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Herbicide Treatment of Striped Maple and Beech in Allegheny Hardwood Stands

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ABSTRACT. Three small-plot experiments evaluated herbicides for killing striped maple (*Acer pensylvanicum* L.) and beech (*Fagus grandifolia* Ehrh.). Glyphosate, applied to striped maple or beech in uncut stands, from June 1 to October 1, produced a high degree of kill at rates of 1.12 to 4.48 kg/ha a.i. (active ingredient). At the 1.12 kg/ha rate, kill varied with time of application. Best kill was with the July 1 through September 1 application dates for striped maple and with the August 1 through October 1 application dates for beech. Applications of 2,4,5-T in an uncut stand, at rates ranging from 0.78 to 4.70 kg/ha a.i., killed at least 97 percent of the striped maple. Applications of 2,4,5-T did not interfere with subsequent development of desirable species of advance reproduction. Bromacil (8.96 to 53.76 kg/ha a.i.), 5 percent picloram pellets (1.68 to 12.10 kg/ha a.i.), and 10 percent picloram pellets (2.24 to 17.92 kg/ha a.i.) were applied to striped maple in a 12-year-old clearcut. About 90 percent of the striped maple were killed with all rates of bromacil, rates of 6.72 kg/ha a.i. or more of 5 percent picloram pellets, and 8.96 kg/ha a.i. or more of 10 percent picloram pellets. Survival and height growth of white ash (*Fraxinus americana* L.) seedlings subsequently planted on the site were not significantly reduced by any rate of application of any of the herbicides. FOREST SCI. 29:103–112.

ADDITIONAL KEY WORDS. *Acer pensylvanicum, Fagus grandifolia,* glyphosate, 2,4,5-T, bromacil, picloram, natural regeneration, artificial regeneration.

REGENERATION IS OFTEN DIFFICULT in the Allegheny hardwood (cherry-maple) forests of Pennsylvania and New York. Excessive deer browsing of advance reproduction and interference from dense ground covers of herbaceous plants have been identified as major causes of regeneration failure (Marquis 1974; Horsley 1977a, 1977b; Horsley and Marquis 1983). Under certain circumstances, striped maple (*Acer pensylvanicum* L.) and beech (*Fagus grandifolia* Ehrh.), common understory trees found in most of the northern hardwood forest types, also interfere with regeneration of desirable hardwood species (Husch 1954, Hamilton 1955, Tierson 1969).

Striped maple seedlings originate primarily from seed, and are capable of surviving for many years as small suppressed trees in the understory (Marquis 1965, Hibbs and Fischer 1979, Hibbs and others 1980). Beech, which is one of the most shade-tolerant trees in the northern hardwood forest, reproduces from seed or from adventitious buds formed on the roots. Root suckers commonly appear after logging damages roots or during senescence of old beech trees, however, root suckers may be present when no injury is apparent in younger stands (Rushmore 1965). These suckers can remain in the understory for many years, dying back and resprouting.

When there are many striped maple seedlings and beech root suckers in the understory before cutting, they frequently become the dominant vegetation after

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cutting, excluding other species of regeneration. For example, in a study of 34 Allegheny hardwood stands in northwestern Pennsylvania, Marquis and others (1975) found that when more than 30 percent of the 1.83-m radius regeneration plots had more than eight striped maple seedlings or beech root suckers before clearcutting, these species became dominant after cutting. Present guidelines for management of Allegheny hardwood stands recommend deferring the cut in such stands. High populations of white-tailed deer (*Odocoileus virginianus virginianus* Boddaert), aggravate the situation because deer browse more heavily on the desirable hardwood timber species than on striped maple or beech, and this browsing significantly favors establishment of these undesirable trees (Shafer 1965, Tierson 1969, Marquis 1981).

If the number of striped maple or beech stems exceeds recommendations, it is essential to reduce the number before harvest cutting to permit regeneration of desirable hardwood species. We have been using ground applications of glyphosate prior to the seed cut of a 2-cut shelterwood to remove undesirable understories of hayscented fern (*Dennstaedtia punctilobula* (Michx.) Moore), New York fern (*Thelypteris noveboracensis* L.), and short husk grass (*Brachyelytrum erectum* Schreb.) (Horsley 1982). It would be valuable if glyphosate also could be used to control striped maple and beech. However, only a few other studies of striped maple or beech control by ground application techniques, necessary where the overstory is to be retained, have been made. Tierson (1969) successfully treated beech stems up to 6 m in height with 2,4,5-T applied from a backpack or tractor-mounted mistblower. Smith and Trimble (1970) applied a mixture of 2,4-D and 2,4,5-T with a backpack mistblower to hardwood stands in West Virginia that contained beech ranging in height from 0.3 m to more than 4.5 m and striped maple stems less than 1.5 m in height.

