Improved Hardwoods for Increased Utilization

STEPHEN G. BOYCE [1/]

The current low utilization of hardwood logs is primarily due to the small size of existing trees. Small trees can produce only a small amount of the best grades of lumber and veneer. Even under intensive silviculture a preponderance of low-grade material must be expected. from small trees. Timber size is important because larger trees are cheaper to harvest, transport, and process, and tend. to have higher product value than small trees. Even though many small hardwood. logs are being used, larger timber is essential to maintain the competitive position of most forest industries. At present only about 11 percent of the total volume of eastern hardwoods is in trees 19 inches and larger (U.S. Forest Service 1965).

One way to increase utilization is to wait for our trees to grow larger. But, this may not occur soon enough to meet our needs. Currently recommended. cultural treatments applied. to natural stands can increase growth and utilization in a reasonable time (Roach 1965). But we also need. more intensive cultural and genetic techniques that greatly increase the utilization of the most valuable hardwood. species in the shortest possible time.

Increased. utilization requires trees with a number of characteristics other than large size. The structure of the wood. must permit minimum waste in manufacturing. Knots must be confined. to a small center core. And uniform wood. structure among logs is needed to permit repeated. manufacturing of uniform products. Large size, cylindrical shape, uniform wood. structure, and. no knots are features that increase the usefulness of hardwood. logs (Lockhard, et. al. 1963). Apparently the most usable hardwood log for lumber and. veneer would be a large cylinder of uniform wood. with a small knotty core. This theoretical log may never be grown but it can serve as a goal for developing some improvement concepts.

The quickest improvements for increased. utilization can be made by applying cultural practices in immature stands. But the greatest progress can be made by improving the inherent potential of valuable species and by using the best cultural practices to grow these trees on productive soils. To do this we must plant vigorous seedlings of inherently superior strains on soils with good. physical properties. We must completely eliminate weeds; add fertilizers to nutrient-deficient soils; provide protection from diseases, insects, and. fire; and. irrigate when necessary. In addition, we can grow the maximum percentage of first-grade wood. by applying the following concepts:

1. The highest percentage of first-grade lumber and veneer can be produced by concentrating cultural and genetic practices on the butt log.

2. Straight, vertical stems have uniform wood. structure and can be efficiently harvested, handled, and processed_

3. Waste can be reduced. and manufacturing efficiency can be increased. by confining buds and branches to a small centered. core of the butt log.

4. A uniformly growing cylindrical bole requires a symmetrical crown centered. and. balanced, over a vertical, straight stem and, provided. with a continously increasing growing space.

5. The most important genetic qualities for increased, utilization are adaptation to the environment, straight, vertical stems, and early abscission of suppressed. buds and. branches.

1/ Chief, Division of Timber Management and. Fire Research, Central States Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Columbus, Ohio.

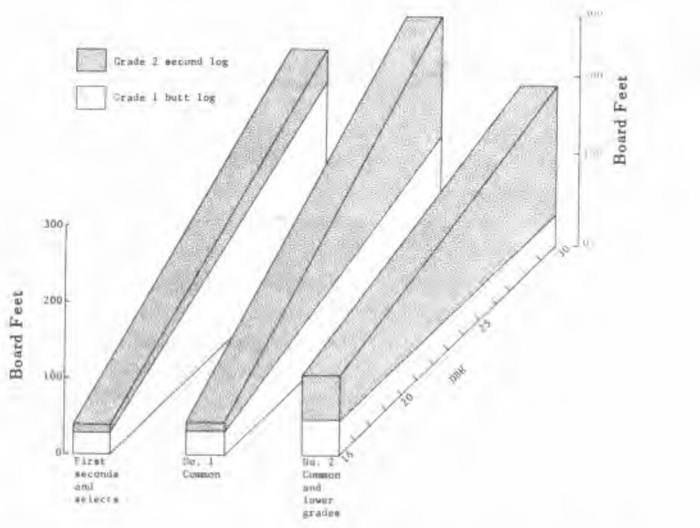

Figure 1 -- A grade 1 butt log has a large amount of first-grade lumber. A grade 2 second log adds large amounts of poorer grades. This diagram shows the expected recovery of Factory Grade lumber from 1- and 2-log black oaks 16 to 30 inches d.b.h.

