FNR-211

Planting and Care of Fine Hardwood Seedlings

Hardwood Tree Improvement and Regeneration Center
North Central Research Station
USDA Forest Service
Department of Forestry and Natural Resources
Purdue University

Regenerating Hardwoods in the Central Hardwood Region: *Soils*

Felix Ponder, Jr.,
North Central Research Station,
USDA Forest Service, Lincoln University

Phillip E. Pope,
Department of Forestry and
Natural Resources, Purdue University

Introduction

A large number of factors determine the successful establishment of trees. The site for a tree refers to where it grows, and includes living and nonliving factors that may have an impact on the tree's survival and growth. Site factors may be similar enough over a large area so as to be considered one site or different enough to be considered different sites. Variation within a site, such as different degrees of flooding, different soil types, slopes, aspects, and existing vegetation, may require that areas be treated as a number of smaller sites (Allen et al. 2001). Each of these may have specific levels of suitability and require different site preparation for different tree species.

Site factors affect the growth of trees that either occupy the site or are to be planted. Once the site has been identified, the first task should be to conduct a site evaluation. It can be informal, involving a casual overview, or it can be much more thorough, involving the development of ecological baseline information by means of monitoring pre-establishment conditions and analytical testing of soil characteristics. The intensity of the evaluation depends on factors, such as the manager's prior experience with similar sites, the degree to which the site has been altered, and how much the owner wants to spend on this phase of the operation. Minimally, the site should be walked over or traversed to confirm the manager's expectations.

General Site Factors

The most important nonliving factors to be considered, aside from soils, are climate and topography, and how these interact with each other to impact tree growth. The primary climatic factors affecting trees are amount and distribution of precipitation, temperature regime, and evapotranspiration.

Although mean climatic factors are important, they are generally not the most important factors of site evaluation as long as the species to be planted are within their natural range. It is more important to know the climatic extremes that can occur. The consideration of climatic extremes becomes most

important with the introduction of a species not indigenous to the area. There are numerous examples of species introduction in the forestry literature that were successful until some natural, but uncommon event occurred, such as a prolonged drought or flood, an unusually long, deep freeze, or an ice storm. Non-native species should not be used in regeneration plantings without successful introductory trials.

Occasionally, microclimate can be an important consideration, but this is less often the case on bottomland sites than on upland sites, where slope and aspect may greatly affect the temperature and moisture regimes. Also, because of the exposed nature of sites being regenerated, conditions can be hotter and drier than in adjacent woodlands. Frost pockets — low, concave areas that tend to trap cold air — are sometimes a problem within the site at higher elevations, especially for trees that leaf out early in the spring.

Alluvial bottomland soils usually have more clay and organic matter than upland soils, thus they tend to have higher moisture-holding capacity, fertility, and productivity. County soil surveys can be a starting place to evaluate soils, but should be used

with caution. Soil information for woodlands is usually less detailed than information for agricultural land. However, because some uplands and most original bottomland forests of the central hardwood region were cleared for cultivation, soil survey information on these sites should be very useful. But within either land classification, the surveys may include areas of several different soil types.

Lands in the central hardwood region (oak-hickory forest) cover a large geographical area with great differences in climate, topography, and soil. These differences can cause considerable variation in site quality and tree distribution (Graney 1989). Dominant tree species in oak-hickory forests are white, black, scarlet, and northern red oak. Other overstory trees are southern red oak, post oak, blackjack oak, chinkapin oak, bur oak, northern pin oak, bitternut hickory, mockernut hickory, pignut hickory, shagbark hickory, blackgum, yellow poplar, red maple, sugar maple, white ash, elms, American beech, black walnut, and black cherry (Robertson et al. 1984). Within groups, most central hardwood species respond similarly to the same favorable site conditions, although the importance of any one site factor or combination of factors may vary among species (Table 1).

Table 1. *Soil factors used to assess site for central hardwood tree species*

Depth, texture, and topography
Drainage, mottling, and color
Pans and depressions
Soil nutrition and organic matter content

Soil Depth

The soil properties that are most often correlated with site quality are surface soil thickness, total soil depth, and surface and subsoil textures. Organic matter content and microbial activity are highest at the surface soil layer, and it is most favorable for root development and the uptake of nutrients and water. It is primarily in the surface soil where nutrients from decomposing organic matter and the nutrient supply of the site become available for plant uptake or leached to lower levels in the soil. Where surface soils are thin, small increases in surface soil thickness can cause large increases in site quality. Effective soil depth should exceed three feet for most central hardwood species.

