SEEDING AND PLANTING UPLAND OAKS

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ABSTRACT. Upland oaks can be established by seeding or planting, but additional experience is needed before these methods become economical alternatives to natural regeneration. Recently forested sites are generally more favorable than abandoned fields. Lack of repellents to protect acorns from animals severely limits direct seeding, but oaks can be planted readily by conventional methods and will survive well on suitable sites. They require ample sunlight for best growth, and competing vegetation must be controlled. At best, however, early height growth is discouragingly slow. Advances in cultural methods and the development of genetically improved stock seem essential to make artificial regeneration practical.

ARTIFICIAL regeneration of upland oaks has never been widely practiced in the United States. A major reason is that natural regeneration is usually so abundant on cutover areas that there is little need for planting or seeding. In addition, oak planting and seeding have been fraught with difficulties. For a similar effort, and with less risk, faster-growing and more valuable hardwoods can be established—yellow-poplar and black walnut, for example.

Although artificial regeneration may never be a primary means of establishing oak forests, it will be needed where cutover areas are poorly stocked, where natural regeneration fails, or when genetically superior stock is to be established. We have much to learn, however, before planting or direct seeding can be practical alternatives to natural regeneration.

Recently cutover forests generally offer the best prospects for oak seeding or planting. As we gain a better understanding of site requirements, abandoned fields suitable for oaks may be selected with more confidence.

CONTROL OF COMPETING VEGETATION

Planted or seeded oaks can survive for many years even where competition is intense enough to reduce growth drastically. For satisfactory development, however, the seedlings require ample light. Northern red oaks grow better in full sunlight than in partial shade, even during their first year from seed *(McGee 1968)*. On Tennessee's Cumberland Plateau, planted white oak and black oak seedlings have growth somewhat faster where all hardwoods were controlled

than under an overstory of 30 square feet of basal area per acre *(Russell and Rollins 1969)*. The ideal preplanting treatment for cutover lands is one that completely removes unwanted hardwoods and brush.

We lack precise information concerning the response of most species to cultural treatments, but it appears that mechanical site treatments, herbicides, or fire—alone and in various combinations—can be used effectively. Choice of method will depend on whether the site is forest or open land, and on the composition and density of existing vegetation. The essential point is that the methods of controlling competion are no different in principle than for other species.

On forested sites, dense understory vegetation is more detrimental than is a high overstory. Grasses and weeds are not initially a problem, although they invade good sites rapidly after existing hardwoods are deadened. As a minimum, unwanted species must be controlled until desirable oaks are established well enough to stay ahead of competition.

Herbicides are often considered to be the most practical way to prepare sites on steep slopes or rocky soil, or where planting areas are too small for efficient operation of heavy equipment. Mist-blowing with herbicides, after injection of overstory trees, is common procedure for initial control of understory hardwoods and shrubs. These treatments seldom give complete kill, and on better sites the slow-starting oaks may be suppressed within 3 or 4 years.

Mechanical clearing of woody vegetation may give more complete and longer-lasting control than chemical methods do. Disking or chopping should be potentially less damaging than methods such as blading, which may strip off considerable topsoil.

Follow-up weeding will be needed on most chemically prepared sites, and on some that have been mechanically prepared. In natural stands total release of sapling oaks has reduced height growth *(Allen and Marquis 1970)*. Thus, weeding should probably be limited to freeing only overtopped or severely crowded trees, and complete removal of all unwanted hardwoods should not be attempted.

Dense stands of broadleaf weeds or heavy sods on old fields must be eliminated. Here herbicides may be cheaper and more effective *(Erdmann 1967)* than treatments such as furrowing, plowing, and disking. After oaks have been planted, competition can be controlled by cultivating, mowing, or applying herbicides. Mulching controls weeds; but rabbits, attracted by the open area around seedlings, have severely damaged planted northern red oak *(Pruett 1959)*. Presumably, spot herbicide treatment or hoeing might create a similar hazard.

DIRECT SEEDING

Provided competition is controlled, the upland oaks can be established by planting either seedlings or acorns. Direct seeding is cheaper than planting, and the seedlings start life with normal root systems. Possibly more research has been done with direct seeding than with planting, but with less success. Considerable is known about seed handling, sowing methods, and season of sowing. The greatest obstacle is the lack of economical ways to protect acorns from animals.