THE BUTT LOG

The butt log is the most valuable part of the stem. Between 40 and 100 percent of the merchantable volume of most hardwood trees is in the first 16-foot log. And, the best lumber and veneer are made from butt logs. This log has the best chance of qualifying for grade 1, either for factory lumber or for veneer, while the second and third 16-foot logs usually are grade 2 or lower. A grade 2 second log adds a small amount of high-grade lumber and a large amount of low-grade lumber (fig. 1). For black oak from 16 to 30 inches d.b.h. a grade 2 second log adds only 13 to 18 percent more top-grade lumber but 120 to 300 percent more low-grade lumber. Similar ratios exist for other hardwoods (Wollin et al. 1949).

The butt log is generally considered to be 16 feet long. Cultural practices can be extended to a butt log 20, 22, 24 and 26 feet long from which two grade 1 logs can be cut. This will increase the volume of high-grade lumber but the increase in high-grade lumber will be less than the increase in low-grade lumber. This is because the knotty core in a 16-foot butt log is shaped like an inverted cone with a 3- to 4- inch base at the top of the log. The second 16-foot log has a knotty core shaped like an inverted frustum of a cone beginning at the top of the butt log and. expanding to a diameter of 12 to 14 inches at the top of the second. log (Holsoe 1947). A second log of any length must contain a smaller proportion of clear wood. than the butt 16-foot log.

It is costly and. difficult to prune and apply other cultural treatments to the second. log because it is higher from the ground. and normally has more and larger branches than the butt log (Krajicek 1959; Brinkman 1955). Therefore, the largest percentage of top-grade lumber and. veneer will be most easily grown in the shortest time by concentrating cultural and genetic practices on the 16-foot but log.

STRAIGHT AND VERTICAL STEMS

Straight and vertical stems are more efficiently processed.. Lean and crook increase the amount of gelatinous fiber and. increase the variability in wood structure, specific gravity, and ring width. All of these cause problems in machining, drying, and finishing (Boyce and. Kaeiser 1964); Davis 1962). Buckling and splitting of veneers, for example, are often caused by variations in specific gravity and the presence of gelatinous fibers. For machining, uniformity in wood. properties is usually more important than specific gravity (Davis 1962). The presence of large numbers of gelatinous fibers in leaning and. crooked stems creates problems in surfacing, sanding and drying. In addition to causing processing problems, crooked. and. leaning trees are more difficult and expensive to harvest, transport, and saw or slice than straight, vertical trees.

The production of a straight, vertical butt log begins with fast initial growth of seedling sprouts and seedlings (Bey 1964). After harvesting a natural stand, all advanced growth should be cut near the ground. to give the seedling sprouts and seedlings the best possible opportunity for fast height growth (Roach 1965). If the first stand. of sprouts does not contain a sufficient number of straight, vertical stems, it should be cut again near the ground. It is better to add. a year or two to the rotation at this age than to invest in stems that cannot possibly grow into straight logs.

Hardwood plantations can have fast-growing trees with vertical, straight stems if only the most productive soil is used; the soil is prepared as for a corn crop; and. large vigorous seedlings are planted. in deep pits. Pits can be drilled to 2 feet deep with power augers. Root collars should be placed several inches below the ground, and, the original

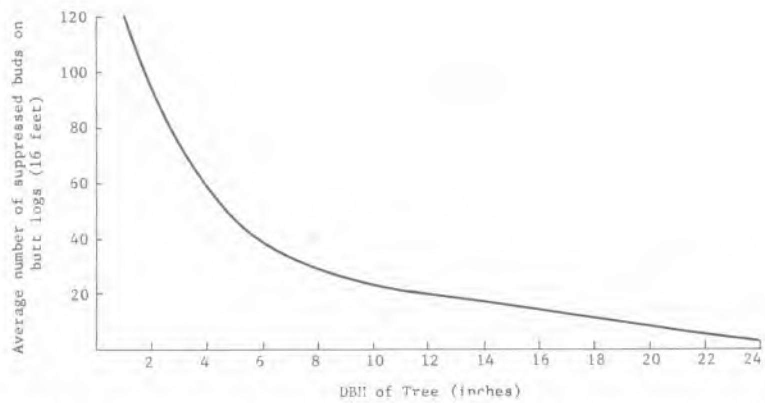

Figure 2 -- As oak trees grow in diameter, the number of suppressed buds decrease. This diagram is based on dissections of white oak, scarlet oak, black oak, and northern red oak trees. There were no important differences among species.

