

MIDSTORY HARDWOOD SPECIES RESPOND DIFFERENTLY TO CHAINSAW GIRDLE METHOD AND HERBICIDE TREATMENT

Ronald A. Rathfon and Michael R. Saunders¹

Abstract.—Foresters in the Central Hardwoods Region commonly fell or girdle interfering trees and apply herbicide to the cut surface when performing intermediate silvicultural treatments. The objective of this study was to compare the use of single and double chainsaw girdle methods in combination with a herbicide treatment and, within the double girdle method, compare herbicide placement in upper, lower, or both cuts. Triclopyr amine (Garlon® 3A) was applied to girdle cuts to blackgum (*Nyssa sylvatica* Marsh.), hickory (*Carya* spp.), and sugar maple (*Acer saccharum* Marsh.) trees. After three growing seasons, sugar maple was killed by all methods tested, with the single girdle without herbicide treatment recommended as the most cost-effective method of control. In hickory, all girdle treatments, with or without herbicide, resulted in almost complete top kill. However, the single girdle produced higher sprout frequency (50%) and lower tree mortality (40%) than other treatments. Blackgum was difficult to kill with any treatment. Girdle treatments using herbicide top killed from 89 to 95 percent of blackgum stems; those not using herbicide killed only 21 to 29 percent. Most treated blackgum bole- or root-sprouted regardless of treatment, with herbicide treatments resulting in slightly lower numbers of trees sprouting. Placement of herbicide within the double girdle treatments had no impacts on mortality or sprouting for any species. These results allow foresters to refine their timber stand improvement methods to save herbicide and labor cost.

INTRODUCTION

Many silvicultural treatments, such as preharvest treatments for promoting desirable advance regeneration, post-harvest timber stand improvement (TSI), and site preparation in regeneration openings, call for the removal of undesirable, interfering trees. Foresters employ several methods for controlling interfering trees including stem injection (hack-n-squirt, frill), basal bark, and chainsaw felling and girdling. Chainsaw girdling usually involves a single, continuous cut around the entire circumference of the stem at a height between 3 and 4 feet from the ground, followed by the application of a herbicide to the cut surface. Where herbicide use is excluded, TSI contracts often require two girdles approximately 6 to 12 inches apart. Double girdling may also be done in stands where certain species, like yellow-poplar (*Liriodendron tulipifera* L.), may be sensitive to herbicide “flashback.” Flashback is believed to occur when an untreated tree takes in herbicide through shared root grafts from a neighboring treated tree of the same species and consequently suffers herbicide damage (Rathfon et al. 2009).

Noel (1970) provides an extensive review of early literature addressing the physiological effects of girdling on trees, but most of the studies he cited involved the use of axes or other non-motorized means of girdling and few involved the use of herbicides. For example, Clark and Liming (1953) reported that early summer girdling of blackjack oak (*Quercus marilandica* Münchh.) in the Missouri

¹Extension Forester (RAR), Purdue University, Department of Forestry and Natural Resources, 12000 Purdue Farm Rd., Dubois, IN 47527; and Assistant Professor of Silviculture (MRS), Purdue University, Department of Forestry and Natural Resources. RAR is corresponding author: to contact, call 812-678-5049 or email at ronr@purdue.edu.

Ozarks resulted in the fewest number of basal sprouts compared to girdling done at other seasons. They also found that shallow girdles (“peels”) that severed only the phloem and cambium but did not cut into the xylem resulted in less sprouting than “notch” girdling, which did cut into the xylem. Perkey et al. (1994) observed that tree species with ring-porous xylem appeared to be more quickly top killed following chainsaw girdling than species with diffuse-porous xylem.

Olson and Boggess (1960) observed that sprouting of hardwoods girdled in Illinois decreased with increasing tree diameter. Some northern hardwoods axe girdled in New Hampshire died within 1 year; most were dead within 4 years (Baldwin 1934). Cut surface herbicide treatments such as girdle, frill, and cut-stump usually perform better when applied during the growing season (Ballard and Nowak 2006, Greth 1957). Midwinter and early spring treatments often result in lower reported mortality. One reason may be heavy sap flow flushing herbicide from the wound. Root reserves during the dormant season are also usually sufficient for most species to at least temporarily maintain crown survival following girdling treatments. For this reason, dormant-season control treatments most often result in greater frequency and abundance of stump and root sprouting in hardwoods when compared to other treatment timings (Kays and Canham 1991).

