g/cc*** [8]	Moderately compacted; firm, moderately tight, bulk density **1.4-1.7** ***g/cc*** [4]	Strongly compacted; tight, bulk density > **1.7** ***g/cc*** [-2]
Structure (in rooting zone)	Granular; single-grained; massive (if sandy, loamy, or silty) [3]	Prismatic; blocky [1]	Massive (if clayey); platy [-3]
Past use and present cover	Undisturbed; near-virgin forest cover [3]	Moderate cultivation; cultivated < 20 years, or open with grass [1]	Intensive cultivation ; cultivated > 20 years, or open and bare [0]

Continued

Table *3.* — *Soil-site properties influencing the four major soil factors and thus sycamore growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6' [1]	1-2'; 7-10' [2]	< 1' [unsuitable]; > 10' [-5][2]
Artificial or inherent pans	No pans [5]	Plowpan [2]	Inherent pan [-5]
Topographic position	Floodplain or stream bottom [2]	Stream terraces or lower slopes [1]	Upland [-2]
Microsite	Concave; depression, pocket, trough [2]	Level; flat [1]	Convex; ridge, mound [-2]
Structure (in rooting zone)	Granular; massive (if silty, loamy, or clayey); stratified [1]	Prismatic; blocky [0]	Massive (if sandy); platy; single-grained [-1]
Texture (in rooting zone)	Silty or loamy, (or stratified) [1]	Clayey [0]	Sandy [-1]
Flooding	Winter through spring [3]	Winter only [1]	None [-5]; continuous [unsuitable]
Past use and present cover	Undisturbed; near-virgin, forest cover [1]	Moderate cultivation; cultivated < 10 years [0]	Intensive cultivation; cultivated > 10 years [-1]

Continued

Table 3. — *Soil-site properties influencing the four major soil factors and thus sycamore growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River Loess, Blackland [12]	Mixed Coastal Plain and other [8]	Coastal Plain [3]
Past use and present cover	Undisturbed; near-virgin, forest cover, cultivated < 5 years [10]	Moderate cultivation; cultivated 5-10 years, or open with grass [6][3]	Intensive cultivation: cultivated > 10 years, or open and bare [2][3]
Organic matter (A-horizon)	> 2% [6]	1-2% [3]	< 1% [0]
Depth of topsoil (A-horizon)	> 6" or no profile development [6]	3-6" [2]	< 3" I-41
Soil age	Young, no profile development (Entisols) [4]	Medium, moderate profile development (Inceptisols) [2]	Old, well-developed profile, leached (Alfisols) I-11
pH (in rooting zone)	5.5-7.5 [1]	4.5-5.5 or 7.6-8.5 [0]	< 4.5 or > 8.5 [-1]
Factor 4. Aeration			
Soil structure (in rooting zone)	Granular, porous; single-grained; or massive (if sandy, loamy, or silty) [7]	Prismatic; blocky [4]	Massive (if clayey); platy i-41
Swampiness	Wet in winter only [10]	Wet January-July [8]	Waterlogged all year [Unsuitable]
Mottling	None to 18" depth [12]	None to 8" depth [10]	Mottled to surface [-5]
Soil color (A-horizon)	Black, brown, red [10]	Yellow, brownish-gray [8]	Gray [-5]

Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

If the soil is a sand or loamy sand, then [-10].

If cultural practices included annual fertilization, then [8].

Table 4. — *Soil-site properties influencing the four major soil factors and thus green ash growth*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
	Factor 1. Physical condition		
Soil depth and presence of artificial or inherent pan	Deep soil (> 4 feet); without pan [8][1]	Medium depth (2-4 feet), or a soil with a plowpan [5]	Shallow soil (< 2 feet), or a soil with an inherent pan [-3]
Texture (in rooting zone)	Medium-textured; silty or loamy [2]	Coarse-textured; sandy [1]	Fine-textured; clayey [-1]
Compaction (in surface foot)	No compaction; loose, porous, friable, bulk density < 1.4 g/cc [5]	Moderately compacted; firm, moderately tight, bulk density 1.4-1.7 g/cc [3]	Strongly compacted; tight, bulk density > 1.7 g/cc [0]
Structure (in rooting zone)	Granular; single-grained; massive (if sandy, loamy, or silty) [2]	Prismatic; blocky [1]	Massive (if clayey); platy [0]
Past use and present cover	Undisturbed; near-virgin forest cover [4]	Moderate cultivation; cultivated < 20 years, or open with grass [2]	Intensive cultivation; cultivated > 20 years, or open and bare [1]