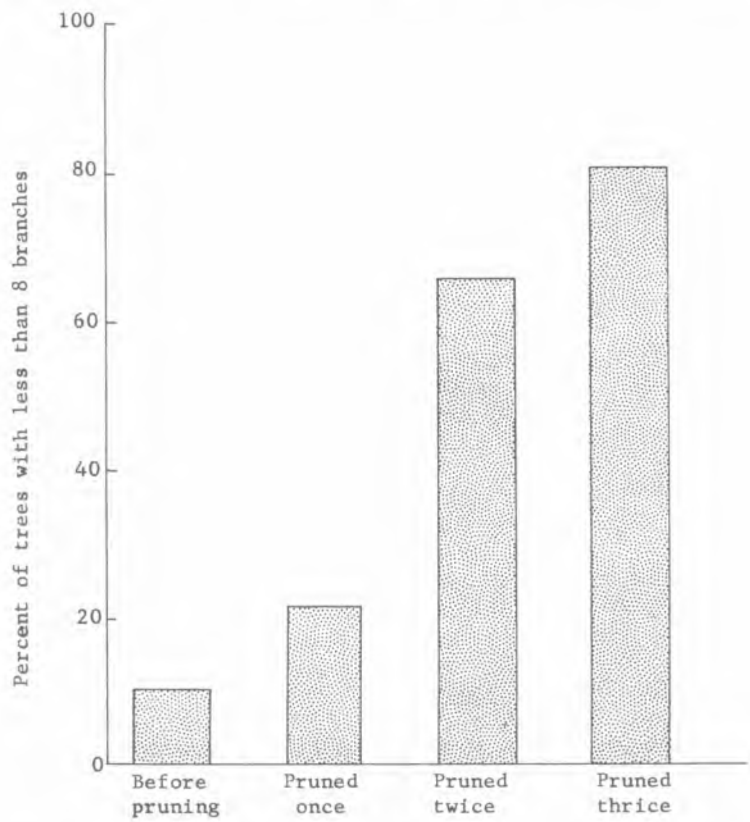

Figure 3 -- Repeated pruning at 2-year intervals can increase the proportion of hardwood trees with less than eight new branches on the butt log. These white oaks were about 5 inches d.b.h. when first pruned.

stems cut so the seedlings sprout near the ground Only one sprout should be permitted to develop. Weeds should be completely eliminated and fertilizers added to nutrient-deficient soils. Weed and. grass competition must be eliminated. because it causes slow growth, forked, and crooked. stems, and. frequent failure in hardwood plantations.

SMALL KNOTTY CORES

Knots are the most common defect limiting the size of clear cuttings in factory lumber, and the usefulness of hardwood. veneers. Knots, regardless of size, character, and condition, are not admitted. in clear cuttings or in first-grade veneers (Lockhard, et. al. 1950; Henley et al. 1963). Although we have not learned. to grow hardwoods without buds and branches, we can confine them to a small core in the butt log.

Knots outside the central core of butt logs are rarely caused by crown branches. The crown branches on the lower 17 feet of most hardwoods normally die and fall off at an early age. But new branches develop from suppressed. buds that originate from apical meristems. These buds are suppressed by chemicals formed. in the crown and may be released. to expand. into branches by environmental changes such as thinning and pruning (Brinkman 1955; Krajicek 1959). Each year suppressed buds grow an amount equal to the radial growth of the stem and. are thus maintained just outside the cambium. In young trees suppressed buds form small branches that persist for varying lengths of time but rarely for more than 15 to 20 years. As trees grow in diameter the number of suppressed. buds in the butt log decreases (fig. 2). The buds die earlier and. epicormic branches are smaller on dominant trees in dense stands than in thin stands (Ward 1964). It is often suggested. that stands be kept dense to kill these buds and branches. But this practice limits diameter growth.

