1997

The Silviculture-Wood Quality Connection in Eastern Black Walnut

Douglas D. Stokke
Bruce E. Cutter, *University of Missouri-Columbia*
John E. Phelps, *Southern Illinois University Carbondale*

THE SILVICULTURE-WOOD QUALITY CONNECTION IN EASTERN BLACK WALNUT

Bruce E. Cutter, John E. Phelps, and Douglas D. Stokke[1]

ABSTRACT.—The known effects of silvicultural practices on eastern black walnut (*Juglans nigra* L.) wood quality are reviewed. Since desirable quality differs from end user to end user, no specific recommendations are made.

INTRODUCTION

In this paper we review the body of knowledge relating wood quality in eastern black walnut (*Juglans nigra* L.) to stand management activities. The latter can be broadly defined as whatever the landowner undertakes that influences the growth of the trees and/or the stand. This includes no action as well since, as we will see, failure to control weeds, remove diseased trees, or to thin also will influence the growth of the stand. A quick review of the literature indicates that black walnut quality-site knowledge is lacking in many areas. While there have been many examples of guidebooks discussing walnut stand management—USDA General Technical Report NC-38 by Schlesinger and Funk (1977) as an example—none of these discuss wood quality. In the Fourth Black Walnut Symposium, Phelps (1989) addressed the tree growth-wood quality relationship from the wood properties perspective.

Wood quality is measured by several parameters whose importance vary from end-user to end-user. These parameters might include cell length, density or specific gravity, growth rate, earlywood-latewood ratio, or, particularly in the case of black walnut, heartwood color. While there will be some exceptions, strength is usually not a concern in black walnut utilization since the majority of the wood is used for decorative veneers and furniture. The notable exception is in the gunstock market where a certain minimum strength may be required for safety in the trigger grip area.

In most wood technology or wood utilization texts, three general sources of variation in wood (and wood properties) are listed: genetics, tree (cambial) age, and environment. The latter includes all the factors typically assumed to be environmental such as climate, soil fertility, moisture, photoperiod, etc. What many people overlook is that deliberate (or accidental!) management activities undertaken by the landowner constitute an environmental impact as well. Typical or traditional forest management activities might include thinning, pruning, fertilization, irrigation, etc. Less activities might include mechanical agitation by shakers to hurry nut drop as is common in harvesting English walnuts or pecans (Reid 1993). Another atypical management activity might be agroforestry alleycropping where alleyways are used for rowcrops and grazing lanes (Garrett *et al.* 1991).

While the bulk of this paper is devoted to management activities, we will first spend a few minutes briefly reviewing the other two sources of wood quality variation—genetics and tree age.

GENETICS AND TREE AGE

Proper selection of planting stock for the desired end purpose may be considered a management activity. There has been considerable time and

[1] Bruce E. Cutter, Associate Professor of Forestry, University of Missouri-Columbia, Columbia, MO 65211; John E. Phelps, Professor of Forestry, Southern Illinois University, Carbondale, IL 62901-4411; and Douglas D. Stokke, Forest Products Technologist, USDA Forest Service, Northeastern Forest Experiment Station, Princeton, WV 24740.

effort expended over the years in black walnut tree improvement programs with modest results (Beineke 1985; Bey 1973; Chenowerth 1995; Rink 1987; Rink and Phelps 1989; Rink *et al.* 1994a, 1994b). Most of the work has been aimed at improving growth and form or at increasing nut yield (Garrett *et al.* 1994, Jones *et al.* 1995). Rink *et al.* (1994a) evaluated wood quality in a thinning of plantation-grown walnut and found that selection for timber growth showed modest genetic advantage. Rink (1987) also has found low heritability for heartwood color in black walnut suggesting that environmental/management factors play a significant role in determining this important wood quality parameter.

Chen *et al.* (1995) examined knots, pin knots, and pin knot clusters in walnut boards cut from logs obtained from a precommercial thinning of a walnut-agroforestry plantation. They found no advantage over selection for either nut or timber characteristics with respect to knots, pin knots, or pin knot clusters. They suggested that retention of suppressed buds was controlled by environmental factors, not genetics.

