Leopold Center
FOR SUSTAINABLE AGRICULTURE

COMPETITIVE GRANT REPORT
90-02

Oak regeneration response to thinning from below

Principal investigator
David W. Countryman

Co-investigators
Richard B. Hall
Richard C. Schultz
Carl W. Mize
Paul H. Wray
Forestry
Iowa State University

Budget
$25,202 for year one
$12,371 for year two
$13,550 for year three

Background

Most of the nation's productive forests are in nonindustrial, private ownership. To meet projected demands, timber harvests will need to increase on these lands. Iowa, which has 0.61 million hectares (ha) or approximately 1.5 million acres of commercial forestland, could benefit from capitalizing on this demand. However, the state's timber resource has been generally under-utilized. For example, Iowans have not harvested poletimber and low-grade sawlog materials from their woodlots because the market for such products has been lacking. Killing such trees to make room for better quality material involves costs that do not immediately increase net returns; thus, incentive to manage these woodlands has not been high.

In short, although farmers own two-thirds of Iowa's forest resource, they are not utilizing the full economic potential of these woodlands. Yet most wooded tracts are large enough (at least 20 ha, or about 50 acres) to help diversify farm enterprises by contributing periodic income from sawlog and veneer harvests. Management and thinning of these stands is needed to improve the regeneration, growth, and quality of the sawlog and veneer crop while producing a continuous supply of fuelwood as a source of on-farm energy and/or for sale to local industries.

Oaks are one of the highest value species in Iowa forests. Because oaks are intermediate in shade tolerance—northern red oak is less tolerant than white oak—leaving lower-quality trees in timber stands makes it nearly impossible to establish adequate oak regeneration for future harvests. Thus, as high-quality oaks are harvested or die, they are replaced with more shade-tolerant species such as sugar maple, American basswood, American elm, white ash, and black cherry.

The percentage of oak in a succeeding rotation is directly related to the amount of oak reproduction present before final harvesting takes place. While stump sprouts can be anticipated, oak's ability to sprout decreases with age. Only 30% of northern red oak stumps and no white oak stumps are expected to sprout after they reach 43.2 centimeters (17 inches) in diameter. Therefore, seedlings must be established to regenerate the new stand. This reproduction must be established over a period of time before the mature overstory trees are harvested ("overstory" refers to the portion of trees in a forest stand that form the upper canopy).

Environmental factors influence the ability of oak seedlings to develop on a specific site. When stands are disturbed during the 20 years before harvest, more sunlight reaches the forest floor. This additional sunlight has been positively correlated with the amount of oak regeneration. On the other hand, the amount of understory in stands has been negatively correlated with oak regeneration. By manipulating the timber stand to change the amount of understory, light, and moisture, it may be possible to keep an oak component in future stands.

The objective of this study was to evaluate various methods of regenerating oak—by removing all non-oak species from upland hardwood stands and then planting oak seed, planting unprotected or growth-tube protected seedlings, or allowing natural regeneration to produce the next generation of trees. Once the new seedlings are established, the overstory oaks will also be removed.

Approach and methods

This project was conducted at two study sites. The Iowa State University McNay Research Farm in Lucas County consists of approximately 809.4 ha, of which 64.8 are forested and 21.9 are in the Conservation Reserve Program, where an energy plantation is being established. Community leaders, farmers, agribusiness representatives, Extension personnel, and agricultural scientists cooperate at this site to investigate problems and demonstrate innovative approaches to agriculture. (One of the Leopold Center's first projects involved the purchase of equipment and installation of a biomass-f ired furnace and boiler to heat buildings and dry grain at the McNay Farm. This equipment and boiler allowed demonstration of on-farm use of renewable energy from woodlot and plantation production. A woodlot management plan was also developed that allowed further research into timber stand improvement that utilizes low-value material from woodlots as a renewable source.)

The other study site, Stephens State Forest, is managed by the Iowa Department of Natural Resources, Forestry Division. Located within 16 kilometers (10 miles) of the McNay Farm, it consists of 3,520 ha of timberland. A primary function of the area is to serve as an example of forest management. The soils and timber types constitute an opportunity to duplicate the study, provide a broader base for the research, and develop a second demonstration area.

During August 1990, square blocks, 46 meters (m) or 150 feet on each side, were laid out in each study area (see Fig. 1). Plots labeled uncut were left untreated to serve as controls. In the other plots, all non-oak trees greater than 2.5 cm (one inch) in diameter and 1.4 m (4.5 feet) above the ground were removed during winter 1990-1991. The stumps of these trees were treated with picloram to prevent resprouting. All treatments were randomly allocated. Blocks designated for herbicides were sprayed with glyphosate during August 1990 to kill all material less than the specified diameter and height.

