# Regenerating Oaks in the Central States

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## ABSTRACT

Although oaks are the most abundant overstory species in many upland stands in the Central States, they are often replaced in the reproduction that follows harvesting of current oak stands because of the lack of adequate oak advance reproduction. Obtaining adequate oak regeneration is especially difficult on highly productive sites where understories are often well developed and dominated by shade-tolerant species. Recommended regeneration methods for these upland stands are based on an evaluation of the oak regeneration potential. Where the regeneration potential is low because oak reproduction is absent, sparse, or too small, stand treatments to enhance oak reproduction establishment and growth are described. Silvicultural treatments for individual stands will vary with site quality, competing species (especially fast-growing competitors such as yellow-poplar) and physiographic-ecological region.

## INTRODUCTION

In the Central United States, geologic history, physiography, and climate vary greatly and many different associations of soils, water, plants, and animals are present. Braun (1950) described the forest regions of Eastern North America using remnants of the "presettlement" forests. The Central United States includes parts of her Oak-Hickory, Western Mesophytic, Mixed Mesophytic, Oak-Pine, Oak-Chestnut, Beech-Maple, and Maple-Basswood forest regions (figure 1), each with its own distinctive characteristics but with wide variation of forest vegetation. Oaks have always been an important stand component in these regions and currently dominate most of the mature or nearly mature stands. Even so, the oak component of new stands following harvesting of many mature stands is often less than expected or desired.

It is generally accepted that a key to replacing these stands with new oak stands is having well-established oak advance reproduction in place when the final harvest is made. Sprouts from stumps of cut overstory trees are also important. It is now apparent that existing oak advance reproduction plus stump sprout potential is not adequate to replace many current oak stands, especially those on the most productive sites. How then do we ensure that when the stand is ready to harvest the oak advance reproduction will be adequate to replace it?

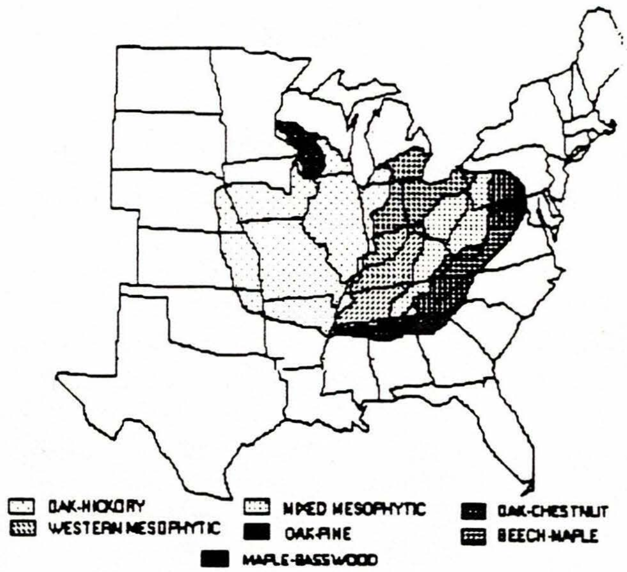


**Figure 1**—Area of central hardwoods with Braun's Forest Regions.

## EVALUATING OAK REGENERATION POTENTIAL

When planning regeneration harvest cuts in oak stands, the important first step is to evaluate the potential of the oak advance reproduction plus stump sprouts to replace the current stand. Oak advance reproduction differs greatly in number and size of individuals. Some of this difference can be attributed to site quality; in general, oak advance reproduction in the Central States is more abundant on average to poor sites than on good sites (table 1). Size of individual stems is important because growth after final harvest is related to both stem height and basal diameter. Thus, height and basal diameter are indicators of total plant size and the potential of the root systems to support vigorous growth after overstory removal.

Assessing oak regeneration potential involves making an inventory of advance reproduction and trees over 2 in. d.b.h. in the midstory and overstory. The advance reproduction data are used to determine the probability that a stem of a given size will attain a specified height by the time it is 5 years old. These probabilities are then adjusted to account for drop-out from mortality and suppression to age 20. Probabilities have been developed for the Ozark Forests in Missouri and are related not only to stem size, but also to aspect and slope position. For stems of equal height and basal diameter, the probabilities are highest on southeast- and northwest-facing middle slopes and lowest on lower, northeast slopes (Sander and others 1984). The coefficients in the regeneration potential equation apply specifically to Missouri and must be used cautiously in other areas.

The midstory and overstory inventory data are used to estimate the proportion of stump sprouts from cut trees that can reasonably be expected to produce dominant or codominant oaks at age 20. This estimate, together with the advance reproduction probabilities, is used to determine if the new stand can be expected to develop into a predominantly oak stand by age 20.

