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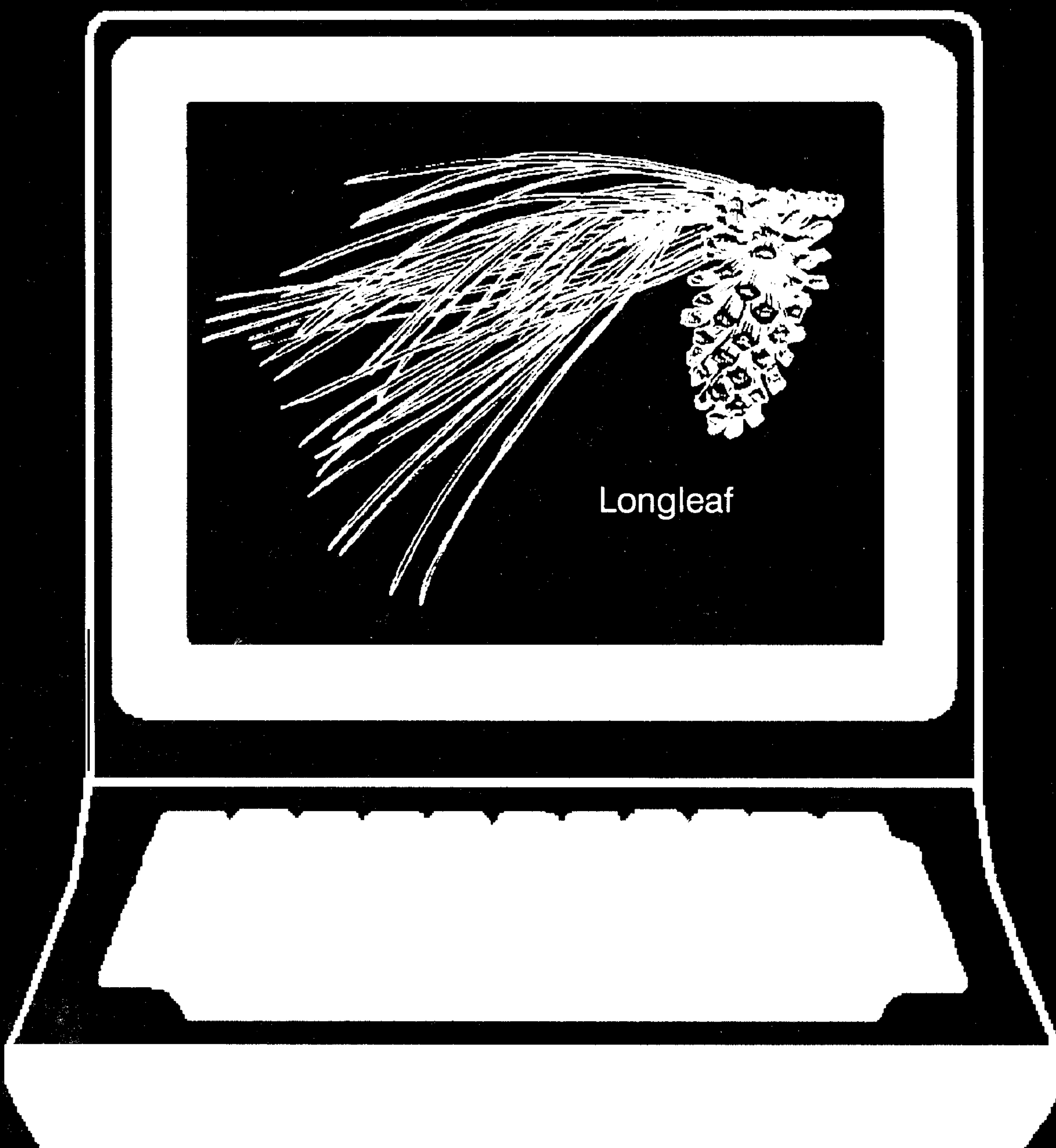
PPSITE—A New Method of Site Evaluation for Longleaf Pine: Model Development and User's Guide

Constance A. Harrington



SUMMARY

A model was developed to predict site index (base age 50 years) for longleaf pine (*Pinus palustris* Mill.). The model, named PPSITE, was based on soil characteristics, site location on the landscape, and land history. The model was constrained so that the relationship between site index and each soil-site variable was consistent with what was known about the biology of the species. The model was quantified empirically with information available from the literature or other sources and with data collected for this study from 50 stands. Because of the way the model was developed, PPSITE is an example of an expert, or knowledge-based, system. For the original set of 50 stands, the difference between site index estimated from tree ages and heights and site index predicted by the model averaged 2.8 feet with the chi-square test of accuracy indicating that site index prediction should be within $\pm$ 5.5 feet ($p<0.05$). A second test of the model with reserved data from an additional 19 stands indicated that the model's predictions were within ± 4.5 feet ($p<0.05$). In comparison with a similar model recently developed for loblolly pine (*P. taeda* L.), this model indicates that maximum site index is less for longleaf pine and that longleaf pine is more sensitive to storm damage, more sensitive to conditions at stand establishment, less tolerant of very poor soil drainage, and less sensitive to suboptimum soil nutrition than loblolly pine.

The PPSITE model is available as an interactive computer program for IBM-compatible personal computers. Supplemental information is provided in appendices to assist users in operating the program and in understanding the structure of the underlying model.

ACKNOWLEDGMENTS

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INTRODUCTION

Knowledge of site quality for each unit of land to be managed is an important criterion for modern forest management. Although other measures of site quality have been proposed, site index is the measure most commonly used in the United States. Site index is the mean height of upper-crown-class trees that have been free to grow in an even-aged stand at a specified index age. Most modern growth and yield models require site index (or another measure of site quality) as input to their prediction systems. In addition, site index often needs to be estimated for land not currently in timber production when decisions must be made as to which species to plant or whether to plant at all. In stands that are uneven-aged, of mixed species, very young or very old, or on sites where the species of interest is not growing, it can be very difficult to accurately assess site index.

Several methods have been developed for predicting site index for a species when it cannot be directly measured (Mader 1965). The most common methods are: (1) prediction of site index from a mathematical equation using measured soil and site characteristics as independent variables, (2) association of site-quality classes with soil series, soil mapping unit, or some other soil or physiographically related group, and (3) prediction of site quality from the presence or growth of other plant species.

Prediction of site index by using soil and topographic characteristics in a multiple regression equation was popular in the United States beginning in the 1930's; good reviews of the subject are available from several sources (Carmean 1975, Coile 1952, Ralston 1964). These classical soil-site studies were useful in identifying the soil and site characteristics that influence tree growth (Hodgkins 1956). However, the biological interpretation of the equations developed in many classical soil-site studies was often obscure, and the applicability of the equations was usually limited to small uniform areas. In addition, the accuracy of the equations was not usually verified with independent data (McQuilkin 1976). This type of mathematical soil-site study has been criticized on both mathematical and biological grounds (Broadfoot 1969, Hodgkins 1959, Lloyd and Lemmon 1970) and is currently used much less than in the past.

Use of soil series, soil mapping unit, or other plant species has been useful in distinguishing between broad classes of productivity, but in most cases these approaches have not yielded the desired precision for predicting site index (Broadfoot 1976, Harding and Baker 1983, Mader 1965, Youngberg and Scholz 1949). Over the years, many modifications and refinements have been made in these types of studies. For example, McKee (1977) demonstrated that a substantial amount of the variation in site index values among plots could be accounted for by chemical and physical properties of soils if the plots were first grouped by soil series. However, this type of approach is not practical when sites representing many soil series need to be evaluated because it requires that the soil series be known for each site and that the significant relationships between site index and the soil-site factors be determined for each soil series of interest. Smalley (1979) divided sites into landtypes within selected geographic areas; his landtype classification system incorporated several physiographic features, could be used in areas where soil series had not been mapped, and provided information on soil-based management considerations as well as productivity for each landtype. However, a landtype classification system is unlikely to yield the precision in site index estimates required for some forest management decisions. Storie and Wieslander (1948) stratified sites into soil profile groups, then evaluated site quality for four California conifers on the basis of several site factors. This approach was usable over a wide range of site conditions, but their timber soil ratings were more in terms of site-quality classes than of specific site index values.

Baker and Broadfoot (1977, 1979) published field guides for evaluating site quality for southern hardwoods that combined both subjective and objective approaches to site-quality evaluation. These research-

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ers first identified, and later quantified, the specific soil-site properties that influenced site quality for a particular species. This approach was different from past work in that: (1) the values used in quantifying the models were constrained by **the** author's knowledge of the silvics of the species involved, (2) it was not necessary to know soil series to use these models, and (3) the number of soil-site characteristics evaluated by their models was high enough to allow accurate prediction (± 5 feet) over a wide range of site conditions. The Baker-Broadfoot field guides were later made available in the form of a computer program (Harrington and Casson 1986). A similar approach to site evaluation was used by Harrington (1986) to develop. a field guide for predicting site index for red alder (*Alnus rubra* Bong.) in the Pacific Northwest. More recently, a Baker-Broadfoot type of model to predict site index for loblolly pine (*Pinus taeda* L.) was developed and made available in the form of a computer program (**Harrington** 1990).

A site quality evaluation system for **longleaf** pine (*Pinus palustris* Mill.) is presented in this paper. This system was based on a Baker-Broadfoot type of site model in that (1) the basic framework of the model was derived from an understanding of the site requirements-of the species, (2) the relationship between each variable and site index was constrained to be biologically reasonable, and (3) the model was designed to account for all the major soil and site characteristics that influence site index. The system differs from the Baker-Broadfoot site models primarily in the selection of variables used (mostly additions) and in providing a wider range of possible answers for most questions. The **longleaf** pine model, named PPSITE, was quantified with concepts from the literature, published and unpublished data sets, and with data specifically collected for this purpose from 50 **longleaf** pine stands. It was tested with data from 19 additional stands that were reserved from the original model development. PPSITE was judged to be fairly accurate (± 5.5 feet) over a wide range of site conditions. A program based on PPSITE was then developed for IBM-compatible personal computers.