The following information was recorded for all trees 10 cm or more at 1.4 m above the ground: species, dbh (diameter by height), merchantable height to 20-cm trunk diameter inside bark, and percent cull. The stands on the McNay and Stephens tracts had approximately the same average total basal areas and oak basal areas. The stand on the McNay Tract was a white oak stand containing other species producing only cordwood, while the Stephens Tract was a mixed white and red oak stand with other species producing some cordwood.

Investigators measured the weight of sample trees at harvest and collected samples of chipped material to determine green weight. Dry weight and moisture content were determined later in the laboratory. These samples were used to determine the average Btu/ha removed from the two study sites.

To compare regeneration techniques, during spring 1991, investigators randomly assigned one of four regeneration techniques—either natural regeneration, seeding, underplanting undercut seedlings, or underplanting seedlings that were not undercut—to each of four subplots that were established within each cut block (Fig. 1). In the middle of each regeneration treatment area, they marked small areas where they would later record the species, height, and caliper at ground level of each stem less than 10.0 cm, as well as the overstory basal area. Oak was recorded as planted or wildling. In the fall, data were recorded after growth had stopped.

Natural regeneration subplots were established; half of the subplot was disked and the other half was left undisturbed. Seeding subplots were established by hand-planting acorns on one-third of the seeding area, planting acorns with a tree planter on one-third of the seeding area, and scattering acorns over one-third of the seeding area and disking that area. In the hand-planted area, 100 acorns were planted in four rows spaced 0.6 m between acorns and 0.9 m between rows. In the seed-and-disc area, 100 acorns were scattered evenly over disked area. Red oak acorns were collected during fall 1990 and planted in spring 1991.

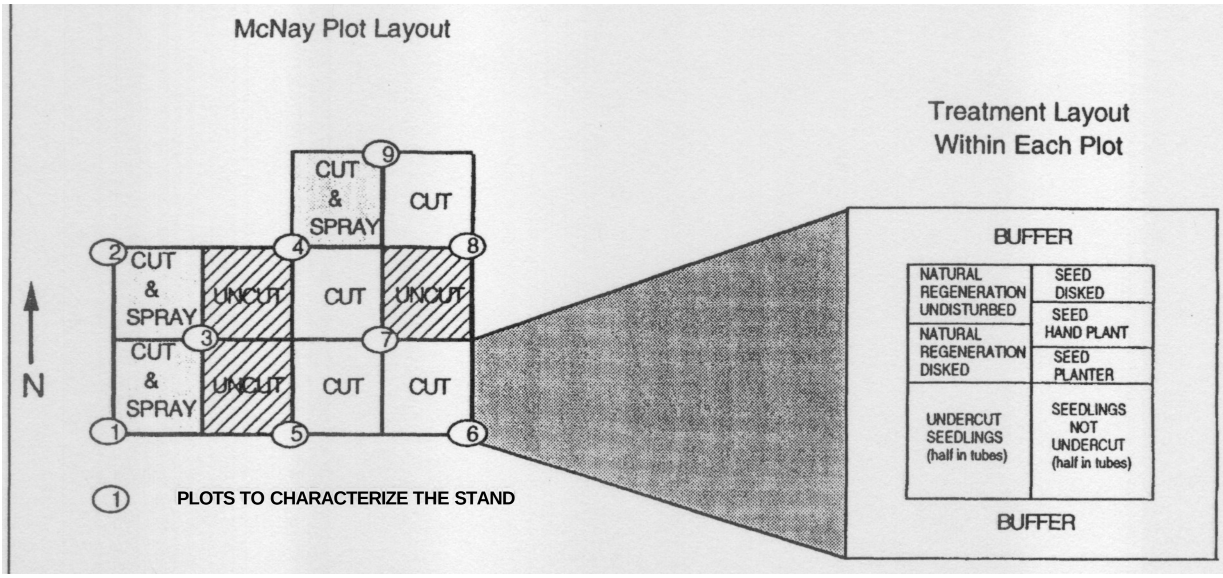

Fig. 1. Block treatment layout for McNay and treatment layout within each plot (Layout for Stephens was similar.)

In the undercut seedling area, 30 seedlings were planted in three rows of 10 seedlings per row at a spacing of 1.2 m between seedlings and 3 m between rows. Seedlings were graded by number of permanent first-order lateral roots. Ten seedlings of various root classes were planted in a randomly assigned row; half received growth tubes. Seedlings were tagged, numbered, and mapped. Growth was recorded annually.

