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ADEQUATE OAK REGENERATION--A PROBLEM WITHOUT A SOLUTION?

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The current supply of oak (*Quercus* spp.) in eastern forests appears abundant. Knight and Hilmon (1978) report a 42 percent increase in total oak sawtimber between 1952 and 1977. In 1977, board-foot growth (Int. 1/4") was slightly less and cubic-foot growth slightly more than twice the amount of annual removals.

But the long term outlook for oak is not so bright. Researchers throughout the East are finding that many new hardwood stands contain much less oak than those now being harvested (Johnson and Krinard 1976, McGee and Hooper 1975, Sander 1977).

The Problem

Oaks will be most scarce on good sites (Sander 1977; Smith, Rosier, and Hammack 1976; Trimble 1973; Trimble and Hart 1961). The reasons are simple but basic--not enough oaks are becoming established, and those that do are not developing adequately. Oaks on poorer sites are usually good stump sprouters. Sprouts grow fast and are thus competitive, especially since on poor sites there are usually fewer fast growing trees for the oaks to compete against.

Natural establishment of oak seedlings varies by years from none to thousands per acre, partly because acorn production differs greatly from tree to tree and year to year. In the southern Appalachians, Beck (1977) found "bumper" crops produced every 4 years by white oak (*Quercus alba* L.) and every 5 years by northern red oak (*Quercus rubra* L.). Most forest-grown oaks probably do not produce seeds until they are 20 to 30 years old. Even during a fair crop year, most acorns are destroyed by insects, squirrels, chipmunks, mice, deer, and other animals. Birds take a terrific toll in some areas, both before and after acorns drop. In a recent test to determine why one upland stand in Pennsylvania had much more advanced reproduction than a similar one close by, Marquis, Eckert, and Roach (1976) found that the area with advanced reproduction had about five times as many viable acorns. They also found loss to rodents severe in the low-reproduction area and relatively unimportant in the high-reproduction area.

Germination of acorns in the spring begins whether seedbed conditions are suitable or not. For seedling establishment, surface soil must be moist enough to allow root penetration from acorns germinating above ground. Rainfall at the proper time thus becomes critical. Leaf litter reduces surface soil drying and can maintain a suitable seedbed longer than exposed soil. Acorns covered by leaves thus have a better chance to establish seedlings. The most consistent seedling establishment is from acorns below ground. Acorns can drop into small holes, or they can be buried by squirrels. Ongoing tests at Stoneville, Mississippi, have shown fair germination from acorns buried 4 inches deep.1/

Oak seedlings can start in full shade, but to survive they require some direct sunlight. Although variable among oak species and sites, seedlings in full shade usually die within 5 to 10 years. A minimum of 2 hours daily sunlight may be required to keep Nuttall oak alive (Johnson 1975). Other oak species may have similar requirements. Nuttall oaks (*Quercus nuttallii* Palmer) with about 2 hours of daily sunlight grew only 2 feet in height over a 15-year period (Johnson 1975). Their height was still under the 4.5 feet considered minimal for oaks to compete when the overstory is removed (Sander 1972). Though the growing tip may die back on older, larger understory oaks, it is soon replaced with new growth. The process of die-back and resprouting may be repeated several times. So, understory oaks a foot or so tall may have root systems 30 years or older (Krajicek 1961, Merz and Boyce 1956).

Slow early growth of seedling oaks after release appears to be an even greater problem than their establishment (Beck 1970, Johnson 1975, Sander 1977). On good sites where several different tree species are present, stump and root sprouts of some species and very fast growing seedlings of others soon overtop the oak. Although the oaks may become suppressed, they appear to live longer in regeneration stands than they do under a canopy of larger trees. Also, they may be able to compete with much taller trees of other species if they have direct overhead sunlight (Johnson and Krinard 1976). Oliver (1978) reports that in mixed stands oaks have a lower rate of mortality than do associated species and that a few well-spaced oaks can simplify future stand management.

Possible Solutions

Natural Regeneration

The oak component in natural stands can be increased by either increasing the number of oak seedlings, increasing the height growth of oak reproduction, or controlling competition from other plants. There are no reliable techniques for increasing the number of seedlings, but a shelterwood cut perhaps 15 to 20 years ahead of the final harvest may help (Sander 1977). This time span should provide several opportunities for the natural establishment of good seedling stands. No one can yet say how successful this approach will be. For Nuttall oak in the Mississippi Delta, new seedlings were established in quantities of 100,000+ trees/acre at the beginning of one study. But, during the next 15 years, annual examinations under good seed trees showed only 2 years in which new seedlings were established and then in small quantities. In the same study, there were small openings that resembled those in a shelterwood. New seedlings started in the small openings at the same time and in about the same numbers. The real benefit of a shelterwood may well be in keeping seedlings alive.

