HERBICIDAL CONTROL OF UNDERSTORY SUGAR MAPLE (*ACER SACCHARUM* MARSH.) IN MISSOURI'S OAK-HICKORY FORESTS[1/]

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Abstract.--Five herbicides, Banvel CST, Tordon RTU, Garlon 3A, Weedone 170 and Weedone CB, were applied to the cut-surface of understory sugar maple following removal with a Poulan 306-A chainsaw. A two-man crew was utilized (one cutting and one applying herbicide). After two growing seasons, only Tordon RTU provided 100 percent kill of stumps. A second study combined the cutting and herbicide application into a single operation and compared its efficiency to that of a two-man crew. A Shindaiwa model B-45 brush cutter was combined with a Solo model 425 JetPak sprayer to enable a single laborer control of the cutting and herbicide application. A cost of $66/acre was incurred using a McCulloch Pro Mac 700 chainsaw and treating 1610 trees/acre. An average of 1756 trees/acre were cut and treated at a cost of $49/acre while using a Shindaiwa B-45 brush cutter and Solo 425 JetPak. It was found that consolidating the cutting and herbicide application into a single operation for controlling small diameter sugar maple (<10cm [4"] dbh) is economically practical.

Keywords: sugar maple, herbicide, chainsaw, brush cutter

INTRODUCTION

Missouri hardwood forests have been considered to be dominated by oak and hickory species, but in recent years encroachment by sugar maple has been documented (Nigh *et al.*, 1983, 1985). Similar increases in maple importance have been noted in other states, including Illinois (Schlesinger 1976), Massachusetts and New York (Lorimer 1984).

Successional studies established in 1968 in the Ashland Wildlife Area (AWA) in central Missouri indicated significant increases in understory sugar maple (Rochow 1972; Nigh *et al.*, 1983, 1985). In 1968, sugar maple was the dominant species on upland sites (59 percent), intermediate slope positions (93 percent) and glade sites (43 percent), while composing 64 percent of the species in mesic coves (Rochow 1972).

The recent encroachment of sugar maple into the oak-hickory forests of Missouri is the result of a complicated series of interrelated events, both natural and anthropogenic. However, ecological and environmental determinants suggest that man's manipulation of the environment is a primary cause of the sugar maple increase (Nigh 1984). The control of fire, elimination of grazing and changing land use patters that leave discontinuous forested blocks, which act as fire breaks, are thought to be primarily responsible. In addition, substantial genetic variability of the species (Beal 1984; Trelease 1894; Anderson and Hubricht 1938; Dansereau and LaFond 1941; Desmarais 1952; Kriebel 1957; Steyermark 1940, 1963) increases its capacity to successfully colonize sites of varying microenvironment.

Sugar maple sprouts prolifically from the stump after cutting (Solomon and Blum 1967; Wendel 1975). In one study, over 90 percent of all sugar maple under six inches dbh sprouted, with an average of eight sprouts per stump (Church 1960). Cutting sugar maple in areas receiving timber stand improvement (TSI), crop tree release, and fuelwood thinnings is a common practice in Missouri. Although the size (height) of the sugar maple component is reduced by the cutting, actual density is increased. A study recently conducted by the authors showed

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increases in number of sugar maple stems (sprouts) ranging from 43 to 197 percent two years after cutting.

Sprouting can be controlled by an application of herbicide to the surface of a stump (Finnis 1968; Warren 1976, 1980). Herbicides which have been demonstrated to be effective include: dicamba [Banvel CST formulation (Velsicol Chemical Co.)], picloram [Tordon RTU (Dow Chemical Co.)], and 2,4-D/2,4-DP combinations [Weedone 170 and Weedone CB (Union Carbide Co.)]. Cutting methods include the use of a chainsaw (Gabriel and Nissan 1974; Miller 1984, 1985) and/or a brush saw (Seymour et al., 1984; Seymour and Gadzik 1985).

This paper reports on two studies conducted to reduce the sprouting of understory sugar maple in central Missouri. The first study screened five cut-surface applied herbicides for effectiveness. The second compared the effectiveness and economics of controlling sugar maple with a two-man crew (chainsaw operator and herbicide applicator) versus a single operator using a modified Shindaiwa model B-45 brush cutter combined with a Solo model 425 JetPak sprayer. The most effective herbicide found in the screening study was used in the comparison of application methods.