There were early efforts to produce figured walnut by grafting (Lamb 1940). Walters (1951) reported that grafted trees had more figure in the outer section of the stem then the inner section.

In most tree species, the early years of growth produce wood that is variously termed "immature wood" or "juvenile wood" (Panshin and de Zeeuw 1980, Haygreen and Bowyer 1989). This wood also has been referred to as "crown-formed wood" since it is associated with the live crown section of the tree stem. Typically, this wood is characterized by shorter cells, steeper S_2 cell wall microfibril angles, and altered chemical composition. As a result of these changes, some physical and mechanical properties are altered as well—increased longitudinal shrinkage, decreased density, decreased strength. Walnut does not appear to be an exception. Cutter and Garrett (1993) found that fiber length increased from pith to bark in a study of 15-year-old thinnings from an agroforestry plantation, i.e., immature wood was composed of shorter cells. Juvenile wood characterization in walnut has been limited to date.

MANAGEMENT ACTIVITIES

FERTILIZATION AND IRRIGATION

Explicit references to the influence of either walnut fertilization or irrigation vis-a-vis walnut wood quality in the literature are lacking. Insofar as improving the growth and vigor of the trees, it is difficult to say that either of these practices would be detrimental to tree and/or wood quality. Certainly, based on the results from other species, one could infer that the results would be at best favorable (Murphey *et al.* 1973a, 1973b; Scowcroft and Stein 1986). Black walnut fertilization research has focused on the effect of fertilization on nut yield (Jones *et al.* 1995).

GRAZING

In many areas of the United States, forest grazing of cattle is a common practice (Lundgren *et al.* 1983). Some agencies explicitly recommend against grazing (Hershey 1991, Williams 1933). Much of the evidence cited against grazing appears to be either anecdotal or based on uncontrolled grazing of not only cattle, but hogs, sheep, goats, etc. and is related to soil erosion and watershed degradation (Patric and Helvey 1986). Cutter *et al.* (1996) found that controlled grazing had no influence on tree grade in slash pine.

PRUNING

Pruning is done for several reasons including the production of a clear stem, corrective pruning to improve tree form, and (in alleycropping regimes) removal of low branches that might impede the access of agricultural equipment. While there have been numerous studies showing the proper way to prune to minimize bole damage, it is important to remember that this is a deliberate wounding of the tree, regardless of the desirability of the end result. While pruning is frequently done to correct a misshapen stem, Reeves (1984) found that the tree will try to correct this on its own, and, if left alone, will do a very good job.

The time of year that pruning occurs has been shown to play a role in both wound healing and scarring. Armstrong *et al.* (1981) and Smith (1980) found that fall pruning/wounding produced more scarring and discoloration in walnuts than did late winter/early spring pruning.

Studies by Clark and several of his co-workers indicated that pruning, while stimulating growth, sometimes produced undesirable results including epicormic branching (Clark 1955, 1961; Clark and Seidel 1961). Indeed, even 25 years following pruning, the pruning wounds had not healed on some stems in one study (Shigo *et al.* 1978, 1979). Shigo and his co-workers noted that dark bands of discolored heartwood were associated with pruning wounds. If the production of clear, uniform color wood is the desired result, this is clearly undesirable.

The general recommendation that may be made is that pruning should be done at an early age and limited to small diameter branches (say less than 1 in. in diameter). Early pruning will allow the production of the maximum amount of clear wood.

THINNING

Typically, thinning is thought of as removal of poorly formed trees, low vigor trees, diseased trees, etc. From a traditional forest management standpoint, thinning is either pre-commercial (i.e., the cut trees are left on the ground) or commercial (the removed trees are large enough for product recovery). In either event, the result is increased water and nutrient availability for the residual stand. In some instances, there have been reports of increased levels of limb-related defects associated with heavily thinned hardwood stands (Sonderman 1986).

