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Diameters of Clearcut Openings Influence Central Appalachian Hardwood Stem Development— a 10-Year Study

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Abstract

Appalachian hardwood stands in West Virginia were studied to determine how reproduction establishment and development were influenced by circular clearcut openings of different sizes, postlogging herbicide treatments, and site quality. Ten-year results indicate that circular clearcuts should be at least 1/2 acre to gain the silvicultural effects of larger clearcuts. Smaller openings on both fair and good sites produced adequate numbers of trees, but diversity in species composition was lacking. Herbicide treatments reduced stump sprouting. After 10 years, 15 to 20 percent of the good dominant or codominant trees were of stump-sprout origin where the most intensive herbicide treatment has been used. Without the postlogging treatment, about 40 percent of the good dominant-codominant trees were of stump-sprout origin.

Introduction

Clearcutting is a silviculturally acceptable way of harvesting central Appalachian hardwood stands. The principal ecological justification for clearcutting is that it opens up forest stands to admit sufficient light for reestablishing reproduction. Within a few years after clearcutting, harvested areas may have 10,000 to 20,000 tolerant and intolerant tree stems greater than 1.0 foot tall per acre.

With reproduction establishment as one measure of the silvicultural success of clearcutting, researchers have recommended different minimum sizes for circular clearcut openings depending on species and geographical location (Merz and Boyce 1958, Marquis 1965, Minckler and Woerheide 1965, Sander and Clark 1971, Trimble 1973). These research data indicate that in most situations if clearcuts are large enough, desirable future reproduction will be established. Although establishment of reproduction is important, development is more important. Tree development after a 10-year period is the main topic in this paper.

Forest managers using cutting practices to encourage reproduction should create conditions for desirable species to become established, or for existing desirable advance reproduction to respond. In the Appalachians, if intolerant species are desired in the future stand clearcutting is silviculturally accepted. However, large clearcuts can be esthetically undesirable and offensive to the public regardless of their silvicultural effectiveness.

This paper reports the results of a study to determine how small clearcuts can be and still obtain desirable species composition and insure good stem development comparable to that obtained with large clearcuts. A second objective of the study was to evaluate herbicide treatments applied to saplings and cut stumps after logging to minimize the influence of sprouts.

Study Area

This study was established on the Fernow Experimental Forest near Parsons, West Virginia. Elevation of the study area is 2,300 to 2,500 feet with slopes that vary from flat to very steep (60 percent). Soils were medium textured, well drained, and derived from sandstone and shale. The Experimental Forest has a cool climate with a well distributed annual rainfall of about 60 inches.

From about 1905 to 1910, the study area was logged by highgrading. When the study was installed, the second-growth stands were about 55 years old. The study was done on two oak sites: one with a site index of 75 (good site) and one with a site index of 60 (fair site). The most numerous sawlog-size species on the good sites were sugar maple (*Acer saccharum Marsh.*), yellow-poplar (*Liriodendron tulipifera* L.), northern red oak (*Quercus rubra* L.), black cherry (*Prunus serotina* Ehrh.), basswood (*Tilia americana* L.), hickory (*Carya* spp.), American beech (*Fagus grandifolia* Enrh.), and sweet birch (*Betula lenta* L.). On the fair sites, the main species were chestnut (*Q. prinus* L.), white (*Q. alba* L.) and northern red oak, red maple (*A. rubrum* L.), sweet birch, black gum (*Nyssa sylvatica* Marsh.), sassafras (*Sassafras albidum* (Nutt.) Nees.), and sourwood (*Oxydendrum arboreum* (L.) DC.).

Methods

Circular openings were made in five sizes, 50, 100, 150, 200, and 250 feet in diameter on the good site and 50, 150, and 250 feet in diameter on the fair site (Figure 1). All stems 5.0 inches in diameter at breast height (dbh) and larger were cut and herbicides applied to residual trees 1.0 to 4.9 inches dbh and cut stumps. A total of 72 openings were made; three of each diameter for each of three treatments on both sites, except that no 100- and 200-foot openings were cut on the fair sites (SI 60). This provided three replications of three treatments in each opening size.

Figure 1. Aerial view of some circular clearcut openings. The larger, irregular clearcut areas were not part of this study.

