Maintaining Early-successional Habitats Using a Metal Wick Herbicide Applicator

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Abstract: We tested the efficacy of an aluminum wick herbicide applicator, the Weed Sweep®, for control of hardwood and pine saplings, 1994–1996. We compared spring and fall applications in 1 trial and, in a second trial, tested 2 herbicide mixes: glyphosate mixed with either trichlopyr or imazapyr. Herbicides plots had 78% fewer sapling stems/ha than control plots ($P < 0.006$). May applications of glyphosate/imazapyr provided greater control of hardwoods but lower control of pines than September applications ($P < 0.05$). Also, glyphosate/imazapyr provided greater control of hardwoods than glyphosate/trichlopyr ($P < 0.05$). Percent ground cover by forbs, grass, and legumes and total number of species in the ground story did not differ between treatment and control plots. Our results indicate that a higher rate may be needed to achieve more consistent control of slower growing genera, such as *Carya* and *Quercus*. However, this technique may be valuable to managers needing an inexpensive alternative to mechanical methods for controlling hardwood resprouts and young pines and require a herbicide application technique more environmentally-sensitive than broadcast spraying.

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Many early-successional wildlife species are declining (Brennan 1991, Peterjohn et al. 1995), so maintenance of grass-forb-shrub communities is an important management issue (Askins 1994). For example, managing strips of early-successional vegetation along edges of crop fields is recommended for bobwhite quail (Puckett et al. 1995). Managers rely on prescribed fire and mechanical treatments to manage tree saplings in upland pine forests, agricultural ditch banks, and power line rights of way

(ROWs). Frequent use of mowing to reduce stature of brush and saplings has negative consequences for many wildlife species (Puckett et al. 1995). Long-term mowing encourages hardwood root sprouts and reduces diversity of plant species in the ground story (Bramble et al. 1990, Johnstone 1990, Bramble et al. 1991, Geyer et al. 1994, Horn 1995). Another situation where hardwood resprouts cause management problems is maintenance of open, park-like pine forests. While managers use fire to kill hardwoods, fuels may not permit fires at a frequency necessary to kill hardwoods (Glitzenstein et al. 1995), and managers are forced to use expensive mechanical methods. Herbicides are an alternative to mechanical control of hardwood resprouts and pines. While herbicide use has reduced long-term maintenance costs on ROWs (Johnstone 1990), most application methods are costly on a per area basis (Nowak et al. 1993). Also, broadcast applications of herbicides may kill non-target plant species.

Therefore, we tested the effectiveness of a metal herbicide wick, the Weed Sweep®, for hardwood and pine sapling control. This tractor-mounted, metal wick scratches the bark of saplings, exposes the cambium, and applies concentrated herbicide. Because herbicide is not sprayed, we hypothesized it should not affect plant species composition or diversity in the short-term. We determined percent control of hardwoods and pines in plots on 2 power line ROWs that had been mowed on a 3-year rotation. We determined control of hardwood and pine saplings from glyphosate/imazapyr (Accord®/Arsenal®) and compared efficacy of spring and fall applications. In a separate trial we compared control of tree saplings provided by glyphosate/trichlopyr (Accord/Garlon®3A) and glyphosate/imazapyr. Finally, we measured plant species diversity on plots with and without herbicide treatment.

Methods

Description of the Weed Sweep

The functional unit of the Weed Sweep (Reddick Equipment Co., Williamston, N.C.) was constructed of 30.5-cm wide channel aluminum bar. Attached to the bar's ventral surface was a sheet of composite plastic with many small holes. Undiluted chemical was pumped to the bar via soaker hose. Two bars—1 front- and 1 side-mounted—were fixed at a 30° forward angle. The side-mounted bar had a break-away mechanism consisting of a tension spring and shear-bolt and was capable of being lowered to an angle of 45° below horizontal and raised to 90° above horizontal. Height could be adjusted from approximately 20 cm to 2 m above ground surface. Total wiping width was 5.18 m.

Herbicide Treatments

We conducted 2 experiments to determine effects of season of application and herbicide tank mix on efficacy of controlling tree saplings. Both experiments use a randomized block design with 3 replications per block. For spring vs. fall herbicide application experiment, 12 15×15-m plots were placed on 2 electric transmission line ROWs designated as ROW1 and ROW2. Herbicides were applied to randomly selected plots during the first week in September 1994 (fall application) and the last week of May 1995 (spring application). A tank mix of 1892 ml glyphosate, 473 ml imazapyr, and 236 ml surfactant was used. Application rates for both fall and spring sweeps were approximately 3.25 liters/ha. Active ingredient rate was 1,560 g/ha glyphosate and 780 g/ha imazapyr.