Paul (1943) reported that open-grown black walnut had higher density than did forest-grown walnut. Open-grown was defined at that time as "trees growing singly or in small scattered groups in pastures and relatively open farm woodlots." This might be analogous to stand densities seen in many agroforestry configurations. In a latter paper, Paul (1963) recommended that management practices producing conditions similar to those where open grown walnut occurs be followed.

On the other hand, Landt and Phares (1973) suggested that open grown walnut would tend to be forked and limby while forest grown walnut would have a straight, clear stem. According to them, the forest grown stems would have a dark colored heartwood with a narrow sapwood band while open grown trees would have lighter heartwood and wider sapwood rings.

Phelps and Workman (1992) compared vessel element area in naturally-grown walnut against plantation grown walnut trees. They found that the faster-growing plantation trees had wider growth rings which in turn have wider latewood zones. This results in a reduction in vessel area in the cross-section that causes poorer wood texture. On the other hand, stand management favors more uniform wood texture.

Other literature suggests that trees growing in a crowded stand may have greater height to diameter ratios. In a study of the effect of stand density, Holbrook and Putz (1989) found that sweetgum (*Liquidambar styraciflua* L.), which like walnut is a light-demanding tree, apparently allocated more wood to height growth than to diameter.

WEED CONTROL

Weed control also could be termed "competing vegetation control" since, under some scenarios, the competing vegetation may be rowcrops or other tree species. Numerous papers have shown that vegetation control during establishment phases of walnut stands is necessary for optimum growth response (Schlesinger and Van Sambeek 1986, Van Sambeek *et al.* 1989). What many do not realize is that the competition for available nutrients and water continues once the tree is into the sapling or pole stage. If the competing vegetation is other trees, be they walnut or some other species, then vegetation control is termed thinning. If the competing vegetation is an annual (such as corn or soybeans) or a perennial (such as clover or lespedeza), then the tree line may need to be kept vegetation-free in order for the tree to successfully compete for water and nutrients. This can be done either through chemical or mechanical means (Jones *et al.* 1990). Cutter and Garrett (1993) indicated that declining growth in an agroforestry plantation on an exceptional site (SI=90+) was coincident with conversion of the alleyways to a perennial cover crop.

PARTIAL BIBLIOGRAPHY

Armstrong, J.E., A.L. Shigo, D.T. Funk, E.A. McGinnes, Jr., and D.E. Smith. 1981. A macroscopic and microscopic study of compartmentalization and wound closure after mechanical wounding of black walnut trees. Wood Fiber 13:275-291.

Beineke, W.F. 1985. Characteristics of Purdue University's patented black walnut trees. Purdue University Cooperative Extension Service FNR-115. 7 p.

Bey, C.F. 1973. Growth of black walnut trees in eight midwestern states—a provenance test. USDA Forest Service Res. Pap. NC-91. 7 p.

Boakye-Yiadom, K. 1986. Properties of the wood of black walnut (*Juglans nigra* L.) at the limb-bole interface zone. M.S. thesis, University of Missouri-Columbia, Columbia, MO.

Boyce, S.G., M. Kaeiser, and C.F. Bey. 1970. Variations of some wood features in five black walnut trees. For. Sci. 16:95-100.

Bresnan, D.T., G. Rink, K.E. Diebel, and W.A. Geyer. 1994. Black walnut provenance performance in seven 22-year-old plantations. Silvae Genetica 43:246-252.

Chen, P.Y.S., R.E. Bodkin, and J.W. Van Sambeek. 1995. Variation in pin knot frequency in black walnut lumber cut from a small provenance/progeny test. p. 488. *In* K.W. Gottschalk and S.L.C. Fosbrike (eds.) Proceedings, 10th Central hardwood forest conference. USDA Forest Service Gen. Tech. Rep. NE-197.

Chenowerth, B. 1995. Black walnut. Sagamore Publishing, Champaign, IL.

Clark, F.B. 1955. Black walnut responds to pruning. J. For. 53:362-365.

Clark, F.B. 1961. Climatic injury found on planted black walnut in Kansas. Central States Forest Experiment Station Note 147. 2 p.

