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Soil pH and Tree Species Suitability in the South

Andrew J. Londo, Associate Professor, Department of Forestry, Mississippi State University
John D. Kushla, Assistant Professor, Department of Forestry, Mississippi State University
Robert C. Carter, Assistant Professor, Biology Department, Jacksonville State University

Introduction

Soil properties largely determine the tree species that will grow on a site. Among the many soil properties, soil pH is one of the most important. Soil pH provides a good indication of the chemical status of the soil and can be used in part to determine potential plant growth. This publication will help landowners and foresters gain a better understanding of soil pH and species site relationships across the south.

What is soil pH?

Soil pH, by definition, is a measure of the activity of hydrogen ions in the soil solution. Neutral soils have a pH of 7.0 (6.5-7.5), acid soils have a pH ≤ 6.5 and basic soils have a soil pH ≥ 7.5. The pH range of most soils lies between 3 and 9. Most foresters believe that pines grow best on acidic soils while hardwoods prefer slightly acidic to neutral soils. While there is some truth in this, most tree species will grow well over a broad range of pH values (Williston and LaFayette, 1978).

Why is soil pH important in forestry?

Soil pH influences nutrient uptake and tree growth. The availability of many plant nutrients in the soil changes as a result of reactions in the soil, which are largely controlled by soil pH. Trees may or may not be able to use nutrients because of these reactions. Soils with a pH of 6.0-7.0 typically have high concentrations of available nutrients (Williston and LaFayette 1978). However, the vast majority of commercially important tree species can live in a broad range of soil pH values so long as the proper balance of essential nutrients is available.

Extremes in soil pH (<4.5 and > 8.5) can make some nutrients toxic and others unavailable to plants. At low pH levels (<4.5), aluminum, iron, and manganese are very available for plant uptake. At high pH levels (>7.5), calcium and potassium are over abundant. In these situations, many plants will take up too much of these nutrients, while absorbing insufficient amounts of the others. Table 1 shows a range of soil pH values and the availability of selected nutrients within those pH ranges.

An opportune time to check soil pH levels on your site is prior to planting. In this way, a landowner can select a species that best meets their management goals and is adapted to growing under the soil pH conditions present.

How do you determine the pH of the soil on your property?

The most accurate way to determine soil pH on your property is to collect a sample of soil and have it analyzed. Your state extension service can do this for you, usually for a modest fee. For routine testing to determine the pH of the topsoil (upper 7 inches), use the following procedure.

1. Obtain a Soil Survey map of your area: These maps are available from the Natural Resources Conservation Service (NRCS) office in your county. If a map is not available, draw a sketch of your property with the areas your interested in highlighted. On the map or sketch, divide your property into timber stand types or fields. A timber stand type is an area of trees with a common characteristic, such as species composition, age, or size. Within each stand type or field, outline several 5- to 10-acre sampling sites.

2. Collect the soil samples: Within each soil types on a NRCS soils map, or within each stand type on your "homemade" map, designate each different soil or stand type with a number. Each of these numbered soil or stand types must be sampled separately for good soil sample accuracy. From each of these numbered areas, collect 15 to 20 soil samples; then combine these samples into one larger sample for each site. Samples should be taken to a depth of 7 inches, using a spade, trowel, auger or soil tube. If you use a spade, dig a V-shaped hole to the plow depth and remove a 1/2-inch thick slice of soil from one side of the hole. Then trim from each side of the spade all but a thin ribbon of soil down the center of the spade face. Collect both the "slice" and the "ribbon" as the sample. Put this sample into a paper bag and record the soil or stand type number on the bag. When the samples are dry, mix them thoroughly. Remember that samples from each soil or stand type that you delineated need to be composited separately.

3. Have the samples analyzed: Take your soil samples to your county extension office. Be prepared to furnish information on the site history. Such things as past and present land use and vegetation will be useful. Soil test results can be interpreted by county extension service or NRCS personnel. Keep the results of soil tests with your forest management plan for future reference.

Although less accurate than laboratory tests, there are other methods available for determining soil pH. Soil pH kits are available from numerous outdoor forestry equipment companies or lawn and garden stores. These kits use color charts with different colored pH indicators. This method usually has an accuracy of 0.2-0.5 pH units. When using these kits, remember that the soil sampling scheme described earlier is still applicable.

You can also estimate soil pH by looking in your county soil survey manual. Your local NRCS office can provide you with copies of the manual, as well as assistance in using it. These manuals provide additional information, including drainage, fertility, best tree species to plant/manage and construction guides.

Fortunately, many trees successfully grow and survive over a range of soil pH levels. Nevertheless, most tree species will grow better at a given soil pH. Tables 2 and 3 list softwood and hardwood tree species common to the southern United States and the soil pH levels at which they grow best.

