Great Plains Research: A Journal of Natural and Social Sciences

Great Plains Studies, Center for

Spring 2006

Reducing Smooth Sumac Dominance in Native Tallgrass Prairie

Susan Tunnell
University of Nebraska - Linocln

James L. Stubbendieck
University of Nebraska - Lincoln, jstubbendieck@unl.edu

Sal Palazzolo
University of Nebraska - Lincoln

Robert Masters
Dow AgroSciences, LLC

Great Plains Research 16 (Spring 2006):45-49

REDUCING SMOOTH SUMAC DOMINANCE IN NATIVE TALLGRASS PRAIRIE

Susan J. Tunnell, James Stubbendieck, Sal Palazzolo

Department of Agronomy and Horticulture
University of Nebraska–Lincoln
P.O. Box 830915
Lincoln, NE 68583-0915
stunnell2@unl.edu

and

Robert A. Masters

Field Research Biologist
Dow AgroSciences, LLC
3618 South 75th Street
Lincoln, NE 68506

ABSTRACT—Smooth sumac (*Rhus glabra* L.) is a resprouting shrub native to the tallgrass prairie region that increases in density without an active disturbance regime. Our objective was to use prescribed fire and herbicides to decrease smooth sumac density as a strategy to improve a degraded tallgrass prairie remnant. In two separate experiments repeated in space and time, we used prescribed fire in combination with herbicides at various rates and two application methods to develop an effective management scheme for reducing smooth sumac. We used a randomized complete block design with 13 herbicide treatments and a control with three replicates in burned and non-burned areas. Results were similar in both experiments in which herbicide treatment and burning were the significant main effects. All herbicide treatments reduced smooth sumac stem density compared to the control, but no distinct advantage was detected regarding specific herbicide, application rate, or whether the herbicide was applied as a broadcast spray or with a hand-held wick. We expected burning to make the plant more susceptible to herbicides, but burning increased stem density. In this tallgrass prairie remnant, we determined that herbicides were the most effective management tool in reducing smooth sumac stem density.

Key Words: Great Plains, herbicide, prescribed burning, *Rhus glabra*

INTRODUCTION

The tallgrass prairie region of the Great Plains is a threatened ecosystem. Few areas remain intact, and of these remnants, many are degraded by an increase in woody plants. This increase of woody plants in remnant prairies and restored grasslands of the tallgrass prairie has become a serious management concern, and those species that reproduce vegetatively or resprout, such as smooth sumac (*Rhus glabra* L.), are of particular concern. Smooth sumac is a native shrub and is generally restricted to ravines and areas protected from disturbance (Weaver and Clements 1938; Stubbendieck et al. 2003). Historically, smooth sumac was recognized as a component of the tallgrass prairie but was reported as a minor species (Weaver and Clements 1938).

The historic disturbance regime of fire and grazing has changed since the settlement of the Great Plains (Steinauer and Collins 1996), and the processes that once kept smooth sumac at low densities and restricted to ravines are limited or no longer occur. This change in the disturbance regime has led to smooth sumac becoming a serious management problem in tallgrass prairie in eastern Nebraska, and in the absence of disturbance, it can move onto the uplands and form dense thickets (Kaul and Rolfsmeier 1987). An increase in woody plants can alter ecosystem structure and function by decreasing species richness and herbaceous production (Briggs et al. 2002b; Lett and Knapp 2003). Management practices are necessary to reduce woody plants such as smooth sumac to avoid a shift in the plant community from grassland to shrubland/woodland. In this threatened ecosystem, management needs to be directed toward maintaining a balance of native woody and herbaceous species.

Herbicides and prescribed fire are commonly used in grasslands to reduce invading species (Engle et al. 1991; Rhoades et al. 2002) and improve forage production for livestock (Waller and Schmidt 1983; Engle et al. 1993; Mitchell et al. 1996). With the significant loss of tallgrass prairie, it is important to conserve the few remaining intact grasslands (Samson et al. 2004). Incorporating proper management on the remaining remnants in the western region of the tallgrass prairie should be a high conservation priority. Therefore, we investigated the influence of herbicides applied at various rates using two application methods in combination with prescribed fire on the reduction of smooth sumac density in a tallgrass prairie remnant.