Clark, F.B. and K.W. Seidel. 1961. Growth and quality of pruned black walnut. Central States Forest Experiment Station Tech. Pap. 180. 11 p.

Cutter, B.E. 1991. Tree and wood quality in 15-year old eastern black walnut (*Juglans nigra* L.) grown in agroforestry regimes. p. 116-123. *In* H.E. Garrett, (ed.) Proceedings 2nd Conference on agroforestry in North America, School of Natural Res., University of Missouri, Columbia, MO.

Cutter, B.E. and H.E. Garrett. 1993. Wood quality in alleycropped eastern black walnut. Agroforestry Systems 22:25-32.

Cutter, B.E., K. Hunt, and J.D. Haywood. 1996. Effects of grazing on tree/wood quality in pine. Poster paper. Forest Products Society Annual Meeting, Minneapolis, MN. June 23-26, 1996.

Dierauf, T.A., J.W. Garner, and J.A. Scrivani. 1995. A study of diameter growth in black walnut stands. Virginia Department of Forestry. Occasional Rep. 118. 10 p.

Englerth, G.H. 1966. Machining and other properties of fast- versus slow-grown trees. p. 77-82. *In* Black walnut culture. USDA Forest Service North Central Forest Experiment Station. St. Paul, MN.

Garrett, H.E. and W.B. Kurtz. 1982. Nut production—a valuable asset in black walnut production. p. 53-65. *In* Black walnut for the future. USDA Forest Service Gen. Tech. Rep. NC-74.

Garrett, H.E. and W.B. Kurtz. 1983. Silvicultural and economic relationships of integrated forestry-farming with black walnut. Agroforestry Systems 1:245-256.

Garrett, H.E. and W.B. Kurtz. 1987. Nut production and its importance in black walnut management. p. 23-28. *In* 78th Annual Report of the Northern Nut Grower's Association.

Garrett, H.E., C. Neelan, and J.E. Jones. 1994. Incidence of yellow-bellied sapsucker damage under walnut agroforestry. p. 25-28. *In* Proceedings of 3rd N.A. agroforestry conference. Ames, IA.

Garrett, H.E., J.E. Jones, W.B. Kurtz, and J.P. Slusher. 1991. Black walnut (*Juglans nigra* L.) agroforestry—its design and potential as a land-use alternative. For. Chron. 67:213-218.

Garrett, H.E., E.F. Lowenstein, J.E. Jones, and G. Rink. 1995. The importance of selecting gain in walnut agroforestry management. In Proceedings, 8th Biennial southern silviculture conference. (in press).

Haygreen, J.G. and J.L. Bowyer. 1989. Forest products and wood science. 2d Edition. Iowa State University Press. Ames, Iowa. 500 p.

Hershey, F.A. 1991. The extent, nature and impact of domestic livestock grazing in Missouri woodlands. p. 248-255. *In* H.E. Garrett (ed.), Proceedings of The 2d conference on agroforestry in North America, School of Natural Resources, Univ. of Missouri, Columbia, MO.

Hiller, C.H., F. Freese, and D.M. Smith. 1972. Relationships in black walnut heartwood between color and other physical and anatomical characteristics. Wood and Fiber 4:38-42.

Holbrook, N.M. and F.E. Putz. 1989. Influence of neighbors on tree form: effects of lateral shade and prevention of sway on the allometry of *Liquidambar styraciflua* (sweetgum). Am. J. Bot. 76:1740-1749.

Jones, J.E., H.E. Garrett, and J.K. Haines. 1989. Production, harvesting, utilization, and marketing of eastern black walnut nuts — an industrial viewpoint. p. 242-247. *In* Proceedings 4th Black walnut symposium. Walnut Council, Indianapolis, IN.

Jones, J.E., H.E. Garrett, J. Haines, and E.F. Loewenstein. 1995. Genetic selection and fertilization provide increased nut production under walnut-agroforestry management. Agroforestry Systems 29:265-273

Kurtz, W.B., H.E. Garrett, and W.H. Kincaid Jr. 1984. Investment alternatives for black walnut plantation management. J. For. 82:604-608.