FIELD AND LABORATORY METHODS

Seventy-two even-aged, well-stocked stands of **longleaf** pine were selected for sampling in seven southern States (fig. 1). About two-thirds of the plots were in the Southern Coastal Plain Major Land Resource Area (**MLRA)—in** Texas, Louisiana, Mississippi, Alabama, and Florida. (See map in USDA FS 1969 for location of the **MLRA's.**) The MLRA's in which the other plots were located are: the Atlantic and Gulf Coast **Flat**woods (North Carolina, South Carolina, and Florida), the North Central Florida Ridge, and the upper Piedmont and Southern Appalachian Ridges and Valleys

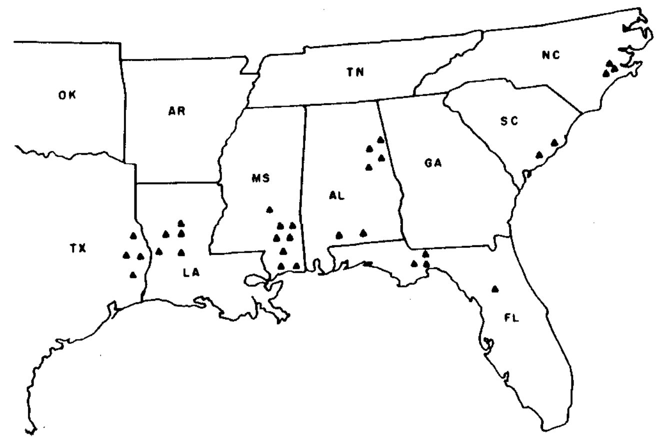

Figure 1.—*General location of sites (indicated by ▲) used in the development and testing of the PPSITE model. In most cases, several sites were sampled at each location.*

(in central Alabama). A deliberate attempt **was made** to sample a wide range of soil conditions and productivity (table 1). The mean and range in site index values were similar to the regional mean and range in site index reported for **longleaf** pine in a large regional study (USDA FS 1976).

Most sampled stands were pure **longleaf** pine; when mixed stands were sampled, the other species were not in a crown position or of an age to have suppressed past height growth of pines. Within **each stand,** one **0.25-acre** temporary plot was established. Plot boundaries were kept away from roads and did not cross any obvious stand boundaries or changes in stand or site conditions. On sideslopes, plots were laid out along the contour to avoid crossing slope-position categories within a plot boundary.

On each plot, seven dominant or codominant trees were selected to be measured for the determination of site index. These trees were apparently healthy and free from past height damage. The trees were bored with an increment borer at breast height to determine age; total height was measured with an altimeter. The rings on the cores were counted in the laboratory; any trees having cores showing signs of suppression were deleted from the sample. Two plots were deleted from the study because of suppression observed in increment cores. Site index at a **50-year** base (**SI_{50}**) was calculated from the equations of Farrar (1975) and based on USDA FS (1976). For natural stands, 7 years were added to the age determination to estimate total age (as recommended in USDA FS 1976); for plantations, the age correction factor was reduced to 5 years. (The reasonableness of this correlation factor was verified with groundline increment cores from several stands). Most stands were 40 to 60 years old.

Physiographic data collected for each plot included position on the slope (fig. **2**), aspect, and percent slope. Depth to water table during the growing season was

Table 1.-Mean and range in selected site characteristics for plots used in the development of the PPSITE model

Characteristic	Mean	Range
Site Index at age 50 (*ft*)	75.8	*52-96*
Slope (*percent*)	4	0-45
Drainage class	4.5	2-7
Elevation (*ft*)	296	20-1320
Surface soil (0-6 *in*)		
pH	*4.9*	4.0-5.7
Organic matter (*percent*)	2.7	0.7-13.5
Phosphorus (*ppm*)	2.2	0.3-34.8
Depth to subsoil (*in*)	16.3	1-65
Texture of subsoil	NA*	sand-clay

* NA = not applicable.

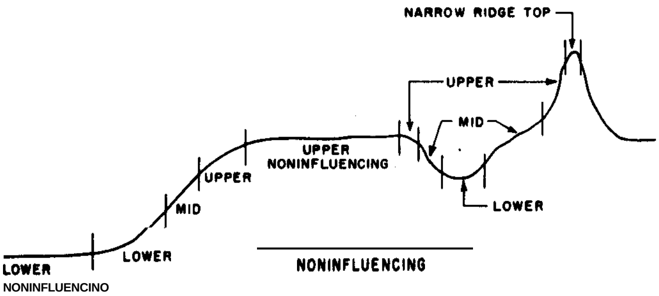

Figure 2.-*Slope-position categories used in the PPSITE model. The category "noninfluencing" should be selected when there is no real change in the topography of the area around the site being evaluated. See appendix A for additional information on slope-position categories.*

estimated for sites along rivers or streams and for areas of poor drainage. In addition, frequency of flooding and depth to a perched water table during winter months were estimated. Site descriptions also included mention of site-specific or microsite topography such as the presence of intermittent or ephemeral stream channels, small depressional areas (hummocks and hollows), and larger bowl-shaped depressions. Plot elevations were determined from topographical maps. Mean annual water deficit (precipitation minus evapotranspiration) values were assigned to each plot on the basis of published maps (USDA FS 1969, U.S. Department of Commerce 1968). Long-term frequency of glaze storms and damaging tropical storms were estimated for each site from published maps (USDA FS 1969) and other available information.

At each plot, a detailed soil profile description was made by a soil scientist. Soil profiles were described to a minimum of 80 inches (or to an impenetrable layer). Profile descriptions included depth, color (including mottles), texture, structure, consistence, pH, and the relative number and size of pine roots and rock fragments in each horizon. The presence of stratification within the profile, soil lenses, clay films on sand grains, and other special features were also noted. Effective rooting depth was estimated for each site. Representative soil samples were taken from each horizon, air-dried, and sieved to remove organic materials and rock fragments. Samples from each horizon were analyzed for pH (standard glass electrode, 1:1 volume ratio of distilled water and soil) (USDA Soil Conservation Service 1972). Field determinations of texture were spot checked in the laboratory using the hydrometer method (Bouyoucos 1962), with sodium hexametaphosphate being the dispersing agent, to ensure that individual soil scientists were not introducing a systematic bias into the data. For sandy soils, sand grain size was measured to allow textural class divisions based on sand size to be verified. Samples from each horizon were sent to Ward Laboratories, Kearney, Nebraska, for analysis of Walkley-Black organic carbon (Allison 1965) and double-acid extractable phosphorus (also called Mehlich 1 phosphorus) (Olsen and Sommers 1982). Soils from sites having suspected high sodium levels and soils from additional arbitrarily chosen sites were also analyzed for exchangeable-sodium-percentage (neutral normal ammonium acetate extraction) (University of Georgia, College of Agriculture Experiment Station 1983).

Samples to determine the bulk density of soils were collected from three arbitrarily selected locations in each plot. At these locations, two samples were collected from the surface horizon, and two were collected from the top B or C horizon (or in the E horizon if the distance to the B or C horizon was greater than 20 inches). Thus, a total of 12 samples were collected in each plot. Samples were taken with care to avoid crossing horizon boundaries; in addition, samples crossing large roots or animal burrows were discarded and new samples taken. Samples of known volume (5.5 in^3) were extracted in metal cores using a drop-hammer sampler; care was taken to avoid compacting the core during sample collection. Ovendry weights (constant weight at 220 °F) were determined in the laboratory and bulk density calculated. Any rock fragments in the samples were sieved out, weighed, and their volume determined by displacement. Final bulk density values were expressed on a rock-free basis. Values were expressed in metric units (grams/cubic centimeter) as these units are more commonly used for bulk density than the equivalent English units.

It was necessary to dig small soil pits to collect the bulk density samples of the subsoil. The depth of the surface horizons was measured in these small pits and at the spot where the complete profile description was being made; this allowed the variability of the depth of the surface horizons to be measured and provided a check on the uniformity of the soil across the plot. If there was any indication that more than one soil series was present, several spots were checked with a soil auger to allow the plot boundaries to be relocated so that each plot encompassed only one soil series.

All data were coded and entered into a computer file. One plot was deleted because of missing information. Of the 69 remaining plots, 50 were used in quantifying the model, and the other 19 were reserved to provide an independent test of the model's accuracy.

MODEL CONSTRUCTION

The goal of this project was to incorporate what was known about site quality for longleaf pine into a general site-prediction model. Development of this type of expert or knowledge-based system incorporated published and unpublished observations on the silvics of the species by foresters and forestry researchers in the Southern United States.[1] General observations and conclusions were supplemented by several types of data sets, which allowed specific relationships to be quantified.

Actual construction of the site-prediction model for longleaf pine was accomplished in stages. The general framework from the model developed for loblolly pine (Harrington 1990) was used as the starting point for the longleaf pine model. The development of the loblolly model is briefly summarized here; those interested in a more detailed description of the procedure should consult Harrington (1991). First, a general theoretical model, which listed the soil and climatic characteristics that could influence tree growth, was developed. Next, a subset of these variables was selected primarily on the basis of the following criteria: (1) variables theoretically considered to be the most important ones in modeling growth, and (2) variables generally independent of other selected variables. The next stage of model construction was to quantify the relationship between site index and each variable being considered. General relationships between each variable and site index were constrained to be consistent with what was known about the silvics of the species (cf., Fowells 1965) and general published relationships between plant growth and specific variables. Interrelationships between variables were also required to be consistent with what was known. For example, bulk density was not evaluated alone but only in the context of soil texture (Daddow and Warrington 1983) and structure, and phosphorous values were evaluated in relation to soil drainage class (cf., Tiarks and Shoulders 1982).

Model quantification was begun by determining the characteristics associated with the best sites (sites having $SI_{50} \geq 90$ feet for longleaf pine). The level of the variable associated with the best sites was assigned a value of zero. Then the amount of reduction in site index associated with other levels of the variable was estimated. When possible, data from sources other than the plots measured for this study were used to determine the preliminary values assigned to the various levels of each variable. For example, data from 431 soil woodland plots for longleaf pine in the Soil Conservation Service's ESC-5[0] data base were used to initially quantify the effects of soil drainage class, soil order, and texture of the surface horizon of the soil.

The implied relationship between site index and each variable was always required to be biologically reasonable; the exact weights assigned to the individual levels were determined empirically. The final weights for the longleaf pine model were determined after approximately 150 iterations. More than 400 iterations were made before settling on the weights for the loblolly pine model; thus, modification of a model already developed for a species having somewhat similar silvical characteristics was much less time-consuming than starting from "scratch." The final model was named PPSITE, the PP portion of the name coming from the scientific name of longleaf pine—*Pinus palustris* Mill.