We applied herbicide to 12 additional plots in July 1995 to compare control rates of glyphosate/imazapyr and glyphosate/trichlopyr. Glyphosate/imazapyr was applied as in the first trial. The second tank mix contained 1,892 ml glyphosate, 473 ml trichlopyr, and 236 ml surfactant. This herbicide combination also was applied at 3.25 liters/ha. Active ingredient rate was 1,560 g/ha glyphosate and 1,170 g/ha trichlopyr. A nonionic surfactant was added to all tank mixes. A ground speed of 5 km/hour was maintained for all applications. The wiping surface was kept at 66 cm above ground level during herbicide applications.

Vegetation Measurements

Plots wiped fall 1994 were evaluated in May 1995 after trees had fully leafed out approximately 8 months post-treatment. Plots wiped during spring 1995 and plots receiving glyphosate/imazapyr vs. glyphosate/trichlopyr applications in July 1995 were not evaluated until May 1996 after full tree leaf-out, approximately 10 months post-application.

For treatment comparisons, all individual stems ≥66 cm were identified to genus and recorded as dead or alive for each plot. Live stems were classified as those with green leaves and signs of bud activity or stems showing green active cambium when cut. Effectiveness for each treatment was represented by kill rate calculated by dividing number of dead stems by total number of stems for each species/genus. In May 1996, we subsampled all plots to compare sapling stem density between spring/fall plots and herbicide combination plots to control plots. We counted live stems in 2 4-m diameter circles/plot to estimate stems/ha.

Ground story vegetation sampling was conducted from the last week in August 1995 to the second week of October 1995. Treatment plots were subsampled by selecting 4 random distances (starting points) along a plot side. At each starting point, 5 equally spaced plots were placed along a transect running perpendicular to the plot side for a total of 20 subsamples per plot.

Herbaceous canopy coverage was calculated using a modified Daubenmire plot. The sampling device consisted of a 50 × 50-cm frame containing a grid of 400 2.54-cm squares. Average values for 3 vegetation coverage categories (% grass, % forb, and % legume) and an overall % cover were used to compare changes in vegetation in response to herbicide treatments. All species occurring in each subsample square were recorded.

Statistical Analysis

Percent control values for tree species for each plot were used to test for treatment differences using a 2-way analysis of variance (ANOVA) (SAS Inst. 1997). If needed, subsamples were averaged for each plot to avoid pseudoreplication. Tests of equal variance were performed on all data using JMP which includes Brown-Forsythe, Levene, and Bartlett tests for equal variance. If variances were unequal, a Welch ANOVA test allowing for unequal variances was used to detect treatment differences. Data were also tested for normality using a Shapiro-Wilk W test (JMP). Small sample sizes made determining normality difficult. As a precaution, the nonparametric Kruskall-Wallis rank sum test also was used.

Results

Sixteen genera received herbicide treatments. Seven commonly occurring genera/species were (listed in order of decreasing stem density) pine (mostly loblolly, *Pinus taeda*), sweetgum (*Liquidambar styraciflua.*), winged sumac (*Rhus copallina*), oak species (*Quercus* spp., mostly *Q. falcata, Q. nigra, Q. phellos*, and *Q. marilandica*), red maple (*Acer rubrum*), pignut hickory (*Carya glabra*), and common persimmon (*Diospyros virginiana*).

Herbicide treatments provided effective control of woody vegetation. Post-treatment the spring/fall treatment plots (ROW1: $\bar{x}$ = 2,133 stems/ha SE = 933, ROW2: $\bar{x}$ = 2,400 stems/ha SE = 693) and herbicide combination treatment plots (ROW1: $\bar{x}$ = 4,266 stems/ha SE = 1,091, ROW2: $\bar{x}$ = 2,400 stems/ha SE = 1,200) did not differ in stem density ($P > 0.05$) but had significantly lower stem densities than control plots (ROW1: $\bar{x}$ = 14,133 stems/ha SE = 3,839, ROW2: $\bar{x}$ = 10,933 stems/ha SE = 7,119) ($P < 0.006$).