Table 1: Soil pH effects on soil nutrient availability. Columns with dark fill show the greatest nutrient availability, light spaces represent moderate nutrient availability, and blank spaces represent limited nutrient availability for that pH level. Adapted from Brady and Weil, 1999.

	pH	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
Nitrogen (N)												
Phosphorus (P)												
Potassium (K)												
Calcium & Magnesium (Ca & Mg)												
Sulfur (S)												
Boron (B)												
Copper (Cu)												
Zinc (Zn)												
Molybdenum (Mo)												
Iron & Manganese (Fe & Mn)												
Aluminum (Al)												
	pH	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0

Table 2: Preferred soil pH ranges for selected southern softwood forest tree species*. (Adapted from Burns and Honkala, 1990a and Williston and LaFayette, 1978).

Softwoods					
Common Name	Scientific Name	pH Range	Common Name	Scientific Name	pH Range
Baldcypress	*Taxodium distichum*	4.6-7.5	Pine, Shortleaf	*P. echinata*	4.5-7.0
Pine, E. White	*Pinus strobus*	>4.0	Pine, Scots	*P. sylvestris*	4.5-6.0
Pine, Loblolly	*P. taeda*	4.5-7.0	Pine, Slash	*P. elliottii*	4.5-7.0
Pine, Longleaf	*P. palustris*	4.5-7.0	Pine, Virginia	*P. virginiana*	4.6-7.9
Pine, Pitch	*P. rigida*	3.5-4.5	Redcedar, Eastern	*Juniperus virginiana*	6.0-7.5

* The pH values provided above are to serve as a guide. These species will often grow on soils outside the pH limits set above. The pH values listed indicate where these species may have the best growth potential.

Conclusions

Soil pH is a measure of the acidity or alkalinity of soil. It can be used as a general guide for determining nutrient availability and therefore the species that may grow on a given site. This publication should be used as a guide to determine the appropriate tree species for your site based on pH. However, soil pH is only one factor affecting tree survival and growth. There are other soil conditions that affect tree growth, such as soil texture, drainage, and topographic position. For more information, contact your state forestry agency, extension forester, or consulting forester.

Literature Cited

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Table 3: Preferred soil pH ranges for selected southern hardwood forest tree species*. (Adapted from Burns and Honkala, 1990b and Williston and LaFayette, 1978).

Common Name	Scientific Name	pH Range	Common Name	Scientific Name	pH Range
American Beech	*Fagus grandifolia*	5.0-7.5	Oak, Cherrybark	*Quercus pagodafolia*	4.5-6.2
American Hornbeam	*Carpinus caroliniana*	4.0-5.6	Oak, Live	*Q. virginiana*	6.0-7.5
Ash, Green	*Fraxinus pennsylvanica*	3.6-7.5	Oak, Northern Red	*Q. rubra*	4.5-6.0
Ash, Pumpkin	*F. profunda*	4.6-7.5	Oak, Nuttall	*Q. nuttallii*	3.6-6.8
Ash, White	*F. americana*	5.0-7.5	Oak, Post	*Q. stellata*	5.0-7.5
Basswood	*Tilia americana*	4.5-7.5	Oak, Shumard	*Q. shumardii*	4.4-6.2
Birch, River	*Betula nigra*	4.5-6.0	Oak, Southern Red	*Q. falcata*	5.0-7.0
Birch, Yellow	*B. alleghaniensis*	5.0-6.5	Oak, Water	*Q. nigra*	3.6-6.3
Blackgum	*Nyssa sylvatica*	4.6-7.0	Oak, White	*Q. alba*	4.5-6.2
Black Cherry	*Prunus serotina*	3.0-5.0	Oak, Willow	*Q. phellos*	3.6-6.3
Black Locust	*Robinia pseudoacacia*	4.6-8.2	Osage Orange	*Maclura pomifera*	4.5-7.5
Cottonwood	*Populus deltoides*	3.6-7.5	Paulownia	*Paulownia tomentosa*	6.0-8.0
Dogwood	*Cornus spp.*	5.0-8.0	Pecan	*Carya illinoensis*	4.8-7.5
Eastern Hophornbeam	*Ostrya virginiana*	4.6-5.6	Persimmon	*Diospyros virginiana*	4.4-7.0
Hackberry	*Celtis occidentalis*	5.0-7.5	Sassafras	*Sassafras albidum*	6.0-7.0
Hickory	*Carya spp.*	4.5-7.5	Sugarberry	*Celtis laevigata*	6.0-6.8
Magnolia, Southern	*Magnolia grandiflora*	5.0-6.0	Sweetgum	*Liquidambar styraciflua*	3.6-7.5
Maple, Boxelder	*Acer negundo*	5.0-7.5	Sycamore	*Platanus occidentalis*	4.4-7.5
Maple, Red	*A. rubrum*	4.4-7.5	Walnut, Black	*Juglans nigra*	5.0-7.5
Maple, Silver	*A. saccharinum*	>4.0	Walnut, Butternut	*J. cinerea*	5.0-7.5
Maple, Sugar	*A. saccharum*	5.5-7.3	Yellow-poplar	*Liriodendron tulipifera*	5.0-7.0

* The pH values provided above are to serve as a guide. These species will often grow on soils outside the pH limits set above. The pH values listed indicate where these species have the best growth potential.