REGENERATING OAKS WITH THE SHELTERWOOD SYSTEM

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It is well known that a new reproduction stand that follows complete overstory removal will contain oaks in proportion to the numbers and size of advance oak reproduction present before the overstory was removed. Furthermore, the individual advance oaks must be relatively large with well-established root systems before they will compete successfully and be dominant in the new stand. In oak stands that are now mature or nearly mature, surveys show oak advance reproduction may be inadequate to replace the stand for one of two reasons: (1) There are not enough oak reproduction stems; or (2) if there are enough, they are too small to grow fast enough to compete successfully in a new stand if the old stand is removed.

The shelterwood system appears to be ideally suited for use in regenerating oaks. But our experience with research shelterwood cuttings has been disappointing. These cuttings followed the classical description of the shelterwood system and generally combined the preparatory and seed cuts into one. These initial cuts removed about half of the stand basal area and contemplated final removal cuts 5 to 10 years later. In southeastern Ohio, we found 3,600 oaks per acre 2 years after the combined preparatory and seed cut; however, there were about as many oaks present before this cut was made.

Our experience in southern Indiana was similar; the removal cut was made 5 years after the seed and preparatory cut. At this time, there were only about 250 oaks per acre, and they averaged less than 4 feet tall, too small to compete effectively. Other species which averaged about 1 to 2 feet taller dominated the stand (Sander and Clark 1971).

In southern Michigan, Rudolph and Lemmien (1976) found about 3,400 oaks one year after the first cut of a shelterwood system that was made following a good acorn crop. Five years later there were about 1,100 oaks taller than 1 foot, but they averaged slightly less than 2 feet tall. There were also about 1,100 red maples that averaged 2 feet tall and about 1,400 sassafras, elm, white ash, and aspen that averaged just over 3 feet tall. The final removal cut was made 10 years after the initial cut. At this time seedling and sapling stems of sassafras, dogwood, and other unwanted species were basal sprayed with 2,4,5-T to reduce competition. The remaining reproduction was dominated by red maple, black cherry, and other species although there were about 500 white oaks that were about as tall. Eleven years later or 21 years after the initial cut there are only 127 oaks in the 1-7 inch dbh classes, and the stand is dominated by other species.

There are probably other examples, maybe even some successful ones, but in general it appears that the shelterwood system, as it has been applied, did not result in establishment of many new oak seedlings. The system also failed to provide for the continuing survival and growth of new oak seedlings until they were large enough to compete in the new stand after the final removal cut.

In spite of these results, the shelterwood system should be a viable means for regenerating oaks. We will have to learn how to use it and develop it specifically for establishing and developing oaks. Unfortunately, we do not have all of the information needed to design the system. However, I think we can do better than we have using the information that is available. First I think we will have to leave a shelterwood with a higher density than we have in the past when we make the preparatory and seed cut. Then we must be patient and nurture the oak reproduction until it is large enough to compete successfully in a new stand before we make the final removal cut.

Where there is not enough oak reproduction, new oak seedlings will have to be established. The basic requirements for good acorn germination were documented by Korstian in 1927 and have been verified by other direct seeding studies (Krajicek 1955 and Sluder et al. 1961). Best germination and first-year-seedling survival occur when the acorns are planted about 1 inch deep in the soil. Some litter covering does not inhibit germination, but rodents often consume the direct seeded acorns unless they are protected with a mechanical barrier.

We know very little about the seedbeds in which natural oak seedlings originate. It appears from our limited observations in Missouri that most 1-year-old oak seedlings come from acorns that are in the soil or at least in contact with the soil and covered by litter. How these acorns get planted is not known for certain, but squirrels and mice or voles surely are at least partially responsible.

