MANAGING JAPANESE STILTGRASS DOMINATED COMMUNITIES IN THE RIDGE AND VALLEY PHYSIOGRAPHIC PROVINCE IN EASTERN WEST VIRGINIA

David W. McGill, William N. Grafton, and Jonathan A. Pomp[1]

Abstract.—Japanese stiltgrass (*Microstegium vimineum*) is an exotic invasive species that can dominate forest understories and suppress native herbaceous and woody species. This study had two objectives: 1) to assess directed spray herbicides for controlling *M. vimineum*; and 2) to collect a set of factors that affect management of *M. vimineum* on the diverse properties of the Connors Hollow, WV, watershed. At 3 weeks following glyphosate and sethoxydim treatments, only glyphosate treatments showed significant differences in cover and mean percent change in height growth over the controls and other herbicide treatments. No significant differences in species richness were detected among herbicide treatments, although the three of four glyphosate treatments ranked lowest in richness. In discussions related to controlling *M. vimineum*, landowners helped to identify 12 major factors and 44 subcategories and issues affecting management of the invasive grass. End-of-season measurements and continued discussion of causal factors are slated for early in the fall of 2007.

INTRODUCTION

Japanese stiltgrass (JSG) (*Microstegium vimineum*) is an exotic invasive graminoid (Poaceae; Barden 1987) that is typically on lists of major plant pests in the eastern United States (e.g., WVDNR 2007). In West Virginia, this species is particularly problematic for landowners who value understory plants for commercial purposes. Native herbs like ginseng (*Panax quinquefolius*), goldenseal (*Hydrastis canadensis*), and black cohosh (*Cimicifuga racemosa*) are some of the common commercial medicinal plants that can be outcompeted and overgrown by *M. vimineum*.

M. vimineum is also a problem in areas where active landowners are interested in developing better wildlife habitat. In some areas, *M. vimineum* dominates the herb layer of vast tracts of forest and spreads rapidly as forest canopies are disturbed (Oswalt and others 2007). This grass is reportedly not used by wildlife (Miller 2003) which compounds the challenge for controlling *M. vimineum*, as wildlife species, notably white-tailed deer (*Odocoileus virginianus*), add additional biotic pressure to the other more palatable native and exotic flora (Waller and Alverson 1997). This preference leaves *M. vimineum* in an even more competitive position.

While broad spectrum herbicides (e.g., glyphosate-based products) are known to kill *M. vimineum*, these will also eliminate many of the associated (non-target) species that grow in close proximity. Pomp and others (in press) found that *M. vimineum*-dominated plots that were treated with both single and double applications of graminicide showed average species richness values that were significantly higher than glyphosate, weed whip, and untreated plots.

Other studies have explored various treatments for controlling stiltgrass using graminicides (Judge and others 2005a, 2005b). These treatments aim to reduce incidental damage to associated species, although herbicide impact to associated herbaceous species have generally not been included in treatment

[1]Forestry Extension Specialist (DWM), Wildlife Extension Specialist (WNG), and Graduate Research Assistant (JAP), West Virginia University, Division of Forestry and Natural Resources, PO Box 6125, Morgantown, WV 26506-6125. DWM is corresponding author; to contact, (304)293-2941, or email dmcgill@wvu.edu.

assessments. Associated species are important as they are potential replacements for *M. vimineum* in ecosystem restoration projects (D'Antonio and Meyerson 2002).

This paper reports first-year results of an *M. vimineum* project to 1) assess various directed herbicide spray rates and chemicals; and 2) begin to clarify other factors that might be related to the successful control of *M. vimineum* in the Connors Hollow watershed.

STUDY AREA

Connors Hollow watershed is a 14-digit watershed located in Morgan County in the eastern panhandle of West Virginia. The forest is dominated by chestnut oak (*Quercus prinus*), white oak (*Q. alba*), and black oak (*Q. velutina*) on the ridges and by many of these same species with yellow-poplar (*Liriodendron tulipifera*), black walnut (*Juglans nigra*), and maples (*Acer* spp.) on the lower reaches of the watershed. In many areas, the canopy has been broken by past timber harvests. In some places, tree-of-heaven (*Ailanthus altissima*) has become established and dominates the overstory.