The variables included in the final model are listed in table 2. All the variables in the loblolly pine model were incorporated in the longleaf pine model. In addition, some new variables were added. The ranges in site index values associated with the possible range in variable values are given in appendix B, which also indicates the site characteristics associated with the most and least favorable model values.

The starting maximum value used in the longleaf pine model for SI_{50} was 105 feet. The values of some variables or combinations of variables were assumed to have additive effects; thus, the theoretical maximum value that the model can predict is 113 feet. This theoretical maximum value is a hypothetical condition that may not exist within the native range of the species; however, a large regional study (USDA FS 1976) reported sampling young natural stands of longleaf pine in the 100- and 110-foot site index classes, so this value may not be unrealistic.

Both the loblolly and longleaf pine models include one climatic variable-mean annual water deficit—that assesses how favorable the site is for tree growth. Water deficit is the difference between precipitation and potential evapotranspiration. The value used in the model is based on long-term records and does not incorporate any measure of year-to-year variability. Although the value is expressed as annual water deficit (based on the usual pattern of precipitation and evapotranspiration in the Southern United States), all

[1] The interested reader is referred to Hu and Bums (1986) for literature available on longleaf pine and to Carmean (1975), Coile (1952), and Ralston (1964) for general reviews on factors influencing tree growth.

Table 2.—*Information needed to run PPSITE, a model predicting site index of longleaf pine from soil and site characteristics*

Main category of information and specific information needed
Physical properties of soils:
Texture of surface horizon
Texture of subsoil
Presence of buried sand, stratified layers, or special features in sands
Bulk density of first subsoil horizon
Thickness of Al or Ap horizon
Thickness of E horizon (if present)
Depth to first subsoil horizon
Effective rooting depth
Structure of surface and subsoil horizons
Consistence of surface and subsoil horizons
Rock fragments in rooting zone
Soil properties influencing nutrient availability:
pH of surface soil (O-6 in) and at 12 in
Extractable phosphorus in surface soil
Organic matter in surface soil
Soil order (from Soil Survey Staff 1975)
Site location on the landscape and in relation to climate:
State and county (or parish)*
Slope position and percent slope
Aspect
Elevation
Drainage classification
Access to extra water
Occurrence of flooding
Land history:
Previous land use
Conditions at stand establishment
Erosional history

* A supplemental data file uses this information to provide estimates for water deficit, frequency of glaze storms, and frequency of damaging tropical storms.

of the mean annual water deficit occurs during the growing season. Thus, this variable is actually assessing water deficit during the growing season.

The longleaf pine model also includes two climatic variables not included in the loblolly pine model; these assess the likelihood of top damage: the frequency of glaze storms and the frequency of damaging tropical storms. The general value for glaze storms in an area was modified according to elevation and slope position. These variables differ from the other variables in the model in that they do not measure the potential of the site for height growth but instead provide an estimate of how much height growth over a 50-year period will be lost during damaging storms.

MODEL VERIFICATION

The final model of PPSITE fit the original data set well (table 3). The correlation coefficient between site index predicted from PPSITE and site index predicted from tree height and age was 0.94 for the initial group of 50 plots used in quantifying the model (fig. 3). Based on the chi-square test of accuracy (Freese 1960), the model was judged to predict site index within ± 5.5 feet (<0.05). Half of the plots were predicted within ± 3 feet.

PPSITE fit the reserved data set of 19 plots with a slightly greater accuracy (±4.5 feet, $p<0.05$, chi-square test of accuracy) than it fit the original data (table 3). The reserved data included sites from North Carolina west to Texas and from Alabama south to Florida and sampled sites that were poorly, moderately well, well, and excessively drained. Site index in the reserved data set ranged from 56 to 93 feet (50-year base). Thus, the model was tested and verified with independent data that represented a wide range of site conditions that occur where longleaf pine is native.

COMPARING PPSITE WITH PTSITE

The PPSITE model for longleaf pine differs from the PTSITE model for loblolly pine (Harrington 1991) in several respects. The longleaf pine model has a lower maximum site index value (105 versus 122 feet), does not include an estimate of site index at index age 25, is slightly less accurate, evaluates some additional variables, and has a different value structure for many of the variables. In addition, PTSITE is restricted for use in the Coastal Plain, whereas PPSITE is usable in several physiographic provinces (see MODEL APPLICABILITY section). In general, the models indicate that longleaf pine is more sensitive to conditions at stand establishment, less tolerant of very poor soil drainage, and less sensitive to suboptimum soil nutrition than loblolly pine.

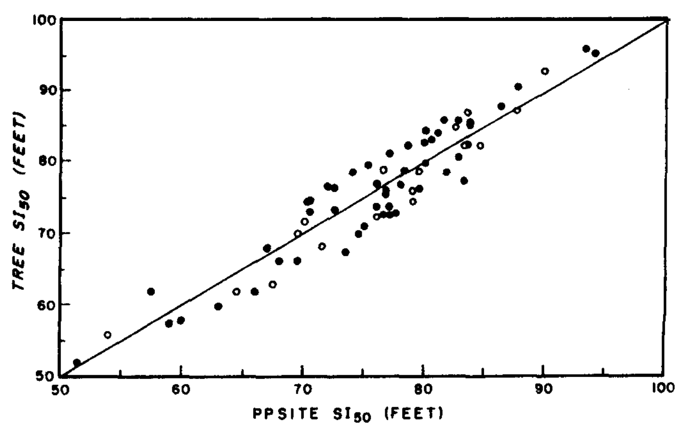

Figure 3.-*Relationships between site index at age + 50 (SI_{50}) calculated from tree heights and ages (Tree SI_{50}) and SI_{50} predicted by PPSZTE. ● = plots in the original data set, 0 = plots in the verification data set. Diagonal line is the 1:1 line; i.e., it indicates where the values for SI_{50} are equivalent.*

Table 3.—*Predictive ability of PPSITE for the data used in model development and for the data reserved for independent testing**

Datasource	Number of plots	Location	A SI		R	Percentage of plots by accuracy class (±ft) of SI					
			Mean†	ABS‡		1	2	3	4	5	6
Original data	50	Southwide	0.18	2.64	0.94	14	36	52	72	96	100
Reserved data	19	Southwide	-0.35	2.32	0.96	21	42	68	89	100	100

* All data came from sites where the species was native; A SI is the difference between site index estimated from tree heights and ages and site index predicted by the PPSITE model, and R is the correlation coefficient.
† Mean of positive and negative numbers for A SI.
‡ Mean of absolute values of ΔSI numbers.

Longleaf pine is also more sensitive than loblolly pine to storm-related top damage. Presumably this greater sensitivity is primarily due to longleaf pine's longer needles (McKellar 1942), although differences in crown form or wood structure may also be involved. The supplemental data file (psite.dat) includes values for frequency of glaze storms and of damaging tropical storms. The program converts these values to estimates of growth likely to be lost over a 50-year period. The incorporation of these variables in the model was critical in achieving the reported level of accuracy. However, storm events are not distributed systematically (e.g., one cannot expect a storm every third year). In addition, storms may not cause equal amounts of damage at different stand ages. Thus, use of these variables, which are based on long-term averages, may be one of the reasons why the PPSITE model is not quite as accurate as the PTSITE model.

Longleaf pine exhibits more variability than loblolly pine in the time it takes a tree to reach breast height. This variability may 'be a consequence of longleaf pine's greater sensitivity to conditions at stand establishment. It was necessary to convert breastheight age to total age to calculate site index. In this study, just one conversion factor was used for each stand origin. The PPSITE model evaluates conditions at stand establishment, and that variable is used in predicting site index. Sufficient information was not available, however, to assign site-specific breast-height age correlation factors. Differences between the conversion factor used and the actual factor may have reduced the accuracy of the site index value calculated from tree ages and heights. Inaccuracy in the site index values used for comparison with the values predicted from the model could have reduced the apparent accuracy of the model.

USING THE PPSITE PROGRAM

The PPSITE program is easy to run. The program is accessed by keying in the name of the program, PPSITE, and pressing the <RETURN> or <ENTER> key. The interactive program prompts the user to answer questions or requests for information on various soil and site characteristics (table 2). Most answers can be selected from a multiple choice format. To respond to each question (or request) the user should press the appropriate number key and then the <RETURN> or <ENTER> key. The user can terminate the program at any point by hitting CONTROL F1 (i.e., by holding down the <CONTROL> key and pressing the F1 key). Some portions of the program require information to be keyed in rather than just selecting a category; examples of this are site name or number, county (or parish) and 'State location, and values for depth of specific horizons and bulk density. In addition, some portions of the program appear only if the answer to a previous question falls into a specific category; thus, some questions or requests for information do not appear on every run of the program.

A question will be repeated if the first response is not a reasonable answer. (On most computers an inappropriate answer is also signaled by a beep.) For example, if a multiple choice question offers the user the choices of 1 to 5 and the user inputs 35, the question will be asked again. PLEASE READ THE SCREEN CAREFULLY!! Users should also be careful when keying in county (or parish) names and State abbreviations as the program will not recognize misspellings. (The program automatically upgrades lowercase letters to uppercase when it gets to those fields; thus, it is not necessary to use the shift or caps lock keys.) Certain answers will trigger a warning message. In most cases, the user is then given the opportunity to change the answer. Additional information on running the program is provided in appendix A, which explains how to answer each question or request for information and provides suggestions on how to collect information or answer questions dealing with unusual or unfamiliar characteristics. Users should read appendix A before running the program.

Many of the questions require users to use their judgment in selecting the answer, Users must be careful to accurately evaluate the conditions on each site. If users "know" that the site being evaluated is a "good site" or a "bad site," they may tend to choose characteristics that are more favorable or less favorable than are warranted. Careful evaluation of each characteristic is essential for accurate site evaluation.

When all the information needed to run the program has been input, the user is given the opportunity to change any of the values before running the program. Each of the input variables is numbered on the screen (fig. 4). For example, if users want to change the value input for texture of the surface horizon, they should input 14 (and press <RETURN>) upon seeing the message at the bottom of the screen that reads: "Enter variable number you want to change (0 for site ID) or press F1 to process." A list of choices corresponding to texture of the surface horizon will appear, and users can select another value. There is no limit to the number of variables that users can change; however, changes can be made only after all the questions have been answered initially. When users are satisfied with all the values, they should press the F1 key to process the program.