One of three herbicide treatments was applied in each of the three replicated openings:

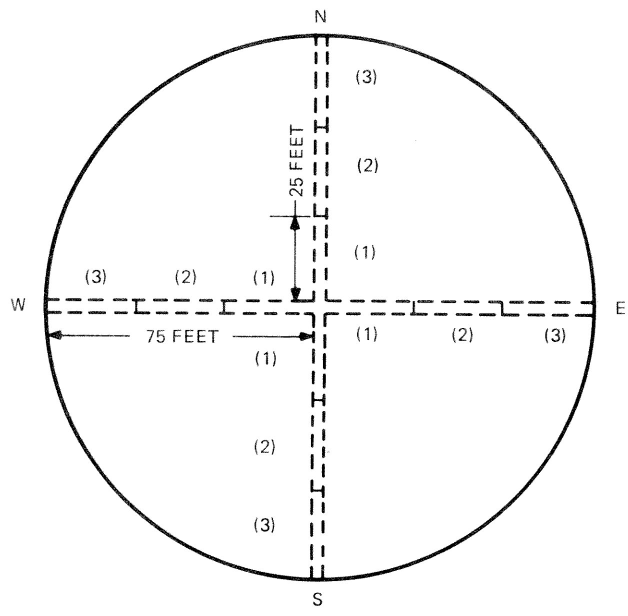
Control	No herbicide treatment.
Moderate	Basal spraying of standing trees.
Intensive	Basal spraying of all cut stumps and standing trees.

The herbicide used for treatment was 2, 4, 5-T[1] in diesel oil mixed at a rate of 16 pounds acid equivalent per 100 gallons.

Ten-year Measurements

Ten years after cutting, all trees 1.0 inch dbh and larger were measured on 25- by 4-foot transects established along radii in the four cardinal directions from the center of each opening. A 50-foot diameter opening had one 25-foot sample strip along each radius or four strips per opening; a 250-foot diameter opening had five 25-foot strips per radius, or 20 strips per opening (Figure 2). Aspect, slope position, and slope percentage were recorded for each opening, but these variables were not evaluated because of the small number of samples in the different categories.

Figure 2. Arrangement of the 25-ft sample strips for a 150-ft diameter opening.



¹This paper reports research involving herbicides. It does not contain recommendations for their use nor does it imply that the uses discussed here have been registered. All uses of herbicides must be registered by appropriate State and/or Federal agencies before they can be recommended.

Crown class, origin (seedling or sprout—if a tree sprouted from a 2-inch diameter stump or larger, it was considered to be of sprout origin), and stem quality were recorded for each commercial tree species to determine crop tree potential. Tree quality estimates were based on crown vigor, visible bole wounds, and tree form, i.e. straight main stem—no forks, although J-shaped butt origin was allowed. Also trees had to be in a free-to-grow crown class (dominant or codominant). In addition, to be classed as a good sprout, sprout origin had to be less than 6 inches above the groundline at the point of stump attachment.

The number of grapevines originating on a sample transect and the number of trees 1.0 inches or more in dbh with grapevines in their crowns were recorded. No efforts were made to control vine growth during the 10-year study period.

Data were statistically analyzed using multivariant and chi-square analyses. Beacuse the experimental error was impossible to determine and tests were often conducted with nearly a hundred closely related variables, significance was set at the 0.01 probability level.

Results

Immediately after Logging

On the fair sites, the number of 1.0- to 4.9-inch trees averaged about 160 per acre in all control openings (those not treated with herbicides) immediately after logging. The trees were predominantly red maple (95 per acre), oaks (30 per acre), and beech (20 per acre). There were nearly 2,900 stems per acre 1.0 foot tall to 0.9 inch dbh with oaks, sassafras, red maple, and beech accounting for about 85 percent of these stems.

On the good sites, there were about 150 trees 1.0 to 4.9 inches dbh per acre in the control openings. Sugar maple (75 per acre), beech (50 per acre), and red maple (20 per acre) were the predominant species. The average number of stems 1.0 foot to 0.9 inch dbh was 4,220 per acre; sugar maple and beech accounted for 50 percent of these small stems. No data of this type were collected in the herbicide-treated openings because theoretically all of the small trees were killed by the herbicide.

Fair Site (SI 60) After 10 Years

Trees per Acre

Openings of all diameters had 100 or more good quality dominant or codominant trees 1.0 inch or more in dbh per acre. However, the number of stems in each of the three sizes of openings (250-, 150-, and 50-foot) was significantly different from the others. Also, the 150- and 250-foot diameter openings had a greater variety of commercial species. A varied species composition is a major silvicultural objective in management of hardwood stands.

