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Development of Reproduction in Allegheny Hardwood Stands after Herbicide-Clearcuts and Herbicide-Shelterwood Cuts

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Abstract. Dense ground covers of fern and grass interfere with the regeneration of Allegheny hardwoods. An herbicide containing N-phosphonomethyl glycine controls the fern and grass, but also kills advance reproduction of desirable tree species. Preliminary results of an experiment comparing regeneration 3 years after herbicide-clearcuts and herbicide-shelterwood seed cuts showed that the amount of desirable hardwood reproduction was substantially greater in the shelterwood treatment than in the clearcuts. Clearcuts were dominated by black cherry, whereas shelterwood cuts contained nearly equal mixture of black cherry and red maple. The herbicide-shelterwood sequence appears to be more reliable than the herbicide-clearcut treatment in obtaining adequate reproduction of desirable species.

Dense ground covers of hayscented fern (*Dennstaedtia punctilobula* Michx.), New York fern (*Thelypteris noveboracensis* L.), and short husk grass (*Brachyelytrum erectum* Schreb.) are found in many mature Allegheny hardwood stands. In some stands they appear to be naturally abundant, but in many others they probably result from invasion after previous cuttings.

These plants interfere with the regeneration of desirable hardwood species; the result often is complete regeneration failure following clearcutting (Horsley 1977b, Horsley and Marquis in press). Fern and grass ground covers can be controlled with Roundup herbicide (N-phosphonomethyl glycine)[1] applied before harvest cutting (Horsley 1981). However, Roundup also kills most advanced reproduction present at the time of application, so the type of harvest cutting used after herbicide treatment must facilitate the development of adequate numbers of new tree seedlings to ensure adequate stocking in the new stand.

Clearcut stands develop new reproduction from seed stored in the forest floor, from seed falling between the time of herbicide application and harvest cutting, and from seed which is blown or carried by animals onto the site. Viable seed of desirable Allegheny hardwoods [black cherry (*Prunus serotina* Ehrh.), sugar maple (*Acer saccharum* Marsh.), red maple (*Acer rubrum* L.), and white ash (*Fraxinus americana* L.)] are found in the forest floor of most Allegheny hardwood stands. However, because large seed crops are infrequent and the storage life of the maples and ash is short, black cherry is the only dependable source of desirable seed in the forest floor (Marquis 1975). Roundup has no effect on this ungerminated seed (Horsley 1981). Shelterwood-cut stands have these same seed sources, but also receive many times more seed from residual overstory trees. And shelterwood cutting provides a more favorable environment for seed germination and early seedling establishment (Marquis 1979).

Shelterwood seed cuts or clearcuts were made following herbicide treatment to remove an undesirable fern understory. In this study I compare regeneration results 3 years after treatment.

Materials and Methods

The experiment was located in a single Allegheny hardwood stand on the Smethport District of Hammermill Paper Company near Smethport, Pennsylvania. A 16-acre area with a dense ground cover of hayscented fern was treated with 2 lb/acre active ingredient of Roundup, applied in a water-herbicide solution (20 gal/acre) from a backpack mist blower, August 9–18, 1977. The area was subsequently divided into eight 2-acre blocks to which four clearcut and four shelterwood treatments were assigned systematically in a checkerboard pattern. The cuttings were made between November 23, 1977, and January 3, 1978. Blocks receiving the shelterwood seed cut were cut to a residual overstory stocking of approximately 60 percent. Mean residual basal area was 110 ft² (black cherry: 47 ft²; sugar maple: 22 ft²; red maple: 38 ft²; birch: less than 1 ft²; beech: less than 1 ft²; eastern hemlock: 1 ft²). All stems larger than 1 inch in diameter were cut in the clearcuts.

In each 2-acre block, herbaceous ground cover and hardwood regeneration were measured on 15 systematically located 6-foot-radius

[1] Manufactured by Monsanto Agricultural Products, St. Louis, MO. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the United States Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

(0.0026-acre) plots. Thus, each treatment was represented by 60 measurement locations. Permanent sample points were located at 66-foot intervals on a grid, at least 66 feet from any cutting boundary. Postspray ground cover control and regeneration were measured in June 1978, at the beginning of the first growing season after treatment, and at the end of each of the succeeding three growing seasons. Numbers and species of regeneration were obtained by direct counts, and were recorded by four height classes: less than 1, 1 to 3, 3 to 5, and 5 or more feet. The tallest stem at each sample point was called dominant.

