OAK REGENERATION BY CLEARCUTTING AFTER A SERIES OF PARTIAL CUTS[1]

Jeffrey O. Dawson, Joseph McCarthy, Joseph A. Roush and David M. Stenger[2]

Abstract.--A gradual increase in the amount of crown opening with successive cuttings over a 30-year period evidently allowed ample time for the establishment, growth and survival of advance oak regeneration. One to five years following a final clearcutting there was oak regeneration on four poor to good sites surveyed. Oaks regenerated best on poorer sites with decreased competition.

INTRODUCTION

In theory, the ideal method for regenerating oak is the shelterwood method (Merritt 1980). Other currently recommended methods of oak regeneration, such as clearcutting and group selection, often require advance regeneration to be present for successful stand establishment (Merritt 1980). For example, when adequate advance regeneration is not present in a mature stand, Sander (1977) recommends reducing overstory density to stimulate seed production prior to clearcutting. When applying the shelterwood method, several light cuttings rather than one heavy cut are preferable to maintain a denser canopy (Sander and Clark 1971), thereby suppressing the development of competing understory species. According to the criteria for advance oak reproduction suggested by Sander (1977), there should be at least 435 oaks per acre 4.5 feet tall or taller well distributed over the area to regenerate oak stands.

Use of the shelterwood method is rare in the central hardwood region, perhaps because optimal cutting sequences and densities have not been determined, compounded by the fact that oak species are notoriously poor seed producers (Merritt 1980). In order to add to the information on oak regeneration, we measured the regeneration of oak and other tree species following the application of a series of partial cuts and a final clearcut at Sinnissippi Forest, where forest managers switched from a single-tree selection method to the shelterwood method in the mid 1970's. Historical obsrvations on the forest had established that the single tree selection method and clearcutting not preceded by partial cuts were inadequate to secure oak regeneration on medium to good sites. Our objective was to describe oak regeneration after a series of cuttings including a final clearcut on four sites of varying quality.

METHODS

This study was conducted in northeastern Illinois at Sinnissippi Forest, a 2200-acre, managed forest in Ogle County. The three major oak species in the forest are white oak (*Quercus alba* L.), northern red oak (*Quercus rubra* L.) and black oak (*Quercus velutina* Lam.). The forest had been heavily logged in the middle 1800's. The forest was grazed until the middle 1930's when the forest owners entered into a cooperative agreement for research and management with the Department of Forestry at the University of Illinois. During the 1940's and 1950's a series of improvement cuttings were instituted. Thinnings from both below and above eliminated defective trees and during the 1950's and 1960's sanitation cuttings, mostly in the poorer-quality black oak stands, were made removing oaks with symptoms of oak wilt and all other trees within a 50-foot radius of the diseased trees.

Four sites of varying productivity were selected for this study. Soils in this forest were developed in sands from Wis consin glacial outwash and in loessal material on sand and glacial till. Productivity classes ranged from a black oak stand of poor quality with a black oak site index of 50 to a stand with a red oak oak site index of 70 (50-year basis).

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[2]The authors are Associate Professor, Sinnissippi Forest Student Interns and Staff Forester, respectively, Department of Forestry, University of Illinois, Urbana, IL

A site that originally had 80% or more black oak stems with a black oak site index of 50 was classified as black oak poor (BOP). Chelsea Loamy Sand is the only soil type present. Soil classification in this paper is that of the USDA Soil Conservation Service. Slopes over 84% of the site ranged from 7-15% and the remaining 16% of the slopes were less than 7%. An improvement cutting in which defective trees were removed was made in 1955 reducing crown cover to 90%. Additional seed cuttings reduced the crown cover to 80% in 1965 and 60% in 1979. The final cut was made in 1984.

Two sites that originally had 50-79% mixed oak stems with oak site index values of 60 were classified as mixed oak medium (MOM). Mixed oak medium site 1 (MOM1) was the poorer of the two medium-quality sites. Soil types were 43% Chelsea Loamy Sand on slopes ranging from 7-15%, 24% Chelsea Loamy Sand on slopes ranging from 1-7% and 33% Boone Sand on 15-35% slopes. An improvement cutting was made in 1952 leaving 90% residual crown cover and was followed by additional cuttings in 1960, leaving 70% crown cover, and 1977, leaving 60% residual crown cover. The final cut was made in 1982.

