Preharvest Herbicide Treatment Improves Regeneration in Southern Appalachian Hardwoods

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ABSTRACT. Preharvest herbicide treatment of undesirable and unmerchantable vegetation was compared to postharvest felling. Ten years after the clearcut harvesting, the preharvest treatment had increased the number and proportion of desirable stems and decreased the number and proportion of undesirable sprouts in the dominant stand. Stands that developed after the preharvest herbicide treatment are dominated by single-stemmed desirable species, and excellent future stocking is assured. Because of the presence of undesirable sprout clumps, plots receiving the postharvest felling have an uncertain future. An effective preharvest treatment that costs about the same as postharvest felling is recommended.

Clearcutting has become the method of choice for natural regeneration of southern Appalachian hardwoods. After the merchantable stand is removed, all or most of the residual unmerchantable stems are felled. The resulting natural regeneration is a combination of seedlings, advance reproduction, and stump sprouts (Beck 1980).

While regeneration has usually been acceptable, postharvest felling of residual unmerchantable stems is not without problems. Logging slash makes traversing the often steep topography difficult. Furthermore, when undesirable species are cut they usually sprout prolifically, and these sprouts can displace stems of more desirable species (McGee and Hooper 1970). These problems can be avoided by treating unmerchantable stems prior to harvest with herbicides. This paper presents the results of two studies comparing postharvest felling of unmerchantable stems with preharvest herbicide treatment.

METHODS

Study 1

Three stands of mature mixed hardwoods were located on the Bent Creek Experimental Forest near Asheville, North Carolina. These sites were moist, north- and east-facing slopes with 50-year oak site indexes ranging from 80 to 90 ft. The overstories were predominantly oaks (*Quercus* spp.) with yellow-poplar (*Liriodendron tulipifera*), hickories (*Carya* spp.), white ash (*Fraxinus americana*), and sweet birch (*Betula lenta*) occurring in the overstories of all three stands.

In each stand a 7- × 10-chain block was established. Each block was divided into four 3.5- by 5-chain plots, providing four 2.5- by 4-chain (1 acre) plots with a 1-chain-wide buffer strip. In each block one of four treatments was randomly assigned to each plot:

(1) No preharvest treatment (check); clearcut in 1972–73, followed by postharvest felling of undesirable and nonmerchantable woody vegetation.
(2) Preharvest treatment in 1969; clearcut in 1972–73.
(3) Preharvest treatment in 1970; clearcut in 1972–73.
(4) Preharvest treatment in 1971; clearcut in 1972–73.

In postharvest felling (check), all residual stems taller than 4.5 ft were cut with chainsaws. The preharvest treatment consisted of killing with herbicides[1] all stems of undesirable species over 1 ft tall, and all stems of desirable species taller than 4.5 ft which would not be harvested in a normal commercial clearcut. Stems with a basal diameter of 2 in or more were injected; smaller stems were treated by basal spraying.

In assessing the results, species were considered desirable solely on the basis of timber value. All oaks, hickories, yellow-poplar, white ash, basswood (*Tilia americana*), black cherry (*Prunus serotina*), black walnut (*Juglans nigra*), sweet birch, all pine species (*Pinus* spp.), Fraser magnolia (*Magnolia fraseri*), and cucumbertree (*Magnolia accuminata*) were classed as de-

[1] Herbicides used were 2,4-D + Picloram, MSMA, and 2,4,5-T. Concentrations and rates of applications were those recommended by the manufacturers. Other herbicides labeled for weed-tree control would be expected to yield similar results.

sirable. All other species were considered undesirable.

A stratified, random sample using 0.025-acre subplots (five subplots per plot) established prior to treatment application was used to sample regeneration 10 years after clearcutting. Diameter at breast height was measured on all stems occupying dominant, codominant, and strong intermediate crown classes in these subplots. And the five stems occupying the most dominant positions were noted. The vast majority of stems that ultimately become dominants and codominants in these stands will come from the first category (all stems); stems from the second category (best five) are currently in the strongest competitive position and will exert a strong influence on future stand composition and stocking.

Analysis of variance was used to evaluate treatment effects. Tests of significance (0.10 level) were performed on two orthogonal comparisons of interest:

Comparison 1—Check *vs.* mean of preharvest treatments in 1969, 1970, and 1971 (to test effect of herbicide treatment).

Comparison 2—1969 preharvest treatment *vs.* 1971 preharvest treatment (to test effect of timing of treatment application).