Recently, studies of aerial applications of herbicides to brush on conifer sites that contained specimens of striped maple or beech have been reported. McCormack and Newton (1980) and McCormack and others (1982) have reported that glyphosate and triclopyr and mixtures of these two herbicides provided excellent control of beech. Only "intermediate" control of striped maple was obtained.

We have conducted small-plot experiments to evaluate control of striped maple and beech in Allegheny hardwood stands before or after harvest cutting. The results of three experiments with five herbicides or herbicide formulations applied at different rates and times are presented here.

General Methods

The stands used in Experiments 1 and 2 were typical 60- to 80-year-old hardwood stands on the Allegheny Plateau. They had variable amounts of black cherry (*Prunus serotina* Ehrh.), sugar maple (*Acer saccharum* Marsh.), red maple (*Acer rubrum* L.), white ash (*Fraxinus americana* L.), red oak (*Quercus rubra* L.), white oak (*Quercus alba* L.), yellow birch (*Betula alleghaniensis* Britton), and beech in the overstory. Striped maple and beech were the dominant understory species. Experiment 3 was conducted in a dense 12-year-old stand of striped maple that originated after clearcutting.

Soils at the seven locations used in these experiments were typical of those encountered on the Allegheny Plateau. Texture of the A horizon is generally a sandy loam; the B horizon ranges from sandy loam to silty clay loam. Soil reaction of these horizons range from 3.8 to 4.2 and 4.2 to 4.6, respectively. Drainage ranges from somewhat poorly drained to moderately well drained, with formation of a fragipan-like layer on the more imperfectly drained sites (typic to aquic fragiudults: loamy, mixed, mesic). Thickness of the A_1 horizon ranges from 12 to 25 mm and the F + H layer from 25 to 40 mm.

In the uncut stands, glyphosate[1] (Experiment 1) or 2,4,5-T[2] (Experiment 2) was applied to the foliage of striped maple or beech. In the clearcut stand, bromacil[3] or picloram[4] (Experiment 3) was applied to the ground and absorbed through the roots.

Rates of glyphosate application were within the range recommended by the manufacturer for other plant materials; rates of bromacil and picloram include some that were higher than those normally recommended. Herbicides for each plot were measured before going into the field. Where appropriate, dilutions were made with water in the field and the diluted solutions were applied with a small, low pressure garden sprayer. Pelleted herbicides were broadcast by hand.

Kill of striped maple or beech was evaluated 11 to 28 months after application and expressed as a percentage of the number of live stems present before treatment. Stems with incompletely killed tops or resprouting from the root collar were considered living stems.

Percentage data were transformed using the arc-sine transformation before the analysis of variance. Duncan's New Multiple Range Test was used for mean separation at the 0.05 level of probability.

Experiment 1—Methods

Striped maple and beech were treated in separate, but identical, applications of glyphosate to evaluate the effects of rate and time of application. Herbicide was applied at four rates, 0, 1.12, 2.24, 4.48 kg/ha a.i., and at five times during the growing season, June 1, July 1, August 1, September 1, and October 1. Field layout was the split-plot method in randomized complete blocks, replicated 3 times. Each date of application was split to receive 4 rates of application. The 7.5- × 7.5-m plots had at least 10 stems in each of the following size classes: newly germinated seedlings, older seedlings <0.3, 0.3 to 1.5, 1.5 to 3.0 m tall. The few stems larger than 3.0 m were tallied and treated, but no effort was made to record a minimum number.

In the field, the herbicide was diluted in 3 l (514 l/ha) of water and sprayed onto foliage to a height of 3.0 m. An effort was made to distribute the spray evenly both horizontally and vertically; all stems less than 3.0 m tall were completely sprayed with the herbicide. There was no rainfall within 6 hours of spraying on any application date. Kill of striped maple or beech was evaluated in September 1980, 11 to 15 months after application.