The better of the mixed oak medium sites (MOM2) had 45% Lamont Sandy Loam on 5-12% slopes, 28% Martinsville Silt Loam on 10-15% slopes and 27% Boone Sand on 15-45% slopes. An improvement cutting was made in 1958, leaving 90% residual crown cover, followed by cuttings in 1972 and 1982 that left 70% and 60% crown cover residual, respectively. The final cutting was made in 1986.

A red oak good (ROG) site had 59% Martinsville Silt Loam on 2-5% slopes and 41% Eleva Sandy Loam on 2-7% slopes. The site originally had 80% or more red oak stems and a red oak site index of 70. A light improvement cutting was made in 1958, leaving 90% residual crown, followed by a cutting in 1974 leaving 70% residual crown and a final cutting in 1983.

The four sites averaged 7 and ranged from 3 to 11 acres in area. At the final cutting all large timber was removed, although some small trees up to 20 feet in height were not damaged by logging and were left on the site. Most stems of the advance regeneration were severed by logging equipment, resulting in a preponderance of seedling and sapling sprouts. A small sample of ten, square milacre plots were randomly located in each stand during July of 1987. Sample size was restricted owing to the limited time and manpower available for the study. All woody stems less than 4 inches diameter at breast height and small trees and shrubs less than breast height (4.5 feet) in each plot were counted by species and visual estimates of the percentage cover by each woody plant species were made. Tree heights were measured and estimates were also made of the percentage of each plot covered by grasses, herbaceous plants, woody vines and brambles.

RESULTS AND DISCUSSION

Oak regeneration from 1 to 5 years after the final cutting ranged from 5600 stems per acre on the black oak site to 1400 total stems per acre on the red oak site (Table 1). Most oak stems observed were seedling and sapling sprouts. Oaks were a major component of tree regeneration greater than 4 feet in height only on the poorer sites (BOP and MOM1) (Table 2). Heights of oak reproduction were variable, but on the poor and medium sites, more oaks tended to overtop competing vegetation than on the good site. Observations of other stands at Sinnissippi Forest reveal a contrasting pattern of oak regeneration in stands that have not had a series of partial cuts. Advance regeneration and regeneration of oaks following hardwood clearcutting on medium and better quality sites in Sinnissippi Forest tend to be almost totally absent in stands without a recent history of major canopy openings.

Table 1. Oak regeneration 1-5 years after final cutting on sites of varying quality. Mean values and relative frequencies are for 10 plots. Standard deviations are in brackets. The number of years since clearcutting are 3 for BOP, 5 for MOM1, 1 for MOM2 and 4 for ROG.

Species	Site and Site Index	Mean No. of Stems/Plot	No. of Stems/Acre	Relative Frequency
Quercus alba	BOP 50	3.3 (3.9)	3300	0.7
	MOM1 60	0.9 (1.3)	900	0.4
	MOM2 60	2.6 (5.2)	2600	0.4
	ROG 70	0.7 (1.3)	700	0.3
Quercus rubra	BOP 50	0	0	0
	MOM1 60	1.4 (1.7)	1400	0.6
	MOM2 60	1.1 (1.6)	1100	0.5
	ROG 70	0.7 (1.3)	700	0.3
Quercus velutina	BOP 50	2.3 (1.6)	2300	0.8
	MOM1 60	0	0	0
	MOM2 60	0.1 (0.3)	100	0.1
	ROG 70	0	0	0

Table 2. Estimated numbers of stems per acre of oaks and other woody plant regeneration by height classes 1-5 years after final cutting on sites of varying quality at Sinnissippi Forest. The number of years since clearcutting are 3 for BOP, 5 for MOM1, 1 for MOM2 and 4 for ROG.