This evaluation procedure is for oaks only. The new stand will contain other species, but we do not have a procedure to estimate their contribution to future stand stocking. We can get a general idea of what the new stand composition might be by looking at the total composition of the advance reproduction and the composition of the overstory (table 1).

**Table 1**—Advance reproduction per acre on good and average sites in some Central States

| State | Oaks[1] | Hickory | Maples | Yellow poplar | White Ash | Other Trees[2] | Total Trees | Under-Story[3] | Total Stems |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Good Site* | | | | |
| Arkansas | 940 | 820 | 1420 | – | 430 | 1640 | – | 4420 | – |
| Indiana | 500 | 360 | 4350 | 40 | 1570 | 1000 | 7820 | 3570 | 11390 |
| Kentucky | 1460 | 610 | 1840 | 150 | 0 | 690 | 4750 | 2920 | 7670 |
| Missouri | 1430 | 640 | 380 | – | 0 | 420 | – | 2060 | – |
| Ohio | 1960 | 550 | 860 | 240 | 80 | 390 | 4080 | 3770 | 7850 |
| | | | | | *Average Site* | | | | |
| Arkansas | 1950 | 600 | 1960 | – | 460 | 1560 | – | 3370 | – |
| Indiana | 1580 | 100 | 1640 | 50 | 800 | 400 | 4570 | 5330 | 9900 |
| Kentucky | 1070 | 580 | 870 | 140 | 490 | 630 | 3780 | 1510 | 5290 |
| Missouri | 1510 | 514 | 329 | – | 0 | 440 | – | 1540 | – |
| Ohio | 3640 | 700 | 420 | 140 | 0 | 840 | 5740 | 7310 | 13050 |

[1] White, black, northern red; includes scarlet oak in Missouri and scarlet and chestnut oaks in Indiana, Kentucky and Ohio.
[2] Good Sites: Elm, blackgum, scattered black cherry and black walnut. Includes American beech in all states except Missouri. Also includes sweetgum in Arkansas. Average Sites: Primarily blackgum in all states.
[3] Good Sites: Primarily flowering dogwood, redbud, hazelnut, witch-hazel, paw-paw, and hophornbean. Includes sourwood in Kentucky and Ohio. Includes Carolina buckthorn in Arkansas. Average Sites: Primarily flowering dogwood, sassafras, and serviceberry. Includes sourwood in Kentucky and Ohio, Carolina buckthorn in Arkansas, and hawthorn in Missouri.

When yellow-poplar is an overstory component, its regeneration potential will be substantial. This potential exists because numerous yellow-poplar seedlings will appear, even after partial harvests, from the large quantity of viable seed in the litter and humus. The primary source of reproduction of species such as white ash, black cherry, hickories, maples, elm, blackgum, dogwood, sourwood, and sassafras is advance reproduction. Like the oaks, their growth after harvest is related to their pre-harvest size; relatively large advance reproduction stems have a higher potential for competing successfully than small ones. Stump sprouts are also an important source of regeneration for these species. Although we do not yet have a system for estimating success probabilities for species other than oaks, we can expect at least some of them to become a dominant component of the reproduction stand after harvest if they are present as relatively large advance reproduction.

## CHOOSING A REGENERATION METHOD

The choice of which regeneration method to use must be based on the outcome of the regeneration potential analysis, the basic ecology of the forest region in which the stand is located, and the overall management objective. On many sites in the areas east of the Mississippi River it is not realistic to expect to be able to naturally regenerate essentially pure oak stands even though the current stand is dominated by oak. The ecological trends due to effective wildfire control, and results of past regeneration efforts, indicate many future stands will be mixtures of a number of species especially on high-quality sites. An oak component can be retained readily on average sites, but on good sites the stands will most likely be dominated by species other than oaks.

If the oak reproduction potential is adequate to replace the current stand, clearcutting is the best method to use. Although understory species may appear to dominate the stand for about 10 years following clearcutting, the oaks and other overstory species begin to assert dominance, and by age 10-15 the understory species are generally in a subdominant position.

If oak reproduction potential is not adequate and the stand is clearcut, the new stand will be dominated by a varying mixture of species. With the exception of yellow-poplar, the species that dominate the advance reproduction will be predominant in the new stand. Yellow-poplar will also be abundant if it is present in the overstory, and some oaks will probably be present.