In the area that was underplanted with seedlings that had not been undercut, the planting scheme was the same. Again, seedlings were graded by number of permanent first-order lateral roots, half received growth tubes, each was tagged, numbered, and mapped, and growth was recorded annually.

Findings

With some exceptions, McNay and Stephens data were combined when statistical analysis showed that location was not significant to oak regeneration. The regeneration techniques used to establish northern red oak seedlings from acorns on McNay and Stephens seemed to have little effect on the average height of the seedlings at the end of their first growing season.

The number of lateral roots and planting in growth tubes significantly affected the survival and average height of growth. In the underplanted seedlings that were planted with growth tubes, survival at the end of the first growing season was 95% for seedlings having 10 or more first-order, lateral roots greater than one mm. In general, seedlings protected by growth tubes had an average of 93% survival compared to 86% survival of seedlings without growth tubes.

Undercutting and spraying with herbicides prior to planting did not make a difference in survival. Initial seedling heights prior to planting were higher for those that had been undercut in the nursery. The greatest average height growth (7.5 cm) occurred among seedlings having 10 or more first-order lateral roots greater than one mm. Average height growth increased for seedlings that were not undercut and had five or more permanent, first-order lateral roots when compared to seedlings that were undercut. The opposite was true for seedlings having zero to four first-order lateral roots. Average growth height was also greatest among seedlings protected by growth tubes.

Competition—including number of competing tree seedlings and shrubs of other species, height of competing tree seedlings and shrubs of other species, and impact of the overstory—is an important factor in the success or failure of red oak seedling establishment. None of the regeneration techniques seemed to stimulate a large increase in the number of new competitors, although all the techniques had competing seedlings and shrubs with an average height greater than that of the red oak seedlings at the end of the first growing season.

Regeneration of oaks by seed planting in the fields had a lower percentage successful germination (2% to 16%) than seed planting in the greenhouse (82% to 84%). While planting acorns by hand appeared to result in a higher germination rate at McNay, it did not at Stephens. Hand planting provided the best control over planting depth compared to scattering seed and disking or using a tree planter to plant the seed. In disked areas, achieving good scarification of the ground was difficult because of difficulty in maneuvering machinery around stumps and trees in the areas. (Scarification, which theoretically improves the seed bed, surprisingly did not increase the number of completing seedlings.) Differences in germination success were attributed to differences in site predation and site preparation. The small plot size limited the amount of acorns that could be planted, which increased the impact of predation.

Tests indicated that overstory density had no major impact on growth or survival in the first growing season. Results did show that seedlings protected by growth tubes did better in height growth, which is attributable to the micro-environment growth tubes create. However, economic analyses indicate that growth tubes may not be economically feasible given that red oak regeneration can be accomplished in 10 to 20 years without using growth tubes.

Herbicide application reduced the amount of vegetation competing with red oak regeneration, although growth of the red oaks was not accelerated as a result. Nor did removing non-oak vegetation promote growth and development of either natural or underplanted northern red oak during the first growing season.

Implications

While Iowa farmers own two-thirds of the woodland resource, they are not deriving the full potential economic benefits that woodlands offer. These woodlands can contribute sustainable income and diversity to farm enterprises through periodic sawlog and veneer harvests while producing a continuous supply of fuelwood or chips from these stands. Because oaks are moderately intolerant to shade, leaving low quality trees in upland hardwood stands after oak harvesting makes it nearly impossible to perpetuate oak stands. The goal of this study was to identify methods to improve regeneration as well as the growth of the oak sawlog and veneer crop. With improved management practices, woodlands can be an economically viable part of Iowa's farming system.

For example, on-farm utilization of the chips produced could transfer dependence on heating energy derived from fossil fuel to on-farm timber resources. Iowa imports 98% of its energy; this costs between \$3.5 and \$4 billion each year. Rising fuel costs, dwindling fuel supplies, and growing environmental concerns underscore the importance of developing alternative, renewable energy resources. *Burning wood biomass can reduce Iowa's consumption of nonrenewable fossil fuels and help to keep the environment cleaner.*

While preliminary results are promising, future research needs to focus on monitoring these stands throughout the rest of the regeneration period, including their height, survival of the oak regeneration, and its competing woody vegetation at the end of five, 10, and 15 years. This way, investigators can determine whether the oak regeneration has made up a significant component of the future stand.

This project has generated a number of publications and presentations, both technical and popular. Demonstrations of this work will be held during field days conducted by Extension personnel at the McNay Research Farm. The project was also supported by Iowa State University and the Iowa Department of Natural Resources, who cooperated to establish the research field plots.

For more information contact D. W. Countryman, Forestry, Iowa State University, Ames, Iowa, 50011, (515) 294-7703.