Continued

Table 4. — *Soil-site properties influencing the four major soil factors and thus green ash growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6' [10]	1-2' [7]; 7-10' [5]	<1' [0]; >10' [-5][2]
Artificial or inherent pans	No pans [9]	Plowpan [5]	Inherent pan [-2]
Topographic position	Floodplain or stream bottom [10]	Stream terraces or lower slopes [7]	Upland [0]
Microsite	Concave; depression, pocket, trough [5]	Level; flat [3]	Convex; ridge, mound [0]
Structure (in rooting zone)[1]	Granular; massive (if silty, loamy, or clayey); stratified [2]	Prismatic; blocky [1]	Massive (if sandy); platy; single-grained [-1]
Texture (in rooting zone)	Silty or loamy, (or stratified) [2]	Clayey [1]	Sandy [-1]
Flooding	Winter through spring [7]	Winter only [4]	None [-3]; continuous [unsuitable]
Past use and present cover	Undisturbed; near-virgin forest cover [2]	Moderate cultivation; cultivated < 10 years [1]	Intensive cultivation; cultivated > 10 years [0]

Continued

Table *4. — Soil-site properties influencing the four major soil factors and thus green ash growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River, Loess, Blackland [6]	Mixed Coastal Plain and other [2]	Coastal Plain [-2]
Past use and present cover	Undisturbed; near-virgin forest cover, cultivated < 5 years [6]	Moderate cultivation; cultivated 5-10 years, or open with grass [3][3]	Intensive cultivation; cultivated > 10 years, or open and bare [-1][3]
Organic matter (A-horizon)	> 2% [4]	1-2% [2]	< 1% [-1]
Depth of topsoil (A-horizon)	> 6" or no profile development [4]	3-6" [2]	< 3" [-1]
Soil age	Young, no profile development (Entisols) [3]	Medium, moderate profile development (Inceptisols) [2]	Old, well-developed profile, leached (Alfisols) [0]
pH (in rooting zone)	5.5-7.5 [3]	4.5-5.5 or 7.6-8.5 [2]	< 4.5 or > 8.5 [-2]
Factor 4. Aeration			
Soil structure (in rooting zone)	Granular, porous; single-grained; or massive (if sandy, loamy, or silty) [3]	Prismatic; blocky [2]	Massive (if clayey); platy [0]
Swampiness	Wet in winter only [3]	Wet January-July [2]	Waterlogged all year [0]
Mottling	None to 18" depth [2]	None to 3" depth [1]	Mottled to surface [0]
Soil color (A-horizon)	Black, brown, red [2]	Yellow, brownish-gray [1]	Gray [0]

1 Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

2 If the soil is a sand or loamy sand, then [-10].

3 If cultural practices included annual fertilization, then [4].

Table 5.—*Soil-site properties influencing the four major soil factors and thus Nuttall oak growth*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 1. Physical condition			
Soil depth and presence of artificial or inherent pan	Deep soil (> 4 feet); without pan [8][1]	Medium depth (2-4 feet), or a soil with a plowpan [5]	Shallow soil (< 2 feet), or a soil with an inherent pan [-3]
Texture (in rooting zone)	Medium-textured; silty or loamy [2]	Coarse-textured; sandy [1]	Fine-textured; clayey [-1]
Compaction (in surface foot)	No compaction; loose, porous, friable, bulk density < 1.4 g/cc [6]	Moderately compacted; firm, moderately tight, bulk density 1.4-1.7 g/cc [3]	Strongly compacted; tight, bulk density > 1.7 g/cc [0]
Structure (in rooting zone)	Granular; single-grained; massive (if sandy, loamy, or silty) [3]	Prismatic; blocky [2]	Massive (if clayey); platy [0]
Past use and present cover	Undisturbed; near-virgin forest cover [5]	Moderate cultivation; cultivated < 20 years, or open with grass [3]	Intensive cultivation; cultivated > 20 years, or open and bare [1]