Acorns are damaged by freezing, and their viability drops rapidly if they dry out *(Korstian 1927)*. Few surface-sown acorns produce seedlings, even where they are protected with screens *(Sluder 1965, Sluder et al. 1961)*. Sowing at depths of 1 to 2 inches usually is satisfactory.

Deep hardwood litter does not reduce germination, but may retard seedling emergence or lessen survival. In Iowa, establishment of four species of oaks was best where acorns were planted and litter was removed *(Krajicek 1960)*. Poorer catches on litter-covered seed spots resulted from losses to disease and insects, as well as somewhat heavier rodent depredations, rather than from any mechanical barrier to seedlings. On a cutover site in Tennessee, however, disking before sowing had no effect on white oak establishment *(Mignery 1962)*. Where hardwood litter is a problem, it can be eliminated easily by burning. Presowing mechanical treatments to control woody

competition will also reduce hardwood litter as a secondary benefit.

Neither burning, disking, plowing, nor furrowing had any important effects on northern red oak seeding on an old field in Ohio *(Plass 1952)*. If dense sods or weeds are treated in advance to control competion, additional seedbed preparation is probably not justified on such sites.

Acorns store best at low temperatures, under conditions that minimize moisture loss and provide oxygen for respiration. Since these conditions are equivalent to stratification, storage effectively overcomes dormancy in the red oaks. Cold storage at slightly above 32°F. retards sprouting and weevil activity better than storage in an outdoor soil pit. Acorns of the white oak group are nondormant but can be held safely over winter in cold storage.

The upland oaks can be seeded in fall or spring. Spring sowing is sometimes recommended to shorten the period of exposure to seed-eating animals—chiefly squirrels, chipmunks, and mice—but repeated trials have failed to show any consistent differences in animal pressures between seasons *(Nichols 1954, Sluder 1964, 1965)*. While predator populations may be higher in fall than in spring, alternate foods usually are more plentiful also.

On the Cumberland Plateau we have obtained good results by seeding white, black, and northern red oaks at various dates from October through May. Recently, unstratified northern red oak acorns, planted under screens in December, yielded a seed-spot stocking of 93 percent. For stratified seed of the same lot sown in April and July, seed-spot stocking averaged 70 and 93 percent. Season of sowing is apparently not critical where animal depredations are controlled.

Planting acorns as deeply as possible, consistent with good germination, helps reduce losses to small mammals. Though removal of hardwood litter over large areas has been recommended *(Nichols 1954)*, heavy damage to northern red oak acorns occurred on barren strip-mine spoil in central Pennsylvania *(Bramble and Sharp 1949)*. Plowing and disking to remove vegetative cover also failed to limit losses of northern red oak acorns on an old field in Indiana *(Crozier and Merritt 1964)*. Depredations by both mice and squirrels occurred at distances up to 93 feet from an adjacent hardwood forest. Even if animal pressures are lower towards the centers of large clearings, a considerable acreage around the edges may be lost.

Screens afford a high degree of protection but are too costly to be practical. Until repellents become available, planting remains the surer method of artificially regenerating oaks.

PLANTING

Conventional planting techniques have proved successful in several regions. On cleared forested sites in central Tennessee, first-year survival of white, black, and northern red oaks is usually better than 90 percent. In the southern Appalachians survival after 2 years averaged 94 percent for six northern red oak plantings spanning a range of site indexes from 76 to 98 feet at age 50 years *(Olson and Hooper 1968)*. Planted northern red oak has survived well also in the Lake States *(Arend and Scholz 1969, and Scholz 1964)*.

Establishing a stand should not be difficult on suitable sites. Excessive mortality most often results from planting stock that is of poor quality or has been carelessly handled and stored.

Though survival is usually good, rapid early growth of oaks cannot be expected. Even on the best sites, growth for 2 or 3 years after planting is seldom more than a few inches a year. Growth accelerates after seedlings become established and if they are kept free from overtopping woody competition or dense weeds. Northern red oak in central Tennessee, for example, generally averages about 1 foot per year from 5 through 10 years after planting.

Upland oaks are fairly hardy, and bare-rooted stock performs well under a wide range of conditions. Most planting is done with 1-0 seedlings; 2-0 stock is occasionally used. Size is a better measure of quality than age alone. Seedlings with stem diameters of $\frac{7}{32}$ inch at the groundline are pre-

ferred for planting of northern red and chestnut oaks in the Central States *(Limstrom 1963)*. The minimum size recommend is 5/32 inch.