When oak advance reproduction is small, scarce, or absent, the regeneration method most likely to produce the best results is the shelterwood method. However, the method must be tailored to produce the micro-environments required by oaks for successful seedling establishment and early seedling growth. These micro-environments are still largely unknown and are likely to differ among differing ecological regions. For example, because of the differences in the basic ecology between the Mixed Mesophytic and the Oak-Hickory forest regions, what is required in one of these areas may not be required in the other.

In 1979, a study of the shelterwood method with overstory densities of 40, 50, and 60 percent stocking and three understory treatments that ranged from heavy (all non-oaks treated with herbicide) to none, was started in Missouri's Ozarks. At the time of treatment the number of oaks per acre varied from about 300 to 1,100 per acre on good sites (Black oak site index 75+) and from about 600 to 1,200 per acre on average sites (Black oak site index 60-75) (Sander 1987). However, a large majority of them were less than 1 ft. tall, much too small to compete if the stands were clearcut. Ten years after treatment the total number of oaks increased and ranged from about 600 to 1,800 and about 2,500 to 3,500 per acre on good and average sites respectively (figure 2), although the total number of oaks increased in all treatments at all overstory stocking levels.[1] Even so, when the advance reproduction evaluation criteria were applied to these plots, stocking values were less than one-half that required for successful oak regeneration on the good sites. Furthermore, about 50 percent of the large reproduction is understory species, primarily dogwood and sassafras. Maple, hickory, and blackgum account for an additional 15 to 25 percent of the large reproduction. Thus the oaks, particularly the smaller stems, are still at a competitive disadvantage.

On the average sites understory treatment had little effect on increasing the number of large oaks, but there were more large oaks on the 40 percent stocking plots than on the plots with higher stocking[1]. The advance reproduction stocking values are

[1] Schlesinger, R.C., Sander, I.L., and Davidson, K.R. 1992. Unpublished draft on file: North Central Forest Experiment Station, Columbia, MO.