Continued

Table 5.—*Soil-site properties influencing the four major soil factors and thus Nuttall oak growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6' [9]	1-2'; i-10' [6]	< 1' [unsuitable] ; > 10' [0][2]
Artificial or inherent pans	No pans [9]	Plowpan [4]	Inherent pan [-2]
Topographic position	Floodplain or stream bottom [8]	Stream terraces or lower slopes [5]	Upland [0]
Microsite	Concave: depression, pocket, trough [4]	Level: flat [2]	Convex; ridge, mound [0]
Structure (in rooting zone)	Granular: massive (if silty, loamy, or clayey); stratified [2]	Prismatic; block> [1]	Massive (if sandy); platy ; single-grained [0]
Texture (in rooting zone)	Silty or loamy, (or stratified) [2]	Clayey [1]	Sandy 101
Flooding	Winter through spring [6]	Winter only [3]	None [0]; continuous [unsuitable]
Past use and present cover	Undisturbed; near-virgin, forest cover [2]	Moderate cultivation; cultivated < 10 years Ill	Intensive cultivation; cultivated > 10 years [0]

Continued

Table 5.—*Soil-site properties influencing the four major soil factors and thus Nuttall oak growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best,	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River, Loess, Blackland [3]	Mixed Coastal Plain and other [1]	Coastal Plain [-1]
Past use and present cover	Undisturbed; near-virgin forest cover, cultivated < 5 years [6]	Moderate cultivation; cultivated 5-10 years, or open with grass [3][3]	Intensive cultivation; cultivated > 10 years, or open and bare [0][3]
Organic matter (A-horizon)	> 2% [6]	1-2% [3]	< 1% [0]
Depth of topsoil (A-horizon)	> 6" or no profile development [6]	3-6" [3]	< 3" [-3]
Soil age	Young, no profile development (Entisols) [3]	Medium, moderate profile development (Inceptisols) [1]	Old, well-developed profile, leached (Alfisols) [-1]
pH (in rooting zone)	4.5-5.5 [6]	5.6-7.5; < 4.5 [4]	> 7.5 [Unsuitable]
Factor 4. Aeration			
Soil structure (in rooting zone)	Granular. porous; single-grained; or massive (if sandy, loamy, or silty) [7]	Prismatic; blocky [5]	Massive (if clayey); platy [0]
Swampiness	Wet in winter only [7]	Wet January-July [5]	Waterlogged all yedr [Unsuitable]
Mottling	None to 13" depth [5]	None to 8" depth [3]	Mottled to surface [1]
Soil color (A-horizon)	Black, brown, red [5]	Yellow, brownish-gray [2]	Gray [0]

[1] Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

[2] If the soil is a sand or loamy sand, then [-10].

[3] If cultural practices included annual fertilization, then [4].

Table 6. — ***Soil-site properties influencing the four major soil factors and thus water oak & willow oak growth***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
	Factor 1. Physical condition		
Soil depth and presence of artificial or inherent pan	Deep soil (> 4 feet); without pan [6][1]	Medium depth (2-4 feet), or a soil with a plowpan [4]	Shallow soil (< 2 feet), or a soil with an inherent pan [-2]
Texture (in rooting zone)	Medium-textured; silty or loamy [4]	Coarse-textured; sandy [2]	Fine-textured; clayey [1]
Compaction (in surface foot)	No compaction; loose, porous, friable. bulk density < 1.4 g/cc [6]	Moderately compacted; firm, moderately tight, bulk density 1.4-1.7 g/cc [4]	Strongly compacted; tight, bulk density > 1.7 g/cc [-2]
Structure (in rooting zone)	Granular; single-grained; massive (if sandy, loamy, or silty) [6]	Prismatic; blocky [4]	Massive (if clayey); platy [0]
Past use and present cover	Undisturbed; near-virgin forest cover [7]	Moderate cultivation; cultivated < 20 years, or open with grass [4]	Intensive cultivation; cultivated > 20 years, or open and bare [1]

Continued

Table 6. — *Soil-site properties influencing the four major soil factors and thus water oak & willow oak growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6' [5]	1-2'; 7-10' [2]	< 1' [unsuitable]; > 10' [-3][2]
Artificial or inherent pans	No pans [5]	Plowpan [2]	Inherent pan [-2]
Topographic position	Floodplain or stream bottom [5]	Stream terraces or lower slopes [3]	Upland [0]
Microsite	Concave; depression, pocket, trough [2]	Level; flat [1]	Convex; ridge, mound [-1]
Structure (in rooting zone)	Granular; massive (if silty, loamy, or clayey); stratified [5]	Prismatic; blocky [3]	Massive (if sandy); platy; single-grained [-1]
Texture (in rooting zone)	Silty or loamy, (or stratified) [5]	Clayey [3]	Sandy [0]
Flooding	Winter through spring [5]	Winter only [3]	None [-1]; continuous [unsuitable]
Past use and present cover	Undisturbed; near-virgin, forest cover [2]	Moderate cultivation; cultivated < 10 years [1]	Intensive cultivation; cultivated > 10 years [0]