A Missouri growth and yield study in 40-year-old black oak stands provided an opportunity to study the effects of stand density on establishment and growth of oak reproduction. We began the reproduction study 10 years after the growth study was started. In May, following a good black oak seed crop, we found more than 100,000 acorns per acre on the ground (Table 1). About 1% or less of these acorns were germinating and there was no relation to overstory density. By the following September, there were about 200-350 1-year-old

Table 1. Black oak acorns on the ground and germinating in May and number of seedlings in September, under four levels of overstory stocking.

Stocking percent	Acorns per acre: On ground	Acorns per acre: Germinating	1-year-old seedlings	Acorns per seedling
	Number	Percent	Number	Number
30	111,000	1.2	300	370
50	108,000	0.2	210	514
70	132,000	1.2	340	390
Unthinned	125,000	0.2	230	543

seedlings present per acre. Although these data are for a single year, indications are that a lot of acorns will be required to get a sufficient number of oak seedlings established.

Three years later, 40-60% of these seedlings had survived; best survival was under moderate overstory densities (Table 2). Regardless of overstory density, light intensity at the ground level, where these seedlings are struggling

Table 2. Survival of black oak seedlings 3 years after establishment under four levels of overstory stocking.

Stocking percent	Seedlings surviving		Light intensity[1]
	Number/acre	Percent	Percent
30	130	43	10
50	125	60	8
70	205	60	9
Unthinned	115	50	9

[1] Percent light at 8 inches above ground is of the light in a nearly open area, June 26-29, 1972.

Table 3. Reproduction per acre under thinned oak stands 10 years after the first thinning at age 40.

Species	Residual stocking percent			
	30	50	70	Unthinned
	Number			
Major oaks[1]				
Under 1 foot	565	445	710	400
Under 4 feet	920	775	965	610
Over 4 feet	285	175	305	165
Other trees[2]				
Under 1 foot	470	690	490	320
Under 4 feet	1,200	1,450	1,065	970
Over 4 feet	485	340	300	275
Understory species[3]				
Under 1 foot	1,375	1,385	1,145	780
Under 4 feet	2,760	2,560	1,975	1,390
Over 4 feet	1,070	945	200	185
Total				
Under 1 foot	2,410	2,520	2,345	1,500
Under 4 feet	4,880	4,785	4,005	2,970
Over 4 feet	1,840	1,460	805	625
Stump sprouts[4]	270	180	130	0

[1] White, black, northern red, and scarlet oaks.
[2] Post and blackjack oaks, hickories, black gum, and red maple.
[3] Dogwood, sassafras, serviceberry, witch hazel, and hazelnut.
[4] Sprouts from stumps of trees cut in thinning.

to exist, was 10% or less of the intensity in a nearby open area. This is not enough light for oaks to survive and grow. A dense understory had developed on the lightly-stocked plots, a situation similar to our previous shelterwood cuts, and this understory allowed no more light to reach the ground than the overstory on the unthinned plots.

Although there are more than enough stems of the major oak species present under all density levels to replace the stands in this Missouri study, about two-thirds or more of them are less than 4 feet tall (Table 3). Furthermore, most of these are less than 1 foot tall. Species other than oak dominate the reproduction under all density levels. Unless given some help, these small oaks will probably not survive much longer.

Under the conditions existing at all density levels, the newly established black oak seedlings did not grow. At age 3 and 4 they were no taller than they were at age 1 (Table 4).

The oak sprout reproduction averaged about 4 feet or less in height 10 years after the original thinning (Table 5). Four years later it had grown very

Table 4. Average height in feet of black oak seedlings established in 1971 and 1972 under four levels of overstory stocking.

Age	Stocking percent 30	50	70	Unthinned
1971 seedlings				
1	0.3	0.4	0.3	0.4
2	0.3	0.4	0.3	0.4
4	0.3	0.4	0.4	0.4
1972 seedlings				
1	0.3	0.3	0.3	0.3
3	0.3	0.3	0.3	0.3

Table 5. Average height of sprout oak reproduction under oak stands 10 and 14 years after first thinning at age 40.