METHODS

Two experiments (Experiment 1, 2001-2002; Experiment 2, 2002-2003) were conducted at Nine-Mile Prairie (40°51′N, 96°51′W; 97 ha), a tallgrass prairie remnant 14 km west of Lincoln, NE. Annual precipitation averages 718 mm, with a majority of the precipitation occurring from April to October (NOAA 2002). The dominant soil in Experiment 1 for the non-burned and burned sites is Pawnee clay loam (fine, montmorillonitic, mesic Aquic Argiudoll). In Experiment 2, the soil at the non-burned site is Shelby clay loam (fine-loamy, mixed, mesic Typic Argiudoll) and at the burned site is Steinauer loam (fine-loamy, mixed [calcareous], mesic Typic Udorthent) (Brown et al. 1980). The plant community of Nine-Mile Prairie is in a late sere and dominated by warm-season grasses including switchgrass (*Panicum virgatum* L.), indiangrass [*Sorghastrum nutans* (L.) Nash], and big bluestem (*Andropogon gerardii* Vitman). Disruption of the historic disturbance regime of fire and grazing has resulted in an increase in native woody plants and invasion of exotic cool-season grasses such as smooth brome (*Bromus inermis* Leyss.) and Kentucky bluegrass (*Poa pratensis* L.). The current management consists of spring burning on a three-year interval with about one-third of the prairie burned each year.

The study was designed as a randomized complete block with 13 herbicide treatments (Table 1) and one control per block. Three blocks were located in each of the burned and non-burned areas. Both experiments were identical in experimental design, allowing this study to be replicated in space and time. The study area consisted of a relatively even stand of dense smooth sumac near ravines. Prescribed burns were conducted in early May in each experiment before herbicide application to determine if burning would increase smooth sumac mortality. Both the burning and herbicide treatments were applied only once in each experiment. Within each block, herbicides were each randomly applied to separate 7 × 10 m plots. Broadcast spray and hand-held wick (Sideswipe, Inc., Custer, SD) were the two methods used to apply herbicide. A CO_2 pressurized sprayer calibrated at 262 kPa and having a delivery volume of 234 l/ha was used to apply the broadcast spray, and a hand-held wick was used to apply herbicide in the wick treatments. The hand-held wick is constructed from PVC pipe. The handle is 3.2 cm in diameter and 1.4 m in length. Herbicide is stored in the handle and applied through an applicator attached at a 45° angle. The applicator resembles a paint roller and allows the herbicide to be wiped directly onto the target vegetation, which reduces contact with non-target species. Herbicides were applied in mid-June 2001 for Experiment 1 and mid-June 2002 for Experiment 2.

To determine stem mortality, smooth sumac stem densities were counted for two growing seasons in each experiment, following herbicide treatments. This sampling scheme included a pretreatment stem count in early June of the first year and three post-treatment stem counts in mid-September of the first year and mid-July and late September of the second year. Smooth sumac stem density was determined by counting all live stems within a 3 × 7 m quadrat in each plot, with stem densities reported as number of live stems/m^2. The live stem count data were square root transformed to follow a normal distribution (Snedecor and Cochran 1989). The untransformed stem count data are reported. Analysis of variance was used to assess treatment differences, and we used Satterthwaite's approximation for degrees of freedom (SAS 1999).

RESULTS AND DISCUSSION

Smooth sumac stem densities were compared before treatment application, and there were no significant differences across all treatments in stem density for Experiment 1 (P = 0.9170) or Experiment 2 (P = 0.2674). No year effect was detected in post-treatment smooth sumac stem density for the three post-treatment stem counts in either experiment. Therefore, the post-treatment stem density data were averaged for and each experiment analyzed separately.