		Height Classes of Regeneration (feet)			
Site	Regen. type	0-4	4-8	8-12	>12
BOP	oaks	4200	1200	100	100
	other trees	300	600	200	500
	shrubs	2100	1800	300	-
MOM1	oaks	1100	700	300	200
	other trees	400	700	200	500
	shrubs	200	1500	-	-
MOM2	oaks	2700	600	200	300
	other trees	400	800	600	500
	shrubs	600	500	-	-
ROG	oaks	1300	100	-	-
	other trees	1000	900	100	400
	shrubs	1700	900	100	-

The regeneration results from the four sites are not strictly comparable because the time since clearcutting varies from 1 to 5 years. The series of cuttings that preceeded the final cuts also occurred at different times, under different climatic regimes and at different times in relation to oak mast production cycles. An examination of table 1 reveals not only that there is more oak regeneration on the poorer quality sites, but also that an additional increment in quantity of oak regeneration seems to occur in the more-recently cut stands. In spite of the differences in timing of the treatments and the interval of time between final cutting and sampling, site quality seems to have been a stronger determinant of oak regeneration than timing of cuttings in relation to short-term climatic regimes and seed-production cycles.

The sum of cover percentages for all oak species on a site was 68% on the BOP site, 53% on the MOM1 site, 28% on the MOM2 site, and 14% on the ROG site (Table 3). Oak cover also constituted a smaller portion of total tree and shrub cover and total plant cover on the better sites (Table 3). The amount of foliar cover by oaks in the regeneration following the final cutting was inversely proportional to site quality. These results are consistent with those of Carvell and Tryon (1959) who found that oaks regenerated better on poorer sites with decreased competition from herbaceous vegetation and shrubs. The sum of foliar cover percentage estimates for herbaceous plants, grasses, brambles (raspberries, gooseberries and greenbriar) and vines in midsummer ranged from 128% on the BOP site to 240% on the ROG site (Table 3), illustrating the greater amount of competition on the good site.

It is possible that midtolerant red oak eventually will dominate initially-faster-growing trees, and develop its characteristically long, clear bole when growing for small canopy openings in dense mixed stands (Oliver 1978). However, on the red oak site our early regeneration survey results indicate the possibility that red oak and white oak will persist only as equal components with other tree species in the developing mixed hardwood stand rather than as the predominant forest species.

Table 3. Mean cover percentages per plot for tree and shrub species and other vegetation (grasses, herbs, brambles and vines) 1-5 years after final cutting on sites of varying quality at Sinnissippi Forest. The number of years since clearcutting are 3 for BOP, 5 for MOM1, 1 for MOM2 and 4 for ROG.

	Site and Site Index			
Species	BOP 50	MOM1 60	MOM2 60	ROG 70
Quercus alba	31	21	12	5
Q. rubra	0	30	16	9
Q. velutina	37	2	1	0
Carya ovata	3	1	5	10
C. cordiformis	5	13	17	18
Prunus serotina	31	15	23	25
P. virginiana	7	3	0	4
Ulmus spp.	2	36	32	3
Corylus americana	10	8	6	9
Cornus spp.	15	3	7	15
Others	16	19	27	1
Subtotal	157	151	146	99
Other vegetation	128	159	171	240
Total	285	310	317	339

Standard deviation values (Table 1) suggest that any randomly-located milacre plot is just as likely to have no oaks, or on average about twice the number of oaks, as the mean value for oak stems in a plot. The relative frequencies for oak species are given in Table 1 and indicate clearly that the relative frequncy of occurence, or stocking, of oak regeneration in randomly distributed milacre plots declines as site quality increases. In addition, the species composition of woody plant regeneration differed markedly according to site quality. Northern red oak regeneration was found only on the good and medium quality sites and ranged from 700 stems per acre on a good site to 1400 stems per acre on a medium site (Table 1). Black oak regeneration occurred only on one MOM site with 100 stems per acre and the BOP site with 2300 stems per acre. White oak regeneration was present on all sites, but was more abundant on the poorer sites (Table 1).

Other trees and shrubs varied in occurence with site quality (Table 4). Bitternut hickory (Carya cordiformis [Wangenh.] K. Koch) and shagbark hickory (Carya ovata [Mill.] K. Koch) were most abundant on the better sites. Black cherry (Prunus serotina Ehrh.) occurred on all sites while chokecherry (Prunus virginiana L.) was prevalent on poorer sites. Hazelnut (Corylus americana Walt.) and several small species of the genus Cornus combined constituted the most common shrub group on all sites.