Glyphosate/imazapyr (G/I) controlled most species better than glyphosate/trichlopyr (G/T) (Table 1). Generally, pines and slower growing hardwoods (oaks and

Table 1. Mean percent control and number of stems treated with glyphosate/imazapyr (G/I) and glyphosate/trichlopyr (G/T) applied using a Weed Sweep herbicide wick on 2 rights-of-way, New Hill, N.C., during 1994–1995.

	Percent control				*N* Stems treated	
Species	G/I Mean	G/I Range	G/T Mean	G/T Range	G/I	G/T
Right-of-way 1						
Acer rubrum	100.0	a	63.4	60.0–66.7	35	26
Diospyrous virginiana	97.3	94.4–100	65.5	16.7–91.7	40	55
Liquidambar styraciflua	94.7	93.5–97.1	69.2	67.7–72.8	323	240
Lyonia spp.	85.4	a	54.2	33.3–75.0	41	7
Pinus spp.	35.1	23.1–53.6	19.1	13.9–25.0	262	120
Quercus spp.	89.2	a	62.3	26.1–100	185	45
Rhus copallina	96.1	88.2–100	94.2	89.4–100	190	296
Right-of way 2						
Carya spp.	14.6	0.0–75.0	14.0	9.1–21.4	59	51
Liquidambar styraciflua	70.8	37.3–100	47.4	38.5–60.0	170	82
Pinus spp.	24.5	0.0–37.4	9.5	1.4–15.0	286	295
Quercus spp.	50.6	0.0–84.1	6.2	0.0–18.5	132	102
Rhus copallina	96.3	92.5–100	61.8	40.0–100	243	80
Salix spp.	54.9	a	20.0	a	51	5

a. Mean is represented by a single value.

Table 2. Mean percent control of saplings treated with glyphosate/imazapyr (G/I) or glyphosate/trichlopyr (G/T) using a Weed Sweep, New Hill, N.C.

	G/I		G/T		Treatment	Block
Species	Mean	SE	Mean	SE	*P*-Value	*P*-Value
Oak sp.	60.3	20.60	34.2	15.96	0.1109	0.0497
Persimmon	66.4	20.36	45.6	15.48	0.2985	0.0892
Pine sp.	29.8	7.23	14.3	3.18	0.0936	0.2515
Sweetgum	82.8	9.78	58.3	5.73	0.0363	0.0467
Winged sumac	96.2	2.45	77.9	11.32	0.1521	0.1960
Hardwoods	81.9	9.05	53.1	10.31	0.0119	0.0048

hickories) had lower control rates than rapidly growing species (red maple, sweetgum, and winged sumac).

Not all species were present in all plots for each treatment. Thus, statistical analysis for treatment effects were performed on 3 species and 3 groups of species: common persimmon, sweetgum, winged sumac, pines, oaks, and hardwoods in general. Control rates for sweetgum and hardwoods were significantly higher for G/I ($P = 0.026$ and 0.01 respectively) (Table 2). Pine control rates were not different ($P = 0.0745$).

May applications controlled most hardwood species better than September treatments (Table 3). Control rates for pines were low for both treatments on ROW1 and spring application on ROW2. Fall application resulted in the best pine control (50%, $N = 66$) of all herbicide applications.

Table 3. Percent control and number of stems treated with glyphosate/imazapyr using a Weed Sweep during fall 1994 and spring 1995 on 2 rights-of-way, New Hill, N.C.

	Percent control				*N* Stems treated	
Species	Fall Mean	Fall Range	Spring Mean	Spring Range	Fall	Spring
Right of way 1						
Acer rubrum	a	b	97.8	95.7–100	8	24
Carya spp.	9.1	0.0–18.2	54.2	33.3–75.0	41	10
Liquidambar styraciflua	63.0	57.1–68.9	84.5	76.5–89.1	242	262
Pinus spp.	40.3	32.9–54.7	13.7	8.7–21.1	568	276
Quercus spp.	36.5	28.9–44.9	68.3	30.8–96.2	208	152
Rhus copallina	95.1	85.2–100	84.2	57.9–100	177	88
Right of way 2						
Acer rubrum	76.7	b	66.7	b	43	225
Carya spp.	3.3	b	76.4	b	3	55
Diospyrous virginiana	a		84.7	68.0–100	0	62
Liquidambar styraciflua	77.4	74.5–80.0	89.2	87.5–90.3	230	346
Lyonia spp.	a		70.0	50.0–89.9	0	71
Pinus spp.	46.0	3.3–57.9	10.0	7.8–13.3	66	219
Quercus spp.	44.5	18.8–70.2	42.4	0.0–75.0	83	77
Rhus copallina	90.6	82.8–98.4	96.0	88.1–100	273	168

a. Not treated.

b. Mean is represented by a single value.