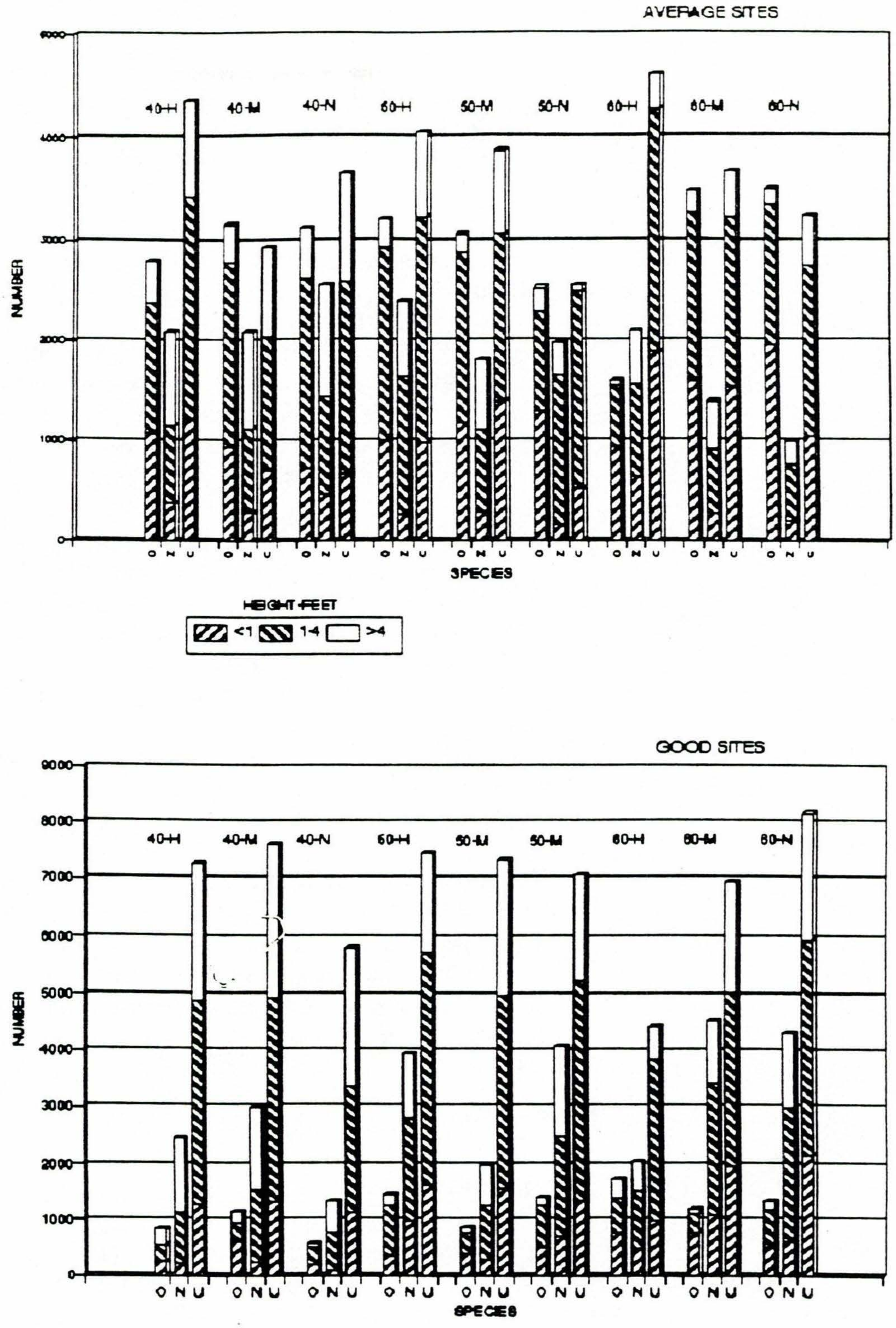


**Figure 2**—Reproduction per acre 10 years after shelterwood cutting in the Missouri Ozarks. Species: O—oaks, N—non-oak overstory species, U—Understory species. Treatments: Overstory—40-, 50-, and 60-percent stocking; Understory—H, Kill all non-oaks; M, Kill all non-oaks taller than 6 ft.; N, Kill nothing.

now close to those required for successful stand regeneration on the 40 percent stocking, but only about one-half to two-thirds of the required value on the higher density plots. The large reproduction is still dominated by hickory, black gum, sassafras, and dogwood. However, the large oaks appear to be at least holding their own and should in a few more years be adequate to replace the original stands.

Results from a similar study in southern Indiana show that all treatments failed to increase the number of oaks. There were few oaks present before treatment so a major objective was to get new oaks established. Two things occurred that precluded new oak seedling establishment. One was the lack of any acorn production the first 3 years after treatment, and the other was the very rapid regrowth of the understory. Nine years after treatment a major windstorm damaged nearly all of the plots and the study had to be abandoned. Although these early results are somewhat discouraging, they provide valuable information and insight for future research, and are useful for making immediate recommendations for using shelterwood cutting to regenerate oaks.

Interest in uneven-age regeneration methods, particularly the group selection system, has increased greatly in recent years. This interest has come about because of political and sociological pressures against clearcutting. Research on the effect of opening size on regeneration has demonstrated that oaks can be reproduced in small openings as well as in large ones (Minckler and Woerheide 1965, Sander and Clark 1971, Smith 1981). However, the requirements that apply to clearcutting also apply to group selection. Creating an opening, even a small one of one or two tree heights in diameter, will not in itself ensure oak reproduction. Oak advance reproduction of adequate size and in adequate numbers must be present where openings are created in order to achieve successful oak stand replacement.

We cannot, however, consider only the regeneration when we use group selection. Because it is a variation of the single-tree selection system, we must also strive to achieve and maintain a reasonably well-balanced diameter distribution. We have only begun to address the problem of how the reproduction in groups eventually contributes to overall future stand structure, and how to maintain balanced diameter distributions in oak stands has not been determined.

## REGENERATION GUIDELINES

The first step in planning for oak regeneration is to evaluate its regeneration potential. The results of this evaluation will determine which even-aged regeneration method should be used. Or, if group selection is planned, such an evaluation can help determine where to locate groups and can provide information on which species are reproducing and how the reproduction is growing.

### Even-Age Methods

**Clearcutting.** If the oak advance reproduction plus stump sprouting is adequate, clearcut.

When clearcutting:

1. Determine size of area to be designated as a stand. Stand size can vary but should be at least 2 acres. Stands smaller than this have a large proportion of their area in a zone around the stand border where reproduction growth will be slow

because of the influence of the surrounding trees. A stand should preferably be restricted to a single condition or size class of timber and site quality. Size of the forest property will also influence stand size. In areas where deer populations are high, stand size may need to be relatively large in order to reduce the impact of browsing on reproduction growth.

2. Arrange and shape clearcuts so they mingle with uncut stands and blend into the landscape as much as possible.

3. Plan, construct, and maintain skid trails and logging roads to minimize erosion.

4. Harvest all merchantable trees.

5. Cut or kill remaining culls and small trees larger than about 2 in. d.b.h. Killing the unwanted trees instead of cutting them reduces sprouting and provides snags for nesting holes and perches for birds. Cutting some of them will provide habitat for other wildlife species such as ruffed grouse.