Little research has been reported on techniques to prepare the seedbed for natural seeding. Scholz (1955) tried disking under seed trees and reported limited success. But after 5 years, the initial stocking advantage of disked plots was lost (Scholz 1959).

1/ Johnson, R. L. Direct seeding Nuttall oak in relation to environment, sowing depth, and stratification treatment. Study Plan FS-SO-1110-06, on file at Southern Hardwoods Laboratory, Stoneville, Miss. 1968.

Our best opportunity today for increasing the natural oak component is through proper handling of natural oak reproduction. To grow understory oaks to at least 4.5 feet tall and thus make them competitive, we should give oak seedlings some overhead light within 5 years. A light thinning or shelterwood cut should suffice. If a midstory of shade-tolerant species, such as *Carpinus* and *Ostrya*, is present, an opening in the overstory will not provide enough light for seedling oaks. So, the midstory must be cut or deadened.

If we cannot manipulate the overstory before harvest, surviving oaks probably will be too small to be competitive after harvest: therefore, we must reduce competition around the oak regeneration. The method most frequently tried has been precommercial thinning to release oaks from overtopping competitors (Lamson and Smith 1978, Smith 1977, Trimble 1974). Five-year results in 7- to 9-year-old stands have not been totally successful. Released trees have not grown any better in diameter or height than have unreleased trees. Also, Lamson and Smith (1978) reported that grapevines seriously damaged about one of four released trees in a 9-year-old stand of Appalachian hardwoods near Parsons, West Virginia. Thinning after the trees have emerged from the vines might be more successful (Johnson 1978).

Another way to reduce competition is controlled burning. Johnson (1974b) reports discouraging results from one test with a single low-intensity spring burn around 1-year-old oaks in Wisconsin. The temperature of 220°F or higher killed more than half the seedlings. Perhaps more importantly, the burn did not hold back competing ferns and shrubs. Sander (1977) sees fire as important in favoring the oak stands that we have today, but he does not recommend its use. Researchers are stepping up their work with fire, and perhaps someday it will become an important silvicultural tool.

A sampling system for evaluating advance oak reproduction on poorer upland sites has been developed (Sander, Johnson, and Watt 1976). Similar systems will probably be developed for most eastern stands, both upland and bottom land. In the interim though, experienced foresters can probably judge the adequacy of advanced oak regeneration. If advanced regeneration does not exist and establishing oak naturally would take too long, we need to establish oak artificially.

Artificial Regeneration

Direct seeding of oak has usually failed because of acorn pilferage by rodents. Mignery (1975), in a direct-seeding study on the Cumberland Plateau, found that without effective animal repellents well-anchored hardware cloth cylinders were the most effective method for oak establishment by direct seeding. Mignery concedes, however, that hardware screens cost too much to be practical. Scholz (1964) used wire screens to protect field-sown northern red oak acorns. After one year, there was 95 percent success in seedling establishment. But, he also had 81 percent success with unprotected acorns and concluded that the added benefit of using screens is probably not worth the extra cost. After evaluating 10-year results, he considered direct seeding a feasible method of regenerating northern red oak. In a more recent publication by Marquis, Eckert, and Roach (1976), direct seeding of northern red oak was felt to be an ineffective system unless repellents could be found.

The Southern Hardwoods Laboratory at Stoneville, Mississippi, has worked with direct seeding of cherrybark (*Quercus falcata* var. *pagodaefolia* Ell.), Shumard (*Quercus shumardii* Buckl.), and Nuttall oaks for several years. Methods of seed storage and stratification, timing of seeding, and seeding depth have been tested. The Forestry Sciences Laboratory at Starkville, Mississippi, has also worked with seed storage and stratification and has published recommendations for several southern oaks (Bonner 1978). Acorns sown 6 inches deep can germinate and produce seedlings, but best seedling establishment comes from acorns sown 1 to 2 inches deep. Deep sowing does not substantially reduce acorn depradation by rodents, but two ongoing studies at Stoneville indicate that sowing in larger forest clearings may. Both studies, one 10 years old and the other 8, involved completely cleared blocks of about 3 acres within the natural forest. One test was in the Mississippi Delta, the other in the silty uplands near Vicksburg, Mississippi. In the Delta study, rodents destroyed acorns sown in the understory and in small forest openings (40 by 90 feet), but they did little damage in the 3-acre blocks. The study area in the silty uplands, prepared similarly, produced similar results--little damage in a large, completely cleared opening. Fast growing seedlings and sprouts of other trees were present in both areas. But, in the Delta the problem of non-oak competition may have been reduced considerably by mowing a 5-foot swath between the 10-foot rows. Blocks were mowed once a year for the first 5 years and after the 10th year.