Grape vines (Vitis spp.) were more abundant on the better-quality sites. The greatest amount of low vegetative cover, proportionately, on all sites was for black raspberry (Rubus spp.), Virginia creeper (Parthenocissus quinquefolia [L.] Planch.), gooseberries (Ribes spp.) and poison ivy (Toxicodendron radicans [L.] Kuntze.).

The amount of oak regeneration measured after clearcutting in this study is much less than the advance regeneration present prior to the final cutting in other Sinnissippi Forest stands of identical quality and similar cutting treatments (Ehlert et al. 1987). This suggests that there is considerable loss of oak reproduction associated with harvesting and opening of the stands to full sunlight.

Ehlert and coworkers (1987) measured regeneration in 1986 in the same stands sampled in 1987 for this study. Between 1986 and 1987 the overall patterns of oak regeneration described in the two studies remained the same. The sample and plot sizes were the same in both studies, although different sets of plots were randomly-located for each study. The similarity

Table 4. Regeneration of woody species other than oaks 1-5 years after final cutting on sites of varying quality. Mean values and relative frequencies are for 10 plots. Standard deviations are in brackets. The number of years since clearcutting are 3 for BOP, 5 for MOM1, 1 for MOM2 and 4 for ROG. Included among others are trees and shrubs, as in table 2, plus vines and branches.

Species	Site and Site Index	Mean No. of Stems/Plot	No. of Stems/Acre	Relative Frequency
Carya ovata	BOP 50	0	0	0
	MOM1 60	0	0	0
	MOM2 60	0.3 (0.5)	300	0.3
	ROG 70	0.4 (0.5)	400	0.4
C. cordiformis	BOP 50	0.1 (0.3)	100	0.1
	MOM1 60	0.1 (0.3)	100	0.1
	MOM2 60	0.2 (0.6)	200	0.1
	ROG 70	0.3 (0.5)	300	0.3
Prunus serotina	BOP 50	1.7 (3.2)	1700	0.5
	MOM1 60	0.2 (0.4)	200	0.2
	MOM2 60	0.4 (0.9)	400	0.2
	ROG 70	1.0 (1.6)	1000	0.4
P. virginiana	BOP 50	0.6 (1.0)	600	0.3
	MOM1 60	0.1 (0.3)	100	0.1
	MOM2 60	0	0	0
	ROG 70	0.1 (0.3)	100	0.1
Ulmus spp.	BOP 50	0.1 (0.3)	100	0.1
	MOM1 60	0.9 (0.8)	900	0.6
	MOM2 60	0.5 (1.0)	500	0.2
	ROG 70	0.1 (0.3)	100	0.1
Cornus spp.	BOP 50	3.3 (4.5)	3300	0.4
	MOM1 60	0.2 (4.0)	200	0.2
	MOM2 60	1.0 (2.8)	1000	0.2
	ROG 70	2.0 (3.0)	2000	0.4
Others	BOP 50	1.8	1800	0.8
	MOM1 60	2.1	2100	0.7
	MOM2 60	2.0	3300	0.6
	ROG 70	1.2	1200	0.7

of results obtained in subsequent years strengthens the likelihood that the oak regeneration estimates of this study are reasonable, in spite of the small sample size. There was a general decline in the number of oak stems from 1986 to 1987, while the estimated percentages of cover increased or remained constant for all oak species including red oak, which doubled in estimated cover. With the small sample size, this could have been a chance result of sampling. However, such a pattern is consistent with the idea that high initial mortality immediately after harvest may be followed by a more-gradual decline in oak reproduction numbers together with a gradual increase in oak crown cover as a portion of the oaks emerge above the tangle of competing low vegetation.

Cuttings in these stands were initially light and extended over a 30-year period, evidently allowing ample time and shelter for establishment, growth and survival of seedlings from the generally-poor and heavily-predated seed crops of oaks. Small, scattered openings resulting from oak-wilt sanitation cuttings, particularly on the poorer sites, may have further aided in the survival and growth of advance regeneration. The rather long time period over which the cuts were made, and the gradual increase in the amount of crown opening with successive cuttings may have contributed to the successful survival and growth of oak regeneration in these cases. These results provide a basis for comparison and further testing of cutting sequences, densities and intervals to obtain optimal systems for oak regeneration in central hardwood forests.

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