After the F1 key is pressed, the user is given the choice of having the output from the program sent to a printer[2] or saved in a file. An example of a sample output is included in appendix C. If the option of saving to a file is selected, the program will ask for the path[3] and file name. File names can be any combination of alpha or numeric characters (up to a maximum of eight characters); however, file names cannot begin with a number or contain blank spaces or punctuation characters. If users do not specify a file extension, the program will add .PPS to their file name; the purpose of the extension is to provide a reminder of the type of information in the file. If users want to print, move, list, or delete a file created by the program, they must include the file extension as part of the file name (i.e., print smith.pps, rather than print smith).

[2] If the user selects the option of sending the output to a printer and a printer is not attached, the screen will show an error message. If the print option is selected and a printer is attached but not online, the output will be lost. The popup menu includes a reminder to the user that the printer must be online.

[3] The path is the disk drive where the user wants the output file to be stored (e.g., A:). If the user does not specify a path, the file will be saved on the disk drive being used.

SITE: **Escambia Experimental Forest, Compartment 3, Stand 7**

1.	COUNTY	ESCAMBIA	2.	STATE	AL
3.	ELEVATION	1	4.	SLOPE POSITION	1
5.	SLOPE CLASS	2	6.	ASPECT	0
7.	SLOPE LENGTH	0	8.	PAST LAND USE	1
9.	ESTABLISHMENT CONDITIONS	2	10.	PAST EROSION	1
11.	DRAINAGE CLASS	5	12.	FLOODING	1
13.	EXTRA WATER	1	14.	TEXTURE OF SURFACE	

Select a value for the texture of the surface horizon.

(1) Sand	(9) Coarse sandy loam	(17) Clay loam
(2) Coarse sand	(10) Sandy loam	(18) Silty clay loam
(3) Fine sand	(11) Fine sandy loam	(19) Sandy clay
(4) Very fine sand	(12) Very fine sandy loam	(20) Clay
(5) Loamy coarse sand	(13) Loam	(21) Silty clay
(6) Loamy sand	(14) Silt loam	(22) Muck or peat
(7) Loamy fine sand	(15) Silt	
(8) Loamy very fine sand	(16) Sandy clay loam	

Enter variable number you want to change (0 for site ID) or press F1 to process

Figure 4.-*An example of the screen and one of the "popup" menus from the PPSITE program.*

After the decision has been made as to where to send the output generated by a run of the program, users are then given the choice to: (1) evaluate another site, starting with the values from the last run; (2) evaluate another site, but delete the old values; or (3) exit the program. Selecting option 1 enables users to make another run of the program without having to input all the variables again. For example, if a user wanted to run the program for the same soil but on two different slope positions, the user would run the program with the first value for slope position, select option 1 when it is presented, change the value for variable 3 (slope position), and then press **F1** to process the values using the new value for slope position. If several variables need to be changed for the new run, it is probably safer for users to select option 2 so that incorrect values cannot be inadvertently retained from the previous run.

MODEL APPLICABILITY

The PPSITE program was developed with data from stands of longleaf pine in the Atlantic Coastal Plain, from North Carolina south to Florida and west to Texas, and in the Valley and Ridge area of central Alabama. Only a few sites were sampled in the Piedmont, and sites were not sampled in the floodplains of major river systems such as the Mississippi River. In addition, all sites sampled were within the native range of longleaf pine (Fowells 1965). The program should not be relied upon outside this geographic area until local users determine the applicability of the program to their site conditions.

An attempt was made to sample a wide range of soil conditions and site indices. However, not all possible conditions were sampled, and the user is cautioned against relying on the model's prediction for unusual or nontypical conditions until the model can be tested under those conditions. For example, only a few of the sampled sites had pH values below 4.0 or above 6.5, had slopes greater than 45 percent, or were on deep organic soils. In addition, samples were not taken on sites that had problems with sodium toxicity* or with known nutrient deficiencies other than phosphorus or nitrogen. The model may be modified in the future, and the author would welcome input on how the model performed under different conditions.

The program was developed using plots located on apparently uniform site conditions. Plot boundaries were laid out to avoid changes in slope, aspect, drainage or other visible site conditions. The greatest accuracy in prediction of site index will be achieved when users limit their evaluations to areas of similar uniformity. It may be helpful to first roughly map areas that appear to be uniform and then to sample within each area. Sampling intensity should vary with the user's need for accuracy; however, soil characteristics can be extremely variable, and some areas may require several point determinations to accurately assess potential site index.

The PPSITE model was developed with data from stands that were considered to accurately represent the potential site quality of the area. Stands having uneven-aged structure or a significant component of upper canopy hardwoods were not included. Trees with ring patterns indicating a period of early suppression were deleted, and uniformity in tree ages within a stand was one of the criteria used for selecting plots to be used in model development or testing. In addition, very young or very old stands were not included because of the possible errors in accurately estimating site index from such stands. Stands showing evidence of major top damage in the prior 10 years were not sampled, but evidence of past top damage was allowed when selecting candidate stands if that condition was common in that area.

PPSITE can be used to provide estimates of **potential site index** in stands having the criteria mentioned above-uneven-aged structure, upper-canopy hardwoods, or suppression, as well as stands that are very young or very old. In fact, a soil-based prediction system like PPSITE is the only way to accurately estimate potential site index for most of these stand conditions. Users are cautioned, however, to follow the previously given criteria for stand and tree selection when **testing** the applicability of the model in new situations.

Most stands used in developing the model had regenerated naturally; however, several of the stands had been planted in the 1930's by the Civilian Conservation Corps. The model considers stand origin and conditions during stand establishment in its evaluation and is applicable for both planted and natural stands.

Actual or apparent changes in site quality associated with forest management practices such as thin-

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[4] Three sites had subsoil horizons where sodium as a percentage of exchangeable cations (by equivalent weights) ranged from 9.9 to 12.1 percent. Exchangeable sodium levels above 10 percent are considered as indicating potential problems (South and Davey 1983). However, these longleaf pine sites appeared to be adequately predicted by the model without adding an additional variable. The effects of higher sodium levels in subsoil horizons or high sodium levels in surface horizons on the site index of longleaf pine are not known.

ning or prescribed burning[5] are not included in the model. Most of the sampled stands had been thinned and burned periodically, but none of them had been intensively managed, thus, potential differences in site index due to specialized management practices were not considered. Because of the long-term effects of conditions during stand establishment on growth (cf., Boyer 1985), the model does include a variable that roughly quantifies those conditions.

If a forest management practice such as intensive site preparation significantly alters long-term soil properties, the change in these properties should result in a change in the site index predicted by PPSITE. Thus, the model can be run with different values for depth of the Al horizon, percentage of organic matter, phosphorus concentration, bulk density, past use, or erosion to determine its sensitivity to changes in those factors.[6] Some users may wish to use PPSITE as a rough method of predicting the effects of management practices on long-term productivity. For example, if onsite investigation or other information indicates that a certain site preparation practice reduces the depth of the A horizon, the change in the value of site index predicted by the model could be used as a measure of the change in site productivity.

The PPSITE model was developed and tested with data from mature stands where soil characteristics would be fairly stable. However, some of the soil characteristics used in the model can change as a result of management practices or natural disturbances. For example, organic matter in the top 6 inches of a very sandy soil may decrease sharply when the overstory is removed, and the soil surface is opened up to full sun. As the trees grow and crown closure occurs, organic matter will again accumulate. On the other hand, extractable phosphorus levels will be quite high immediately after fertilization, then will decrease and eventually level off at a new equilibrium value. Thus, users are cautioned not to overestimate or underestimate the long-term effects on site productivity based on a soil characteristic that is changing over time. Estimates of soil characteristics used in the model that are made 10 or more years after disturbance are probably fairly close to equilibrium values. Estimates made before that time may need to be modified according to experience or other available information.

The PPSITE model does not take genetic variability of the species into account. Actual increases in measured site index may be realized when specific genotypes are used. These increases may result from higher overall growth rates associated with certain genotypes or from using genotypes having tolerances for specific conditions. The program can be used to rank sites in order of potential site index; however, how accurately the program will predict actual site index under a variety of forest management practices is unknown. Users having some knowledge of programming can add or alter sections of PPSITE so that its predictions are in line with their experience. The basic framework of the model is expected to remain intact, but additional modules could be added to take other site conditions or specific genotypes into account.

[5]Burning has been shown to increase growth of longleaf pine seedlings (Grelen 1983); however, repeated burning in older stands decreases growth (Boyer 1987, MacKinney 1931). The beneficial effects of burning in seedling stands have been attributed to reductions in hardwood competition and brown-spot needle blight infection (i.e., the effects are not directly soil-related). It is not known whether the deleterioius effects of burning in older stands are due to the direct effect of damaging root systems during burning or are the indirect effect of fire-induced changes in the chemical characteristics of soils or in the physical environment of surface roots. If future research shows the cause of growth reductions to be associated with long-term changes in soil characteristics, the model could be modified to incorporate this effect.

[6] Users can refer to the sections in appendix A on past land use, access to extra water, and organic matter for additional ideas of how to handle specific management practices.

PROGRAM AVAILABILITY

A copy of the PPSITE program may be obtained by contacting the Southern Forest Experiment Station, PO. Box 3516, Monticello, AR 71655 (501-367-3464). Requests by mail should include the requester's name, address, and telephone number as well as a blank **formatted** diskette (3.5- or 5.25-inch). The diskette **must** be labeled with the requestor's name. Unless otherwise specified, a compiled version of the program will be provided. Upon request, a program listing or an interpreted version of the program is available. The interpreted program version can be changed by the user; however, to actually run an interpreted program, users must have a BASIC interpreter software program on their computer. The compiled program can be run without additional software but cannot be altered.

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Appendix A

—Additional information to help users respond to the questions and requests of the PPSITE program

General note

The questions or requests for information listed below that are preceded by an asterisk (*) are asked only if the answer to a previous question (or request) fell into a specific category. Thus, some parts of the program do not appear every time the program is run. Screen prompts appear in bold-face type.

What is your site name or number?

A site identification label in the form of a name or number is optional; any combination of letters, numbers, spaces, or special characters can be used, up to a maximum of 256 characters or spaces. If users do not wish their output to be labeled, they should press <RETURN> or <ENTER> when this question is asked.