Experiment 1—Results

Striped Maple.—Kill of striped maple was significantly affected by time and rate of glyphosate application and by tree height. Best kill was obtained with August

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[1] Glyphosate (*N*-phosphonomethyl glycine) is marketed under the trade name Roundup by Monsanto Agricultural Products, St. Louis, MO.

The use of trade, firm, or corporation names in this paper does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service.

[2] 2,4,5-T (2,4,5-Trichlorophenoxyacetic acid, propylene glycol butyl ester ethers) is an emulsifiable concentrate marketed under the trade name Esteron 245 by Dow Chemical Co., Midland, MI.

[3] Bromacil (5-bromo-3-*sec* butyl-6-methyl uracil) is marketed under the trade name Hyvar X by E. I. DuPont de Nemours and Co., Wilmington, DE.

[4] Picloram (4-amino-3,5,6-trichloropicolinic acid) is marketed under the trade name Tordon by Dow Chemical Co., Midland, MI. The 5 percent formulation is not commercially available. Picloram is applied as a pelleted dry product containing picloram as the potassium salt.

TABLE 1. Percentage of mean kill of striped maple by glyphosate applied at different rates and times, by stem-height class in Experiment 1.[a]

Stem height class and application rate (kg/ha a.i.)	Mean kill by glyphosate applied in—				
	June	July	August	September	October
	Percent				
Stem height < 0.3 m (mean stems/plot = 111)					
1.12	95a	99a	99a	100a	92a
2.24	97a	99a	99a	100a	92a
4.48	100a	99a	100a	100a	97a
Stem height 0.3–1.5 m (mean stems/plot = 136)					
1.12	53d	81a–d	95ab	97ab	57cd
2.24	95ab	87abc	97ab	97ab	77bcd
4.48	97ab	97ab	98ab	99a	90ab
Stem height 1.5–3 m (mean stems/plot = 27)					
1.12	39d	75bc	84bc	92ab	58cd
2.24	86abc	87abc	96ab	100a	80bc
4.48	90abc	95ab	96ab	100a	85bc
All stems < 0.3–3 m					
1.12	62e	85cd	93bc	96ab	69de
2.24	93bc	91bc	97ab	99ab	83cd
4.48	96ab	97ab	98ab	100a	91bc

[a] Values in the same stem-height class followed by the same letter were not significantly different at the 0.05 level of probability.

1 and September 1 applications; for most rates and tree sizes up to 3.0 m, kill was greater than 90 percent (Table 1). Applications on October 1, after some autumn yellowing began, resulted in significantly less kill of all but the smallest (<0.3 m) trees. Glyphosate applications before August 1 also produced less kill of 0.3-m to 3.0-m trees, particularly at the low (1.12 kg/ha a.i.) application rate.

The 1.12 kg/ha a.i. application rate was the most sensitive to time of application. Kill of 0.3-m to 3.0-m trees was less than 60 percent for the June 1 and October 1 application dates, but ranged from 75 to 100 percent for the July 1 through September 1 application dates. The 2.24 and 4.48 kg/ha a.i. application rates killed more than 85 percent of all sizes of striped maple up to 3.0 m in height when applied monthly from June 1 through September 1.

As tree size increased, striped maple were more difficult to kill, particularly with glyphosate applications made on June 1, July 1, or October 1. On trees larger than 3.0 m, the entire crown was not treated, however, many of these trees were killed, too. There were not enough of these larger trees to perform a statistical analysis, but trend information was obtained by pooling trees from all blocks. Kill ranged from 70 (1.12 kg/ha a.i.) to 90 (2.24 kg/ha a.i.) percent for 3.0-m to 4.5-m trees and 25 (1.12 kg/ha a.i.) to 100 (4.48 kg/ha a.i.) percent for 4.5-m to 6.0-m trees treated August 1 or September 1. Most trees that were not completely killed were seriously damaged, except for 4.5-m to 6.0-m trees that had only lower branches killed. A few trees that were not completely killed resprouted along the length of the stem; the remaining unkilled trees resprouted from the root collar.