Some soils, although deep, may have a reduced volume of soil available for root development because of the large volume of coarse fragments. However, large amounts of loose or unconsolidated chert or coarse fragments usually have no detrimental effect on root development. Effective soil thickness, or depth, can also be affected by soil textures, which can limit or restrict soil water, air drainage, and root development.

Soil Texture

The best hardwood sites are usually on medium-textured soils (loamy soils-very fine sandy loam, loam, silt loam, and silt). Texture and coarse fragment content affect available moisture, nutrient levels, internal drainage, and aeration. Coarse-textured soils (sandy soils-sands and loamy sands) generally are less productive than medium-textured soils because they hold less moisture and nutrients. Medium-textured soils are good sites because they generally have adequate available moisture and nutrients, good structure, internal drainage, and aeration, which all favor root development. Fine-textured soils (clayey soils to sandy clay, silty clay, and clay) generally have adequate soil moisture and nutrients, but are often poorer sites because they commonly have clay subsoils that impede internal drainage, aeration, and root development.

Topography

Topographic variables often associated with site quality are aspect, slope position, slope gradient, slope shape, and elevation. Topographic features are often closely associated with soil depth, soil profile development, amounts of available soil moisture and nutrients, and microclimate. The best hardwood sites are generally north- and east-facing, gently sloping, concave, or lower slope positions. These landscape positions tend to have better soil moisture, soil depth, and higher organic matter. The poorest sites are on narrow ridges or south- and west-facing, steep, convex upper slopes. In hilly and mountainous terrain, topographic features have the strongest relationships with site quality.

On more level terrain and bottomlands, site quality is influenced more strongly by soil properties; for example, bottomland soils generally have more clay and organic matter than uplands. Many bottomlands are subjected to flooding, which favors tree species that are tolerant of inundation. Sediments deposited by flood waters favor the regeneration of species that require bare mineral soil seedbeds.

Soil Drainage

Typically, moving away from the lowest position in the bottomland to the upland, internal drainage

Table 2. *Tree species characteristics according to relative site requirements by site index, soils, and topography*[1]

Site Index[2]	Species	Soils[3]	Topography[4]
75+[5]	**Cottonwood**	Moist, well-drained, fine sandy loams or silts	Well-drained flats, former stream courses
	Northern red oak	Fine textured soils ranging from clay to loamy sands and valley floors	Northerly and easterly aspects, lower, and middle slopes, coves
	Black oak	Loamy to sandy	Lower slopes, valleys, and coves
	Black walnut	Deep, well-drained, moist and fertile, nearly neutral	Lower slopes, alluvial deposits, and well-drained bottomlands
	Yellow poplar	Moderately moist, well-drained, loose-textured	Lower slopes and alluvial deposits
	Sycamore	Good moisture supply, but not wet during growing season	Alluvial soils along streams and bottomlands
	White ash	Fine textured, moderately well-drained, and fertile	Lower and middle slopes
	White oak	Deep, well-drained, loamy	Northerly and easterly lower slopes and coves
	Silver maple	Moist, well-drained	Alluvial flood plains of rivers and on small river and creek bottoms
55-74	**Scarlet oak**	Fine textured, usually unfertile and dry	Ridges, and upper and middle slopes
	Post oak	Loamy, sandy or gravelly, and unfertile	Rocky ridges, sandy outcroppings, and southern exposures
	Pin oak	Heavy textured, poorly drained	Upland flats
	Bur oak	Calcareous, heavy clay-pan, also gravelly and coarse textured	Moist flats, limestone ridges, and coarse-loessial hills
	Eastern red cedar	Alluvial, deep, and well-drained	Ridgetops, slopes, and flat lands

[1] Adapted from Burns, R.M. and B.H. Honkala (tech. coords.). 1990. *Silvics of North America: Vol. 2 Hardwoods.* Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. 877 p.

[2] Expression of forest site quality based on height of a free-growing dominant or co-dominant tree at age 50.

[3] Soil properties associated with best growth.

[4] Species occurrence is common, but not limited to these landscapes.

[5] Many of these species also respond satisfactorily in the 55-74 site index range, but provide higher potential return on better sites.

increases and the occasion for flooding decreases. However, sometimes depressions underlain by slowly permeable soils may be present on areas of better drained soil. Depending on the size of the depression, it may need to be a separate site. Soil drainage affects soil air, which can limit tree distribution and tree growth. Poorly drained soils usually are dark and dull in color with streaks of grays and browns (mottles) indicating poor drainage and prolonged water saturation. Brightly colored soils arrayed with streaks of red and yellow usually indicate good drainage and little or no water saturation.