Input county (or parish) name:
Input the two-letter State abbreviation for the site being evaluated:

First the user should input the county (or parish) name (followed by pressing the <RETURN> or <NEW LINE> key) for the area where the site being evaluated is located. Next, the user should enter the two-letter State abbreviation (the program will prompt the user). This information will appear on the output as an additional site identifier. In addition, the program checks a supplemental file (psite.dat, included with the program) to determine whether longleaf pine is native to that county (based on the range map in Fowells 1965). If longleaf pine is not native, a warning message is triggered, and the user is given the option of changing the site location or continuing with the same location. The warning message is also triggered if the county (parish) name or State abbreviation is spelled incorrectly (e.g., Georgia is GA, *not* GE). The program automatically upgrades lowercase letters to uppercase letters, so it is not necessary to use the shift or caps lock keys. Counties or parishes named for saints are spelled ST with no punctuation, for example-ST CLAIR, ST TAMMANY, or ST JOHNS. Spaces are optional between words in a county or parish name if the common spelling uses spaces (e.g., either REDRIVER or RED RIVER, or ST FRANCIS or STFRANCIS will work, but RICH LAND for RICHLAND will not). When in doubt, the spaces should be left out.

The supplemental file also contains values for mean annual water deficit,[1] frequency of glaze storms, and frequency of damaging tropical storms for each county. or parish in the Southern United States (based on the maps in USDA FS 1969). The program uses water deficit, the difference between mean annual precipitation and mean annual potential evapotranspiration, in conjunction with the codes for access to extra water in evaluating site quality. Water deficit values are not included for counties in central or western Texas nor for States where longleaf pine is not native. If a water deficit value is not available for the county/parish selected, a warning message is triggered, and the user will be given the choice of selecting another location or exiting the program.

***What is the elevation of your site (in feet)?**

(1) <250
(2) 250-499
(3) 500–999
(4) 1000-1499
(5) 1500– 1999
(6) > =2000

This question is not asked if the site is in a county or parish assigned a low glaze value. Users should select the evaluation category appropriate for the site being evaluated. Elevation is used to calculate a glaze-damage estimate for sites in areas having significant glaze hazards.

Select a value for slope position of the site from the following list:

(1) Lower Hlope
(2) Lower noninfluencing
(3) Midslope
(4) Upper noninfluencing
(5) Upper slope and broad ridgetop
(6) Noninfluencing (flatwoods)
(7) Narrow ridgetop

Users can refer to figure 2 to categorize slope position. **This is an important variable and should be assessed carefully.** Sites characterized as noninfluencing, lower noninfluencing, or upper noninfluencing should have slopes ≤5 percent. Noninfluencing (without a modifier) should be selected when there is no major change in topography in the area (such as flatwoods). The categories upper noninfluencing or lower noninfluencing should be selected for sites having slopes ≤5 percent; the slope position of these sites would be obviously different from the surrounding topography. The program uses this information to assess relative water movement. Sites in depressional areas or those with a bowl-shaped topography should be classified as having a lower slope position if the user perceives them as gaining moisture from adjoining areas, regardless of their elevational relationship to the overall topography of the area. Similarly, sites on terraces located in midslope positions should be classified as having a lower slope position if the user believes that they are likely to have a net gain in soil moisture due to down-slope water movement. Small differences in elevation can alter the appropriate

[1] The values for water deficit in the psite.dat file are in millimeters.

slope-position code if the differences will influence water movement. For example, a large flatwoods area would generally be coded as noninfluencing; however, there may be: (a) depressional areas within the larger area that should be coded as lower or lower noninfluencing if they are in moisture-gaining positions or (b) elevated flats that should be coded as upper noninfluencing if they are in moisture-losing positions. It may be helpful to examine a topographical map having small contour intervals to pick out areas likely to be moisture gaining or losing. The narrow ridgetop slope position (category 7) should be separated from broad ridgetops, saddle positions, and sites considered to be upper noninfluencing, based on the width of the ridgetop and the relative change in topography. Generally, narrow ridgetops will be less than 100 feet wide.

Select a value for percent slope from the following list:

(1) o-1
(2) 2-4
(3) 5-7
(4) 8–10
(5) 11-14
(6) 15-19
(7) 20-29
(8) >=30

Users should select the percentslope category that best fits the site being evaluated. The program is fairly sensitive to changes in percent-slope categories, so users should be as accurate as possible. They should select the value for the average slope of the general lay of the land in the area of interest rather than the value for the maximum slope. This is particularly important in eroded areas having gullies. It is also important to separate areas on terraces or steps or in bowl-shaped topography from those on nearby sideslopes.

***Categorize the aspect of your site from the following list:**

(1) South or southwest, with full exposure to the sun
(2) South or southwest, but partially shaded by surrounding topography
(3) Southeast, with full exposure to the sun
(4) All other combinations

This request for information is made only if the slope is ≥5 percent. A site would be considered partially shaded if the surrounding topography reduced the time of exposure by at least 15 percent.

***How far is it from your site to the bottom of the hill or to a major change in slope (e.g., midslope terrace)?**

(1) <= 100 feet
(2) 100-200 feet
(3) >200 feet

This question is asked only for sites in midslope or upperslope positions or on narrow ridgetops. The response is used to modify the values assigned for slslval (the program variable assessing slope position and percent slope).

Select a value for past land use from the following list:

(1) Previously forested
(2) Farming or pasture

Past land use can have both negative and positive effects on growth of the current (or planned) forest stand. Negative effects such as compaction, erosion, and loss of organic matter are addressed in other parts of the program. This request is primarily concerned with assessing any positive carryover effects from past agricultural use. Category 2 should **not** be selected for sites that have been out of agricultural use for more than one rotation.

Select a value for conditions at stand establishment:

(1) Naturally or artificially seeded, severe brush problems
(2) Naturally or artificially seeded, brush problems major but not severe
(3) Naturally or artificially seeded, moderate competition control
(4) Naturally or artificially seeded, good competition control
(5) Planted, severe brush problems
(6) Planted, brush problems major but not severe
(7) Planted, moderate competition control
(8) Planted, good competition control

This request for information asks the user to indicate the stand origin and the amount of early competition that was or will be present at stand establishment. Evaluation of existing stands without records of competition control are necessarily subjective. Plantations having excellent survival and uniform heights would almost certainly have had good competition control. Conversely, open stands with many unstocked areas may have had a major brush problem. Most natural stands that do not have (or will not have) **unusual** problems with brush and that have not had some management practice applied to reduce competing vegetation would fit into category 2. Experience with stands on similar site conditions can be helpful in estimating the likelihood of significant amounts of competing vegetation being present.

Characterize past erosion on the site from the following list:

(1) None or slight (include sites with uniform sheet erosion)

(2) Moderate, rill erosion or slightly gullied (often with irregular depths of A on sideslopes)
(3) Major, gullies >2 feet and <5 feet deep
(4) Severe, gullies >5 feet deep

The request for information asks the user to categorize rill and gully erosion induced by human activity. Sheet erosion is not included here because its effects are accounted for in questions on depth of the A horizon and effective rooting depth. The model was not tested with data from any sites that had severe gully erosion; thus, site evaluation for severely eroded sites should be considered as approximate.

Select a value for drainage class from the following list:
(1) Very poorly drained
(2) Poorly drained
(3) Somewhat poorly drained
(4) Moderately well drained
(5) Well drained
(6) Somewhat excessively drained
(7) Excessively drained
(8) Permanently swampy or flooded

These drainage codes (except for category 8) are the same as the standard soil drainage classes used by the USDA Soil Conservation Service (SCS). Users should select the most appropriate drainage class for the specific site being evaluated rather than the average drainage class that might be associated with the soil series or mapping unit for the area. If users are not familiar with drainage classes or other soil terminology, they should contact their local SCS office for assistance.

Select one of the following descriptions that best describes the timing and duration of flooding:
(1) Never flooded
(2) Flooded in winter only, or if in early spring for only a few days
(3) Frequently flooded in late spring or summer, flood waters can cover the tops of seedlings for more than a week during the growing season
(4) Continuously flooded

Users should select the category that best describes the timing of flooding (if any) on the site. Sites frequently or continuously flooded are unsuitable for longleaf pine; selection of these categories will trigger a warning message, and the user will be given the choice of selecting a new category.

Select one or two of the following categories for access to extra water from the following list (If two characteristics are selected, input the value as a two-digit code with the smaller number first—17, not 71):
(1) Water table during the growing season of 6-10 feet
(2) Water table during the growing season of greater than 10 feet
(3) Water table during the growing season at 5 feet or less
(4) Seasonally perched water table, water table = >2 feet during winter months
(5) Seasonally perched water table, water table <2 feet during winter months
(6) Microsite relief, mounds and depressions
(7) Intermittent or ephemeral stream channels on plot
(8) Bowl-shaped topography

The characteristics listed above can markedly influence soil moisture and thus site quality. The possible choices for access to extra water describe summer water tables (categories 1–3), winter water tables (categories 4 and 5), and characteristics associated with microrelief or local topography (categories 6-8). Users should be careful to select the one or two characteristics considered to be most important in influencing soil moisture. Users can input information on both summer and winter water tables; for example, a code of 25 would indicate that the water table during the growing season is deeper than 10 feet and that the site has a perched water table[2] during the winter that is within 2 feet of the soil surface. These characteristics modify the values assigned for soil drainage; some of them also modify the values for water deficit.

Users should carefully consider the possible characteristics for each site to be evaluated. Several of the extra water characteristics can be affected by management activities. The effects of some activities, such as ditching, are obvious, but the effects of other activities are more subtle. For example, road construction activities can alter water movement patterns and in some situations can create bowl-shaped topography. The effects of bedding can be accounted for by selecting "Intermittent or ephemeral stream channels on plot"

[2] A perched water table is a saturated layer that is separated from ground water (the true water table) by soil or rock layers that are not saturated. Perched water tables often develop during the winter on sites that have well-developed fragipans or other soil layers of low permeability. County soil surveys (available from most local SCS offices) include information on the type and depth of water tables commonly associated with a soil series or association. **Caution**—SCS soil surveys categorize sites having deep water tables as having a water table greater than 6 feet (their deepest category). Unless the selected site is on a stream terrace or floodplain, users should assume that this means that the water table during the growing season is greater than 10 feet (category 2), rather than at 6-10 feet (category 1).

and the appropriate water table category. (On bedded plots, the drainage classification should also be changed to reflect the altered water relations, and the value for effective rooting depth should be increased). Categories 4 and 5 refer to **seasonally perched** water tables and should **not** be selected for poorly drained sites that are saturated during the winter.