Planting is another alternative for increasing the proportion of oak. But, as with natural regeneration, planted trees must compete with other trees and herbaceous plants. To do so, seedlings must show rapid early growth or competitors must be held back. Experimental plantings of northern red oak from Tennessee north have been on upland sites and in recently clearcut areas. Results have been inconsistent, but about 50 percent survival and a foot of annual height growth after 5 to 10 years in the field are not uncommon (Hilt 1977, Loftis 1979). Spot weed-control around individual trees, top and root pruning at planting time, fertilization, and older and larger planting stock have all failed to produce a significant increase in early growth[2/] (Russell 1973). Johnson (1976) estimated that 11 northern red oak seedlings would have to be planted to have one "successful" tree after 8 years. A "successful" seedling was one that grew to 80 percent of the height expected from a northern red oak sprout on the same site. Ongoing research at Stoneville is aimed at improving early height through planting nursery-grown trees that are up to 3 years old, 10 to 15 feet tall, and 2 inches in diameter at the root collar. Trees were top and root pruned and planted in 9-inch diameter auger holes. Potential benefits are rapid early growth and a planting height beyond the range of deer. Marquis, Eckert, and Roach (1976) contend that deer browsing could cause complete failures in oak plantings in Pennsylvania.

Containerized planting of oak is just beginning, but the problems are similar to those encountered with other forms of oak regeneration. Johnson (1974a), in a preliminary test, found early growth rates of oak to be too slow to be competitive. He speculates that a larger container and a longer propagation period offer the best opportunities for increasing early growth of tubelings. Wendel (1979) has also gotten poor results from field plantings of oak tubelings.

Oak plantings with complete weed control have been successful in the bottom lands of the Midsouth and along the Atlantic Coast. Using straddle-cultivation and disking, weed control techniques developed for eastern cottonwood, researchers at Stoneville have established several successful oak plantings on plots ranging from 20 to 200 acres. Covering five different sites, plantings include five different southern red oaks and thousands of seedlings. Clearly, oak can be successfully planted. Best results are from seedlings >24 inches tall and at least 0.3-inch at the root collar. Patterns of growth are also becoming clearer. Oaks average only a foot or two of annual height growth the first 1 or 2 years in the field. Then, usually during the 3rd or 4th year, growth increases to about 3 or 4 feet per year.

2/ Wendel, G. W. Growth and survival of planted northern red oak seedlings in West Virginia. (Manuscript accepted for publication in South. J. Appl. For.)

This good growth continues until at least age 8, which is the limit of the Stoneville data. The slow growth during years 1 and 2 is no different from the growth exhibited by natural or direct seeded oaks, so transplant shock is not apparent. One species that seems to start growing fast right away is Shumard oak. Our tests with this species, however, are limited to a couple of locations.

Where quality oaks are removed from a site, they can be planted back with assurance. But plantings on old fields or in cleared areas where a species is not found can lead to problems. For example, we planted Nuttall, cherrybark, and water oak (*Quercus nigra* L.) on a moist, fertile bottom-land soil with a pH of 7.5, and all three species failed, presumably because they were unable to extract iron from the soil. On the same site, though, a planting of Shumard oak survived and is growing extremely well. In central Arkansas, we planted Nuttall, cherrybark, and water oak on a Coastal Plain soil with a pH of 5.2 and a phosphorus content of only 7 to 8 ppm. All three species had excellent survival and growth. Cherrybark and water oak had been growing in the general area, but not Nuttall, a species normally found in very low, wet areas. Our experience from this and other tests indicates that oaks normally found in areas inundated for extended periods can be successfully planted on higher, better drained soils, but the opposite is not true. Even lowland oaks can be killed by extended growing season inundation during the first year in the field. But, thereafter, they appear much more tolerant of standing water.

Planting combined with complete weed control is relatively dependable for increasing the oak component. But a recent article by Malac and Heeren (1979) states that oak plantings may cost $280.00/acre, with clearing the most expensive item. Their projections, based on a 36-year period of comparison, indicate that plantings of oak and three other species can produce at least 50 percent more volume at one-third the cost of growing hardwoods under a system of natural regeneration.

Is there a solution to increasing the oak component? For most situations there probably is. But costs and the time required to get the job done may not yet be attractive to many. Research is continuing, though, over a wide area, and the more we learn about the problem, the more likely we will be able to find simpler, less expensive solutions.

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