On untreated control plots, natural mortality occurred among seedlings in the smaller size classes. Sixty percent of stems <0.3 m and 10 percent of the 0.3-m

TABLE 2. Percentage of mean kill of beech by glyphosate applied at different rates and times, by stem-height class in Experiment 1.[a]

Stem height class and application rate (kg/ha a.i.)	Mean kill by glyphosate applied in—				
	June	July	August	September	October
New germinants < 0.3 m (mean stems/plot = 44)	*Percent*				
1.12	100a	100a	100a	100a	100a
2.24	100a	100a	100a	100a	100a
4.48	100a	100a	100a	100a	100a
Stem height < 0.3 m (mean stems/plot = 30)					
1.12	100a	93b	99ab	95b	100a
2.24	91b	100a	100a	100a	100a
4.48	98ab	100a	100a	100a	100a
Stem height 0.3–1.5 m (mean stems/plot = 73)					
1.12	91bcd	97a–d	93bcd	98abc	97a–d
2.24	88cd	88cd	98abc	98abc	100a
4.48	86d	100a	95bcd	96a–d	99ab
Stem height 1.5–3 m (mean stems/plot = 29)					
1.12	74c	96ab	95b	100a	100a
2.24	76c	86bc	100a	98a	100a
4.48	78c	100a	98a	100a	100a
All stems new—3 m					
1.12	91e	92de	97bcd	98bc	99ab
2.24	89e	94cde	100a	99ab	100a
4.48	90e	100a	98bc	99ab	100a

[a] Values in the same height class followed by the same letter were not significantly different at the 0.05 level of probability.

to 1.5-m stems died during the interval between measurements. There was no natural mortality among stems taller than 1.5 m. Thus, some small stems that were killed by the herbicide on treated plots would have died naturally without treatment.

Beech.—Most of the beech stems treated were of root sucker origin, but there were large numbers of newly germinated seedlings present on most plots (Table 2). Beech was more sensitive to glyphosate than striped maple, and there was a high degree of kill with most treatments. Beech kill was significantly affected by time of glyphosate application and stem height. Rates of application greater than 1.12 kg/ha a.i. did not significantly increase beech kill.

Best kill of stems up to 3.0 m in height was obtained with July 1 to October 1 applications (Table 2). Applications on June 1 produced significantly less kill, particularly among stems larger than 1.5 m in height. All new germinants were killed by glyphosate at any time of application. As the size of stem increased from <0.3-m to 3.0-m, kill decreased. Although this decline in kill is statistically significant, it is not important because kill of most <0.3-m to 3.0-m stems was greater than 90 percent.

Stems taller than 3.0 m were also killed. The small number of trees in these sizes prevented statistical testing, but trend information was obtained by pooling data. Best kill of stems from 3.0 m to >6.0 m tall was obtained with September 1 and October 1 applications. Kill of the smaller 3.0-m to 4.5-m trees ranged from 96 to 100 percent, and kill of trees greater than 6.0 m tall ranged from 65 to 75 percent for these dates. Most stems <6.0 m in height that were not killed were heavily damaged.

Treatments that killed beech root suckers did not always kill the root which bore the sucker, and the lower 0.3 m of some stems with dead crowns remained alive but did not resprout. No root kill was observed for any stem on the June 1 or July 1 application dates, however, most roots were killed near the point of stem attachment for August 1 to October 1 application dates. Roots located close to large beech trees remained alive regardless of treatment. Living roots produced an average of four new root suckers per plot the year after treatment. An average of six new root suckers per plot was found on untreated control plots.

Experiment 2—Method

Striped maple were treated with 2,4,5-T at five rates—0, 0.78, 1.57, 3.14, and 4.70 kg/ha a.i.—and one time of application, June 15, 1977. Field layout used a randomized block design with three replications. The 10- × 10-m plots with each block received a different rate of herbicide, and were separated from adjoining plots by a 12-m wide isolation strip. Five randomly located 0.0004-ha subplots in each treatment plot were used to evaluate striped maple kill 1 year after herbicide application and to measure any residual effects on establishment of new hardwood reproduction. Striped maple stems were tallied in height classes as in Experiment 1; no striped maple stems larger than 1.5 m were found on these plots. Counts of seedling reproduction were made at the end of the growing season after herbicide application and for 2 subsequent years. Small seed traps were randomly located throughout the study area to determine what, if any, seeds were dispersed into the area. The herbicide was mixed with water in the field to a final volume of 1.9 l (187 l/ha).

Experiment 2—Results

Before treatment there were 74 new germinants, 560 stems less than 0.3 m tall, and 617 stems 0.3 to 1.5 m tall per plot. Twenty-five percent of the striped maple stems on untreated control plots died naturally during the first year of the study. Application of 2,4,5-T on treated plots killed almost all striped maple. Kill exceeded 97 percent in all size classes at the lowest rate applied, 0.78 kg/ha a.i. There were no significant differences among rates of herbicide applied. No resprouting was observed on any striped maple stem during the three growing seasons of the experiment.