Select a value for texture of the surface horizon from the following list:

(1) Sand
(2) Coarse sand
(3) Fine sand
(4) Very fine sand
(5) Loamy coarse sand
(6) Loamy sand
(7) Loamy fine sand
(8) Loamy very fine sand
(9) Coarse sandy loam
(10) Sandy loam
(11) Fine sandy loam
(12) Very fine sandy loam
(13) Loam
(14) Silt loam
(15) silt
(16) Sandy clay loam
(17) Clay loam
(18) Silty clay loam
(19) Sandy clay
(20) Clay
(21) Silty clay
(22) Muck or peat

Users should first enter the one- or two-digit code for the texture of **the** uppermost or surface horizon (below an organic horizon or litter layer if present). They should carefully consider sand size because the model distinguishes between textures based on sand size; e.g., sand and fine sand are rated differently.

The program will next ask the user to enter the code for the dominant texture of the subsoil horizons in the main rooting zone (the same list of codes will appear). Most soil profiles are finer textured with depth or have little change in texture in the profile; the presence of sand or sandy loam layers below a finer textured subsoil horizon is addressed in a separate question.

The program will then prompt the user to enter the code for the texture of the horizon where bulk density was measured. **If bulk density was not measured,** users should input a value of 0.

What is the bulk density in the main rooting zone of the subsoil?

Bulk density should be measured in the first or top subsoil horizon unless the depth to the subsoil is greater than 20 inches. If the depth to the subsoil is greater than 20 inches, bulk density should be measured at a depth of 10 to 15 inches. Horizon boundaries should not be crossed when measurements are being taken. Bulk density should be expressed in grams per cubic centimeter (g/cm^3) and the value input to the nearest 0.05 if possible (e.g., 1.35 g/cm^3). The values used in the program were derived from samples taken with a core sampler. The bulk density values associated with deductions in site index vary by soil textural class and the strength of the soil structure.

If the user indicated that bulk density was not measured (by inputting a 0 [zero] when asked for the texture of the horizon where bulk density was measured), the program will skip over the question on bulk density and assume that bulk density in the rooting zone was at an optimum level.

Most accurate site determinations are made when all variables, including bulk density, are measured rather than estimated. If necessary, with experience a user can roughly estimate bulk density from soil texture, organic matter, consistence, and structure. The bulk density values associated with deductions in site index vary by soil textural class and the strength of the soil structure. Use of the growth-limiting bulk density values based on soil texture (Daddow and Warrington 1983) can indicate approximate upper limits for bulk density values in structureless soils. Average bulk density values can sometimes be obtained from soil interpretation records available from the SCS. Obtaining accurate bulk density values is probably most important when the user knows or suspects that previous practices associated with causing soil compaction have occurred, for example, if the area was farmed for many years or had a lot of heavy equipment used on it. However, **please note** that some soils-especially silt loams, silty clay loams, and sandy clay loams-may have higher than optimum bulk densities independent of human activities. If users or others wish to measure bulk density for a site and have not taken this measurement before, their local Cooperative Extension Service or SCS office can be contacted for helpful information.

Is most of the soil profile stratified?

(1) Yes, it is stratified
(2) No, it is not stratified

This question sets apart sites that have soil profiles consisting of numerous layers of deposited material. Stratified soils are usually on stream terraces or in floodplains. These profiles are an indication that little in-place soil development had occurred; thus, stratified soils are usually classified as Entisols or Inceptisols. Most soil profiles are **not** stratified; if there is doubt that the profile being evaluated is stratified, the user should select answer "(2) No. . . ." The user should not answer "(1) Yes. . ." if only one horizon in the profile is stratified.

If the top subsoil horizon is not a sand or sandy loam, is there a sand, loamy sand, or sandy loam horizon below it?

(1) Yes, there is a sand, loamy sand, or sandy loam horizon below a finer textured B horizon

(2) No, there are no buried or stratified sand layers (includes soils that are sandy throughout)

Some profiles will not be adequately characterized by surface and subsoil texture because of the presence of deeper horizons that are much sandier than those above. These include soils having buried horizons, some bisequal soils, and soils having stratified, mixed, or layered horizons. If the answer to the question is "(2) No. . .," the program skips down to the question on structure. If the answer is "(1) Yes. . .," two or three additional questions will follow to determine the depth and texture of the sandier horizon or layer.

***Please characterize the soil using the following list as to the texture and location of the sandy layer:**

(1) Within 30 inches of the surface, texture changes from a finer texture to sandy loam

(2) Within 30 inches of the surface, texture changes from a finer texture to a sand or a loamy sand

(3) Within 60 inches of the surface, texture changes from a finer texture to a sandy loam

(4) Within 60 inches of the surface, texture changes from a finer texture to sand or loamy sand

(5) Pickup in sand content occurs at =>60 inches

This part of the program appears only if the answer to the previous question is "(1) Yes. . ." The purpose of this request for information is to determine the texture of the buried sandy layer and where in the profile it occurs.

- *** How thick is the sandy loam layer before a finer textured horizon is encountered?**
- *** How thick is the sand or loamy sand layer before a finer textured horizon is encountered?**
- *** What texture are the horizons below the sandy loam layer?**
- *** Characterize the profile from the sand or loamy sand layer on down.**
- *** Is the sand below 60 inches stratified, mixed, or layered?**

One of these five questions[3] will be asked, depending on the response to the previous query on the texture and location of the sandy layer.

***Please indicate whether the soil profile has any of the following characteristics:**

(1) Many, moderately thick, continuous, clay bridges or films on sand grains

(2) Discontinuous or patchy clay bridges or films on sand grains

(3) Alternating bands of same textural class but different colors

(4) Alternating bands of different textural classes (e.g., sl, ls, sl, ls)

(5) Presence of one or more finer textured layers at least 3 inches thick

(6) No special features present

This request for information appears only if information previously provided by the user indicated that the soil was a well-drained or excessively drained sand. If the user selects answers 1 through 5, the following question is asked:

***At what depth do the special sand characteristics first occur?**

(1) <65 inches

(2) 65-85 inches

(3) >85 inches

This question is asked only if the answer to the above request indicated the presence of special characteristics in deep sands that should be taken into account in predicting site index.

Select a value for the structure of the main rooting zone in both the surface and major subsoil horizons from the following list (use a two-digit code with one digit coming from each list; for example, weak blocky structure would be coded as 23):

(1) Structureless	**(1) Platy**
(2) Weak	**(2) Prismatic**
(3) Moderate	**(3) Blocky**
(4) Strong	**(4) Granular or crumb**
	(5) Single grained
	(6) Massive

This request asks the user to characterize the strength and type of structure in the surface soil and subsoil

[3] To conserve space the answers to these questions are not listed here. The possible answers for each of these questions are provided in a multiple-choice format.

using standard codes. In addition to its effect as an independent variable, structure is also used in evaluating bulk density.

Select a value for consistence of the surface horizon from the following list:

(1) Loose
(2) Very friable
(3) Friable
(4) Firm
(5) Very fiim
(6) Extremely firm
(7) Cemented

Consistence of moist soil should be characterized for the surface horizon. If cementation or brittleness occurs within the surface 6 inches, the consistence of the A horizon should be coded as "(7) Cemented." The consistence of the subsoil should also be characterized using the same codes (the program will prompt the user).

What is the average thickness of the Al or Ap horizon (in inches)?

The thickness of the surface topsoil horizon should be input. Only Al and Ap horizons should be counted (i.e., do not include A2 or E horizons). The user should input the value to the nearest 0.5 inch if the horizon thickness is less than 2 inches (e.g., 1.5). If the horizon thickness is greater than 2 inches, values can be rounded to the nearest inch. Thickness of the Al or Ap horizon should be checked at several locations across the site and an average value used. If an Al or Ap horizon is not present, the user should enter a value of 0. If an A/E horizon is present, the user should add two-thirds of the measured value for the thickness of the A/E horizon to the thickness of the Al or Ap horizon. For example, if the site has a 2-inch-thick A horizon and a 3-inch-thick A/E horizon, input for the thickness of the A horizon would be 2 + (2/3)(3), giving an input value of 4.

The model evaluates topsoil thickness in relation to soil order and slope position. Shallow topsoil depth will be most detrimental to site quality when soil horizons are well developed (e.g., Ultisols) and sites are in midslope or upperslope positions.

What is the depth to the first B horizon (or subsoil) in the soil profile (in inches)?

The answer to this question is used, in conjunction with slope position and the change in texture between the surface soil and subsoil, to calculate a correction factor to the texture value for the surface horizon. Depth to the first C horizon should be used when evaluating young soils without B horizons. If the first B horizon is much coarser in texture than the deeper B horizons (e.g., B1 of fsl, B2 of cl), users should use the depth to the deeper horizon.

How thick is the E horizon (in inches)?

If an E or A2 horizon is not present, enter a value of 0. All E horizons **above** the first B horizon should be included, that is, the thickness of an El horizon and an E2 horizon are added together if both are present. A B/E horizon should not be included unless it is the same texture as the E horizon above it and differs from the B horizon below. Buried E horizons should not be included; they are accounted for in another section of the program.

***Are there several A or E horizons that have different textures?**

(1) Yes, there are three or more A or E horizons having different textures (e.g., sl, ls, s, ls)
(2) No, there are only two A or E horizons, or if three or more horizons are present, they have the same texture

This question accounts for the slowing of water movement through the profile when soil texture in coarse-textured horizons changes several times. If the top B horizon is also coarse textured and deeper B horizons are fine textured, then-just for the purpose of answering this question-the top B horizon is counted as if it were an E horizon. For example, one might consider the following soil profile:

Horizon	'Depth	Texture
A	O-6	sl
El	6-20	s
E2	20-30	ls
B1	30-35	sl
B2	35-70	scl

In this example, there are four coarse-textured horizons that alternate in texture (A, El, E2, B1), so the answer to the question would be "(1) Yes. . . ." This question is asked only if the depth to the B horizon is greater than 19 inches and the profile is well drained.

Estimate the percentage of rock fragments in the A horizon(s), express as a percentage, not as a decimal.

This request asks the user to categorize the percent of the soil volume in the topsoil that is occupied by rock fragments. The values should be input as whole numbers (0 if no rock fragments are present). The program will also request the user to estimate the percentage of rock fragments in the subsoil.