Continued

Table 6. — ***Soil-site properties influencing the four major soil factors and thus water oak & willow oak growth (continued)***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River, Loess, Blackland [2]	Mixed Coastal Plain and other [1]	Coastal Plain [0]
Past use and present cover	Undisturbed; near-virgin, forest cover, . cultivated < 5 years [5]	Moderate cultivation; cultivated 5-10 years, or open with grass [3][3]	Intensive cultivation; cultivated > 10 years, or open and bare [1][3]
Organic matter (A-horizon)	> 2% [4]	1-2% [2]	< 1% [0]
Depth of topsoil (A-horizon)	> 6" or no profile development [5]	3-6" [2]	< 3" [-3]
Soil age	Young, no profile development (Entisols) [2]	Medium, moderate profile development (Inceptisols) [1]	Old, well-developed profile, leached (Alfisols) [0]
pH (in rooting zone)	4.5-5.5 [5]	5.6-7.5; < 4.5 [3]	> 7 . 5 [Unsuitable]
Factor 4. Aeration			
Soil structure (in rooting zone)	Granular, porous; single-grained; or massive (if sandy, loamy, or silty) [7]	Prismatic; blocky [5]	Massive (if clayey) ; piaty [0]
Swampiness	Wet in winter only [8]	Wet January-July [4]	Waterlogged all year [Unsuitable]
Mottling	None to 18" depth [7]	None to 8" depth [5]	Mottled to surface [-2]
Soil color (A-horizon)	Black, brown, red [7]	Yellow, brownish-gray [5]	Gray [-2]

[1] Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

[2] If the soil is a sand or loamy sand, then [-10].

[3] If cultural practices included annual fertilization, then [4].

Table 7. — ***Soil-site properties influencing the four major soil factors and thus cherrybark oak growth***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
	Factor 1. Physical condition		
Soil depth and presence of artificial or inherent pan	Deep soil (> 4 feet); without pan [6][1]	Medium depth. (2-4 feet), or a soil with a plowpan [4]	Shallow soil (<2 feet), or a soil with an inherent pan [-2]
Texture (in rooting zone)	Medium-textured; silty or loamy [5]	Coarse-textured; sandy [3]	Fine-textured; clayey [1]
Compaction (in surface foot)	No compaction; loose, porous, friable, bulk density < 1.4 g/cc [6]	Moderately compacted; firm, moderately tight, bulk density 1.4-1.7 g/cc [4]	Strongly compacted; tight, bulk density > 1.7 g/cc [-2]
Structure (in rooting zone)	Granular; single-grained; massive (if sandy, loamy, or silty) [6]	Prismatic; blocky [4]	Massive (if clayey); platy [0]
Past use and present cover	Undisturbed; near-virgin forest cover [8]	Moderate cultivation; cultivated < 20 years, or open with grass [4]	Intensive cultivation; cultivated > 20 years. or open and bare [1]

Continued

Table 7. — ***Soil-site properties influencing the four major soil factors and thus cherrybark oak growth (continued)***

Soil-site property	Soil-site condition and relative quality		
	Best	Medium .	Poor
Factor 2. Moisture availability during growing season			
Water table depth	2-6′ [7]	1-2′; 7-10′ [3]	< 1′ [unsuitable]; > 10′ [-3][2]
Artificial or inherent pans	No pans [6]	Plowpan [3]	Inherent pan [-2]
Topographic position	Floodplain or stream bottom [6]	Stream terraces or lower slopes [4]	Upland [0]
Microsite	Concave; depression. pocket, trough [2]	Level; flat [1]	Convex; ridge, mound [0]
Structure (in rooting zone)	Granular; massive (if silty, loamy, or clayey); stratified [5]	Prismatic; blocky [3]	Massive (if sandy); platy; single-grained [-1]
Texture (in rooting zone)	Silty or loamy, (or stratified) [5]	Clayey [3]	Sandy [0]
Flooding	Winter through spring [6]	Winter only [3]	None [0]; continuous [unsuitable]
Past use and present cover	Undisturbed; near-virgin, forest cover [2]	Moderate cultivation; cultivated < 10 years [1]	Intensive cultivation; cultivated > 10 years [0]