Compaction caused by plow pans associated with cultivation and the use of heavy equipment and naturally occurring fragipans can also impede soil air and water movement, thus affecting tree root development. The growth of most hardwoods will be detrimentally affected at bulk densities above 1.4 gm cm^{-3}.

Soil Nutrition

Whether the land manager wishes to utilize a site's existing hardwood growth capacity or amend it, the soil must be tested. Soil test results can also help determine the ideal choice of tree species for the site based on soil chemistry (Ponder 1998). Testing the soil before planting provides the opportunity to correct most chemical imbalances using equipment that might be prohibited after planting. Correcting the soil pH is probably the most common problem and one of the cheapest to address. Tree performance generally is improved if the soil pH is between 6.0 and 7.2. Apply agricultural lime if the pH is lower. The best time to apply the lime is before the trees are planted, preferably during site preparation. Use dolomitic lime if the soil is low in magnesium.

Apply phosphorus and potassium only if shown necessary by a soil test. Be careful not to over fertilize. Newly planted trees lack the root system and above ground biomass to utilize large applications of nutrients. However, if either one or both nutrients are needed, apply during site preparation. Zinc, boron, and other nutrients recommended by soil tests, but required in small amounts, will improve the nutrition and growth of the young tree. They can be broadcast, banded, or mixed with the soil before planting. Soil should be retested every three to five years or when growth problems occur that may be related to nutrition.

What To Plant

Unfortunately, many attempts to establish oak and other hardwoods such as hickory, black walnut, and ash as productive plantations have failed despite our best knowledge and efforts (Dey et al. 2003). Some of the largest areas of land being regenerated to trees are lands that were cleared for cultivation, but the landowner now wants to plant trees. See Table 2 for tree species. Although problematic at times, hardwoods such as oak and black walnut are among the best trees for the production of food for wildlife and high value wood products. Careful planting of high-value hardwoods such as red oak, white oak, white ash, and black walnut on good sites could be profitable. Numerous tree species are available that will do well on sites with limitations. It is important to remember that as site productivity increases, so does the growth of competitors. Therefore, there may be more need for vegetation management on good to high site qualities. There are resources available to help make the right decision on what to plant.

Help Is Available

It is important to keep in mind that nearly all tree species achieve best growth in moist, well-drained, deep, and fertile soil. For example, most of the trees listed in Table 2 perform well on good soils. But, only a few of these species can be as productive on sites that are less than optimal. State specialists in the Department of Conservation or Natural Resources and federal specialists in the Natural Resources Conservation Service (NRCS) are good sources of assistance. The NRCS developed detailed soil interpretations for land uses for states (See http://soils.usda.gov/index.htm). They can help interpret the soil survey report, and they can help you select the right tree species or combination of tree species for your site. In most instances, the local specialist is familiar with the species and site relations for soils in the area. Their involvement could greatly increase the opportunities for success.

Literature Cited

Allen, J.A., B.D. Keeland, J.A. Stanturf, A.F. Clewell, and H.E. Kennedy, Jr. 2001. *A guide to bottomland hardwood restoration*. U.S. Geological Survey, Biological Resources Division Information and Technology Report USGS/BRD/ITR-2000-0011, U.S. Department of Agriculture, Forest Service, Southern Research Station, General Technical Report SRS-40, 132p.

Burns, R.M. and B.H. Honkala (tech. coords.). 1990. *Silvics of North America: Vol. 2. Hardwoods*. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. 877p.

Dey, D., J. Kabrick, J. Grabner, and M. Gold. 2003. Restoring oaks in the Missouri River floodplain. In: *29th Hardwood Symposium Proceedings*. Sustaining natural resources on private lands in the central hardwood region. p. 8-20. French Lick, IN.

Graney, D.L. 1989. The importance of site quality (note 4.01). In: Clark, F.B., and J.G. Hutchinson (eds.), *Central Hardwood Notes*. USDA Forest Service, North Central Research Station, St. Paul, MN 55108. 3p.

Ponder, F., Jr. 1998. Characteristics of good growing sites for black walnut. p. 38-43. In: Jones, J.E., R. Mueller, J.W. Van Sambeek (eds.), *Nut Production Handbook for Eastern Black Walnut*, Southwest Missouri Resource Conservation & Development (RC&D), Inc. Republic, MO.

Robertson, P.A., M.D. MacKenzie, and L.F. Elliott. 1984. Gradient analysis and classification of the woody vegetation for four sites in southern Illinois and adjacent Missouri. *Vegetation* 58(2): 87-104.

This publication is printed on recycled paper using soy-based inks.

Purdue Extension
Knowledge to Go
1-888-EXT-INFO

NEW 9/03

FNR-211