Since practically all epicormic branches form from suppressed. buds, epicormic branching can be prevented by killing these buds. As soon as the lower one-third. of the tree is tall enough to form the core of a butt log (Holsoe 1947), buds and branches on this section should, be killed. (Boyce 1962).

Certain oils and other chemicals kill suppressed buds but practical methods for controlling the concentration and making efficient applications have not been developed (Boyce and Neebe 1963).

Mechanical removal of suppressed buds is possible because the meristem projects into

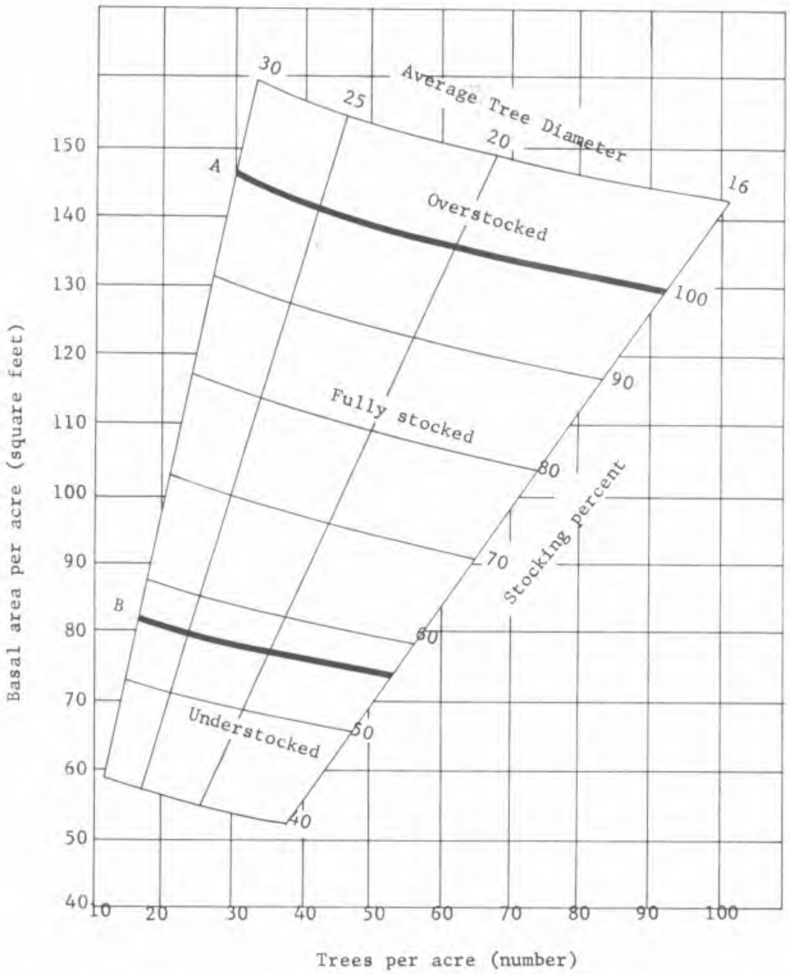

Figure 4 -- An extension of Gingrich's stocking guide for trees 16 to 30 inches d.b.h. Below the B-line crowns are independent of each other and diameter growth is maximum. Between the B- and A-lines crown growing space is fully used and diameter growth decreases with increased stocking. Above the A-line mortality is high and yield per acre is reduced.

the bark. We have experimentally demonstrated. that shaving the dead. bark off with a draw knife will kill suppressed. buds on white oak and. black walnut stems. But, an efficient and. practical mechanical tool has yet to be developed.

Repeated. pruning of branches is still the most effective and. practical way to eliminate suppressed. buds. Each epicormic branch has a ring of suppressed buds at its base and sometimes there are adjacent bud. clusters. When the branch is pruned, the adjacent suppressed. buds can be removed. by scraping the saw blade over this part of the tree stem. The first pruning releases additional buds and sometimes results in as many branches as before pruning. The second. and. third. prunings reduce the number of hew branches and repeated removal of epicormic branches and their associated buds will further reduce the number of new branches. The number of prunings required. depends on the diameter of the tree and the density of the stand_ At low stand. densities fewer prunings are required. because more buds grow into branches. And, fewer prunings are required. for trees larger than 8 inches d.b.h. (fig. 2). Three prunings of 120 white oaks less than 5 inches d.b.h. reduced. the number of new branches (fig. 3).