Although foresters have much collective experience with what treatments are effective and which tree species are difficult to control, few results of controlled experimentation on the chainsaw girdle method in combination with herbicide treatment have been published. The objectives of this experiment were to: (1) test the use of single and double chainsaw girdle methods in combination with an herbicide treatment for the control of several common interfering tree species during intermediate stand treatments and site preparation in Central Hardwoods forests; and (2) within the double girdle method, determine the most effective placement of herbicide, i.e., applied to the lower girdle, upper girdle, or to both.

METHODS

The study was conducted in a 33-acre mature oak-hickory stand on Ferdinand State Forest in Perry County in the nonglaciated region of south-central Indiana. The study was conducted in conjunction with post-harvest TSI following a single-tree selection commercial thinning that removed 2,400 board feet (Doyle) per acre. The overstory forest was composed primarily of oak (*Quercus* spp.) and hickory (*Carya* spp.), which accounted for 70 percent of the total preharvest stocking. A midstory canopy was dominated by sugar maple (*Acer saccharum* Marsh.), blackgum (*Nyssa sylvatica* Marsh.) and a mix of other shade-tolerant species. Pignut (*C. glabra* [Mill.] Sweet) and shagbark (*C. ovata* [Mill.] K. Koch) hickories were prominent in the intermediate and overtopped crown classes. The timber harvest occurred in winter 2006. Cull tree removal, crop tree release, and midstory removal were conducted over 3 days from February 2 through February 16, 2007. High temperatures ranged from 19 to 43 °F, averaging 31 °F, with sunny to partly sunny conditions. Sugar maple sap flow on cut stems ranged from none to heavy; and most stems produced at least some sap flow. Although midwinter TSI is not the optimal time for control of many hardwood species, foresters often prefer this period to growing-season TSI operations to avoid excessive heat, humidity, and pests.

Six treatments were applied randomly to individual trees. They were:

- 1) Single girdle
- 2) Single girdle + herbicide
- 3) Double girdle
- 4) Double girdle + herbicide delivered to lower cut
- 5) Double girdle + herbicide delivered to upper cut
- 6) Double girdle + herbicide delivered to both cuts

Girdles were made to a depth of approximately 0.25 to 0.5 inches into the sapwood using a Stihl 200T® (Stihl Inc., Virginia Beach, VA) professional arbor saw with a 14-inch bar and 3/8-inch pitch and 0.05-inch gauge Stihl Picco® chain. Herbicide was triclopyr amine (Garlon® 3A) (Dow AgroSciences, Indianapolis, IN), diluted at 1:1 ratio (22.2 percent active ingredient) with water, applied to the cut surface with one of the ordinary garden, hand-pump, 1-quart spray bottles most commonly used by foresters for TSI work in the Central Hardwoods Region.

Because this was an operational TSI job, there was some variation in the numbers of trees receiving each treatment. Although 10 species were treated, only blackgum, hickory, and sugar maple were present in large enough numbers to include in the analysis. A total of 453 stems were treated, with blackgum, hickory, and sugar maple comprising 183, 92, and 139 stems, respectively. Stem diameter at breast height (4.5 ft; d.b.h.) of treated trees ranged from 4 to 14 inches with a mean of 7.4 and standard deviation 1.85. Sugar maple stems were smaller (6.7 inches mean d.b.h.) whereas the blackgum and hickory stems were comparable in size to one another (7.7 and 7.8 inches mean d.b.h., respectively).

Treatment results were observed for individual trees at five different times over the three growing seasons following treatment application: June and October 2007, June and October 2008, and September 2009. Stem mortality (SM) or top kill, defined as death of the aboveground portion of the tree, was observed and recorded as alive or dead. Stump, bole, and root sprouting frequency (SP) were reported as having sprouts or not having sprouts. Tree mortality (TM), defined as trees completely dead, both above and below ground, was determined for each stem by whether the tree experienced stem mortality and whether it had living sprouts. TM was recorded as alive or dead for each treated tree.