Species	Residual stocking percent and years since thinning: 30		50		70		Unthinned	
	10	14	10	14	10	14	10	14
				Feet				
White oak	3.8	4.0	3.5	3.7	4.3	4.2	3.0	2.9
Black oak	2.4	2.5	1.8	1.9	0.9	0.6	0.3	0.2
Northern red oak	3.9	3.2	2.4	2.6	0.9	0.8	—	—
Scarlet oak	2.8	4.2	—	—	2.0	2.2	—	—

little; on the higher density plots, the average height of these oaks had even decreased slightly.

Although limited, these data indicate how a shelterwood system for reproducing oaks might work. New seedling establishment will depend on the occurrence and size of acorn crops. How long it might take to get a sufficient number established is uncertain. It depends to some extent on how many seedlings are needed. On the average, we might expect 5-10 years. Some type of seedbed preparation might be helpful, but it would have to be timed to coincide with a good seed crop. Our experience with site preparation has been that although more oak seedlings were initially established on sites prepared by disking than on unprepared sites, a few years later there were about the same number of seedlings on both sites (Sander and Clark 1972 and Scholz 1959). In these studies, however, we attempted nothing more to ensure oak seedling survival.

Most critical will be maintaining conditions that will allow a larger proportion of new oak seedlings and other small oaks to grow more quickly to the size necessary for them to be competitive in a new stand following the final removal cut.

The light intensity at which oak seedlings reach their maximum photosynthetic rates is about 30% of full light. In Missouri, this light intensity is attained at ground level at about 40% overstory stocking and no understory (Figure 1). Experience tells us, however, that at this overstory density, all species in the understory will develop rapidly especially if the understory contains many stems over 4-6 feet tall. And, simply reducing overstory density will not ensure that light intensity at the ground will be adequate for oak seedling growth. So, an effective shelterwood system must not only reduce overstory density, but also control the understory to achieve adequate light at ground level.

In our mature or nearly mature oak stands, I think the first cut of a shelterwood system should reduce overstory density to not less than 60% stocking, according to Gingrich's (1967) stocking criteria for upland central hardwoods. Although light intensity at this overstory density is not optimum, it should be sufficient for the oak advance reproduction to survive and grow. This density is also the minimum required for full site utilization and will inhibit rapid development of other species in the understory. The first trees removed in this cut should be those in the lower crown classes. Crown coverage of the residual stand should be as uniform as possible with no large holes in the overstory canopy.

If there is an understory present, it will most likely have to be controlled or at least have its density reduced, particularly if it is already well-developed. The answers to the questions, "How dense is too dense, or how much control is necessary?" are not known. However, we must at least remove the understory stems that are larger than the oaks they are competing with. The most effective and economical way to do this may be with herbicides, but to avoid damaging existing oaks a selective stem treatment or cut surface treatment will probably be necessary. Prescribed burning may be a viable option, but we need to learn more about how the various understory species and reproduction size classes react to fire before it can be recommended for wide-scale use. We must also know if and how fire can be used without unduly damaging the overstory trees.

How long a period might be required to grow the oak reproduction to the minimum size needed is uncertain. Observations of the advance reproduction under unmanaged stands indicate that 15-25 years are needed. With intensive application of the shelterwood system, however, we should be able to shorten this time, hopefully to not more than 10 years. During this period an additional cut might be needed to maintain a crown cover that will not unduly restrict growth of the oak reproduction. At what point this cut might be needed, or the best residual density it should leave, are not known. However, it seems reasonable to let the stocking percent increase to about 75 or 80% before making another cut. It also seems reasonable to reduce the overstory stocking