TABLE 1
MEAN AND STANDARD ERROR FOR THE NUMBER OF SUMAC STEMS/M² BY TREATMENT FOR EXPERIMENT 1

Treatment	Application method	Sumac stems/m² $\bar{x} \pm$ (se)
Control	N/A	1.71 (0.17)
1.06 kg ae 2, 4-D LV Ester/ha	Spray	0.03 (0.01)
2.13 kg ae 2, 4-D LV Ester/ha	Spray	0.02 (0.01)
1.40 kg ae 2, 4-D Amine/ha	Wick	0.07 (0.02)
0.15 kg ae Picloram + 0.56 kg ae 2, 4-D LV Ester/ha	Spray	0.13 (0.06)
0.20 kg ae Picloram + 0.84 kg ae 2, 4-D LV Ester/ha	Spray	0.02 (0.01)
0.20 kg ae Picloram + 0.74 kg ae 2,4-D Amine/ha	Wick	0.02 (0.01)
1.26 kg ae Triclopyr + 0.42 kg ae Clopyralid/ha	Spray	0.04 (0.03)
1.12 kg ae Triclopyr/ha	Spray	0.06 (0.02)
2.24 kg ae Triclopyr/ha	Spray	0.13 (0.04)
1.48 kg ae Triclopyr/ha	Wick	0.03 (0.01)
1.11 kg ae Glyphosate/ha	Wick	0.21 (0.06)
0.56 kg ae Picloram/ha	Spray	0.43 (0.23)
0.74 kg ae Picloram/ha	Wick	0.02 (0.02)

No interactions between herbicide and burning were detected in Experiment 1, but the main effects of herbicide treatment and burning on smooth sumac stem density were significant. Compared to pretreatment stem density, there was a 21-fold decrease in the number of stems/m² in the herbicide treatments from spring 2001 to fall 2002. Stem density was significantly reduced compared to the control ($P < 0.0001$), regardless of the herbicide used or the application method. The herbicide treatments that had the greatest remaining stem densities were the spray-applied picloram and wick-applied glyphosate (Table 1). These treatments reduced stem density less effectively than did the other herbicide treatments, but both treatments significantly reduced stem density compared to the control (Table 1). Smooth sumac stem density in the burned plots (0.27 stems/m² ± 0.06) was significantly greater ($P = 0.0047$) compared to the non-burned plots (0.14 stems/m² ± 0.04). However, the lack of a burning and herbicide treatment interaction indicates the treatment combination of burning and herbicide application did not synergistically increase smooth sumac mortality.

In Experiment 2, the main effects of herbicide treatment ($P < 0.0001$) and burning ($P = 0.0126$) significantly influenced smooth sumac stem density. All herbicide treatments reduced stem density compared to the control (Table 2), but the specific herbicide treatment response of stem density was more variable compared to Experiment 1. The herbicide treatment resulting in the lowest smooth sumac stem density was picloram applied with a wick, and the greatest stem density occurred where triclopyr was broadcast applied. Stem densities where both these treatments were applied were significantly less than the control (Table 2). Similar to Experiment 1, stem density of the non-burned plots (0.23 stems/m² ± 0.04) was less than that of the burned plots (0.32 stems/m² ± 0.04). Therefore, burning before applying herbicide did not increase smooth sumac mortality.

We found that smooth sumac stem density was reduced regardless of herbicide used or method used to apply the herbicide (broadcast spray versus hand-held wick). Although smooth sumac can resprout following top kill, we expected that shoots resprouting after the burn would be more susceptible to herbicide. Our data indicate that burning did not increase herbicide efficacy in relation to smooth sumac mortality. Instead, burning increased the number of stems compared to the non-burned plots. Burning has secondary effects that benefit the plant community, and although smooth sumac resprouting occurred,