Adequacy of stocking was evaluated by the method of Marquis and Bjorkbom (1982). This method recognizes that different criteria of acceptable stocking are applicable at different stages during the regeneration process. Uncut stands or stands that have received only a shelterwood seed cut usually have many small stems that produce little growth. Deer browsing of these stems is not serious. Regression analysis has shown that if 70 percent of the 6-foot-radius regeneration sample plots have at least 25 black cherry stems or 100 stems of all desirable species, the stand has a high probability of developing successfully and may be considered satisfactorily stocked at this stage in the regeneration process. Following the final removal cut for a shelterwood cut or a clearcut, the number of stems declines and the seedlings grow taller, having been released from the shade of overstory trees. Deer browsing of these now highly visible seedlings becomes a serious problem at this time. During this stage, at least two desirable stems must reach a height of 5 or more feet on 70 percent of the regeneration sample plots to be out of the reach of deer. Most stands require 5 to 10 years to attain this goal.

From their regression studies, Marquis and Bjorkbom have devised a measure of progress toward this goal that can be applied earlier in the life of the new stand. To be satisfactorily stocked 2 to 5 years after final harvest cutting, the average of the proportion of plots with five desirable stems greater than 3 feet and the proportion of plots with 25 desirable stems total must be at least 70 percent. Each of these proportions is determined separately, then the two are averaged.

Results

Ground Cover

Before herbicide treatment, ferns covered 75 to 80 percent of the area. Treatment with Roundup reduced the fern cover to 1 percent or less (Table 1). Slow reinvasion in both cutting treatments increased coverage to 10 percent in clearcuts and 3 percent in shelterwood areas. A small amount of short husk grass, amounting to less than 1 percent before treatment, was killed by the herbicide. However, dormant seed of wild oat grass (*Danthonia compressa* Aust.), a species common in forest openings on the Allegheny Plateau and in the forest floor of many Allegheny hardwood stands, was stimulated to germinate by logging conditions. In heavily disturbed areas, such as skid trails or areas where hardwood reproduction was not vigorous, wild oat grass became established in dense stands. Germination of grass seed was greater in the clearcuts than in the shelterwood cuts. In portions of two clearcuts where little hardwood reproduction became established, a heavy grass cover became established. On adequately stocked areas where hardwood and grass seedlings germinated at the same time, grass has not interfered noticeably with seedling growth.

Desirable Hardwood Seedlings

In June 1978, at the beginning of the first growing season following the herbicide and cutting treatments, there were less than 10,000 seedlings per acre in either clearcut or shelterwood stands (Table 2). These were small seedlings that survived the herbicide treatment. During the succeeding three growing seasons, five times more seedlings of desirable species became established in shelterwood than in clearcut blocks (Table 2). In June 1978, stocking ranged from 5 to 11 percent (Table 3). On shelterwood blocks, stocking with desirable reproduction increased to 95 percent 1 year after treatment and to 100 percent 3 years after treatment. Stocking on clearcut blocks was 44 percent 1 year after treatment and averaged 64 percent after 3 years (Table 3). However, one-half of the clearcut blocks had less than 70 percent stocking, compared with 100 percent stocking in all shelterwood blocks:

Table 1.—Mean ground cover before and after herbicide-clearcut and herbicide-shelterwood cut treatment, in percent

Measurement date	Clearcut		Shelterwood seed cut	
	Fern	Grass	Fern	Grass
August 1977[a]	78	1	78	1
June 1978[b]	<1	5	1	2
September 1978	1	24	<1	8
October 1979	9	48	4	20
August 1980	10	47	3	21

[a] Before treatment.
[b] After treatment.

Table 2.—Mean numbers of desirable hardwood seedlings regenerating after herbicide-clearcut and herbicide-shelterwood cut treatments[a]

Measurement date	Clearcut				Shelterwood seed cut			
	Black cherry	Red maple	Sugar maple	All desirable	Black cherry	Red maple	Sugar maple	All desirable
	(Thousands/acre)							
June 1978	2.1	2.1	0.5	4.7	6.4	2.5	0.7	9.6
September 1978	27.6	15.4	2.0	45.0	50.6	64.3	1.2	116.1
October 1979	20.0	13.6	1.5	35.1	47.6	57.9	0.8	106.2
August 1980	20.3	12.1	1.2	33.4	75.0	85.8	0.6	161.4

[a] Small numbers of desirable species other than black cherry, red maple, and sugar maple are not included.