Two separate lines of analysis were performed to address the objectives of the study. To test the combinations of girdle type and herbicide application for objective 1, data included only responses to treatments 1 to 3 plus the sum of responses to treatments 4, 5, and 6 (i.e., double girdle + herbicide). To test the placement of herbicide in the double girdle treatment for objective 2, data included only responses to treatments 4 to 6. For both analyses, chi-square contingency tables of the count data were used to determine overall independence of the response variables, namely SM, SP and TM, from September 2009, from girdle or herbicide placement treatments. Separate tests were conducted for each species. If the null hypothesis was rejected ($\alpha = 0.05$), multiple comparison chi-square tests were calculated to test for differences between individual treatments. A Bonferroni adjustment was made to determine significant differences in these multiple comparison tests, with significant differences occurring at $P < \alpha/t$, where t = total number of comparisons.

Table 1.—Stem mortality, tree mortality, and sprouting frequency 3 years following chainsaw girdle treatments with and without herbicide applied to the girdle cut(s) for several Central Hardwoods tree species[†]

Several Central Hardwood Tree Species						
Species	Treatment				χ^2	P
	Single girdle	Single girdle + herbicide	Double girdle	Double girdle + herbicide		
----- Stem mortality (%) -----						
Blackgum	21 b [‡]	95 a	29 b	89 a	78.02	<0.001
Hickory spp.	90	100	100	100	7.30	0.063
Sugar maple	100	100	97	100	1.82	0.611
----- Tree mortality (%) -----						
Blackgum	17	24	8	26	5.57	0.134
Hickory spp.	40 b	81 ab	71 ab	91 a	13.54	0.004
Sugar maple	100	100	97	100	1.82	0.611
----- Sprouting frequency (%) -----						
Blackgum	83	71	92	73	7.12	0.068
Hickory spp.	50 b	19 ab	29 ab	9 a	9.73	0.021
Sugar maple	0	0	0	0	0.00	1.000

[†] Chi-square contingency analysis was performed on stem count data (not shown) to test for overall differences between treatments within each species group (χ^2 and P). Species groups with significant differences at $\alpha = 0.05$ were further tested with a chi-square multiple comparison on the count data using the Bonferroni adjustment.

[‡] Treatments with the same letter were not significantly different from one another when $P > 0.05/t$, where the number of comparisons (t) = 6.

RESULTS

Girdle Method

With the exception of the double girdle treatment, all sugar maple trees were dead with no sprouts within 3 years, regardless of the treatment (Table 1). Only 1 out of 39 sugar maple trees treated with the double girdle survived. All girdle treatments resulted in almost complete SM in hickory. The exception was the single girdle, which resulted in 1 out of 10 stems surviving (90% SM). The single girdle produced higher SP (50%) and lower TM (40%) than all other treatments applied to hickory. Where herbicide was applied to both the single girdle and the double girdle, SM in blackgum was greater than their non-herbicide counterparts. Thirty-six of 38 (95%) and 65 of 73 (89%) blackgum stems were dead following treatment with single girdle + herbicide and double girdle + herbicide treatments, respectively. Only 11 of 38 (29%) and 5 of 24 (21%) blackgum stems were dead following double girdle and single girdle treatments, respectively. SP was high and ranged from 27 of 38 (71%) in the single girdle + herbicide treatment to 35 of 38 (92%) in the double girdle treatment. TM was low, ranging from 3 of 38 (8%) in the double girdle treatment to 19 of 73 (26%) in the double girdle + herbicide treatment. None of the SP or TM treatment differences in blackgum was considered significant, however.