TABLE 2
MEAN AND STANDARD ERROR FOR THE NUMBER OF SUMAC STEMS/M² BY TREATMENT FOR EXPERIMENT 2

Treatment	Application method	Sumac stems/m² $\bar{x} \pm$ (se)
Control	N/A	1.98 (0.15)
1.06 kg ae 2, 4-D LV Ester/ha	Spray	0.08 (0.02)
2.13 kg ae 2, 4-D LV Ester/ha	Spray	0.10 (0.03)
1.40 kg ae 2, 4-D Amine/ha	Wick	0.16 (0.06)
0.15 kg ae Picloram + 0.56 kg ae 2, 4-D LV Ester/ha	Spray	0.22 (0.08)
0.20 kg ae Picloram + 0.84 kg ae 2, 4-D LV Ester/ha	Spray	0.14 (0.05)
0.20 kg ae Picloram + 0.74 kg ae 2,4-D Amine/ha	Wick	0.07 (0.04)
1.26 kg ae Triclopyr + 0.42 kg ae Clopyralid/ha	Spray	0.22 (0.06)
1.12 kg ae Triclopyr/ha	Spray	0.26 (0.10)
2.24 kg ae Triclopyr/ha	Spray	0.21 (0.06)
1.48 kg ae Triclopyr/ha	Wick	0.06 (0.02)
1.11 kg ae Glyphosate/ha	Wick	0.19 (0.04)
0.56 kg ae Picloram/ha	Spray	0.16 (0.05)
0.74 kg ae Picloram/ha	Wick	0.01 (0.01)

herbicides effectively reduced stem density. Burning the grassland before herbicide application removes litter and can increase efficiency of herbicide application by reducing accidental interception by non-target species. In addition, we did not detect an advantage of increased smooth sumac mortality by using the spray or wick application method. However, using a wick would reduce herbicide contact of non-target species such as native forbs.

All herbicide treatments reduced smooth sumac stem density, but no single treatment was consistently superior in both experiments. Therefore, there are several herbicides to select from when considering which chemical to use, whether broadcast or wick applied. Annual fluctuations in populations, including older stems dying and new stem formation along with interannual climatic variability, may help to explain the inconsistent response of the herbicide treatments between the two experiments. By extrapolating smooth sumac stem density to a hectare basis, pretreatment density was 25,600 stems/ha in Experiment 1, which was reduced to 720 stems/ha. In Experiment 2, pretreatment levels were 23,400 stems/ha and were reduced to 1,710 stems/ha. Although smooth sumac remains a component in the plant community, the closed canopy that promotes invasion by exotic cool-season grasses has been at least temporarily eliminated.

Our study site is a tallgrass prairie remnant that has been degraded by the invasion of smooth sumac. On this prairie, there is no longer the historic interactive force of fire and grazing, which influences the threshold between grassland and woodland dominance. When applied properly, fire is an important management tool in tallgrass prairie. For example, eastern redcedar (*Juniperus virginiana* L.), a native woody plant of concern in tallgrass prairie (Briggs et al. 2002a), does not resprout following top kill, and using fire alone is a successful management tool (Bragg 1995). However, there are instances where fire alone cannot control resprouting plants once they have invaded and established in grasslands (Lett and Knapp 2003). Selective herbicide use to reduce smooth sumac stem density can indirectly increase grass cover and fine fuel accumulation. Increased fine fuel loads will result in more intense fires that may prevent smooth sumac spread. The combination of the judicious use of herbicides followed by repeated burning over time will reduce the smooth sumac dominance. The role of fire as a primary disturbance in tallgrass prairie is essential in maintaining an herbaceous-dominated plant community and to prevent woody plant invasion (Steinauer and Collins 1996). Disturbance is also a necessary component when developing a long-term management plan for threatened ecosystems such as tallgrass prairie.

CONCLUSIONS

In this tallgrass prairie remnant with moderate to high densities of smooth sumac, fire alone cannot constrain this resprouting species. Even with moderate levels of fire (three-year return interval) without an additional disturbance such as herbicides, smooth sumac most likely will not be adequately managed. Therefore, the threshold between grassland and shrubland/woodland for this smooth sumac-infested remnant is not driven by fire alone, but by the interaction of multiple disturbances (i.e., fire and herbicide, or historically, fire and grazing). Determining a woody species' ability to reproduce vegetatively should be given careful consideration when applying management strategies that target those specific species. Therefore, it is imperative to understand the constraints on the ecosystem, especially a threatened ecosystem, to ensure a successful long-term conservation of the ecosystem.