The largest openings had the best stocking of young stems. We found between 250 and 300 good quality dominant or codominant trees per acre in 50-foot openings, 350 to 400 in 150-foot openings, and 450 to 500 in 250-foot openings. The average weighted stand dbh for the good quality dominant or codominant trees for all opening sizes was 2.2 inches dbh, based on an average of 385 trees per acre. The average weighted dbh for each opening size was 1.7 inch (50-foot), 2.6 inches (150-foot), and 2.5 inches (250-foot). However, as expected, the herbicide treatments influenced average dbh. The average weighted dbh values for the good quality dominant or codominant trees on the control openings ranged from 2.2 to 3.2 inches for the 50- to 250-foot openings (Table 1). For the openings treated with moderate herbicide, dbh values ranged from 1.4 to 2.6 inches; and the average dbh of good dominant or codominant trees on the intensively treated openings ranged from 1.5 to 2.0 inches for the 50- to 250-foot openings.

Table 1. Weighted average dbh (in inches) by opening size, herbicide treatment, and site class 10 years after treatment.

Treatment	Opening size				
	50-foot	100-foot	150-foot	200-foot	250-foot
			FAIR SITE (SI 60)		
Control	2.2		3.2		3.0
Moderate	1.4		2.6		2.4
Intensive	1.5		1.9		2.0
			GOOD SITE (SI 75)		
Control	1.6	2.2	2.5	2.8	2.9
Moderate	1.5	1.8	2.0	2.0	2.1
Intensive	1.4	1.8	1.8	1.9	2.2

Regeneration was well distributed throughout the openings. After 10 years, from 50 to 72 percent of the sample transects were stocked with at least one good quality dominant or codominant commercial tree. This percent stocking was consistent for all opening sizes and herbicide treatments. Red maple and sassafras were the most numerous species, averaging about 120 trees per acre per species, and present on about 25 percent of the transects. Red oak, along with some chestnut, white, and scarlet oak (*Q. coccinea* Muenchh.), accounted for about 50 good quality trees per acre; the red and chestnut oaks were found on about 10 percent of the sample transects. About 35 good-quality dominant or codominant beech trees per acre were in the 50-foot openings, but beech was generally absent in 150- and 250-foot openings. Also about 35 black cherry trees per acre were found in the larger 150- and 250-foot herbicide-treated openings. Species variety increased with size of opening. The 50-foot openings contained an average of 6 commercial species per opening, while the 150- and 250-foot openings averaged 10 species per opening.

Postlogging Herbicide Treatment

Herbicide treatments were used to minimize the influence of sprouting. Based on number of good quality dominant or codominant sprouts present 10 years after treatment, the most effective treatment was intensive basal spraying, though data for this treatment were not consistent. For intensive treatments, the percentage of sprouts differed among the three openings (Table 2); about 15 percent of the good quality dominant or codominant trees in the 50- and 250-foot openings were sprouts, while, for unknown reasons, nearly 50 percent were sprouts in the 150-foot openings. Among the moderate herbicide and control openings, an average of about 35 percent of these trees were of sprout origin. But none of the herbicide treatments consistently resulted in a larger number of good quality dominant or codominant trees for a given opening size, although the moderate and intensive herbicide treatments provided more trees than the controls.

When considering the total number of sprouts versus seedlings for all trees 1.0 inches and more in dbh, the intensive herbi-

Table 2. Number per acre of good dominant or codominant trees of sprout and seedling origin 1.0 inch or more in dbh, by herbicide treatment, opening, and site class 10 years after treatment.

Opening Size (feet)	Control		Moderate		Intensive	
	Sprouts	All[a]	Sprouts	All	Sprouts	All
			FAIR SITE (SI 60)			
50	35	220	110	325	35	290
150	170	340	120	375	230	470
250	180	460	220	510	80	480
			GOOD SITE (SI 75)			
50	35	110	0	180	0	110
100	90	345	20	165	55	220
150	180	300	75	230	60	340
200	255	420	55	410	120	625
250	130	405	80	320	60	240

[a] All good dominant or codominant trees of seedling and sprout origin.

cide treatment averaged 28 percent sprouting, the moderate treatment 49 percent, and the control had 54 percent trees of sprout origin. With the exception of the intensively treated stems on the 150-foot diameter openings, sprouting was significantly less after the intensive treatment than after moderate and control treatments. No significant differences were found between the moderate treatment and the controls. Red maple was the most prolific sprouting species, averaging 63 percent of the total stems sprouting in treated openings, 57 percent for the moderate herbicide treatment, and 36 percent for the intensive treatment. Also, oak (red, chestnut, and white) sprouts averaged about 25 percent of the total number of sprout stems for each of the three cultural treatments.