Application of the herbicide also killed almost all of the desirable reproduction. However, 2,4,5-T had no residual effect that prevented establishment of new reproduction. Seedlings of desirable species became established quickly on the treated plots. Most seedlings were black cherry that originated from seed stored in the forest floor, but small amounts of seed of all desirable species were found in the seed traps. In September 1979, at the end of the third growing season after treatment, the number of seedlings of desirable species on treated plots had increased 120 percent over the pretreatment numbers (Table 3). During the same time, numbers of desirable seedlings increased 31 percent on untreated plots.

Small numbers of new striped maple seedlings also became established (Table 3). These seedlings apparently originated from seed stored in the forest floor, because striped maple seeds are known to remain dormant in the forest floor for

TABLE 3. Development of reproduction after treatment of an Allegheny hardwood stand with 2,4,5-T. Experiment 2.[a]

Measurement date and size class (m)	All desirable species[b]		Striped maple	
	Control	Treated	Control	Treated
June 1977	*Thousands/ha*			
(pretreatment)				
<0.3[c]	59.7	66.4	20.7	16.1
0.3–1.5	0.4	0.1	4.3	6.3
All heights	60.1a	66.5a	25.0a	22.4a
September 1979				
<0.3[c]	77.4	146.1	10.1	1.8
0.3–1.5	1.5	0.0	6.2	0.2
All heights	78.9a	146.1a	16.3a	2.0b

[a] Values in each column followed by the same letter were not significantly different at the 0.05 level of probability.

[b] Desirable species included black cherry, sugar maple, red maple, and white ash.

[c] Includes new germinants and older seedlings that were <0.3 m tall at the time of measurement.

at least a short time (Marquis 1975), and no striped maple seeds were found in the seed traps.

Experiment 3—Methods

Experiment 3 was established in a 12-year-old stand that developed after clearcutting. This stand contained about 2,145 stems/ha. Most stem diameters ranged from 2.5 to 10.0 cm, and stem heights from 4.0 to 8.0 m. Ninety percent of the stems were striped maple; 7 percent were beech and 3 percent were birch, maple, or cherry. Few tree seedlings or herbaceous plants were found on the ground beneath this young stand. Several herbicide and rate combinations were evaluated to determine whether they might be used to remove undesirable striped maple overstories like this.

Three herbicides were tested and each was applied at five different rates. Bromacil as the 80 percent wettable powder was applied at rates of 0, 8.96, 17.92, 26.88, and 53.76 kg/ha a.i. Picloram was applied in the 5 percent pellet formulation (M-3864) at 0, 1.68, 3.36, 6.72, and 12.10 kg/ha a.i. and also in the 10 percent pellet formulation (M-4180) at 0, 2.24, 4.48, 8.96, 17.92 kg/ha a.i. All herbicides were applied on a single date in May 1977. Bromacil was mixed with water in the field to a final volume of 2.4 l (4ll l/ha). Pellets of picloram were broadcast by hand.

The study was laid out as a randomized block experiment. Within each block, each of the three herbicides was randomly assigned to each plot. Plots were 7.5 × 7.5 m with isolation strips of at least 6.0 m between plots. Within each plot, 10 striped maple stems were randomly selected as sample trees. Defoliation of these sample trees was evaluated 4, 16, and 28 months after herbicide application; kill was evaluated after 16 and 28 months.

One year after herbicide application, in the spring of 1978, two blocks were planted with white ash seedlings to evaluate the possibility of establishing this species on herbicide-treated Allegheny hardwood sites. Ten seedlings were planted in the center of each plot and protected from deer browsing by placing plastic mesh tubes around each seedling. Seedling survival and growth was evaluated 16 months after planting.