Understory is sparse with clear browse lines from white-tailed deer. In some areas there is little green on the forest floor; in others, there is a heavy, nearly complete herbaceous layer of *M. vimineum*. Shrub species are predominately black huckleberry (*Vaccinium* spp.), spicebush (*Lindera benzoin*), and Japanese barberry (*Berberis thunbergii*).

RESEARCH METHODS

Directed Spray Treatments

We used a point-intercept system to monitor this herbicide screening. Aluminum angle stakes were set up 22 ft apart in areas with 100 percent *M. vimineum* cover. Measurements were made by stretching a metal logger's tape from stake to stake and placing a PVC pole 0.75 inches in diameter in a vertical position every 2 ft beginning at the 2-ft mark on the tape. The height of the tallest JSG plant touching the pole was recorded to the nearest 2 inches.

Pretreatment measurements were conducted in early June 2007 and just prior to treatment on July 14, 2007. One 3-week post treatment (3WAT) measurement was conducted on August 3, 2007 along with an herbaceous species survey using a systematic meander where two observers moved up one side of the plot and down the other recording all herbaceous and woody species. During this census, all herbaceous and woody species less than 4.5 ft were recorded. An end-of-growing season measurement of *M. vimineum* was recorded 10WAT on September 16, 2007.

Herbicide treatments were limited to glyphosate and sethoxydim. These were selected to represent a broad spectrum herbicide (glyphosate; applied as Accord®) and a graminicide (sethoxydim; applied as Poast®). Target spray areas were flagged to surround the 22-ft measurement plot in an approximate 25-ft by 30-ft area. These were laid out to provide a visual target area surrounding the measurement plot. One pass was made over this entire area. If residual herbicide was in the tank, the sprayer would go outside of this area to empty the tank before washing and mixing a new treatment. Two tanks were used for the treatments. One tank was reserved for the glyphosate treatments and the other for the sethoxydim treatments.

The treatments were applied using solo backpack sprayers and a fan nozzle. The herbicide was sprayed in a systematic fashion in a manner that might be used by landowners desiring to treat *M. vimineum* on their own properties. Plots were sprayed along the edges first, then down the central measurement area, and finally outside of the flagged area to eliminate the residual herbicide in the tank. Approximately one quart of mixture was used for each treatment area. This treatment approach does not let us estimate the application rate per treatment area. However, it does provide the opportunity to give landowners an idea of how they might treat other areas as they commonly mix and apply herbicides on a percentage basis.

Two rates of each herbicide were used with and without a recommended surfactant. Surfactants included Entry II® (an ethoxylated fatty amine) with the glyphosate treatments and crop oil concentrate with the sethoxydim treatments. Both herbicides were applied using a 1.5 percent and 0.25 percent volume to volume (herbicide:water) rate. A control and a control with surfactant (Entry II) plots were also included in the study. Three replicates of each herbicide treatment were established.

Percent cover and percent post-treatment change in height were used a dependent variables in a completely randomized analysis of variance (PROC GLM, SAS 9.1 software; SAS Institute, Cary, NC, 2003).

RESULTS

Measurements taken at both 3WAT and 10WAT showed that glyphosate had the most visible effectiveness. These treatments had essentially desiccated all *M. vimineum* on the plots and at 3WAGT had the only plots that deviated from the initial 100 percent *M. vimineum* cover. Low glyphosate (0.25 percent V:V) averaged 52 percent cover and high glyphosate (1.5 percent V:V) averaged 3 percent cover of *M. vimineum*. All other plots retained their 100 percent cover of *M. vimineum*.

Measurements taken 10 WAT demonstrated significant differences in mean *M. vimineum* percentage cover and relative post-treatment growth rates. All herbicide treatments had statistically different height growth rates compared with control plots (Fig. 1, Table 1). In general, glyphosate treatments were statistically different from both control and sethoxydim treatments with *M. vimineum* in high (1.5 percent) glyphosate plots all but disappeared from the plots with a decrease in height of 98 to 100 percent and 0 to 7 percent cover (Table 2).

Three weeks post treatment, 148 different species of woody and non-woody plants were found on the treatment plots (Table 3). Although the three glyphosate treatments had the lowest species richness of all other plots (Table 3), these differences were not statistically different (p=0.72) and the low glyphosate treatment with a surfactant added had the highest species richness values.

Table 1.—Average percentage change in height between pretreatment measurements to 10 weeks after treatment. Percentages followed by different letters are statistically different (Duncan's mean separation procedure; alpha=0.05).