Good Site (SI 75) After 10 Years

Trees per Acre

Stocking on the good sites was similar to that on the fair sites in that all diameter openings had at least 100 good quality dominant or codominant trees per acre. However, stocking in the 50-foot openings was somewhat marginal in two of the three herbicide treatment categories, averaging only about 110 trees per acre (Table 2).

The 50-foot diameter opening had significantly fewer good dominant or codominant trees than the 100-, 150-, 200-, and 250-foot openings. The numbers of good quality trees in the 100-, 150-, and 250-foot openings were not significantly different. The 50- and 100-foot openings averaged 3 to 4 different species per opening, while the 200- and 250-foot openings averaged about 12 different species per opening.

Ten years after cutting, we found an average of about 125 good quality dominant or codominant trees per acre in the 50-foot openings. Generally, openings 100 feet in diameter or larger contained from 200 to 400 trees per acre (Figure 3).

The average weighted stand dbh for the good quality dominant or codominant trees for openings of all diameters was 2.0 inches, based on an average of 295 trees per acre. Weighted stand dbh values for each opening size were 1.5 (50-foot), 2.0 (100-foot), 2.1 (150-foot), 2.2 (200-foot), and 2.5 (250-foot). As expected, trees in the control openings had a higher average dbh than those in the openings that had moderate or intensive herbicide treatment. The weighted average dbh values for the good dominant or codominant trees in the control openings ranged from 1.6 to 2.9 inches for the 50- to 250-foot diameter openings (Table 1). Similar dbh values for the openings with moderate herbicide treatment ranged from 1.5 to 2.1 and for those with intensive herbicide treatment, average dbh ranged from 1.4 to 2.2 for the 50- to 250-foot diameter openings.

For openings of all diameters and herbicide treatments, except the intensive treated 200- and 250-foot openings, sugar maple was consistently the most abundant good quality tree, averaging 100 trees per acre in many instances. Sugar maple was the most abundant species in the 50- to 150-foot openings. Yellow-poplar, sweet birch, and black cherry were numerous, especially in the 200- and 250-foot openings, combining for an average of about 100 good quality dominant or codominant trees per acre. Black locust (*Robinia pseudoacacia* L.) and sassafras were also present in the large openings. Generally, in openings of the same diameter, species composition did not appear to be influenced by herbicide treatment.

From 25 to 33 percent of the sample transects in the 50-foot openings and from 38 to 79 percent of all other openings were stocked with at least one good quality dominant or codominant commercial tree. When all opening sizes and cultural treatments were considered, more than 50 percent of the transects were stocked with at least one good tree. Sugar maple was present in more than 20 percent of the sample transects for all opening sizes and cultural practices—the highest percentage for any species. All other species were in less than 10 percent of the sample plots. Few intolerant species were found in the 50- and 100-foot openings. For the 150-, 200-, and 250-foot openings, good dominant or codominant black cherry occurred in 4 percent and yellow-poplar in 9 percent of the sample strips. Few oak stems were on the good site—few were in the understory to begin with.

Figure 3. Typical stand development 10 years after clearcuting on a good site.

Postlogging Herbicide Treatment

The three herbicide treatments did not have a consistent influence on the number of good quality trees per acre; the control treatment usually resulted in as many good dominant or codominant trees as either of the herbicide treatments, or more. Approximately 20 percent of the good quality dominant or codominant trees in the moderately and intensively treated openings were of sprout origin (Table 2). In the control openings, at least 40 percent of the trees were of sprout origin. The number of good quality sprout-origin trees was most consistent in the intensively treated openings, ranging from 18 to 26 percent, while the control openings were the most variable, ranging from 26 to 61 percent.

To evaluate the effects of herbicide treatments, all sprouts, regardless of stem quality or crown class, were combined. There were significantly fewer sprouts in the intensively treated openings than in the moderately treated or control openings. Also, sprouting was significantly less in the moderately treated than in the control openings. Trees of sprout origin in all sizes of openings totaled 23, 36, and 45 percent respectively for the intensive, moderate, and control treatments.