STUDY SITE

The studies were conducted in the Ashland Wildlife Area (AWA), which is located in the southeast corner of Boone County (38°45'N, 92°12'W, T46N, R11W) in central Missouri. The AWA is a University of Missouri-owned experimental tract, consisting of 900 ha (2280 acres) mostly of second grown oak-hickory forest in the 70 to 80-year age calss. The dominant trees of the overstory include white oak (Quercus alba L.), northern red oak (Quercus rubra L. [Quercus borealis Michx. F.]), black oak (Quercus velutina Lam.) and shagbark hickory (Carya ovata [Mill.] K. Koch). Canopy closure averaged over 90 percent. Common understory species, in addition to sugar maple, include hophornbeam (Ostrya virginiana Mill.), flowering dogwood (Cornus florida L.), downy serviceberry (Amelanchier arborea Michx.), American hornbeam (Carpinus caroliniana L.), and eastern redbud (Cercis canadensis L.).

Although there are at least eight soil types present at the AWA, in general soils in the area are classified as Steep Stony Land (Sn) and Weller (We) (Krusekopf and Scrivner 1962). The Weller soils are of loessial origin with 5-11 percent slopes. Slight profile differentation is discernible. Steep Stony Land soils are a miscellaneous landtype that include stony and rocky soils on 15 to 50 percent slopes. Little profile differentiation is apparent in the latter soil type.

Underlying the AWA are limestones of Mississippian and Ordovician origin. The topography is dissected into ridgetops, sideslopes of varying steepness, and hollows. Exposed limestone outcroppings are fairly abundant and can be found throughout the AWA. Ridgetops are covered with a relatively thin layer of Kansan ice age glacial debris and Pleistocene loess deposits.

MATERIALS AND METHODS

Study #1 -- Herbicide Screening For Sugar Maple Control

Eighteen circular 0.02 ha (0.05 acre) plots were established in the spring of 1984. The study was divided into three replications of six plots each in a randomized complete block design. Plots within replicates were separated by 6 m (20') buffers, while replicates were separated by 12 m (40'). Sixteen vigorously growing sugar maples from 5-8 cm (2-3") in dbh were selected within each plot and identified with colored plastic flagging. Forty-eight trees per treatment were established, for a total of 288 sample trees.

Treatments included Banvel CST, Tordon RTU, Garlon 3A, Weedone 170 and Weedone CB and a control (no chemical). Rates of application were label recommendations in all cases (Table 1). Treatments within replicates were selected using a random number table.

Treatments consisted of cutting all trees with a Poulan model 306-A (3.0 cu. in.) chainsaw approximately 15-20 cm (6-8") above the ground. The entire cut-surface was immediately painted (using a brush) with the appropriate herbicide by a second laborer or left untreated (control). Stumps were identified with consecutively numbered aluminum tags. The diameter of each stump was measured to 0.02 mm. All plots were treated between June 19-June 21, 1984.

Three sprouting data sets were collected at approximately 30-day intervals starting 30 days after treatment in 1984. Two additional sets were taken at 30-day intervals starting 30 days after bud burst in the spring of 1985. The number of sprouts per stump were noted as well as any abnormalities in leaf morphology and phytotoxic symptoms in nearby plants. Data were statistically analyzed using an F test to determine the significance of differences based on the percent of stumps sprouting.

Study #2 -- Brush Cutter and Pressure Sprayer Versus Chainsaw And Brush Application Comparison

The experiment was designed as a side-by-side randomized complete block time study with two treatments. Ten square, 0.04 ha (0.1 ac) plots (five replicates of two plots each) measuring 20 m [66'] were established in the spring of 1985 on east-facing slopes of 14 percent. Replicates were separated by buffer zones of six to 12 m (20 to 40 feet).

Half of the plots were treated by cutting all

Table 1.--Active ingredients(s) [AI], formulation, company, percent AI, carrier and rate of application for the five herbicides tested.

PRODUCT/COMPANY	AI	FORMULATION	%AI	RATE/CARRIER
Banvel CST (Velsicol)	Dicamba	Salt	13.3	Undiluted
	Related Acids	Salt	3.3	
Tordon RTU (Dow)	Picloram	Salt	5.4	Undiluted
	2,4-D	Salt	20.9	
Garlon 3A (Dow)	Triclopyr	Salt	44.4	1:1 (water)
Weedone 170 (Union Carbide)	2,4-D	Ester	29.3	133 ml/gal (Diesel fuel)
	2,4-DP	Ester	29.9	
Weedone CB (Union Carbide)	2,4-D	Ester	11.7	Undiluted
	2,4-DP	Ester	11.9	

sugar maple trees with a McCulloch Pro Mac model 700 chainsaw at a height 15-20 cm (6-8") above the ground. A second laborer painted Tordon RTU herbcide (selection based on responses in Study #1) on the cut-surface of each stump with a brush. All five plots were cut on August 20, 1985. Time required to complete each plot and the fuel and herbicide consumed were recorded.

