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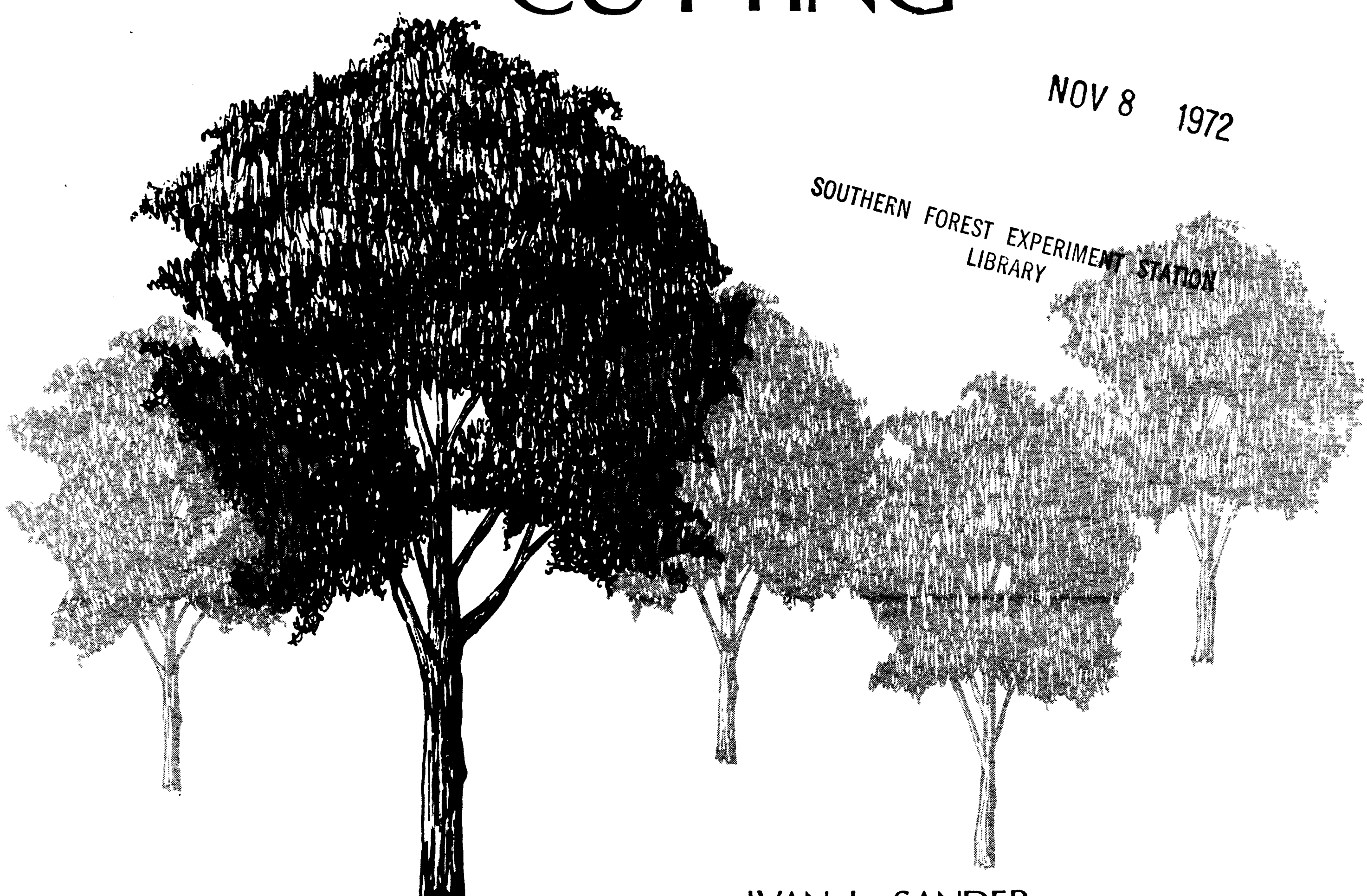

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Size of Oak Advance Reproduction: Key to Growth Following Harvest Cutting

Ivan L. Sander

When a mature upland oak stand is harvested, the oaks in the new stand come from advance reproduction already present on the area. Some oak reproduction is present under most mature stands over the commercial range of oak species. However, the amount varies greatly from stand to stand, and ranges from almost nothing to thousands of stems per acre (Minckler and Jensen 1959, Trimble and Hart 1961, Arend and Scholz 1969). The oak component of newly regenerated stands is sometimes inadequate even when oak advance reproduction is abundant, because it fails to grow fast enough to compete successfully. Thus, numbers alone do not indicate how many oaks will become dominant in the new stand.