The most numerous species of sprout origin in the control openings were basswood, red maple, and yellow-poplar, combining for a total of about 60 percent of the good dominant or codominant sprouts in these openings. For openings that had received the intensive treatment, yellow-poplar and sugar maple together averaged about 30 percent of the good dominant or codominant sprouts.

Grapevines

Grapevines severely damage young saplings by deforming the tops, breaking branches, reducing stem quality, and retarding growth (Figure 4); often the trees are killed. Snow or ice storms intensify the grapevine problem.

Grapevines were more of a problem on the better sites and in the larger openings. After 10 years, the major damage was confined to the 150-, 200-, and 250-foot diameter openings on good sites. Grapevines ranged from an estimated 35 to 930 vines per acre in these larger openings, with about 30 percent of the trees 1.0 inch dbh and larger having grapevines in their crowns—occasionally more than 50 percent. In 50- and 100-foot openings, about 6 percent of these trees had grapevines in their crowns. The herbicide treatments did not influence the prevalence of grapevines in the openings. The preference of large grapevine populations in some of the large openings is no doubt partially responsible for differences in number of good quality trees within an opening size class, but the extent of this influence is unknown.

Discussion

In general, for both the fair and good sites, there was an adequate number of good quality dominant or codominant trees 1.0 inch or more in dbh in all diameter openings and herbicide treatments at the 10-year measurement period. However, 10-year-old stands with 100 to 125 good quality dominant or codominant trees per acre may have too few trees for crop tree selection because of species composition and spacing. The major difference among openings occurred in species composition and the variety of species present in the larger 150- to 250-foot openings.

The main purpose of the herbicide 2,4,5-T basal spray on cut stumps was to control sprouting. In general, with the exception of intensive herbicide treatment in the 150-foot diameter openings on SI 60, sprouts were reduced by the intensive herbicide treatment (basal spraying of 1.0- to 4.9-inch dbh stems plus cut stumps) more than by other treatments. After 10 years, 15 to 20 percent of the good dominant or codominate trees were of stump-sprout origin in the intensively treated openings; about 40 percent of the stems were of sprout-origin where no herbicide treatments had been used. The major sprouting species was red maple, along with basswood and yellow-poplar. Perhaps a different herbicide would have been more effective in controlling the sprout vegetation; red maple is a difficult species to kill. However, many times sprouts can and do develop into good quality trees (Lamson 1976, Beck 1977, Smith 1979), and the cost of controlling sprouts needs to be considered by forest managers in relation to the results.

As expected, the herbicide cultural treatment did influence average dbh; i.e., the control openings had more good larger dominant or codominant trees than the herbicide-treated openings because residual trees in the 1.0- to 4.9-inch dbh class were not cut or herbicided in the control openings.

Predictions based on our study methods and 10-year results indicate that sawtimber-size stands on fair sites will be dominated by red maple, oaks, and beech in the 50-foot openings. The 150- and 250-foot openings will be dominated by red maple, oaks, and sweet birch. Sassafras, though present in large numbers, should rapidly drop out of these stands. On the good sites, sugar maple will probably be the most numerous tree species in the future sawtimber-size stands in the 50- and 100-foot openings, though there are some good dominant or codominant yellow-poplar, basswood, and beech in the 100-foot openings. In the larger openings, yellow-poplar, black cherry, and sweet birch now dominate, though there are a number of other species. However, in this locale, birch is questionable as a major component of the sawlog-size stand.

Figure 4. Grapevine damage in young even-aged Appalachian hardwood stands on good site.

Conclusion

Data based on the 10-year results and methods used in this study indicate that openings approximately 150 feet in diameter or larger provide adequate reproduction establishment, variety of species composition, and growth development to resemble large clearcuts. Thus, in this instance, approximately 1/2-acre openings are desirable as the minimum to satisfy silvicultural objectives of even-age management, in Appalachian mixed hardwood stands.

Where controlling stems of sprout origin is the main objective, the most effective study treatment was basal spraying of cut stumps and standing stems with herbicide. Spraying the cut stumps was necessary to reduce sprouting. However, because sprouts often develop into quality stems, the desirability of controlling sprouts in Appalachian hardwood stands can be questioned.

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