Block	*Clearcut*	*Shelterwood seed cut*
	Percent	
1	96	100
2	70	100
3	50	100
4	40	100

Inadequate stocking in clearcut blocks 3 and 4 was due primarily to poor spacial distribution of seedlings. Few new seedlings became established in large portions of these blocks after treatment and these areas were invaded rapidly by wild oat grass.

Species composition differed between clearcut and shelterwood blocks (Table 2). In clearcuts, there were nearly twice as many black cherry seedlings as red maple, the second most abundant species. Three years after cutting, black cherry had outgrown other desirable species and was the dominant species on nearly 80 percent of the sample plots (Table 4). In shelterwood cuttings, red maple was as abundant as black cherry. Despite little height growth due to the presence of the residual overstory, red maple had a higher percent dominance in relation to black cherry in the shelterwood cut than in the clearcut (Table 4). It will not be possible to determine the relative growth rates of black cherry and red maple in the shelterwood blocks until the final removal cut is made.

Table 3.—Percent stocking of Allegheny hardwood reproduction after herbicide-clearcut and herbicide-shelterwood treatment

Measurement date	Stocking in clearcuts			Stocking in shelterwood seed cuts[b]
	% plots w/25 desirable seedlings	% plots w/5 stems >3 feet	Mean[a]	
June 1978	10	0	5	12
September 1978	87	2	44	95
October 1979	85	33	59	98
August 1980	77	52	64	100

[a] Stocking in clearcut stands was calculated as the mean of the proportion of plots with 25 stems of desirable species and the proportion of plots with 5 desirable stems greater than 3 feet tall.

[b] Stocking in shelterwood cut stands was calculated as the proportion of plots with 25 black cherry stems or 100 stems of any desirable species.

Discussion

The herbicide treatment successfully removed the fern ground cover, and the small amount of regrowth seems of little consequence. Nor does invasion by wild oat grass appear to be serious in the shelterwood areas. However, in portions of clearcuts lacking large numbers of vigorous seedlings, a dense ground cover of wild oat grass has become established and few new tree seedlings are evident. Wild oat grass is a major ground cover component in old forest openings on the Allegheny Plateau and has been associated with allelopathic interference with growth of hardwood reproduction (Horsley 1977a). Hence, portions of clearcuts with heavy grass cover probably will fail to regenerate.

On the basis of these preliminary results, shelterwood cutting appears more reliable than clearcutting in establishing adequate desirable reproduction following herbicide treatment. Additional seed provided by the residual overstory trees and the more moderate environmental conditions of the shelterwood sequence were major factors in establishing reproduction. Although some clearcut blocks regenerated satisfactorily, acceptable stocking was inconsistent. In stands where black cherry is not a major overstory component (as it was here), or there is

Table 4.—Numbers of desirable Allegheny hardwoods 3 years after treatment, by height class, and percent dominance

Height class (feet)	Clearcut				Shelterwood seed cut			
	Black cherry	Red maple	Sugar maple	All desirable	Black cherry	Red maple	Sugar maple	All desirable
	(Thousands/acre)							
<1	3.4	5.8	0.4	9.6	72.8	85.3	0.4	158.4
1–3	9.2	5.8	0.7	15.6	2.2	0.5	0.2	3.0
3–5	6.7	0.3	0.1	7.0	0.0	0.0	0.0	0.0
5 or more	1.0	0.2	0.0	1.2	0.0	0.0	0.0	0.0
All heights	20.3	12.1	1.2	33.4	75.0	85.8	0.6	161.4
Dominance	78	8	0	86	58	18	5	82

little black cherry seed stored in the forest floor at the time of harvesting, clearcutting probably would result in an even higher proportion of failures than were observed here.

Despite the presence of relatively large numbers of stems of other desirable species, such as red maple, black cherry is the dominant species of reproduction and it is likely that it will remain so in subsequent years. We have observed this pattern of reproduction in many clearcut Allegheny hardwood stands on the Allegheny Plateau.[2] It is unclear why other species of reproduction that are abundant and capable of rapid growth, such as red maple, fail to compete successfully with black cherry.

The applicability of the herbicide-shelterwood sequence over a range of site and stand conditions on the Allegheny Plateau is now being studied.

Caution about Pesticides

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Environmental Protection Agency, consult your local forest pathologist, county agricultural agent, or State Extension specialist to be sure the intended use is still registered.

[2] Grisez, Ted G. Unpublished data on file at the Northeastern Forest Experiment Station, Warren, PA.

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