Treatment	Change in height (%)
Control, no surfactant	20 a
Control, surfactant	16 a
0.25% sethoxydim, surfactant	-20 b
0.25% sethoxydim, no surfactant	-31 bc
1.5% sethoxydim, no surfactant	-60 cd
0.25% glyphosate, surfactant	-61 cd
1.5% sethoxydim, surfactant	-63 cde
0.25% glyphosate, no surfactant	-92 def
1.5% glyphosate, no surfactant	-98 ef
1.5% glyphosate, surfactant	-100 f

Table 2.—Percent cover of *M. vimineum* 10 weeks following herbicide treatments. Percentages followed by different letters are statistically different (Duncan's mean separation procedure; alpha=0.05).

Treatment	Percent cover
Control, no surfactant	100 a
Control, surfactant	100 a
0.25% sethoxydim, no surfactant	100 a
0.25% sethoxydim, surfactant	100 a
1.5% sethoxydim, surfactant	80 ab
1.5% sethoxydim, no surfactant	77 ab
0.25% glyphosate, surfactant	53 ab
0.25% glyphosate, no surfactant	37 bc
1.5% glyphosate, no surfactant	7 c
1.5% glyphosate, surfactant	0 c

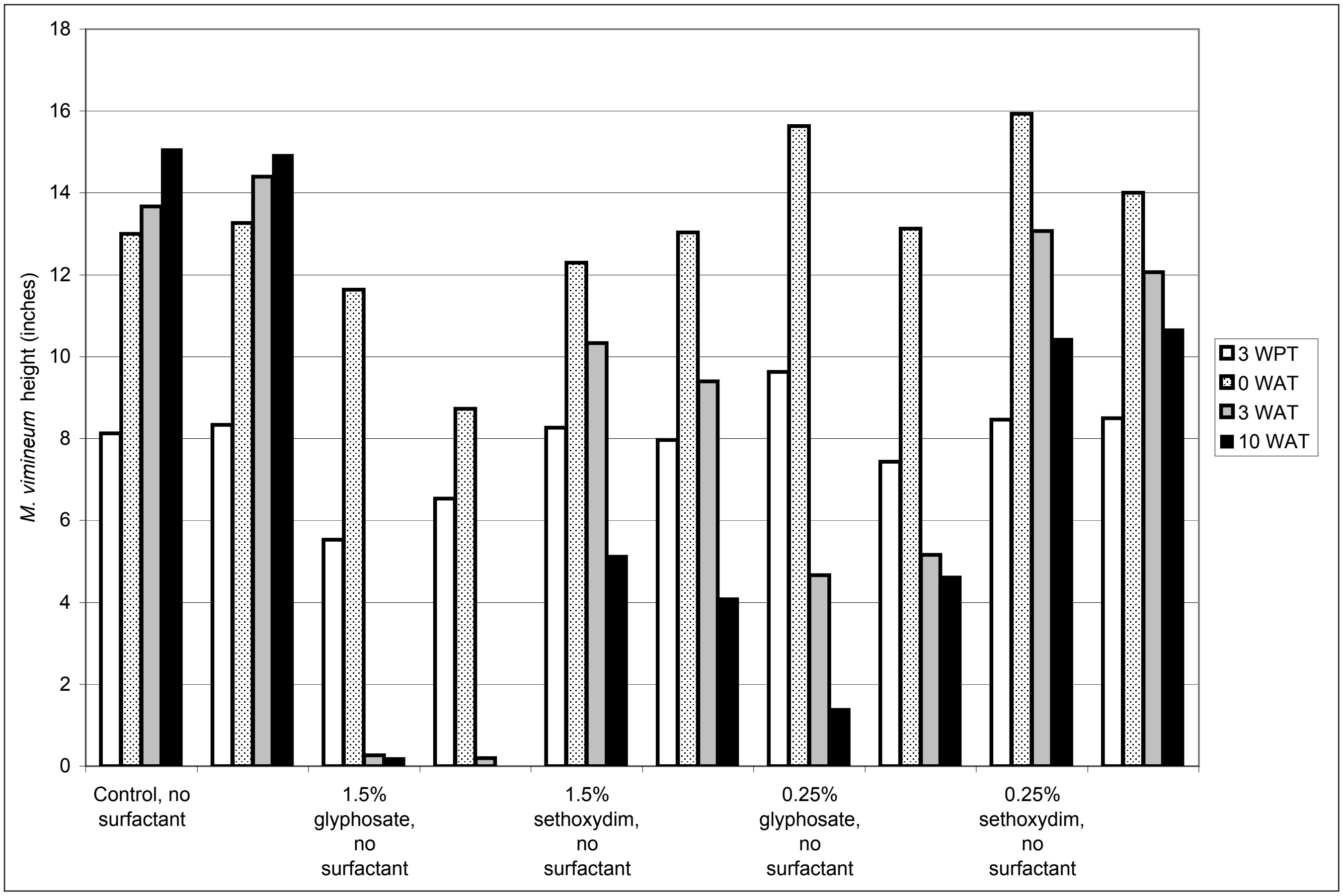

Figure 1.—Average heights of *M. vimineum* 3 weeks prior to treatment (3 WPT), immediately prior to treatment (0 WAT), 3 weeks after treatment (3 WAT), and 10 weeks after treatment (10 WAT). Note: Table 1 shows statistical comparison among treatments for the percentage change in height between 0 WAT and 10 WAT.

During the summer of 2007, as the herbicide portion of this project was being implemented, we compiled a list of factors, opinions, and ideas related to the *M. vimineum* problem in the watershed. These were recorded from informal sessions among the authors and collaborators of this paper and with members of the Seldom Seen Hunt Club of Connors Hollow. These informal sessions took place on June 7, July 14, and August 3, 2007. Notes from sessions were gleaned for major factors by the lead author and sent to collaborators for comments and additions. This list is intended to be a first step in developing a causal loop diagram (Maani and Cavana 2000) to help identify interrelationships among variables associated with M. vimineum. Table 3 lists a preliminary set of key variables and ideas related to managing *M. vimineum* and serves as the first step in this causal loop modeling process. In all, there were about 12 categories with 44 subcategories of issues that were related to factors possibly affecting the persistence and management of *M. vimineum* (Table 4).