The remaining five plots were treated using a Shindaiwa brush cutter. The Shindaiwa B-45 brush cutter was modified to enable a single operator to cut the tree and apply herbicide to the cut-surface simultaneously. A spray nozzle, with a cone-shaped spray pattern, was attached directly to the blade guard. One-quarter-inch Tygon tubing connected the nozzle to a trigger assembly affixed to one of two brush cutter handles. A second Tygon tube connected the herbicide trigger to the outlet port of a Solo model 425 JetPak sprayer. Three of the five plots treated on August 24, 1985; the remaining two were treated on August 25. Fuel and quantity of herbicide used and the time required to treat each plot were recorded.

All plots were reinventoried approximately one year later (July 7, 1986), allowing the vegetation on plots a full growing season to respond. Any stump that sprouted was measured with Mishoto calipers calibrated to 0.02 mm accuracy. The height of the dominant sprout was measured and average height of all sprouts per stump was estimated. Sprouts with herbicide-damaged leaves were noted.

RESULTS AND DISCUSSION

Cutting young sugar maple stems without the benefit of herbicide application results in low percentage kill and heavy sprouting. Of 48 control-treatment stems severed in the spring of 1984, 90 percent (43) had sprouted after two years (Table 2).

These findings are comparable to those of Church (1960) who observed 91% sprouting of similarly treated sugar maple three years after treatment. He reported an average of seven sprouts per stump compared to eight in our study. Consequently, to control sprouting of sugar maple, some form of herbicide must be applied. All herbicides tested in our study provided at least some control of sprouting during the first year of treatment. However, only two (Tordon RTU and Garlon 3A) still gave satisfactory control (90-100%) after two growing seasons and only Tordon provided 100 percent kill. The reduction in effectiveness of treatments during the second year emphasized the importance of at least a two-year evaluation period. A correlation between percentage kill and stem diameter was observed in most treatments with most sprouting on stumps less than 2.5" dbh. Sprouting of large stumps (>6" dbh) was rarely observed. Solomon and Blum (1967), Prager and Goldsmith (1977) and MacDonald and Powell (1983) also reported decreases in sprouting of sugar maples with increased stump diameter.

While Tordon RTU was highly effective in controlling sprouting of maple, the traditional method of cutting with a chainsaw and applying the herbicide to the cut surface with a brush was slow and of questionable utility. Consequently, a second study was conducted comparing the effectiveness and cost of the traditional two-man cut and brush application method and a single operator method which combined a brush cutter with a pressure sprayer.

After one year, eighty of 805 stems (10%) cut with a McCulloch Pro Mac 700 saw and painted with Tordon RTU sprouted. The 90 percent control compared favorably to the 100 percent observed in Study #1 which also employed Tordon RTU. An average of 3.5 sprouts per stump were found and 18 percent of the sprouts showed signs of herbicide damage. Of the stumps observed to sprout, 63 percent were from stems smaller than ½" and 40 percent were smaller than ¼".

Percentage kill using the brush cutter-pressure sprayer application combination was comparable

Table 2.--Percentage sugar maple stumps failing to sprout following application of herbicide to the cut-surface in June, 1984.

Herbicide	Percent Kill	Percent Kill	% Reduction in Effectiveness
	----1984----	----1985----	--1984/1985--
Tordon RTU	100	100 a[1]	0
Garlon 3A	100	94 a	6
Weedone CB	98	58 b	40
Banvel CST	98	54 b	45
Control	20	10 c	--
Weedone 170	77	6 c	92

1/Common letters denote treatments without significant differences ($p < 0.01$)

to that obtained with the chainsaw and brush application method. Ninety-four percent of the stems treated were killed (821/878) with an average of 2.5 sprouts per stump. Of the 57 stumps that sprouted, almost half (43%) showed typical herbicide damage after one growing season. Most of the sprouting occurred on stumps of the smaller diameter - - 60 percent were less than ¼" while only 6 percent were greater than 1".

An economic analysis comparing the chainsaw-brush application and brush cutter-pressure sprayer application methods demonstrated greater speed and substantial dollar savings resulting from use of the latter method (Tables 3 and 4). Using the brush cutter-pressure sprayer, 675 stems could be treated per hour compared to only 626 with the chainsaw method - - an eight percent improvement. While more herbicide was actually used per acre (5,468 ml compared to 3,693 ml) cost per acre for the brush cutter-pressure sprayer technique was 24 percent less than for the chainsaw-brush application method ($50 vs $66). The savings was primarily in labor costs since only one operator is required with the brush cutter-sprayer combination while two are needed for the chainsaw method.