Lamb, G.N. 1940. Figure in wood. Northern Nut Growers Assoc. Annual Report 31:28-33.

Landt, E.F. and R.E. Phares. 1973. Black walnut....an American wood. USDA Forest Service Publication No. 270. 7 p.

Lundgren, G.K., J.R. Conner, and H.R. Pearson. 1983. An economic analysis of forest grazing on four timber management situations. South. J. Appl. For. 7(3):19-24.

Lutz, J.F. 1958. Color in walnut veneer. Veneers and Plywood 52(11):15, 21-22.

Maeglin, R.R. and N.D. Nelson. 1970. Surface soil properties of black walnut sites in relation to wood properties. Soil Sci. Soc. Am. Proc. 34:142-146.

McGinnes, E.A., Jr. 1968. Extent of shake in black walnut. For. Prod. J. 18:80-82.

McGinnes, E.A., Jr. 1975. Response of black walnut to environmental mishaps. p. 102-107. *In* 66th Annual Report of the Northern Nut Growers Association.

McGinnes, E.A., Jr., C.I.-J. Chang, and K.Y.-T. Wu. 1971. Ring shake in some hardwood species: the individual tree approach. J. Poly. Sci.:Part C. 36:153-176.

Miller, R.B. 1976. Wood anatomy and identification of species of *Juglans*. Bot. Gaz. 137:368-377.

Murphey, W.K., W.J. Young, and B.E. Cutter. 1973a. Effects of sewage effluent irrigation on various physical and anatomical characteristics of northern red oak. Wood Sci. 6(1):65-71.

Murphey, W.K., R.L. Brisbin, W.J. Young, and B.E. Cutter. 1973b. Anatomical and physical properties of red pine and red oak sprayed with municipal wastewater. p. 295-310. *In* W.E. Sopper and L.T. Kardos (eds.) Recycling treated municipal wastewater and sludge through forest and cropland. The Pennsylvania State University Press. University Park, PA.

Nelson, N.D. 1975a. Extractives produced during heartwood formation in relation to amounts of parenchyma in *Juglans nigra* and *Quercus rubra*. Can. J. For. Res. 5:291- 301.

Nelson, N.D. 1975b. Important influences on heartwood formation and heartwood-sapwood proportions in black walnut. p. 156-160. *In* 66th Annual Report of the Northern Nut Growers Association.

Nelson, N.D. 1976. Gross influences on heartwood formation in black walnut and black cherry trees. USDA Forest Service Res. Pap. FPL-268. 12 p.

Nelson, N.D. 1978. Xylem ethylene, phenol-oxidizing enzymes, and nitrogen and heartwood formation in walnut and cherry. Can. J. Bot. 56:626-634

Nelson, N.D., R.R Maeglin, and H.E. Wahlgren. 1969. Relationship of black walnut wood color to soil properties and site. Wood and Fiber 1:29-37.

Panshin. A.J. and C. DeZeeuw. 1980. Textbook of wood technology. Vol. I. McGraw-Hill. New York. 722 p.

Patric, J.H. and J.D. Helvey. 1986. Some effects of grazing on soil and water in the eastern forest. USDA Forest Service Gen. Tech. Rep. NE-115. 25 p.

Paul, B.H. 1943. Black walnut for gunstocks. Southern Lumberman. April 15, 1943:

Paul, B.H. 1963. The application of silviculture in controlling the specific gravity of wood. USDA Forest Service Tech. Bull. 1288. 97 p.

Phelps, J.E. 1989. How management practices influence black walnut wood properties. p. 21-29. *In* J.E. Phelps (ed.) The continuing quest for quality (Proceedings of the Fourth black walnut symposium). Walnut Council, Indianapolis, IN.

Phelps, J.E. and P.Y.S. Chen. 1989. Lumber and wood properties of plantation-grown and naturally grown black walnut. For. Prod. J. 39(2):58-60.