Study 2

In the earlier report of Study 1 (Loftis 1978), it appeared that, although the cost of the preharvest treatment was at least two times that of postharvest felling, a less costly but equally effective preharvest treatment could be devised. Injecting undesirable stems larger than 2 in (basal diameter) and eliminating the basal spraying of smaller undesirables would cut the cost in half. To examine the effectiveness of this alternative, a study was installed with a field design and sampling similar to that used in Study 1. In this study three treatments were compared:

(1) No preharvest treatment; clearcut in 1978, followed by postharvest felling of undesirable and nonmerchantable woody vegetation.
(2) Preharvest herbicide injection and spraying (Study 1) in 1977; clearcut in 1978.
(3) Preharvest herbicide injection (only) in 1977; clearcut in 1978.

RESULTS AND DISCUSSION

Study 1

Species composition: Although oaks were the dominant overstory species on these sites prior to harvest, yellow-poplar and sweet birch are the most abundant desirable species in the new stands (Table 1). The oaks are present on fewer than 50% of the subplots, and are clearly headed for a secondary role in the new stands. Oliver (1975) suggested that oaks assume a dominant canopy position after occupying a subordinate position in the early life of the stand. However, on sites of the quality studied here, with yellow-poplar as the primary competitor, this seems unlikely. A comparison of height growth patterns (Beck 1962, Olson 1959, Doolittle 1958) suggests that once oak falls behind yellow-poplar, it will not catch up.

As at age 4 (Loftis 1978), black locust was the most abundant undesirable species at age 10. Herbicide treatment did not prevent root-suckering in this species or in sassafras. Both are distributed across all treatments. Red maple, dogwood, and sourwood stems, on the other hand, are almost all stump sprouts, and are concentrated on the check plots.

Treatment comparisons: Treatment means and results of comparisons among treatment means are shown in Table 2. There were no differences in the number

Table 1. Species composition of the stands in Study 1, 10 years after clearcutting, Bent Creek Experimental Forest, North Carolina.[1]

Species	Number of stems per acre
Desirable	
Yellow-popular	407
Sweet birch	191
Oaks[2]	45
Others[3]	22
Undesirable	
Black Locust	86
Dogwood	21
Red maple	21
Sourwood	21
Sassafras	20

[1] Includes all stems judged to be dominant, codominant, or strong intermediate in crown class, averaged over replications and treatments.
[2] Northern red oak (*Quercus rubra*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), chestnut oak (*Q. prinus*), and white oak (*Q. alba*).
[3] Hickories, white ash, black cherry, cucumbertree, Frazer magnolia, and shortleaf pine (*Pinus echinata*).

Table 2. Treatment means for selected variables in Study 1, 10 years after clearcutting, Bent Creek Experimental Forest, North Carolina.

Variable	Year of herbicide treatment				Comparisons[1]	
	1969	1970	1971	Check	1	2
	.... *Number/acre*					
Desirable stems	685	717	613	528	**[2]	NS[3]
Undesirable seedlings	107	152	171	144	NS	NS
Undesirable sprouts	16	59	19	125	**	NS
	.... *Percent*[4]					
Desirable seedlings	92.2	96.0	90.9	88.1	NS	NS

[1] Linear, orthogonal comparisons: 1—treated plots *vs.* check; 2—1969 treatment *vs.* 1971 treatment.
[2] **—significant at 0.05 level.
[3] NS—not significant.
[4] Percent of all desirable stems which are of seedling origin. Analysis of variance of percentage variables was performed on the arcsin $\sqrt{\text{percent}}$

Table 3. Stand composition by treatments in Study 1, 10 years after clearcutting, Bent Creek Experimental Forest, North Carolina.

Variable	Year of herbicide treatment				Comparisons[1]	
	1969	1970	1971	Check	1	2
	.... *Percent*[2]					
ALL DOMINANT, CODOMINANT, AND STRONG INTERMEDIATE STEMS						
Desirable stems	84.3	83.2	83.7	65.5	**[3]	NS
Undesirable sprouts	2.0	11.3	5.7	17.0	*	NS
DOMINANT FIVE STEMS PER PLOT						
Desirablr stems	88.0	92.0	85.3	69.3	*	NS
Undesirable sprouts	2.7	1.3	1.3	16.0	**	NS

[1] Linear, orthogonal comparisons: 1—treated plots *vs.* check; 2—1969 treatment *vs.* 1971 treatment.
[2] Percent of all stems. Analysis of variance was performed on the arcsin $\sqrt{\text{percent}}$.
[3] **—significant at 0.05 level; *—significant at 0.10 level; NS—not significant.

of single-stemmed undesirable species per acre between herbicide treatments and the check (comparison 1). These stems were almost all black locust and sassafras. There were significantly more undesirable sprouts on the check plots than on the herbicide-treated plots. These undesirable sprouts were multistemmed clumps of dogwood, red maple, and sourwood. Neither the number of single-stemmed undesirable species nor the number of undesirable sprouts differed between the 1969 and 1971 herbicide treatment (comparison 2).