Table 2.—Stem mortality, tree mortality and sprouting frequency 3 years following double chainsaw girdle treatments with herbicide applied to lower, upper, or both girdle cuts for several Central Hardwoods tree species[†]

Species	Herbicide placement			χ^2	P
	Lower cut	Upper cut	Both cuts		
----- Stem mortality (%) -----					
Blackgum	74 b [‡]	95 ab	100 a	9.33	0.025
Hickory spp.	100	100	100	0.00	1.000
Sugar maple	100	100	100	0.00	1.000
----- Tree mortality (%) -----					
Blackgum	19	24	36	3.33	0.344
Hickory spp.	73	100	100	7.41	0.060
Sugar maple	100	100	100	0.00	1.000
----- Sprouting frequency (%) -----					
Blackgum	78	76	64	2.42	0.489
Hickory spp.	27	0	0	7.41	0.060
Sugar maple	0	0	0	0.00	1.000

[†] Chi-square contingency analysis was performed on stem count data (not shown) to test for overall differences between treatments within each species group (χ^2 and P). Species groups with significant differences at $\alpha = 0.05$ were further tested with a chi-square multiple comparison on the count data using the Bonferroni adjustment.

[‡] Treatments with the same letter were not significantly different from one another when $P > 0.05/t$, where the number of comparisons (t) = 3.

Herbicide Placement within Double Girdle

All sugar maple trees were dead with no live sprouts 3 years following double girdle treatment, regardless of which girdle cut herbicide was applied to or whether it was applied to both cuts (Table 2). Double girdle treatment with herbicide, regardless of herbicide placement, controlled 100 percent of hickory stems. Placing herbicide in the lower girdle cut of hickory seemed to reduce TM and increase SP from the 100 percent mortality and no sprouts of the other two herbicide placements. Those differences were not significant ($p = 0.060$) (Table 2), however. There were, however, differences in SM among placement treatments for blackgum ($p = 0.025$) (Table 2). Applying herbicide to the lower girdle cut controlled 20 of 27 (74%) blackgum stems. Applying herbicide to the upper girdle cut or to both girdle cuts controlled 20 of 21 (95%) and 25 of 25 blackgum stems, respectively. TM for blackgum ranged from 5 of 27 (19%) where herbicide was applied to the lower cut, to 9 of 25 (36%) where herbicide was applied to both cuts. SP ranged from 21 of 27 (78%) where herbicide was applied to the lower cut, to 16 of 25 (64%) where herbicide was applied to both cuts. None of the TM and SP treatment differences in blackgum was significant.

DISCUSSION

The choice of whether to use a single or double chainsaw girdle and herbicide depends on tree species being treated, silvicultural objectives for the stand, and timing of application. In intermediate stand treatments such as thinning and crop tree release, particularly in stands beyond the sapling stage of stand development, tree mortality of the competitors is not essential to the release of the crop trees as long as competitors die back long enough to allow the crop tree to fully capture the growing space. Sprouting in these treatments may occur with little chance of those sprouts regaining a position in the

stand canopy. On the other hand, controlling sprouting is critical for site preparation in regeneration openings and silvicultural clearcuts or where desirable advance reproduction is developing in a shelterwood.

In oak shelterwoods in southern Indiana where sugar maple dominated the midstory canopies, complete tree mortality was achieved within 16 months of a midsummer treatment by using a single chainsaw girdle with Pathway® (Dow AgroSciences) herbicide (5.4 percent picloram + 20.9 percent 2,4D) (Rathfon 2011). In this study, sugar maples from 5 to 11 inches in d.b.h. were readily killed within 3 years by using a single girdle with no herbicide applied. Therefore, regardless of silvicultural objectives, a single girdle will suffice in controlling unwanted sugar maple. Herbicide is unnecessary and often wasted if applied midwinter due to sugar maple's heavy sap flow. Although all treatments in this study resulted in some level of sprouting in sugar maple in the first growing season after treatment, no live sprouts remained by September 2009, the end of the third growing season.

Sugar maple can reproduce through stump sprouts of trees that have been broken or cut off (Godman et al. 1990). Sprouting frequency decreases as tree size increases (Solomon and Blum 1967). Perala (1974) observed that 85 percent of sugar maple from 10 to 14 inches in d.b.h, stem killed by a prescribed fire, had sprouts 5 years later. This stem killing would be similar to that resulting from girdling. However, Olson and Boggess (1960) found that 93 percent of girdled sugar maple in southern Illinois were top killed whereas only 19 percent sprouted. Sugar maple tends to sprout less vigorously in the southern part of its range (Godman et al. 1990). Sugar maple sprout survival may also depend on light levels at the forest floor. Although sugar maple is shade tolerant, its sprouts may require more sunlight than occurred in this study following the single-tree selection harvest and TSI.