Phelps, J.E. and E.A. McGinnes Jr. 1983. Growth-quality evaluation of black walnut wood. Part III — An anatomical study of color characteristics of black walnut veneer. Wood and Fiber Science 15:212-218

Phelps, J.E. and E.C. Workman, Jr. 1992. Vessel area studies in black walnut (*Juglans nigra* L.). Wood and Fiber Science 24:60-67.

Phelps, J.E., E.A. McGinnes, Jr., H.E. Garrett, and G.S. Cox. 1983. Growth-quality evaluation of black walnut wood. Part II — Color analyses of veneer produced on different sites. Wood and Fiber Science 15:177-185.

Reeves, G.B. 1984. Selected wood properties of self-straightening black walnut trees. Ph.D. dissertation, University of Missouri-Columbia, Columbia, MO.

Reid, W. 1993. Mid-summer shaking reduces alternate bearing. Quandong 19:10-12.

Rink, G. 1987. Heartwood color and quantity variation in a young black walnut progeny test. Wood and Fiber Science 19:93-100.

Rink, G. and J.E. Phelps. 1989. Variation in heartwood and sapwood properties among 10-year old black walnut trees. Wood and Fiber Science 21:177-182.

Rink, G., F.H. Kung, and B.E. Cutter. 1994a. Selection effectiveness for black walnut nuts and timber. p. 101-105. *In* R.C. Schultz and J.P. Colletti (eds.) Opportunities for agroforestry in the temperate zone worldwide. Proceedings of the Third North American agroforestry conference, Iowa State University, Ames, IA.

Rink. G., G. Zhang, Z. Jinghua, F.H. Kung, and E.R. Carroll. 1994b. Mating parameters in *Juglans nigra* L. seed orchard similar to natural population estimates. Silvae Genetica 43:261- 263.

Schlesinger, R.C. and D.T. Funk. 1977. Manager's handbook for black walnut. USDA Forest Service Gen. Tech. Rep. NC-38. 22 p.

Schlesinger, R.C. and J.W. Van Sambeek. 1986. Ground cover management can revitalize black walnut trees. North. J. Appl. For. 3:49-51.

Schumann, D.R. 1973. Mechanical, physical, and machining properties of black walnut from Indiana and Missouri. Wood Fiber 5:14-20.

Scowcroft, P.G. and J.D. Stein. 1986. Simulating growth of stagnated *Acacia koa* by thinning and fertilizing. USDA Forest Service Res. Note PSW-380. 8 p.

Shigo, A.L., E.A. McGinnes, Jr., D.T. Funk, and N.F. Rogers. 1979. Internal defects associated with pruned and nonpruned branch stubs in black walnut. USDA Forest Service Res. Pap. NE-440. 27 p.

Shigo, A.L., N.F. Rogers, E.A. McGinnes, Jr., and D.T. Funk. 1978. Black walnut on Kansas stripmine soils. Some observations 25 years after pruning. USDA Forest Service Res. Pap. NE-393. 14 p.

Smith, D.E. 1980. Abnormal wood formation following fall and spring injuries in black walnut. Wood Science 12:243-251.

Sonderman, D.L. 1986. Changes in stem quality on young thinned hardwoods. USDA Forest Service Res. Pap. NE-576. 9 p.

Szopa, P.S., H.E. Garrett, and E.A. McGinnes, Jr. 1980. Growth-quality evaluation of black walnut wood. Part I—Specific gravity, growth rate, and percent extractables for trees grown on three different sites in Missouri. Wood Science 13:95-98.

Van Sambeek, J.W., R.C Schlesinger, P.L. Roth, and I. Bocuma. 1989. Revitalizing slow-growth black walnut plantings. p. 108-114. *In* Proceedings of the 7th Central hardwood conference. USDA Forest Service Gen. Tech. Pap. NC-132.

Walters, C.S. 1951. Figured walnut propagated by grafting. J. For. 49:917.

Williams, W.K. 1933. Protect hardwood stands from grazing. USDA Leaflet No. 86. 3 p.