The herbicide-treated plots had significantly more desirable stems per acre than did the check, but timing of herbicide treatment had no effect on the number of desirable stems. The percentage of desirable stems of seedling origin was unaffected by either herbicide treatment or timing of herbicide treatment.

Preharvest herbicide treatment has improved stand composition (Table 3). On the herbicide-treated plots 83.7%[2] of all stems sampled and 88.4% of the five most dominant stems on each subplot were desirable species. Undesirable sprouts comprised 17.0% of all stems and 16.0% of the five most dominant stems per subplot on the check plots. On the herbicide-treated plots these figures were 6.3 and 1.8%, respectively.

As suggested in the previous report of this study (Loftis 1978), the plots that received the postharvest felling are developing into acceptable stands. The number of desirable stems as a percentage of all stems has increased from 28% at age 4 to 65% at age 10. And the number of undesirable sprouts as a percentage of all stems has decreased from 42% at age 4 to 17% at age 10. However, it is visually apparent at age 10 that undesirable sprouts are

[2] Mean of preharvest treatments in 1969, 1970, and 1971.

Table 4. Stand composition by treatment in Study 2, 5 years after clearcutting, Bent Creek Experimental Forest, North Carolina.

	Treatment		
	Postharvest felling	Inject	Inject + spray
	.... *Percent*[1]		
Desirable stems	33.7	48.0	64.1
Undesirable sprouts	23.6	5.0	8.9

[1] Percent of all stems > = 4.5 ft tall.

occupying a large amount of growing space on the check plots. The growing space occupied by a sprout clump far exceeds that occupied by a single-stemmed individual. Red maple is particularly noteworthy in this respect. Even at an early age a red maple sprout clump can occupy as much as 500 sq ft of growing space (McGee and Hooper 1970). So even though the 528 desirable stems per acre on the check plots would seem adequate to fully stock the stand with desirable species, sprout clumps have preempted valuable space in some areas. In contrast, competition for growing space on the herbicide-treated plots is almost entirely among single-stemmed desirable species.

Although black locust is classified as an undesirable species, its widespread occurrence is no cause for concern. It casts a light shade and interferes with more desirable species only when it occurs in dense thickets (Beck and McGee 1974). It may even provide some useful products from thinnings, and its role as a nitrogen fixer may be very important in the nitrogen budget on harvested sites (Swank and Waide 1980).

Study 2

Early results from Study 2 show that both preharvest herbicide treatments provided good control of stump sprouts (Table 4). Both preharvest treatments also resulted in stands having a higher percentage of desirable stems than the postharvest felling. The difference between the two preharvest treatments results from a slightly larger number of desirable stems and a slightly lower number of undesirable seedlings on the inject-and-spray plots than on the inject-only plots.

RECOMMENDATIONS

Based on the results of these two studies, preharvest injection of undesirable species with a basal diameter of 2 in and larger is recommended. Operational application of this treatment costs $50 to $70 per acre—about the same as postharvest felling.[3]

[3] Personal communication, Doug Gray, Brasstown Ranger District, Blairsville, Georgia.

CONCLUSIONS

Ten years after clearcutting, stands that developed after preharvest herbicide treatment of undesirable vegetation look very good. These stands are composed of single-stemmed trees, overwhelmingly dominated by desirable species. Previous experience suggests that the check plots, which developed after postharvest felling of undesirable vegetation, will also become acceptable stands. However, undesirable sprout clumps have displaced desirable species in some areas of the check plots, creating a patchy distribution of desirable stems. It is possible that future sawtimber volume and value of these stands may be reduced because of this displacement. Thus, while excellent stocking of desirable species in the herbicide-treated plots is assured, some questions remain about the future of the stands on the check plots.

Early indications are that a less intensive, less costly preharvest treatment than used in the first study will produce nearly as good results. Injecting stems of undesirable species having a basal diameter of over 2 in, rather than injecting these items and spraying smaller undesirable stems, costs about the same as postharvest felling, but produces a better regeneration stand.

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