Table 3.--Economic analysis of chainsaw-herbicide application utilizing a McCulloch Pro Mac 700 (4.3 cu.in.) chainsaw.

STEMS CUT & TREATED[1]	805
STEMS CUT & TREATED/HOUR	626
HERBICIDE USED IN 5, 0.1 AC PLOTS (ml)[2]	1,842
AVG. HERBICIDE/STUMP (ml)	2
HERBICIDE REQUIRED/AC (ml)	3,693
HERBICIDE COST ($/ac)[3]	16.12
FUEL COST ($/ac)[4]	2.36
PRODUCTIVE HOUR ($/ac)[5]	5.69
LABOR COST ($/ac)[6]	42.14
TOTAL COST ($/ac)[7]	66.30

1/Total number of sugar maple stems on the five, 0.1 acre plots
2/Tordon RTU applied undiluted to stump
3/@ $16.50/gallon for Tordon RTU (Tri Sentry Chemical, Springfield, MO.)
4/Fuel costs @ $1.40/gallon regular gas (incl. 2-cycle mix)
5/PH=Productive Hour (fixed and variable costs) based on work by Gary W. Miller-McCulloch Pro Mac 800 chainsaw (Miller, 1984)
6/@ $5.00/hour base rate plus $1.55/hour fringe benefits
7/Herbicide + Fuel + PH + Labor costs $/ac

As the use of a brush saw is a relatively new innovation in hardwood silviculture in the United States, there is little literature currently available on feasibility of use or operating costs. Seymour and Gadzik (1985) used a brush saw to thin overstocked spruce-fir stands in Maine and reported a cost of $62 per acre. However, herbicides were not employed in the treatment. Results of studies using chainsaws have yielded variable costs depending on type and condition of stands treated. Miller (1984a) reported a cost of $14.58/acre (150 stems cut/acre) using a Pro Mac 800 in a cherry-maple stand in West Virginia.

CONCLUSIONS

Cutting of sugar maple understory, without an herbicide treatment, further increases its density because of vigorous sprouting. While several herbicides were tested that appeared to provide

Table 4.--Economic analysis of herbicide application utilizing a Shindaiwa B-45 brush cutter (2.3 cu. in.) combined with a Solo model 425 JetPak sprayer.

STEMS CUT & TREATED[1]	878
STEMS CUT & TREATED/HOUR	675
HERBICIDE USED IN 5, 0.1 AC PLOTS (ml)[2]	2,739
AVG. HERBICIDE/STUMP (ml)	3
HERBICIDE REQUIRED/AC (ml)	5,468
HERBICIDE COST ($/ac)[3]	23.82
FUEL COST ($/ac)[4]	1.49
PRODUCTIVE HOUR ($/ac)[5]	5.17
LABOR COST ($/ac)[6]	19.50
TOTAL COST ($/ac)[7]	49.98

1/Total number of sugar maple on the five, 0.1 ac treatment plots
2/Tordon RTU applied undiluted to stump
3/@ $16.50/gallon for Tordon RTU (Tri Sentry Chemical, Springfield, MO.)
4/Fuel costs @ $1.40/gallon regular gas (incl. 2-cycle mix)
5/PH=Productive Hour (fixed and variable costs) based on work by R. S. Seymour, R. A. Ebling and C. J. Gadzik on Husqvarna model 165 R brush saw (Seymour et al., 1984)
6/@ $5.00/hour base rate plus $1.55/hour fringe benefits
7/Herbicide + Fuel + PH + Labor cost $/ac

reasonable percentage kills during the first year following application, only two (Tordon RTU and Garlon 3A) continued to control sprouting after two years, and only Tordon provided 100 percent kill. Of two cutting and herbicide application methods tested, a single operator (one man) method, which combined a brush cutter with a pressure sprayer, proved superior to the time-honored method of cutting with a chainsaw and painting the stump with herbicide. Cost figures indicate a 25 percent savings independent of area using the brush cutter-pressure sprayer combination. One factor that was not addressed in this study concerns the blade life of the B-45 and ease of sharpening in the field. A standard ten-inch (80-tooth) tree blade was used. This method is effective in controlling sugar maple but is for the most part limited to sites containing trees less than 4" dbh although occasional larger trees can be cut.

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