An Ohio study showed the size of the advance reproduction to be an important determinant of new oak sprout growth following clearcutting (Sander 1971). In this study the old stems were cut off near the ground to force them to sprout. Growth of the new sprouts was related to the diameter of the old stem at the ground line; the larger the old stem cut off, the faster the sprout that originated from its stump grew.

These results have been confirmed by a study in southern Illinois reported here. This study shows that oak reproduction growth following overstory treatment depends on size of the reproduction before cutting, whether or not an advance reproduction stem was cut or broken off during logging, and the amount of overstory left after cutting.

THE STUDY

The study consisted of two blocks, each containing three overstory treatments (complete cutting, partial cutting, and uncut) of 0.4 acres each. It was installed in a 60- to 80-year-old sawtimber stand (site index 65) on the Kaskaskia Experimental Forest in southern Illinois.

Basal area before cutting ranged from 56 to 67 square feet per acre in trees larger than 3.5 inches d.b.h. (table 1). White, black, northern red, and scarlet oaks constituted about 80 percent of the basal area, hickory about 15 percent, and scattered black gum, sassafras, and dogwood made up the balance.

All plots were treated during the dormant season. In the complete cutting treatment, all merchantable trees were removed, then all remaining stems taller than 4.5 feet were cut. In the partial cutting treatment, some trees in nearly all diameter classes were removed, leaving about one-half of the stand basal area. No trees were removed from the uncut plots (table 1).

Table 1. – Stand Characteristics before and after treatment (Per acre)

Treatment	Original stand				Residual stand			
	Number of trees	Basal area	Stocking	Aver.1/ d.b.h.	Number of trees	Basal area	Stocking	Aver.1/ d.b.h.
		Sq. ft.	Percent	Inches		Sq. ft.	Percent	Inches
Uncut	107	56	48	9.8	107	56	48	9.8
Partial cut	112	67	56	10.4	65	34	29	9.8
Complete cut	159	67	60	8.8	0	0	0	0

1/ Diameter of the tree of average basal area.

Reproduction was sampled on 16 4.35-milacre subplots in each plot. Before treatment, all oak stems less than 4.5 feet tall on each subplot were classified according to their origin (fig. 1). The following classification was used throughout the study.

Reproduction Type	*Description*
A	New seedlings. – True seedlings established after treatment.
B	Seedling advance reproduction. – Individuals less than 4.5 feet tall in which the roots and stems are the same age and present before treatment.
C	Seedling sprout advance reproduction. – Individuals less than 4.5 feet tall in which the roots are older than the stems and present before treatment.
D	New sprouts from seedling advance reproduction. – New stems originating after treatment from dormant buds at the root collar. These were type B before treatment.
E	New sprouts from seedling sprout advance reproduction less than 4.5 feet tall. – New stems originating after treatment from dormant buds at the root collar. These were type C before treatment.
F	New sprouts from seedling sprout advance reproduction over 4.5 feet tall and less than 2 inches in diameter at the ground. – New stems originating after treatment from dormant buds at the root collar. These were not measured before treatment.

Their heights were then measured, and they were permanently marked. At the end of the first growing season after treatment, all stems were remeasured and those that had new sprouts were reclassified. In addition, new seedlings that had become established were permanently marked and measured. Advance reproduction stems taller than 4.5 feet were not measured before treatment, but 1 year later it became apparent that new sprouts from these stems would be an important element in the reproduction. So, at this time they were measured and permanently marked. Remeasurements were made on the completely cut and partially cut plots 1, 2, 6, and 12 years after treatment, and on the uncut plots 1, 2, and 12 years after treatment.