6. There may be some other options for harvesting and getting rid of the unwanted and unmerchantable trees. These options are generally used for special purposes, such as to soften the aesthetic impact or provide special wildlife habitat. Their use depends on owner policy rather than silvicultural desirability.

If the clearcut stand is on southeast or northwest middle and upper slopes, we can expect to have a stand at about age 20 that can be molded into an essentially pure oak stand by thinning. On north and east aspects and lower slopes, the stand composition may be highly variable. In the mixed and western mesophytic forest regions, yellow-poplar will likely be abundant. Other species such as white ash, black cherry, and red and sugar maples will also be present. However, if the oak advance regeneration is adequate, we can expect to have a predominantly oak stand 20 years after clearcutting.

**Shelterwood.** When the regeneration potential of the existing oak advance reproduction is not adequate to replace the stand, use the shelterwood method. Oak advance reproduction is most likely to be inadequate on the middle and lower north- and east-facing slopes, where it will be difficult to obtain oak regeneration. Costs will be high because of the intensive site preparation needed on these high-quality sites.

When applying the shelterwood method:

1. Determine stand size, arrangement, and shape the same as for clearcutting.

2. Control the understory by cutting or preferably killing the non-oak species that will compete with the small oaks in the oak-hickory and oak-pine forest regions.

3. Reduce the overstory to 40-60 percent stocking. In the other forest regions, a somewhat higher stocked residual stand (70-80 percent stocking) might be desirable to inhibit yellow-poplar seed germination and rapid redevelopment of the understory. Leave the best dominant and codominant oaks as uniformly spaced as possible. Kill all stems of unwanted species.

4. If possible, apply the understory and overstory treatments before seedfall in a good seed year.

5. Monitor seedling establishment and growth and make additional light cuts to keep the overstory from restricting growth. Apply additional understory control if the understory redevelops to a point where it restricts the oak reproduction

growth. This control may be desirable 5-10 years after the original treatment, particularly on high-quality sites.

6. When the regeneration potential of the oak reproduction is adequate to replace the stand, remove the remaining overstory trees in one cut.

The length of time required to establish oaks and grow them to adequate size under a shelterwood is not yet known, but will probably be 10 to 20 years or more.

### Uneven-Age Methods

**Single-tree selection.** The establishment and development of oak regeneration is not possible using the single-tree selection system. Harvesting single trees to achieve and maintain a specific diameter distribution does not provide the microclimate needed for oak regeneration, but does provide the conditions needed for the establishment and growth of shade-tolerant species. Over time, single-tree selection will convert the stand from oaks to shade-tolerant species.

**Group selection.** This method can be used to reproduce oaks satisfactorily, but the diameter of the circular openings created should not exceed 1 to 2 times the height of the surrounding dominant trees in order to maintain the uneven-age character of the stand.

When applying group selection cutting:

1. Evaluate the potential of the oak advance reproduction to fill each opening (group) that will be created by cutting.
2. If the oak advance reproduction is adequate, harvest the merchantable trees in the group and cut or kill remaining culls and small trees as described under clearcutting. The reproduction response will be similar to the responses after clearcutting except that reproduction growth will be retarded in a large part of the opening area because of the influence of the surrounding stand.
3. If the oak advance reproduction is not adequate to fill the opening, cutting the trees to create the opening will not result in oak reproduction and the opening will be filled by whatever species are present in the understory. In this case, follow the procedure for the shelterwood method where the openings will be located. The percentage stocking goal may not be attainable in the small groups, so make sure seed-producing oaks are left where the groups will be located. Treat the understory as in the shelterwood system. Removing sub-canopy overstory trees and the understory competition may be all that is needed to increase the amount of light reaching the forest floor and enhance oak reproduction establishment and growth.
4. Cut trees also between the groups to maintain the selected diameter distribution and to enhance oak reproduction establishment and growth throughout the stand.
5. Group selection may not be successful in areas with high deer populations because of excessive browsing in the small openings.

## IN CONCLUSION

There is no guarantee that applying the above guidelines will regenerate oaks successfully in all situations. However, doing nothing in the current mature or nearly mature stands will not increase the chances of regenerating oaks. On high-quality sites in particular, regenerating oaks is a difficult task. In some parts of the Central States, particularly in the mixed and western mesophytic, Maple-Basswood, and Beech-Maple forest regions, regenerating essentially pure oak stands on high-quality sites may not be possible. However, oaks have always been components of stands in these forest regions on all sites and it is likely that oaks will at least be a component in future stands. In the Oak-Hickory and Oak-Pine forest regions, oak regeneration should not be difficult to obtain on average sites; however, on high-quality sites intensive treatments are probably going to be necessary.

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