Continued

Table 7. — *Soil-site properties influencing the four major soil factors and thus cherrybark oak growth (continued)*

Soil-site property	Soil-site condition and relative quality		
	Best	Medium	Poor
Factor 3. Nutrient availability			
Geologic source	Mississippi River, Loess, Blackland [3]	Mixed Coastal Plain and other [1]	Coastal Plain [0]
Past use and present cover	Undisturbed; near-virgin forest cover, cultivated < 5 years [5]	Moderate cultivation; cultivated 5-10 years, or open with grass [3][3]	Intensive cultivation; cultivated > 10 years, or open and bare [1][3]
Organic matter (A-horizon)	> 2% [5]	1-2% [3]	< 1% [0]
Depth of topsoil (A-horizon)	> 6" or no profile development [5]	3-6" [2]	< 3" [-3]
Soil age	Young, no profile development (Entisols) [2]	Medium, moderate profile development (Inceptisols) [1]	Old, well-developed profile, leached (Alfisols) [0]
pH (in rooting zone)	4.5-5.5 [5]	5.6-7.5; < 4.5 [3]	> 7.5 [Unsuitable]
Factor 4. Aeration			
Soil structure (in rooting zone)	Granular, porous; single-grained; or massive (if sandy, loamy, or silty) [8]	Prismatic; blocky [4]	Massive (if clayey); platy [0]
Swampiness	Wet in winter only [8]	Wet January-July [4]	Waterlogged all year [Unsuitable]
Mottling	None to 18" depth [8]	None to 8" depth [4]	Mottled to surface [-2]
Soil color (A-horizon)	Black, brown, red [71]	Yellow, brownish-gray [4]	Gray [-2]

[1] Each bracketed number indicates the site quality rating (SQR) of a particular soil-site condition.

[2] If the soil is a sand or loamy sand, then [-10].

[3] If cultural practices included annual fertilization, then [4].

Table R.--Expected *stand and production data for cottonwood at various ages by site class*

Site index range (Ft @ 30 yrs)	Site class	Thinning	STAND DATA: No. trees per acre	Mean ht. (ft.)[a]	Mean dia. (in.)	Basal area (ft.²)	EXPECTED PRODUCTION PER ACRE: VOLUME: Cu ft[b]	Cords[c]	M Rd. ft.[d]: Doyle	Int.	DRY MATTER (TONS)[e]: Branches	Stems
					AT ACE 5 (Before thinning)							
80 - 90	III (Low)	None	325 ± 20	30 ± 5	42,	30 ± 5	250 ± 80	3 ± 1	-		4 ± 1	4 ± 1
100 - 110	II (Med.)	1/2 BA	325 ± 20	35 ± 5	6 ± 1	65 ± 10	735 ± 205	8 ± 2			5 ± 1	8 ± 2
120 - 130	I (High)	1/2 BA	325 ± 2"	45 ± 5	7 ± 1	85 ± 10	1505 ± 310	17 ± 3	-		7 ± 1	14 ± 3
					AT AGE 10 (Before thinning)							
80 - 90	III (Low)	1/2 BA	310 ± 20	45 ± 5	7 ± 1	80 ± 10	1430 ± 250	16 ± 3			6 ± 1	14 ± 2
100 - 110	II (Med.)	1/3 BA	155 ± 15	60 ± 5	10 ± 1	85 ± 10	2185 ± 375	24 ± 4			5 ± 1	18 ± 4
120 - 130	I (High)	1/3 BA	155 ± 15	80 ± 5	13 ± 2	140 ± 2"	4155 ± 565	46 ± 6			8 ± 1	43 ± 7
					AT AGE 15 (Before thinning)							
80 - 9"	III (Low)	1/3 BA	145 ± 15	60 ± 5	9 ± 1	65 ± 5	1450 ± 2""	16 ± 3	-	-	4 ± 1	15 ± 3
100 - 110	II (Med.)	1/3 BA	90 ± 15	80 ± 5	13 ± 2	85 ± 10	251" ± 360	28 ± 4	3 ± 1	6 ± 2	6 ± 1	29 ± 4
120 - 130	I (High)	1/3 BA	90 ± 15	100 ± 5	16 ± 2	125 ± 15	447" ± 52"	50 ± 6	10 ± 3	16 ± 4	8 ± 1	58 ± 7
					AT AGE 2" (Before thinning)							
80 90	III (Low)	None	85 ± 15	70 ± 5	11 ± 2	55 ± 5	,600 ± 25"	18 ± 3	-		4 ± 1	17 ± 3
100 - 110	II (Med.)	None	65 ± 10	90 ± 5	16 ± 2	75 ± 10	2675 ± 390	30 ± 4	6 ± 2	10 3	5 ± 1	30 ± 6
120 - 130	I (High)	1/3 BA	55 ± 10	110 ± 5	18 ± 2	95 ± 10	426" ± 530	48 ± 6	11 ± 3	6 4	6 ± 1	50 ± 7
					AT AGE 30							
80 90	III (Low)	CC	7.5 ± 10	85 ± 5	14 ± 2	80 ± 10	2730 ± 450	30 ± 5	5 ± 2	8 2	5 ± 1	31 ± 6
100 110	II (Med.)	cc	50 ± 5	105 ± 5	20 ± 2	110 ± 20	4255 ± 585	48 ± 6	15 ± 4	21 ± 5	6 ± 1	51 ± 7
120 - 130	I (High)	cc	30 ± 5	125 ± 5	28 ± 3	130 ± 25	6125 ± 615	68 ± 7	32 ± 6	38 ± 6	8 ± 1	73 ± 8
					NET PRODUCTION AT AGE 3" (Clear-cut @ age 30 plus previous thinnings)							
80 90	III ILOWI						3930 ± 640	43 ± 7	5 ± 2	8 ± 2	9 ± 1	43 ± 8
100 - 110	II (Med.)						6190 ± 935	69 ± 10	16 4	23 5	13 ± 2	71 ± 10
120 - 130	I (High)						,170 1305	124 14	39 8	49 8	19 ± 2	130 ± 15