During early spring following treatment, an incendiary fire burned over the study plots. The fire was set in the early evening and apparently did not burn extremely hot or uniformly over the plot areas. The major effect of the fire was the top-killing of some advance reproduction stems. This resulted in more new sprouts at the end of the first growing season than would ordinarily be present after logging alone. All of the new sprouts on the uncut plots resulted from this fire.

RESULTS

Mortality

Mortality was variable and not consistent for all reproduction types within and between treatments, and analysis of variance showed no significant differences. However, some general trends were apparent. At the start of the study there were 2,376 stems of oak reproduction per acre on the completely cut plots, 3,032 on the partially cut plots, and 2,046 on the uncut plots (table 2). Twelve years later, the proportion of stems that had died was greatest on the uncut plots (60 percent), least on the completely cut plots (42 percent), and intermediate on the partially cut plots (53 percent) (table 3).

Table 2. – Oak reproduction prior to, and 1 and 12 years following overstory treatment (Number of stems per acre)

Treatment	Reproduction type						All
	A	B	C	D	E	F	types
Prior to:							
Complete cut	0	684	928	0	0	--	1,612
Partial cut	0	742	828	0	0	--	1,570
Uncut	0	944	562	0	0	--	1,506
One year after:							
Complete cut	382	266	317	252	590	382	2,189
Partial cut	1,109	338	360	245	432	353	2,837
Uncut	288	266	187	418	353	252	1,764
Twelve years after:							
Complete cut	130	93	187	173	454	338	1,375
Partial cut	317	180	211	70	303	301	1,382
Uncut	43	137	115	209	173	152	829

Mortality of reproduction types A and B was generally greater than that of types C and D; the lowest mortality occurred in types E and F regardless of overstory treatment. Mortality of the relatively small reproduction types A, B, and D was highest from 2 to 6 years after treatment, while most of mortality in the larger types C, E, and F occurred later.

These trends suggest that mortality is related to the size and relative vigor of the various reproduction types as well as to the amount of overstory left on the plots. The smaller stems had more restricted root systems, were less vigorous, and thus more likely to succumb to competition and other forces than the larger stems.