Similar to the herbicide combination treatments, not all species/groups were present in every treatment plot used for testing season of application. Again, only 4 species/groups (pine, sweetgum, oak, and winged sumac) and the pooled group hardwoods could be statistically analyzed for treatment effects. Spring application resulted in significantly better control for sweetgum and hardwoods ($P = 0.0157$). Fall herbicide application resulted in significantly better control of pine ($P = 0.0004$) (Table 4).

Vegetation Characteristics

A total of 197 species of 115 genera were recorded. Common grass species included broomsedge (*Andropogon virginicus*), three-awn grass (*Aristida* spp.), poverty grass (*Danthonia* spp.), *Dichanthelium* spp. and Beardgrass (*Gymnopogon brevifolius*). Common forbs included boneset/throughwort (*Eupatorium* spp.), common cinquefoil (*Potentilla canadensis*), blackberry (*Rubus* spp.), goldenrods (*Solidago* spp.), *Bidens aristosa,* trumpet creeper (*Campsis radicans*), poison ivy (*Rhus toxicodendron*), greenbrief (*Smilax* spp.), Japanese honeysuckle (*Lonicera japonica*) and muscadine grape (*Vitis rotundifolia*). Lespedezas most common included *Lespedeza procumbens, L. repens, L. virginiana,* and *L. cuneata.*

Numbers of species were significantly greater for ROW2 (= 57.6, SE = 2.47) than ROW1 ($\bar{x} = 49.6$, SE = 1.87) ($K\text{-}W^2 = 7.23$, 1 df, $P = 0.0072$), but there was no significant difference in number of species among herbicide-treated plots and control plots. Control plots had an average of 54.2 (SE = 3.9) species compared to 57.2 (SE = 1.8) and 50.5 (SE = 2.1) for plots treated spring or fall and with different herbicide combinations, respectively. There were no significant differences in percent forbs, legumes, grasses or overall plant cover between treatment plots and control plots ($P > 0.05$).

Discussion

This study was our first attempt to manage hardwood and pine tree species using the Weed Sweep. However, even at the relatively low rates applied, control achieved was similar to other types of herbicide applications. Pitt et al. (1993) found that glyphosate treatments at doses >0.5 times the label maximum rates reduced woody cover by 77% relative to untreated areas. Johnstone (1990) reported 90% control of

Table 4. Percent control of tree saplings treated with glyphosate/imazapyr using the Weed Sweep during fall 1994 and spring 1995, New Hill, N.C.

Species	Spring Mean	Spring SE	Fall Mean	Fall SE	Treatment *P*-Value	Block *P*-Value
Oak sp.	55.4	14.42	39.7	8.73	0.4572	0.6502
Pine sp.	11.9	2.02	43.1	4.71	0.0003	0.8545
Sweetgum	86.8	2.11	70.2	3.64	0.0003	0.0089
Winged sumac	90.1	6.72	91.6	4.43	0.8796	0.5153
Hardwoods	82.6	2.91	68.3	5.57	0.0157	0.0425

undesirable plant species with a fall application of glyphosate. Geyer et al. (1994) showed that a fall application of imazapyr/picloram provided approximately a 50% tree control. Nowak et al. (1992) showed an 87% decrease in undesirable woody stem densities using a selective stem foliar treatment with a trichlopyr/picloram tank mix over a 3-year period (second conversion maintenance cycle).

One major advantage herbicide wiping has over other herbicide application methods and mowing is cost effectiveness. Abrahamson et al. (1991) showed stem foliar treatment costs ranged from $815 to $1,037/ha and basal treatment costs ranged from $1,359 to $1,705/ha for areas with stem densities of 3,200 to 17,000 stems/ha. Johnstone (1990) showed that herbicide treatment costs decreased from $642/ha to $247/ha with better planning and reduced brush density, and that mechanical mowing costs were $197/ha in 1980 for 1-year-old brush and $370/ha in 1987 for 3-year-old brush. This was similar to Carolina Power and Light's mowing costs, which ranged from $148–$247/ha (Doug Meier, CP&L transmission forester, pers. commun.). Herbicide wiping costs were estimated to be $94/ha (Anderson unpubl. data). Based on the control ratings observed in this study and the cost effectiveness, use of this herbicide wiping technique may be more cost effective than other chemical or mechanical techniques used in ROW vegetation management.