It is improbable that all suppressed buds and epicormic branches can be eliminated. But, to increase the proportion of top-grade lumber and. veneer, the number of grading defects on the butt log must be reduced to less than eight and preferably to less than three (Boyce and. Schroeder 1963).

CYLINDRICAL STEMS WITH STEADY GROWTH

The shape and, diameter of the stem, the structure of the wood, and the growth rate are all related to the physiological activities in the tree crown. The rate of stem diameter growth is related. to crown expansion (Kozlowski 1962; Thimann 1958; and. others); the stem diameter is directly related to the crown diameter, and asymmetric crowns result in asymmetric annual rings (Sorensen and Wilson 1964). Therefore, steady growth of approximately cylindrical logs requires trees with symmetrical crowns centered and. balanced. over vertical, straight stems and. provided. with growing space continually increasing at the rate required. to produce the desired ring widths.

This is possible. Krajicek, Brinkman, and. Gingrich (1961) found. a very high correlation between the d.b.h. and. crown diameter of open-grown hardwoods. This relation was used. to develop a simple stocking guide for even-aged. hardwood stands and. plantations (Gingrich 1965). An extension of this guide is shown in figure 4 for trees 16 to 30 inches d.b.h. At the B-level of stocking the crowns begin to compete for space. As the stocking continues to increase the annual rings begin to narrow and crowns become asymmetric as spacing becomes uneven. The higher the percent stocking above the B-line, the slower the diameter growth and the longer the rotation. To grow the maximum volume on the shortest rotation the stocking percent should be kept near the B-line (Roach 1965).

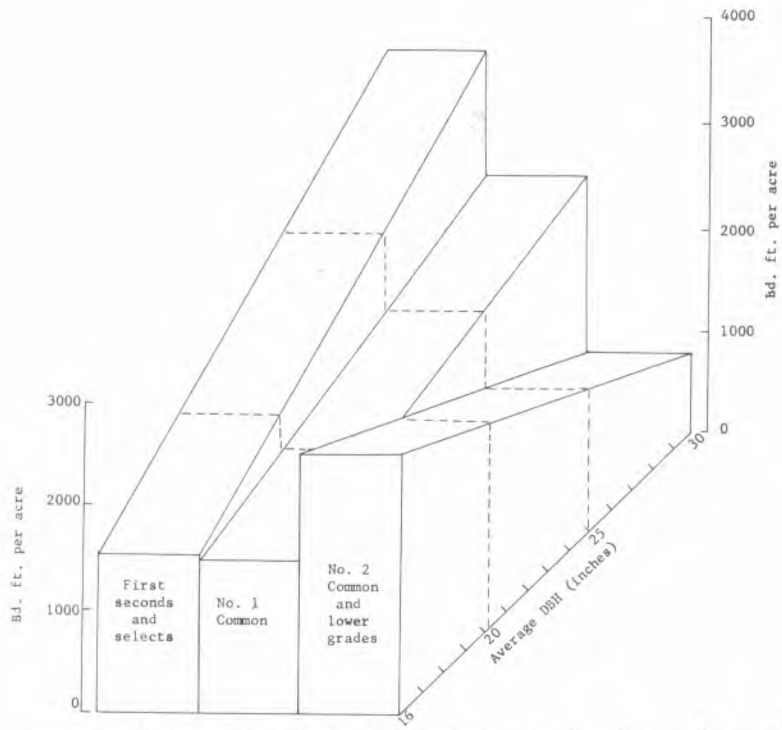

Figure 5 -- Open-grown, 1-log hardwood trees can produce large volumes of first-grade lumber and veneer. This diagram shows the expected recovery of Factory Grade lumber per acre for grade 1 butt logs from open-grown black oak trees when at the B-level of stocking. The number of trees per acre of the various diameters can be read from the chart in figure 4.