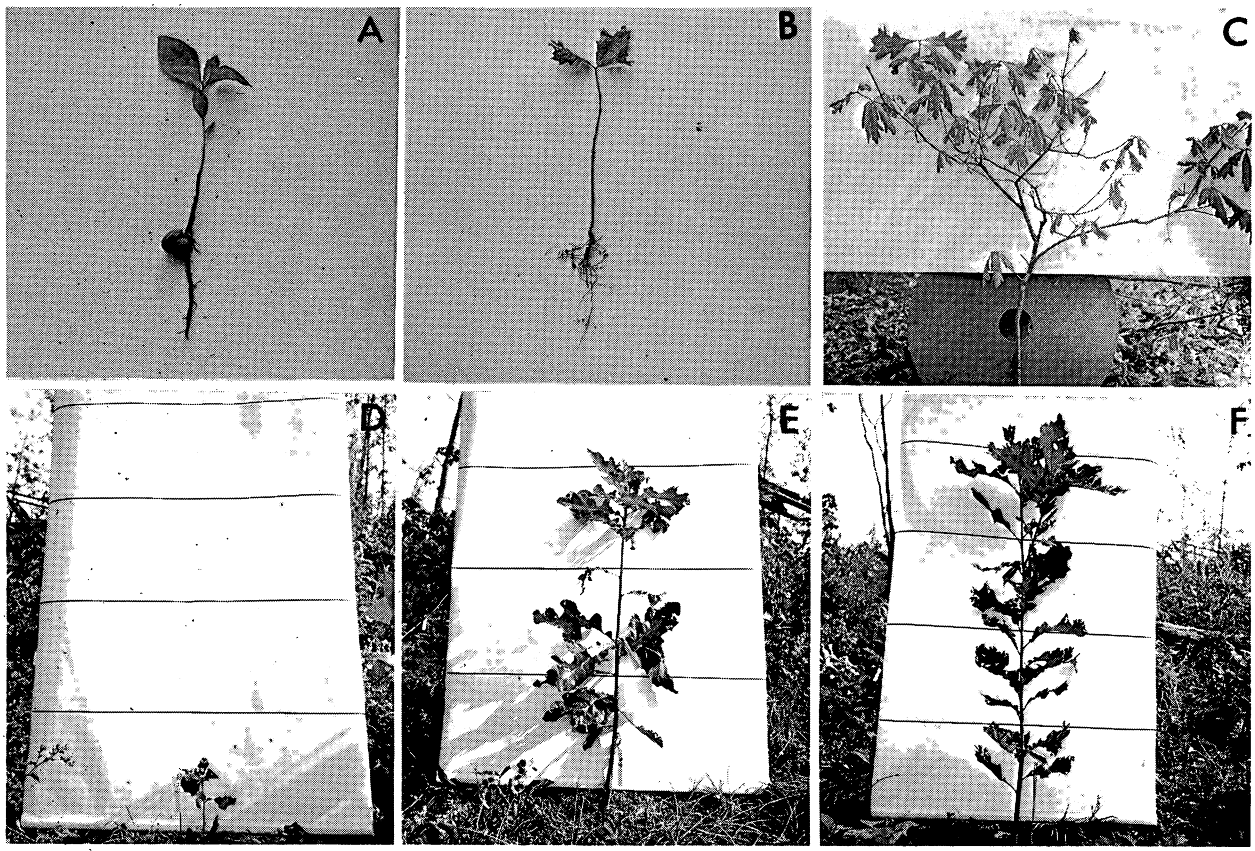

Figure 1. – Oak reproduction types: (A) new oak seedling; (B) seedling advance reproduction; (C) seedling sprout advance reproduction; (D) new sprout from seedling advance reproduction; (E) new sprout from seedling sprout advance reproduction less than 4.5 feet tall; (F) new sprout from seedling sprout advance reproduction more than 4.5 feet tall.

HEIGHT GROWTH

Treatment Comparisons

The effects of overstory density on height growth of oak reproduction began to show up the first year after treatment. The first-year differences were small, but by the end of the second year all reproduction types were generally tallest on the completely cut plots and shortest on the uncut plots (fig. 2). After 6 years, all reproduction types were significantly taller on the completely cut plots than on the partially cut plots. Furthermore, the differences increased, until at age 12 the reproduction on the completely cut plots averaged about twice as tall as on the uncut plots.

These results confirm those from earlier studies showing that even a relatively light residual overstory reduces growth of reproduction and that complete overstory removal provides the conditions necessary for best reproduction growth (Tryon and Carvell 1958, Sander and Clark 1971).

Regardless of residual overstory, 12 years after treatment reproduction type F was the tallest, type A was the shortest, type C was taller than type B, and type E was taller than type D (fig. 2). Thus, total height of reproduction at this age is dependent upon height before cutting as well as amount of overstory left, and in the case of new sprouts, probably upon size of the root system as well.

Table 3. – Mortality of oak reproduction following overstory treatment
(In percent)

Time since treatment (years)	A1/	B	C	D	E	F	All types
COMPLETE CUT							
2	6	53	6	3	1	0	12
3-6	41	15	15	14	9	2	15
7-12	19	10	23	14	13	9	15
Total	66	78	44	31	23	11	42
PARTIAL CUT							
2	9	33	11	15	2	0	12
3-6	42	22	11	41	7	2	25
7-12	21	9	15	15	22	12	17
Total	72	64	37	71	31	14	53
UNCUT							
2	50	59	21	21	8	0	30
3-12	35	15	24	29	43	40	30
Total	85	74	45	50	51	40	60

1/ Includes only new seedlings established the first year after treatment.