We believe this technique has merit for many situations in wildlife management where control of hardwood resprouts is a long-term management problem. These include ROW maintenance, controlling trees in fallow fields, hardwood resprouts in open upland pine habitats, and removing hardwoods from edges of agricultural fields or in drainage ditches. Benefits to wildlife would depend on management goals and use. In an on-going study, the Weed Sweep is being used to remove hardwoods from field borders and edges of drainage ditches to avoid mowing activity typically conducted during the nesting season of bobwhite quail (P. T. Bromley, unpubl. data). In upland pine ecosystems, prescribed fire is the most cost-effective tool to control invasive hardwoods and to maintain plant communities dominated by grasses and forbs. However, there are many situations when prescribed fire alone is not adequate for controlling invasive hardwoods. These situations occur when pine canopy is too low to provide fuels, hardwoods have become co-dominant in the overstory and suppress fuels, and when flammable native ground cover (i.e., such as wiregrass [*Aristrida stricta*]) has been removed. In these situations when prescribed burning is difficult or not feasible this herbicide technique may offer relatively inexpensive control of invasive hardwoods without undesirable effects on other desirable groundstory species. Once hardwoods have been controlled, prescribed fire can be reinstated to manage the herbaceous vegetation rather than to control hardwoods.

We observed very little herbicide dripping from the Weed Sweep. Kill of non-target plants was limited to situations where non-targets touched the bar and when herbicide was carried by tractor tires after running over treated brush. Also, some forbs immediately surrounding the root collar of trees treated with imazapyr were killed. However, these situations occurred infrequently. Therefore, we believe this technique may have utility in situations where managers need to selectively remove undesirable woody vegetation overtop sensitive or rare grass/forb communities.

The Weed Sweep has several disadvantages versus broadcast herbicide applications. First, because of its size it cannot be used in situations with high tree stocking. Second, multiple treatments may be needed to achieve control of hardwoods in areas that have a high density of shrubs or saplings. This occurs when shrubs are so dense the herbicide-laden bar does not touch brush bent under other brush being treated. Also, unlike broadcast spraying, small trees and shrubs below the bar are not treated with herbicide. Therefore, this wiping technique is ideally applied to relatively open areas with low to moderate shrub or sapling densities.

Choice of herbicide used to control undesirable woody vegetation is important. The herbicides chosen must provide good control at cost-effective application rates. Also, different herbicides control some woody plant species better than others due to plant factors (translocation patterns, waxy cuticles, etc.) and by a herbicide's mode of action (Green et al. 1992). Glyphosate, imazapyr, and trichlopyr were chosen for this study because these 3 herbicides are commonly used in controlling undesirable woody species in forestry and utility ROW applications (Johnstone 1990, Nowak et al. 1992, Pitt et al. 1993, Nowak et al. 1993, Horn 1995). Also, these 3 herbicides are considered environmentally safe (Horn 1995).

The herbicides in combination with the Weed Sweep in this study provided good control for most species treated. As anticipated, control rates varied greatly for some species treated. This variation may be partially accounted for by low stem densities for many of the species treated in 1 or more of the plots. Variability in control rates also may have been caused by the low application rates. Pitt et al. (1993) found reduced application rates gave acceptable levels of control, but the consistency of the levels of control suffered. Anderson et al. (1997) achieved higher control rates and greater consistency with double the application rates used in this study.

Lack of overall pine control may be a concern for some management problems, such as ROW maintenance, as neither tank mix provided adequate pine control. Green et al. (1992) found similar results studying glyphosate absorption and translocation in 4 woody species, including loblolly pine.

The glyphosate/imazapyr tank mix provided good control for both spring and fall applications. However, spring control was slightly better for most species and significantly better for sweetgums and grouped hardwoods. This finding seems logical based on the fact that in early spring leaves are growing rapidly and producing and moving photosynthate out to the rest of the plant. Green et al. (1992) showed some woody plants may translocate glyphosate out of the roots and back to the leaves. If this translocation to the leaves occurring during the fall, then glyphosate could potentially be lost during leaf senescence and would be unavailable to control regrowth the following spring.

Data for this project were collected over a period of only 2 years and are representative of North Carolina Piedmont soils and typography. More research using the herbicide wiping method is needed in other areas and for longer periods of time to verify our results. However, the findings of this study suggest the combination of effective control of undesirable woody vegetation throughout the growing season and low application costs potentially could make herbicide wiping a valuable technique for managing early-successional vegetation.

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