But, to grow the largest log of top-grade wood in the shortest time the stocking percent must be low enough for each crown to be independent of every other crown. This occurs below the B-line. This may reduce total yield. per acre but, in conjunction with the other concepts described. here, it produces the largest proportion of recoverable FAS and. Select grades of lumber and veneer. During most of the rotationstands should be kept at 40- to 50-percent stocking. Near the time for harvesting the stocking may be permitted. to approach or exceed. the B-level. Figure 5 shows the expected. recovery of Factory Grade lumber per acre from grade 1 butt logs of open-grown black oak at the B-level of stocking. Total yield is 5,600 to 6,800 board. feet per acre but, most important, the proportion of high-grade lumber is from 28 to 54 percent. In trees larger than 16 inches d.b.h. the volumes of FAS and Select grades of lumber increase and grades below No. 1 Common decrease. Similar relationships occur for other eastern hardwoods.

GENETIC IMPROVEMENT

The most important genetic quality for increased. utilization of hardwoods is adaptation to the environment (Limstrom 1965). Since the rate of physiological processes is influenced. by environment, useful trees must be adjusted. to their surroundings. Trees must have the inherent potential both to efficiently use the energy and materials of the environment for growth and to tolerate environmental extremes without serious losses in growth and wood usefulness. The protection of investments in intensive cultivation requires trees inherently capable of surviving unusual droughts, ice and wind storms, late frosts, and similar climatic extremes. Intensive culture for top-grade wood requires trees inherently capable of growing in nurseries, recovering from planting damages, efficiently using large growing spaces and abundant nutrients, and. responding favorably to other cultural practices. Examples can be cited of varieties of many wild. and cultivated, plants that are superior in yield. and. quality because of their generally more efficient physiological processes (Allard 1960; and. others). The major problem of the tree geneticist is to find. strains to fit a given environment. In fact, all other genetic modifications must be made within the limitations of environmental adaptation. We are now devoting a large part of our genetics research to finding and. developing strains and. clones of black walnut best fitted. to various environments.

It also may be possible to breed and. select stains and. clones of most hardwoods with the inherent potential for forming straight, vertical stems. This feature is inherited in the genus Populus and our observations of oak, yellow-poplar, and walnut suggest that it may also be inherited. in this species. These qualities are so important for increased. utilization that we can devote much genetics research toward. this goal. We do not have these inherently straight strains and clones now but we do have geneticists working on the problem.

Selection and breeding programs also should aim to develop races of hardwoods that inherently form four or less knots outside a small core of the butt log when 16 inches d.b.h. (Boyce and. Schroeder 1963). These are superior phenotypes that should, be evaluated. for their ability to transmit genes for few epicormic branches. Those with proven ability can then be used in breeding and selection programs.

Since suppressed. buds are a part of the inherently controlled developmental process of trees, it may be possible to find. genotypes that do not retain or form suppressed. buds. For millions of years oaks and. other hardwood. seedlings that retained suppressed. buds had. the best chances for sprouting and surviving after fire, browsing, freezing, and other injuries. This selective pressure is reduced. in nurseries and plantations and. these are the best places to look for trees without suppressed. buds. But, to date, we have not found an oak, yellow-poplar, or walnut that does not form and retain suppressed. buds. Our search continues.

ONE-LOG SILVICULTURE

Intensive culture of hardwoods for maximum utilization implies the growth of one-log trees with straight, vertical stems made up of small knotty cores encased in thick cylinders of uniform wood_ The method. is to plant inherently superior hardwoods on soils with the best physical properties; eliminate weeds and. brush; fertilize nutrient-deficient soils; protect trees from diseases, insects, and fire; irrigate when needed.; repeatedly prune the butt log; and maintain stocking at 50 percent or less. Retired. but fertile farmland is ideal for this system. Soybeans and, other crops can be grown for several years between the widely spaced. rows of trees. The Central States Forest Experiment Station is currently developing this system for the production of large volumes of high-quality walnut.