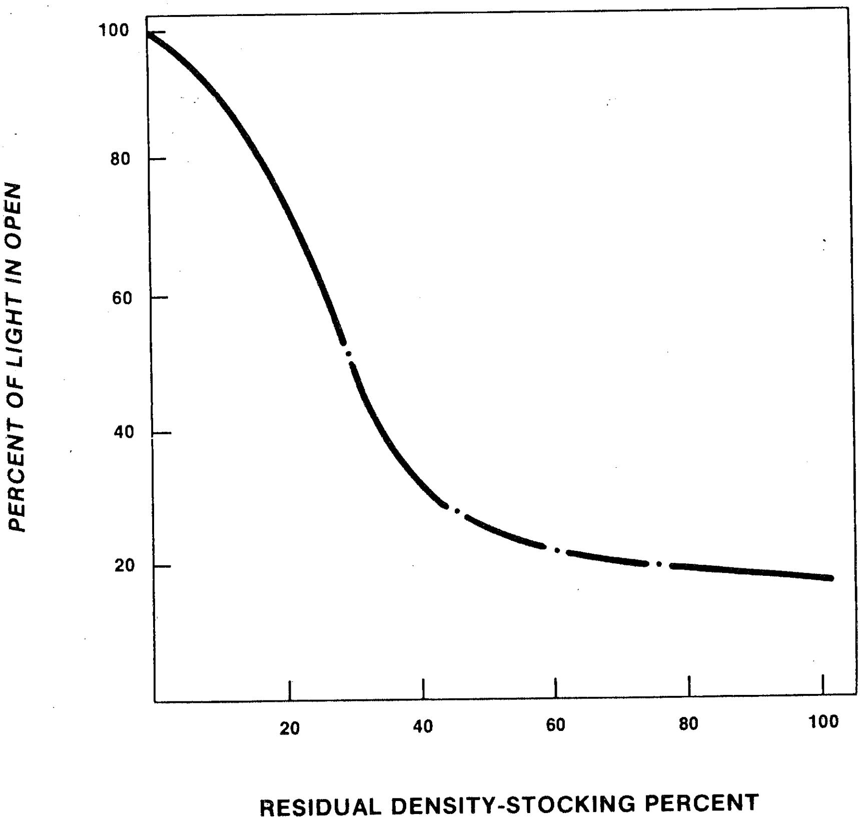

Figure 1. Relation between residual overstory density and light intensity 8 inches above the ground.

to about 50% when the oaks average about 3 feet tall. Further control of unwanted species in the reproduction may also be needed. When there are at least 435 oaks 4.5 feet tall or taller present, the remaining overstory should be removed in one final cut.

An alternative to depending on natural establishment of oak seedlings is to underplant them, especially where a particular oak species is wanted but no seed source is present. The planted seedlings would have to develop under a shelterwood the same as natural reproduction. We have a study in progress now to determine if this will work, but it is only one year old, and we have no results yet.

Until we obtain the information needed to refine the shelterwood system, our approach should be cautious. We are currently working on a study to get this information, but it will likely be several years before we have the data to establish trends. I think successful application of the shelterwood system to regenerate oaks will require all of the silvicultural expertise we can muster. It will be intensive silviculture of the highest order.

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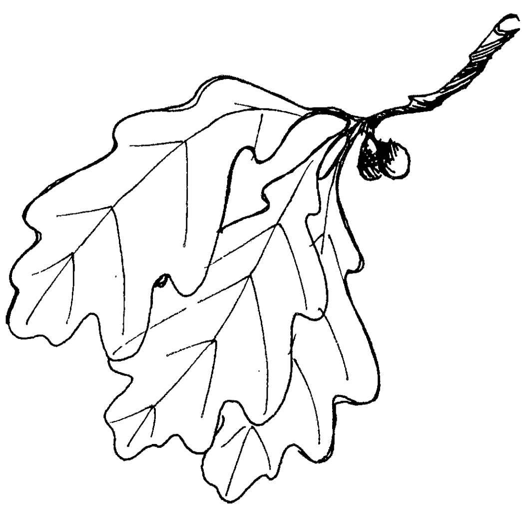

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