Few studies have been made of the effect of morphological grade on field performance. In North Carolina, northern red oaks from 5/32 to 9/32 inch in rootcollar diameter grew better for 2 years after planting than those larger than 9/32 inch *(Olson and Hooper 1968)*, though they did not fully make up initial differences in height. In the Tennessee Valley, large northern red oak seedlings have grown considerably faster than bed-run seedlings *(Foster and Farmer 1970)*.

If they are to reach the desired size in 1 year, seedlings must be grown at a low density in the nursery. In a Tennessee nursery, 1-year-old northern red oak grown at a density of 12 per square foot averaged only 0.17 inch in diameter at the groundline and 9.4 inches in height *(Taft 1966)*. At a density of 4 per square foot, seedlings were 0.26 inch in diameter and 15.7 inches tall.

Roots and tops are often pruned to make packing and shipping cheaper. Preferably, seedlings should be root-pruned in the nursery before they become dormant. Top clipping is done when they are dormant. Seedlings can be field-pruned for ease in handling and planting if they were not pruned at the nursery. Cutting roots shorter than about 8 inches is unnecessary and may adversely affect initial survival or growth.

Seedlings should not be allowed to dry out, heat, or freeze during shipment or in storage. They can be kept safely in bales for about a week in a cool shaded place. They can be heeled in for longer periods, but should be planted before new leaves unfold. Refrigeration at about 36°F. is best for long-term storage *(Limstrom 1963)*. At Sewanee, cold storage has kept seedlings in good condition and dormant for at least 5 months.

Optimum planting dates will vary with the local climate. Seedlings planted in the fall or winter may be injured by frost-heaving, particularly on heavy soils or where all vegetation has been removed; hence spring planting is usually preferable. Where summer temperatures are moderate and rainfall is dependable, dormant seedlings can be planted well into the growing season *(Russell and Rollins 1969)*. On Tennessee's Cumberland Plateau, white and black oaks planted in August and September were shorter after 4 years than those planted at monthly intervals from April through July, but survival was good in all but the September plantings.

Whether machine or hand methods are chosen will depend primarily on the size of the planting area, its soils and topography, and the density of trees, brush, or logging debris. For ordinary nursery stock, and on most soils, bar-slit planting or machine planting is as good as the more expensive hole planting. Hole planting is necessary only for rocky sites or for very large seedlings. Regardless of planting method, seedlings should be set with the rootcollar slightly deeper than in the nursery.

The possible gains from planting container-grown hardwoods have aroused much interest. In one test, northern red oak grew better in paper tubes filled with peat potting mixture, and other containers that provided good aeration, than in paper tubes filled with soil *(White et al. 1970)*. Such methods may become more widely used when the techniques are perfected, particularly if they can markedly increase growth.

PLANTATION INJURIES

Insects seldom cause serious losses in young plantations. Animals are a greater problem. Severe and repeated browsing by deer and rabbits may reduce survival and growth considerably. Oaks are less palatable than many other woody plants, however, and are also vigorous sprouters, so that top-clipped seedlings soon recover from moderate damage. Mice and voles girdle seedlings near the groundline and have caused heavy mortality, particularly on old fields.

Deer and rabbit populations can at times be controlled by managed hunting. Repellents can be used *(Besser and Welch 1959, Hildreth and Brown 1955)*, but repeated applications may be needed since contact repellents do not protect new growth. Mice and voles can be controlled by poisoning.

Such direct measures are expensive, however, and are not justified unless severe losses are likely.

More extensive planting experience may reveal unanticipated problems. But oaks are no more susceptible to animal attack than most hardwoods, and the threat of damage to seedlings should not discourage planting where conditions are otherwise favorable.

OUTLOOK

The prevalent belief that oaks are difficult to plant or seed is not entirely justified. They can be established readily with ordinary nursery stock and standard planting techniques. They could easily be direct-seeded if dependable repellents were available.

The major limitation to planting is the slow initial growth. Some possibilities for speeding growth include improved planting stock, better methods of competition control, and fertilizers. That early growth can be increased substantially is indicated by a recent study in Tennessee. Here the use of selected stock and nitrogen fertilizer produced northern red oak saplings averaging over 6 feet in height 4 years after planting *(Foster and Farmer 1970)*. For the long term, genetic improvement may be the most promising way of getting oaks to grow at acceptable rates.

Improvements in any of these areas will help. For maximum gains we must learn how to apply effective cultural measures to high-quality seedlings that have the genetic capability for superior performance. Until this is done, artificial regeneration of the oaks will remain largely in the experimental stage.

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