Completely Cut Plots

Early height growth determines whether or not stems will attain and maintain dominance after complete cutting. Type F reproduction grew almost 3 feet per year the first 2 years after complete cutting, much faster than any other reproduction type (fig. 2). From then until age 12, type F stems grew at a uniform rate of about 2 feet per year. Reproduction type E grew at a uniform rate of about 1.7 feet per year for the first 6 years following cutting. Then growth declined and averaged about 0.9 feet per year between age 6 and 12. Type C growth followed a pattern similar to that of type E, but at a lower average rate. Reproduction types B and D grew at similar rates throughout the 12 years, but always grew at a lower rate than types C, E, and F. Type A stems grew slowest of all, and at age 12 averaged only about 2.5 feet tall.

It is obvious that no stems of reproduction types A, B, and D will ever grow into the dominant stand on the completely cut plots. At age 12, all stems of these types were either intermediate or suppressed, with over 90 percent in the suppressed crown class (table 4). Most type C and E stems were also intermediate or suppressed, but a few grew fast enough to become codominant.

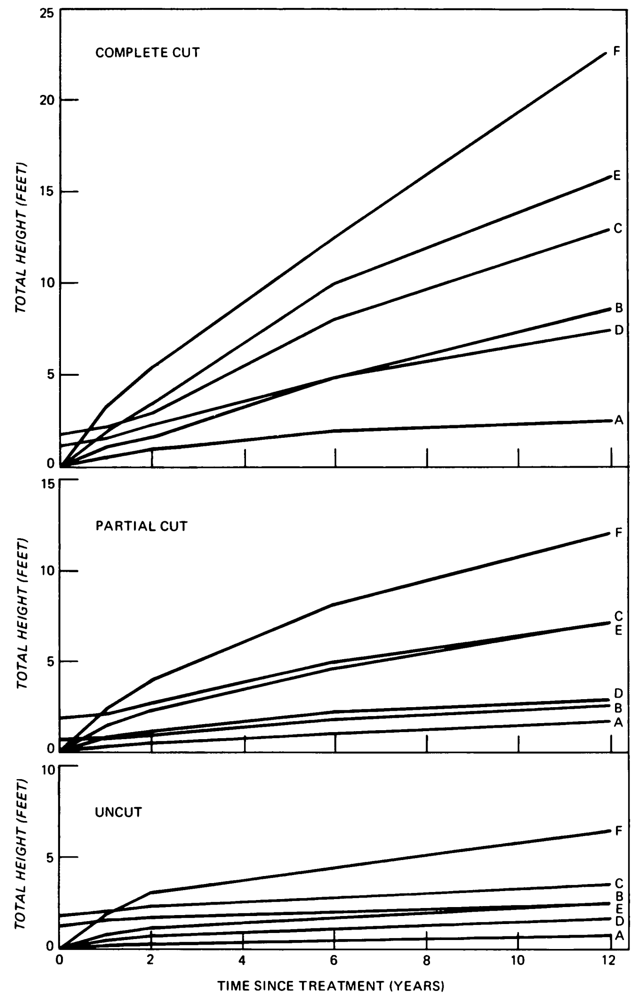

Figure 2. – Height of oak reproduction following different intensities of overstory treatment.

Type F stems were the only ones to grow fast enough so that most of them (63 percent) were either dominant or codominant at 12 years of age.

Partially Cut Plots

The relative height growth and position in the stand of the various reproduction types 12 years after partial cutting were much the same as after complete cutting (fig. 2). Reproduction type F stems grew fastest, followed by types C and E, which grew at about the same rate. Types A, B, and D grew slowest, and although their heights differed slightly after 12 years, their growth rates were similar (fig. 2). None of the reproduction

Table 4. — Distribution of oak reproduction types by crown or height class 12 years after overstory treatment

(In percent)

Crown or height class	Reproduction type A	B	C	D	E	F	All types
			COMPLETE CUT				
Dominant	0	0	0	0	0	23	6
Codominant	0	0	7	0	5	40	13
Intermediate	0	8	12	4	19	26	15
Suppressed	100	92	81	96	76	11	66
			PARTIAL CUT				
15+	0	0	3	0	2	14	4
10-15	0	0	0	0	7	41	10
6-10	0	4	24	0	19	28	15
<6	100	96	73	100	72	17	71
			UNCUT				
10-15	0	0	0	0	0	19	3
6-10	0	0	0	0	4	19	4
4-6	0	5	12	3	13	14	9
<4	100	95	88	97	83	48	84

types on the partially cut plots grew at a uniform rate. Rather, all grew slower during each succeeding period.