TABLE 4. Mean defoliation and mortality of striped maple sample trees, in percent, by bromacil and picloram applied at different rates in Experiment 3 and evaluated after 4, 16, and 28 months.[a]

Herbicide and application rate (kg/ha a.i.)	Defoliation—months after application			Mortality—months after application	
	4	16	28	16	28
Bromacil	Percent				
8.96	96a	92a	90a	87a	90a
17.92	94a	96a	97a	97a	97a
26.88	100a	100a	100a	100a	100a
53.76	100a	100a	100a	97a	100a
Picloram (5 percent pellet)					
1.68	23b	27b	34b	7b	23b
3.36	44ab	65a	68ab	47a	67a
6.72	76ab	85a	90a	73a	87a
12.10	84a	87a	93a	77a	90a
Picloram (10 percent pellet)					
2.24	34c	22c	32c	7d	30c
4.48	63b	45b	59bc	37c	47bc
8.96	73a	89a	91ab	83b	83ab
17.92	84a	93a	100a	93a	97a

[a] Values under each herbicide in the same column followed by the same letter were not significantly different at the 0.05 level of probability.

EXPERIMENT 3—RESULTS

Responses of striped maple sample trees were affected differently by the different herbicides and their rates of application (Table 4). Within 4 months after application of bromacil at least 94 percent defoliation of striped maple crowns was achieved, regardless of the rate applied. After sixteen months, 87 percent of the stems were dead where the lowest rate, 8.96 kg/ha a.i., had been applied; 97 to 100 percent were killed at higher application rates. Similar striped maple kill was achieved with picloram. At rates of 6.72 kg/ha a.i. (5 percent pellets) or 8.96 kg/ha a.i. (10 percent pellets) or greater, three-fourths of the striped maple crowns were defoliated 4 months after application. Defoliation was 85 to 90 percent or greater at these rates 16 and 28 months after application, respectively. Most stems treated at these rates ultimately died, producing 83 percent kill or greater 28 months after application. There were no statistically significant differences between the 5 and 10 percent formulations of picloram.

Rates of bromacil and picloram (regardless of formulation) had no residual effects on the survival and height growth of white ash seedlings planted 1 year after herbicide application. Bromacil at the lowest rate tested, 8.96 kg/ha a.i., gave satisfactory control of the striped maple overstory without reducing seedling survival (95 percent) or height growth (37 cm) as determined 16 months after planting. At this same time, planted white ash seedlings averaged over 85 percent survival and 30 cm in height growth regardless of the rate or formulation applied on picloram treated plots.

DISCUSSION

Tierson (1969) showed that 2,4,5-T was effective for reducing the numbers of beech in the understory of northern hardwood stands. We also have demonstrated that 2,4,5-T is effective in removing striped maple and that it does not interfere with subsequent development of desirable Allegheny hardwood reproduction. Glyphosate readily killed understory striped maple and beech at 1.12 kg/ha a.i. and is approved for use in silvicultural applications. Furthermore, glyphosate does not interfere with regeneration that develops naturally from black cherry seed stored in the forest floor, or with black cherry seedlings planted after application (Horsley 1981). Our work corroborates that of McCormack and Newton (1980) and McCormack and others (1982), but demonstrates that rates of glyphosate even lower than they used are effective in controlling these species.

Time of application affected the performance of glyphosate at the 1.12 kg/ha a.i. application rate. By applying this rate at the optimum time (on the Allegheny Plateau)—August 1 through mid-September for striped maple, and August 1 through October 1 for beech—it was possible to obtain the same high degree of kill achieved at the higher application rates for stems up to 3.0 m in height. The same timing effect with glyphosate has also been observed for control of understory ferns and grass found in many Allegheny hardwood stands, fern, goldenrod, and aster found in forest openings on the Allegheny Plateau (Horsley 1981) and for forest brush including beech on conifer sites in Maine (McCormack and others 1982). Hence, all of the major understory plants that interfere with reproduction of Allegheny hardwoods can be controlled with a single application of glyphosate at 1.12 kg/ha a.i. in August or early September. In a large-plot (4 ha) study now in progress, we treated stands containing the herbaceous plants, striped maple, and beech using this prescription and have obtained high rates of kill of all of these plants.

In stands where an overstory is absent, a wider range of herbicide application techniques are available. Ground sprayers are adequate for brush less than about 3 m tall. Where large acreages of taller brush are in need of treatment, aerial techniques are apparently satisfactory (McCormack and Newton 1980, McCormack and others 1982). Root absorbed materials, such as those used in Experiment 3, are probably most useful for treating small acreages of brush taller than about 3 m where the cost of aerial applications cannot be justified. Bromacil and the 5 and 10 percent formulations of picloram all produced a high degree of striped maple kill. None of these chemicals affected survival or growth of white ash seedlings subsequently planted on the site, although we recognize that white ash may not be a good indicator of suitability for planting of other species, due to its insensitivity to residues of some herbicides.

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