Although hickory was easy to top kill, herbicide was needed to achieve greater than 70-percent TM. Even when herbicide was used in a single girdle, only 81 percent of treated trees died with no sprouts. In hickory trees girdled in southern Illinois, 89 percent were top killed and 43 percent produced sprouts (Olson and Boggess 1960). A double girdle with herbicide placed in the upper cut or both cuts was required to assure 100-percent mortality with no live sprouts. The double girdle with herbicide placed in the lower cut performed no better than the double girdle with no herbicide. This lack of sprout control along with the complete control produced by the double girdle with herbicide placed in the upper girdle seems counterintuitive. Herbicide placed in the lower girdle might be expected to be more readily transported via the phloem to the roots. If the herbicide is placed in the upper girdle where the phloem below it is cut off, the transport of herbicide to the roots would presumably be cut off (Hess 1995). Nonetheless, when greater than 8-percent tree mortality is desired when controlling hickory, these results show that double girdling with herbicide placed in the upper girdle is sufficient to that end.

As easy as sugar maple was to kill, blackgum was difficult to kill. MacKinney and Korstian (1932) found that black gum was the species most resistant to non-chemical ax girdling and to herbicidal frilling treatments among 21 species treated in the Appalachian Mountains of North Carolina. Blackgum not only has the ability to produce vigorous stump sprouts, but it also sprouts prolifically from its roots (McGee 1990). In southern Illinois, 67 percent of girdled blackgum were top killed and 74 percent sprouted (Olson and Boggess 1960). By most forest management standards, herbicide is necessary for the control of blackgum regardless of silvicultural objectives and stand development.

Double girdling did not improve stem kill over the single girdle without the use of herbicide. Whereas a double girdle with herbicide applied to both cuts produced 100-percent stem kill (Table 2), a single girdle with herbicide provided nearly the same result (Table 1) for half the cost. Double girdling with herbicide provided no advantage over single girdling with herbicide in preventing sprouting or obtaining tree mortality.

The high rate of sprouting and low tree mortality rate for the best treatments does not pose a serious problem in intermediate stand treatments. When the objective is to promote desirable regeneration where a substantial number of blackgum are present, alternative methods for controlling blackgum, such as injection or basal bark, may prove more effective and timely. Growing-season treatments may also prove more effective than dormant season treatments (Ballard and Nowak 2006, Kays and Canham 1991, Kossuth et al. 1978, Zedaker et al. 1987). Ultimately all the treatments will result in the majority of blackgum stems dying. On virtually all girdled blackgum stems not experiencing stem mortality, the trunk below the girdle appeared dead and was decaying, while above the girdle the trunk appeared normal. Eventually decay will advance enough to cause the stem to collapse. For most stems this process apparently takes at least 3 years.

Treatment cost data were not collected in this study. Rathfon (2011) found that an experienced operator performing the single chainsaw girdle method with application of herbicide using the type of spray applicator used in this study, treated 8.4 ft² of basal area per hour, compared to 10.7 ft² per hour for both a spaced injection treatment (approximately one cut per inch stem d.b.h.) and a basal bark treatment. With herbicide and saw costs included and a labor rate of \$25 per hour, the single chainsaw girdle with herbicide treatment cost \$3.64 per ft² of basal area treated versus \$3.61 per ft² for the injection treatment and \$7.09 per ft² for the basal bark treatment.

CONCLUSIONS

Foresters and landowners can save time and money optimizing tree control methods according to species being controlled and stand objectives when performing TSI, intermediate stand treatments, and site preparation in Central Hardwoods forests. For pole- to small sawtimber-sized individuals, a single chainsaw girdle, applied during the dormant season, is sufficient to kill all sugar maple and most hickory in southern Indiana. Nearly complete control of hickory can be achieved by use of a double girdle with herbicide applied to the upper cut. However, chainsaw girdling applied during the dormant season, either with or without herbicide, will not provide complete control of blackgum. The most cost-effective option for stem control of blackgum among those tested in this study is a single girdle with herbicide. A different herbicide, different treatment timing, or both may provide better control of blackgum sprouts.

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