Please estimate the maximum effective rooting depth for longleaf pine (in inches) using the following list:

(1) <=15
(2) 16-20
(3) 21-25
(4) 26-30
(5) 31-35
(6) 36-40
(7) 41-45
(8) 46–60
(9) >60

Effective rooting depth is the **maximum** general depth of root penetration and **not** the depth where **most** of the root system is located. Effective rooting depth should be measured from the level of the root collar to the depth of maximum root penetration. Estimating maximum rooting depth is fairly easy if the site is being evaluated using a large soil pit and if mature longleaf pine trees are present on the site. Effective rooting depth is probably similar for many tree species, so rooting depth for longleaf pine could be estimated from rooting depth of loblolly or slash pine (*P. elliotii* Engelm. var. *elliottii*) if longleaf pine is not on the site. Tree species have low rooting densities compared to grasses or many agricultural plants; thus, the person doing the estimating should be careful not to underestimate rooting depth based on roots seen when using an auger.[4]

If roots from mature trees are not present on the site, rooting depth must be estimated from soil characteristics (and experience). Longleaf pine roots do penetrate into and through some horizons having cemented pans. Thus, rooting depth should **not** be taken as the depth to the top of the first horizon with cementation or brittleness. If better information is not available, effective rooting depth for sites having well-developed pans can be estimated by adding 10 inches to the depth of the first horizon having a well-developed pan. (Horizons with only partial or moderate pan development should be included in the estimation of rooting depth). Tree rooting is restricted by firm or very firm clay layers; however, effective rooting depth should not be estimated as the depth to the top of the clay layer because: (a) the clay layer will supply some water to overlying soil layers via capillary rise, and (b) some rooting will probably occur into the clay layer along ped faces' or in areas where organic materials are decomposing. Estimating effective rooting depth as the depth to a clay layer would imply that the clay layer is as inert as rock. Thus, to determine an equivalent value for effective rooting depth when other information is not available, the user should add 15 inches to the depth of the clay layer when the consistence of the clay is firm or 10 inches when the consistence is very firm. For example, if a very firm clay layer begins at 20 inches, one can estimate that effective rooting depth is approximately 30 inches (category 4, 26-30 inches).

Effective rooting depth is evaluated in conjunction with soil drainage classification. One should be careful not to underestimate rooting depth on bedded sites or when microtopography is present. On poorly or very poorly drained sites having microrelief (natural or artificial), most trees will be on the high spots. This relationship should be kept in mind when estimating effective rooting depth (i.e., remembering to measure from the root collar).

The following values may be used to determine an approximate value for effective rooting depth on sites where rooting extends into an R or Cr horizon (i.e., rooting extends below the main soil layers into weathered parent material or parent material having seams of soil). Under these circumstances, these values do not indicate the maximum rooting depth that may be achieved by some roots but do provide an equivalent value for rooting depth that can be used in the model.

Type of Cr material	Amount to add
	Inches
Unweathered rock, no soil seams	0
Unweathered rock, some soil seams*	2
Unweathered rock, mixed with soil	5
Weathered rock, mixed with soil	15
Highly weathered rock, no seams of soil	6
Highly weathered rock, seams of soil* at fractures	15
Soil massive or very firm	3

* Assumes that the soil seams are oriented vertically.

For example, assume one is evaluating a site that has highly weathered rock having no seams of soil. An R or Cr horizon begins at a depth of 2'7 inches. Based on the table, 6 would be added to the value of 27 (6 + 27 = 33) to get the user's equivalent value for rooting depth. The value of 33 would be used to determine the correct category for rooting depth (for this example, the correct category would be (5) 31-35 inches). Users should use their judgment in interpolating among the above categories for other combinations of weathered and unweathered materials.

Very shallow rooting depths will trigger a warning message that the site is unsuitable for longleaf pine. The user will be given the option of selecting another value for rooting depth or exiting the program.

[4] If medium-size roots are present in an auger sample, that is usually an indication that fine roots are present at greater depths.

[5] Peds are the natural units of soil structure, such as a block or granule. Aped face is the surface of this structural unit.

Select a value for soil order from the following list:

(1) **Entisol or Inceptisol**
(2) **Alfisol**
(3) **Ultisol**
(4) **Spodosol**
(5) **Vertisol**
(6) **Histosol**
(7) **Mollisol**

These soil orders are those used by the Soil Conservation Service (Soil Survey Staff 1975). If the area is mapped by soil series, soil association, or soil mapping unit, the appropriate order can probably be determined from that information. It is **not** necessary to know soil series. Soil order is used in the model as an indication of weathering (i.e., nutrient availability). In addition to its use as an independent variable, soil order is also used to evaluate the effects of topsoil depth and percentage of organic matter on site quality.

The model was developed and tested primarily with data from Entisols, Alfisols, Ultisols, and Spodosols. Selection of other soil orders will trigger warning messages to be printed on the program output. The warning message for Vertisols is that trees may have form problems, especially on sideslopes, due to the presence of shrink-swell clays. Selection of Histosols results in a warning message that model values for organic soils should be viewed as preliminary. Selection of Inceptisols or Mollisols results in a message that the model has not been tested with data from these soil orders.

Select a value for average pH of the surface soil (from 0 to 6 inches):

(1) <3.5
(2) 3.5-3.89
(3) 3.9-4.29
(4) 4.3-5.59
(5) 5.6-6.79
(6) 6.8-7.59
(7) 7.6-8.49
(8) > =8.5

First, the user should select a value for pH (measured in water) for the surface soil. If the top horizon is less than 6 inches thick, the pH value should be weighted according to the depths of the horizons in the 0- to 6-inch layer. Soil pH is used as an indication of nutrient availability. Very low or high pH values (i.e., category 1 or 8) will trigger a warning message that the site is unsuitable for longleaf pine. The user is given the choice of changing the pH value for the site or exiting the program.'

Next, the user should select a value for average pH of the soil at 12 inches (the program will prompt the user). The intent of this request for information is to identify sites having major changes in pH in the portion of the profile where heavy rooting occurs. Most sites exhibit little change or a small decrease in pH with depth. Sites that have been limed may exhibit a major drop in pH below the surface layer. In contrast, some sites change from acidic to basic because of differences in parent material. Although the program asks for the pH at 12 inches, users should use their judgment in responding to it. For example, if a major change in pH occurs between the surface soil and a horizon that begins at 14 inches, the pH value from the horizon beginning at 14 inches is probably a better choice than the value at exactly 12 inches. On the other hand, even major changes in pH that occur deep in the profile are probably not significant in their effects on nutrient availability.

Select a value for extractable phosphorus concentration of the surface soil (0 to 6 inches) from the following list:

(1) CO.5
(2) 0.5-0.9
(3) 1.0-1.3
(4) 1.4-1.7
(5) 1.8-2.1
(6) 2.2-3.0
(7) 3.1-5.0
(8) 5.1-7.0
(9) 7.1-10.0
(10) 10.1-15.0
(11) 15.1-25.0
(12) 25.1-50
(13) >50
(14) I have no idea

Extractable phosphorus (P) concentration (P soluble in dilute hydrochloric acid and sulfuric acid [Olsen and Sommers 1982]—also known as double-acid P or Mehlich-1 P) is evaluated in relation to drainage class. The values are expressed in parts per million (ppm). If extractable P is not known for the site being evaluated, values from similar sites in the area or published values from the soil series can be used as an estimate if the same chemical analysis procedure was used. However, some soil series[6] have wide ranges in P concentrations; use of average values for these series may markedly reduce the accuracy of the site index prediction. In addition, for imperfectly drained sites, the model predicts large changes in site index based on P concentration. Thus, the user is strongly encouraged to obtain site-specific information on extractable P if accurate estimates of site index are desired. If no information is available on P concentration, the user can select the "I have no idea" option. The program will then give the user the choice of having the program select a "BEST GUESS" value for P concentration or

[6] Soils having the widest range in P values appear to be located primarily on the eastern half of the Atlantic Coastal Plain.

exiting the program. "BEST GUESS" values are based on averages by drainage class and should be considered as only very approximate values. If the user selects the "BEST GUESS' option, the value used in the program will be footnoted on the output.

If information is available for sites on **thick sands,** which indicates that higher P values exist below the top 6 inches of soil but within the effective rooting zone, the user should select one category higher than the values for the 0- to 6-inch layer would otherwise warrant.

Users or others who would like to obtain a value for extractable P but have not collected soil samples before should use the following procedure: Collect soil from the 0- to 6-inch layer at several (5 to 10) spots in the area of interest. Remember to remove the organic layer before taking the sample. An easy way to take the samples is with a push probe. (Many local Cooperative Extension or SCS offices have push probes that can be borrowed). Remove any roots, other organic material (such as needles, leaves, and twigs), and gravel or rock (either with a 2-mm sieve or by picking the pieces out by hand). Thoroughly mix together the soil from the different sampling spots. Let the sample air-dry, and then send a representative subsample to a laboratory for analysis.

Cooperative Extension agents have access to a soil testing service, so users or others concerned should contact their local Extension office for more information. The Extension office will specify how much soil to send and may provide a shipping container for this purpose. **Remember** to specify that the laboratory is to use the double-acid extractable-phosphorus procedure (also known as Mehlich 1) and ask that the results be reported in ppm[7]. Users or others involved will probably also want to have the laboratory analyze the sample for organic matter content. If suitable soil analyses' are not available through the local Extension office or through one's own organization, the Extension agent should be asked to check with a soils specialist, or one can contact the soils department at a nearby college or university and ask for the name of a reliable laboratory.

Select a value for the percentage of organic matter in the surface soil (from 0 to 6 inches) from the following list:

(1) <1
(2) 1-1.9
(3) 2-3.9
(4) 4-6.9
(5) 7-9.9
(6) > = 10

Choices are given for percentage of organic matter content in the top 6 inches of soil. If the user has values for individual horizons, a weighted value for the top 6 inches of soil should be used. Organic matter content is evaluated in relation to soil order. Concentrations of 1.5 to 2.5 percent are common on well-drained forest sites when soil orders are not Spodosols or Histosols. Sites having fresh alluvium, a history of agricultural use, or intensive site preparation will probably have lower values. Organic matter in piles or windrows should not be considered as part of the site; i.e., organic matter determinations made before major site disturbance should not be used.

Users may want to have the soil tested at a laboratory for organic matter content. They should refer to the discussion above on phosphorus for the procedure to be used in collecting the samples. If users want to obtain accurate values for organic matter determinations, it is especially important that roots, charcoal, and other organic material be carefully removed before analysis.