I have presented. a group of model concepts. Economic considerations rarely permit investment in this sort of biological perfection; practices must be fitted. to economic and, physical limitations. However, a cultural system based. on these concepts but subject to other limitations can be devised now to improve hardwoods for increased. utilization. Later, when better strains and clones are developed, they can be incorporated. into the system.

Literature Cited

Allard, R. W. 1960. Principles of plant breeding. 485 pp., illus. New York: John Wiley and Sons.

Bey, C. F. 1964. Advance oak reproduction grows fast after clearcutting. Jour. Forestry 62: 339-340.

Boyce, S. G. 1962. Selecting white oaks as parent stock for growing high-quality logs. Cent. States Forest Tree Impr. Conf. Proc. 3: 15-18.

and Neebe, D.J. 1963. Reduce the sprouting of pruned. white oak trees with motor oil. U.S. Forest Serv. Res. Paper CS-3, 9 pp., illus. Cent. States Forest Expt. Sta., Columbus, Ohio.

________ and Schroeder, J. G. 1963. Evaluating the benefit of defect reduction in hardwood logs. Forest Sci. 9: 315-322.

________ and. Kaeiser, Margaret. 1964. Improve wood. quality in eastern cottonwood. by breeding and selecting for straight, vertical stems. South. Lumberman 209 (2609): 115-118, illus.

Brinkman, Kenneth A. 1955. Epicormic branching on oaks in sprout stands. U. S. Forest Serv. Cent. States Forest Expt. Sta. Tech. Paper 146, 8 pp.

Davis, E.M. 1962. Machining and. related. characteristics of United. States hardwoods. U. S. Dept. Agr. Forest Serv. Tech. Bul. 1267, 68 pp., illus.

Gingrich, S. F. 1965. Criteria for measuring stocking in forest stands. Soc. Amer. Foresters Proc. 1964% 198-201.

Henley, J. W., Woodfin, R.O., and. Haskell, H. H. 1963. Recommended. veneer grades for the development of hardwood, log grades. U.S. Forest Serv. Res. Paper FPL 9, 12 pp., illus. Forest Prod_ Lab., Madison, Wis.

Holsoe, T. 1947. The relation of tree development to the timing of the first thinning in even-aged. hardwood. stands. Harvard. Forest Papers 1(2): 20-25.

Kozlowski, T.T. (Editor) 1962. Tree growth. 442 pp., illus. New York: The Ronald. Press Co.

Krajicek, John E. 1959. Epicormic Branching in even-aged, undisturbed white oak stands. Jour. Forestry 57: 372-373.

________ Brinkman, K. A., and Gingrich, S. F. 1961. Crown competition--a measure of density Forest Sci. 7: 35-42, illus.

Limstrom, G. A. 1965. Interim forest tree improvement guides for the Central States. U.S. Forest Serv. Res. Paper CS-12, 64pp., illus.Cent. States Forest Expt. Sta., Columbus, Ohio.

Lockhard, C. R., Putnam, J. A., and. Carpenter, R. D. 1950. Log defects in southern hardwoods. U.S. Dept. Agr. Handb. 4, 37 pp.

Roach, B.A. 1965. Growing and. perpetuating desirable hardwoods. Third. Ann. Governors Conf. Wood. Util. Proc. 1963: 60-67, illus.

Sorensen, R. W., and Wilson, B. F. 1964. The position of eccentric stem growth and. tension wood. in leaning red. oak trees. Harvard. Forest Papers 12, 10 pp., Illus.

Thimann, K. V. (Editor) 1958. The physiology of forest trees. 678 pp., illus. New York: The Ronald. Press Co.

U. S. Forest Service. 1965. Timber trends in the United. States. U.S. Dept. Agr. Forest Resource Rpt. 17, 235 pp., Illus.

Ward, W.W. 1964. Potential tree grade of young red. oaks growing in even-aged. stands. Forest Sci. 10: 321-329.

Wollin; A. C., Vaughn, C.L., Miller, R.H.P., and. Sweet, C. V. 1949. Hardwood log grades for standard lumber--proposals and results. U.S. Forest Prod_ Lab. Rpt. 1737, 63 pp. (Information reviewed. and, reaffirmed. October 1959. And. curved lumber grade-yields based. on these tables.)