The small reproduction types A, B, and D grew slowly following the partial cut and are of doubtful value for replacing the part of the stand that was removed. Twelve years after cutting, few stems of these types were taller than 6 feet (table 4). Furthermore, as the overhead canopy and the large reproduction continue to expand, many of the reproduction type A, B, and D stems will become more suppressed than they were at age 12, and many may die.

Although a few Type C and E stems were among the tallest reproduction, nearly three-fourths of them were less than 6 feet tall at age 12 (table 4). Some have grown fast enough to become part of the stand that is filling the openings created by cutting, but most have not. However, if they persist they should be large enough to grow well and comprise the principal oak component in the reproduction after future cuts.

The tallest reproduction on the partially cut plots consisted mostly of Type F stems, which comprise the dominant oak component in the reproduction that is filling the openings. These results suggest that the large advance reproduction should be depended upon to regenerate partially cut stands.

Uncut Plots

All reproduction types grew slowly on the uncut plots. Type F grew fastest but averaged only 6.5 feet tall after 12 years. All other reproduction types averaged less than 4 feet tall, and grew only about 0.1 foot per year from age 2 to 12 years (fig. 2). Eighty percent or more of the stems of all reproduction types except type F were less than 4 feet tall, whereas about one-half of the type F stems were taller than 4 feet (table 4).

Reproduction will continue to grow slowly on the uncut plots. Much of it will probably die back, and mortality is likely to be high, especially in the smaller reproduction types. The larger types with well-established root systems are most likely to persist and be available to regenerate the area when a harvest cutting is made.

MANAGEMENT IMPLICATIONS

The results of this study suggest that careful consideration should be given to the size as well as the amount and distribution of oak advance reproduction when planning harvest cuttings to regenerate oak stands. Although some stems resulting from advance reproduction less than 4.5 feet tall grew satisfactorily, the bulk of the reproduction that made acceptable growth came from advance reproduction over 4.5 feet tall. Thus, an average height of at least 5 feet, preferably 6 to 8 feet, should be a useful guide for determining whether oak advance reproduction on a harvest area is likely to compete successfully and become dominant in the new stand.

If a planned harvest area contains enough of these large oak advance reproduction stems to satisfy reproduction objectives, the harvest cutting can be made immediately. Complete overstory removal will provide the conditions for most rapid growth of the new stand and should be used unless esthetics or multiple-use coordination dictate otherwise.

If oak advance reproduction is plentiful, but predominantly small, harvest cutting should be delayed. In such situations a period of 20 years or longer may be necessary to allow the advance reproduction to become large enough so that it will grow satisfactorily following a harvest cut. If overstory stands are heavily stocked, oak reproduction beneath them will grow slowly and may even die. Even overstories that are at the lowest limit of stocking that fully utilizes the site, such as on the uncut plots in this study, greatly suppress oak reproduction growth.

Some type of partial cut should be helpful in enhancing reproduction growth, and possibly shortening the development period. But just how partial cutting can be applied to best advantage is still not clear. Several light cuts that gradually open the overstory may work better than one or two heavy cuts. An important factor to consider is the density, composition, and size of the understory species other than oak. Any cutting designed to enhance oak advance reproduction growth would also benefit other species, possibly to the detriment of the oaks. So, some understory treatment in combination with cutting in the overstory may be necessary.

Hardwood reproduction following all types of harvest cutting has generally been adequate to form acceptable new stands, especially in the eastern and central parts of the upland oak range (Minckler and Jensen 1959, Trimble and Hart 1961, Sander and Clark 1971). However, the oak component has not always been as large as desired, and in some areas along the western edge of the oak range it has been inadequate (Arend and Scholz 1969). If both size and numbers of advance reproduction are considered when planning harvest cuts, better predictions of how many oaks are likely to compete successfully in new stands will be possible.

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