ACKNOWLEDGMENT

This is a contribution of the University of Nebraska Agricultural Research Division, Lincoln, NE 68583, Journal Series No. 14742.

REFERENCES

Bragg, T.B. 1995. The physical environment of Great Plains grasslands. In *The Changing Prairie: North American Grasslands*, ed. A. Joern and K.H. Keeler, 64-81. Oxford University Press, New York, NY.

Briggs, J.M., G.A. Hoch, and L.C. Johnston. 2002a. Assessing the rate, mechanisms, and consequences of the conversion of tallgrass prairie to *Juniperus virginiana* forest. *Ecosystems* 5:578-86.

Briggs, J.M., A.K. Knapp, and B.L. Brock. 2002b. Expansion of woody plants in tallgrass prairie: A fifteen-year study of fire and fire-grazing interactions. *American Midland Naturalist* 147:287-94.

Brown, L.E., L. Quandt, S. Scheinost, J. Wilson, D. Witte, and S. Hartung. 1980. *Soil Survey of Lancaster County, Nebraska*. U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS), Washington, DC.

Engle, D.M., J.F. Stritzke, T.G. Bidwell, and P.L. Claypool. 1993. Late-summer fire and follow-up herbicide treatments in tallgrass prairie. *Journal of Range Management* 46:542-47.

Engle, D.M., J.F. Stritzke, and F.T. McCollum. 1991. Vegetation management in the Cross Timbers: Response of understory vegetation to herbicides and burning. *Weed Technology* 5:406-10.

Kaul, R.B., and S.B. Rolfsmeier. 1987. The characteristics and phytogeographic affinities of the flora of Nine-Mile Prairie, a western tall-grass prairie in Nebraska. *Transactions of the Nebraska Academy of Sciences* 15:23-35.

Lett, M.S., and A.K. Knapp. 2003. Consequences of shrub expansion in mesic grassland: Resource alterations and graminoid responses. *Journal of Vegetation Science* 14:487-96.

Mitchell, R.B., R.A. Masters, S.S. Waller, K.J. Moore, and L.J. Young. 1996. Tallgrass prairie vegetation response to spring burning dates, fertilizer, and atrazine. *Journal of Range Management* 49:131-36.

National Oceanic and Atmospheric Administration (NOAA). 2002. *Nebraska Annual Climatic Summary*. National Climatic Data Center, Asheville, NC.

Rhoades, C., T. Barnes, and B. Washburn. 2002. Prescribed fire and herbicide effects on soil processes during barrens restoration. *Restoration Ecology* 10:656-64.

Samson, F.B., F.L. Knopf, and W.R. Ostlie. 2004. Great Plains ecosystems: Past, present, and future. *Wildlife Society Bulletin* 32:6-15.

SAS Institute Inc. 1999. *SAS/STAT User's Guide*. Version 8. SAS Institute, Cary, NC.

Snedecor, G.W., and W.G. Cochran. 1989. *Statistical Methods*. 8th ed. Iowa State University Press, Ames, IA.

Steinauer, E.M., and S.L. Collins. 1996. Prairie ecology: The tallgrass prairie. In *Prairie Conservation: Preserving North America's Most Endangered Ecosystem*, ed. F.B. Samson and F.L. Knopf, 39-52. Island Press, Washington, DC.

Stubbendieck, J., M.J. Coffin, and L.M. Landholt. 2003. *Weeds of the Great Plains*. Nebraska Department of Agriculture, Lincoln, NE.

Waller, S.S., and D.K. Schmidt. 1983. Improvement of eastern Nebraska tallgrass range using atrazine and glyphosate. *Journal of Range Management* 36:87-90.

Weaver, J.E., and F.E. Clements. 1938. *Plant Ecology*. 2nd ed. McGraw-Hill, New York, NY.

Manuscript received for review, October 2005; accepted for publication, January 2006.