Select a value for the parent material of the soil from the following list:

(1) Coastal Plain sediments or any parent material other than those listed below
(2) Loessal material deposited over Coastal Plain sediments (loess less than 4 feet thick)
(3) Silty alluvium
(4) Thick loessal deposits (loess greater than 4 feet thick)

The information on parent material is used to help characterize the general fertility of the soil. In addition, thin loess deposited over Coastal Plain sediments is much less favorable for tree growth than thick loess deposits because of both the thinner layer of nutrient rich material and the presence of fragipans that commonly develop when this combination of materials is present (particularly on sites having slow internal water movement). Sites having a loessial layer approximately 4 feet deep should only be classified as "(4) Thick loessal deposits. . ." if a pan is not present within 4 feet of the surface.

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[7] Users having extractable P values in units of pounds per acre or pounds per acre-furrow-slice should divide by 2 to convert to ppm.

[8] For example, some laboratories are primarily set up for analyzing nutrient requirements for agricultural crops and may not be able to provide information on double-acid extractable P.

Appendix B

—Definitions and ranges for program variables

alorval-Evaluation of thickness of Al or Ap horizon in relation to soil order and slope position. Possible values range from 0 (thickness of A horizon any value if soil order is Entisol or Inceptisol, an A horizon at least 5 inches thick if any other order) to – 7.5 (A horizon less than 1 inch thick, soil order not Entisol or Inceptisol, slope position of midslope, upperslope, or narrow ridgetop).

aspval-Evaluation of aspect in relation to percent slope and slope exposure. Possible values range from 0 (aspects other than south, southwest, or southeast) to -4 (south or southwest aspects with full exposure and slope ≥30 percent). Aspect is not considered for sites having slopes <5 percent.

consval-Evaluation of soil consistence. Possible values range from 0 (any consistence except cemented if rooting depth is more than 40 inches) to – 13 (rooting depth less than 40 inches and A horizon is cemented, or cementation or brittleness is present in the top 6 inches of soil).

drexval-Evaluation of soil drainage class and access to extra water. Possible values range from + 3 (well drained with summer water table at 6 to 10 feet and intermittent stream channels present) to – 11 (excessively drained with no special features). Very poorly drained sites or areas permanently swampy or flooded are unsuitable unless drained.

drppval-Evaluation of extractable phosphorus in relation to soil drainage class. Possible values range from + 3 (P>30 ppm, drainage class well drained or poorer) to – 12 (P<0.5 ppm **and** drainage class is poor). Within a drainage class the relationship between phosphorus class and drppval is exponential.

ebandval-Evaluation of layering in surface A or E horizons. Possible values range from 0 (no banding) to 3 (presence of three or more A or E horizons having different textures).

eroval-Evaluation of past gully erosion. Possible values range from 0 (no or slight erosion) to 10 (severe gully erosion).

estabval-Evaluation of conditions during stand establishment. Values range from -3 (naturally or artificially seeded, severe brush problems) to 4 (planted with good competition control).

floodval-Evaluation of frequency and timing of flooding. Possible values range from + 2 (flooded in winter or early spring) to 0 (never flooded). Frequent or continuous flooding will result in site being judged unsuitable for longleaf pine.

glzval-Evaluation of height growth lost to glaze storms based on glaze storm zone, elevation, and slope position. Possible values range from 0 (glaze zone 1) to – 13 (glaze zone 3, elevation >1,500 feet, narrow ridgetop position, or glaze zone 4, elevation 500 to 1,000 feet, narrow ridgetop position). Selection of sites in glaze zone 4 with elevations >1000 feet, or in glaze zone 5, results in a warning message indicating that the site is unsuitable due to frequency of glaze storms. The user is given the choice of selecting a new location or exiting the program.

omorval-Evaluation of organic matter in relation to soil order. Possible values range from 0 to – 8. Low amounts of organic matter are considered less detrimental when the soil order is an Entisol or an Inceptisol than when it is one of the other possible orders for mineral soils (unless the soil is a deep sand) Histosols are automatically assigned a value of 0 for omorval.

orval—Evaluation of soil order. Possible values range from 0 (Entisols or Inceptisols having soil texture not sand[1]) to -5.5 (Spodosols) and -8 (Histosols). Several soil orders result in warning messages being printed on the output.

phval-Evaluation of surface pH. This value is modified if pH changes with depth. Possible values range from 0 to – 12. The highest value of phval is assigned for sites with pH ≥4.4 and 15.5. Phval can also result in the site being judged unsuitable for longleaf pine (pH<3.5, pH>8.5).

pmval-Evaluation of parent material of the soil. Possible values range from + 4 (thick loess deposits) to 0 (not loessial or silty alluvium; i.e., Coastal Plain sediments, most Piedmont or Ridge and Valley sites, or organic parent material).

puval-Evaluation of past land use. Possible values range from +2 (agricultural past use) to 0 (past land use was forest).

rfval—Evaluation of rock fragment content. Possible values range from 0 to – 8. No deduction is made unless rock content in the A horizon or average rock content in the soil profile is equal to or greater than 20 percent.

rtdval-Evaluation of effective rooting depth. This is done separately for each drainage class. Possible values range from 0 to – 15. Extremely shallow rooting depths (less than 15 inches) will result in the site being judged unsuitable for longleaf pine.

sbandval-Evaluation of special features in deep, well-drained sands that improve site quality. The type of feature and the depth in the soil profile where the feature is first observed are used in the evaluation. Values range from 0 (no special features) to +5 (one of the following occurring within 65 inches of the soil surface: continuous clay films on sand grains, layers of alternating texture, or presence of at least one finer textured layer ≥3 inches thick).

[1] The purpose of this textural restriction is to separate sands that have low nutrient-holding capacity from other young soils that generally have higher nutrient-supplying abilities.

slslval-Evaluation of slope position, percent slope, and length of slope. Possible values range from 0 to -22. Sites in lower or lower noninfluencing slope positions having slopes of 0 to 2 percent receive the best rating. Sites on narrow ridgetops receive the worst rating. The values for slslval are modified for sites having short slope lengths.

stratval-Evaluation of stratified soil profile. Possible values are + 3 (stratified) and 0 (not stratified).

stval-Evaluation of soil structure. Possible values range from 0 (granular or crumb structure) to – 6 (massive, and subsoil texture is clayey). Structure is also considered in the evaluation of texsval.

tckeval-Evaluation of thickness of E horizon. Possible values range from 0 to -2.5. E horizons less than 6 inches thick are assigned a value of 0. Sites having sandy surface horizons are not penalized for having thick E horizons.

texaval-Evaluation of texture of the surface horizon. Possible values range from 0 to + 13. Soil textures receiving the highest values for texaval are loam, silt loam, and silt. Soil textures receiving the lowest values are sand and coarse sand.

texbval-Evaluation of texture of the subsoil in relation to texture of the surface horizon. Possible values range from +5 (sites having sandy topsoil and much finer textured subsoil) to -2 (sandy or coarse sand subsoil when surface soils are finer textured). Potential positive values for texbval are reduced for imperfectly drained sites.

texsand-Evaluation of the presence of a sand or sandy loam horizon below the first subsoil horizon. Possible values range from 0 to – 12. Thick, coarse-textured horizons close to the soil surface are more detrimental than thin, finer textured horizons deep in the profile. Texsand values can be modified based on the value for texaval (the combination of texaval and texsand cannot exceed the lowest possible value for texaval).

texsval-Evaluation of bulk density of the subsoil with soil texture and structure taken into account. Possible values range from 0 to – 8. For a given bulk density and soil texture class, the values of texsval are higher (i.e., less negative) when soil structure is strongly developed.

trpstval-Evaluation of height growth lost to damaging tropical storms based on tropical storm zone. Possible values range from 0 (tropical storm zones 3 or less) to – 8 (tropical storm zone 6).

wdval-Evaluation of the effects of water deficit. The value is modified by the codes used for access to extra water. Possible values range from 0 to -5. Mean annual water deficits of less than 50 mm (less than 2 inches) are optimum. Wdval is lowest for sites having water deficits of 100 mm or more (4 + inches) and seasonally perched water tables close to the soil surface during the winter.

Appendix C

—Example of sample output

The meaning of the numerical codes used in the listing of the program inputs (the top section of the output) can be determined from appendix A. An input value of 0 can indicate that the question was not asked (for example, aspect is not asked when slope class is 1 or 2) or that the soil-site feature was not present (for example, no rock fragments were present). Negative values for program variables (listed at the bottom section of the output) indicate which variables are considered to be at suboptimum levels. Program variables are defined in appendix B.

PPSITE

Soil-site prediction system for **longleaf** pine
Site ID-Escambia Experimental Forest, Compartment 3, Stand 7
Input Values

County	ESCAMBIA	State	AL
Elevation	1	Slope position	3
Percent slope	3	Aspect	4
Slope length	2	Past land use	1
Establishment conditions	3	Past erosion	1
Drainage class	5	Flooding	1
Extra water	2	Texture of surface	10
Texture of subsoil	16	Texture for bulk density	10
Bulk density	1.35	Stratification	N
Presence of sand layer	N	Special features in deep sands	0
Structure of the surface	24	Structure of the subsoil	33
Consistence of the surface	3	Consistence of the subsoil	4
Thickness of Al or Ap	4	Depth to subsoil	21
Thickness of E horizon	17	A/E texture changes	1
Surface rock content	0	Subsoil rock content	5
Effective rooting depth	7	Soil order	3
pH surface	4	**pH** subsoil	4
Extractable phosphorus	4	Organic matter	3
Parent material	1	Water deficit	0
Glaze storm frequency	2	Tropical storm frequency	5

Site index **(50-year)** = 83 feet

Program Variables

alorval	- 1	aspval	0.5
consval	0	drexval	- 5
drppval	- 1	ebandval	3
eroval	0	estabval	1
floodval	0	glzval	0
omorval	0	orval	- 4
phval	0	pmval	0
puval	2	rfval	0
rtdval	−1.5	sbandval	0
slslval	-3.5	stratval	0
stval	- 2	tckeval	- 1
texaval	- 4	texbval	0
texsand	0	texsval	0
trpstval	- 5	wdval	0

Harrington, Constance A. 1990. PPSITE-A new method of site evaluation for longleaf pine: model development and user's guide. Gen. Tech. Rep. SO-80. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 28 p.

A model, PPSITE, was developed to predict site index for longleafpine based on soil characteristics, site location on the landscape, and land history. The model was tested with data from several sources and judged to predict site index within ±5.5 feet ($p<0.05$). A computer program for IBM-compatible personal computers was developed based on the model; the program is available by request.

Keywords: Computer programs, expert systems, models, *Pinus palustris,* site index, site quality.