[a] Dominants and codominants.
[b] From Mohn end Krinard's (1971) volume equations for merchantable volume outside bark to a 3½-inch top.
[c] Cords = cu ft volume ÷ 90.
[d] From giant-tree volume tables (F.C. = 781 for gross tree volume outside bark to a 10-inch top (Grosenbaugh 1954, Putnam *et* al. 1960). Remaining tops left on site end not included in cu ft or cord production.
[e] From Mueller's (1976) dry matter equations.

APPENDIX

Explanation of Terms

The explanation of terms is for use with Tables 1-7. For terms not defined., *see Glossary of Soil Science Terms* (1975) or *Soil Survey Manual* (1951).

Depth of Topsoil or A-Horizon: Depth of surface soil or depth to B-horizon. Topsoil depth can be distinguished by a rather abrupt change in soil color or texture. Topsoil is ordinarily darker in color and coarser in texture than subsoil.

Geologic Source: Geologic origin of the soil or the physiographic area in which the soil occurs. Soils in the Mississippi River, Loess, and Blackland areas are generally high in native fertility. Coastal Plain soils are relatively low in native fertility and have low pH (<5.5); when mixed with other geologic sources that are more fertile, they usually have a pH higher than 5.5.

Mottling: Spots or blotches of different color (normally gray, yellow, or light brown) interspersed within the'dominant color of the soil. Mottling is usually caused by poor internal drainage and poor aeration.

Organic Matter: The organic fraction of the soil: includes plant and animal residues at various stages of decomposition. Soils with high organic matter content are generally dark in color and have visible humus particles, while soils with low organic matter content are light colored.

Pans: Layers in the soil that are strongly compacted, hardened, or very high in clay content. Pans often restrict root penetration and vertical movement of soil water.

Artificial Pans (Plowpans or Pressure-Pans): A subsurface soil layer that is compacted as a result of normal tillage operations or other artificial means. These pans can normally be detected as resistance to downward movement of a soil auger and by the tightly compacted, dense, and often dry soil condition.

Inherent or Genetic Pans: A natural subsurface soil layer that is harder or more cemented or brittle than the soil above and below it. Often called claypan or fragipan.

Water Table Depth: The average depth to a non-stagnant "true" water table during the growing season. Water table depth can often be determined by soil boring to free water or by observing free water elevations in nearby streams, lakes, ponds, etc., in relation to the elevation of the site.

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A new method of evaluating sites for planting cottonwood, sweetgum, sycamore, green ash, and Nuttall, water, willow, and cherrybark oaks is presented.

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