DISCUSSION

The results of the herbicide trial were somewhat surprising, especially the seeming lack of control in the sethoxydim treatments. However, Judge and others (2005a) showed that sethoxydim in outdoor container experiments had 78 percent control at 4 weeks after treatment, which increased to 99 percent control 8 weeks following treatment. Our findings may be the result of late applications or variability due to local climate, although plants appeared to be healthy and not drought-stressed at the time of treatments. Indeed, the *M. vimineum* plants showed signs of stunting and the measurements indicate a decrease in plant size.

Table 3.—Twenty most common tree species and 20 most common semi-woody and herbaceous species found 3 weeks post-treatment on 30 *M. vimineum* study plots. Total number of species < 4.5 ft was 148.

Scientific name	Common name	Number of plots
	-----------Tree species-----------	
Ailanthus altissima	Tree-of-heaven	15
Fraxinus americana	White ash	13
Liriodendron tulipifera	Yellow-poplar	12
Carya glabra	Pignut hickory	11
Acer rubrum	Red maple	10
Acer saccharum	Sugar maple	7
Quercus alba	White oak	6
Quercus rubra	Red oak	6
Robinia pseudoacacia	Black locust	5
Ulmus americana	American elm	3
Amelanchier	Serviceberry	2
Pinus strobus	Eastern white pine	2
Betula lenta	Sweet birch	1
Carpinus caroliniana	American hornbeam	1
Nyssa sylvatica	Black gum	1
Ostrya virginiana	Hop hornbeam	1
Pinus virginiana	Virginia pine	1
Quercus prinus	Chestnut oak	1
Sassafras albidum	Sassafras	1
Juglans nigra	Black walnut	1
	-----------Other woody and herbaceous species-----------	
Viola sororia	Common blue violet	21
Amphicarpa bracteata	Hog-peanut	16
Polygonum persicaria	Spotted ladysthumb	15
Alliaria petiolata	garlic mustard	14
Oxalis stricta	Common yellow oxalis	11
Perilla frutescens	Beefsteak plant	11
Panicum clandestinum	Deertongue	9
Parthenocissus quinquefolia	Virginia creeper	9
Potentilla simplex Michx.	Common cinquefoil	9
Smilax rotundifolia	Roundleaf greenbrier	9
Cynoglossum virginianum	Wild comfrey	8
Dichanthelium boscii	Bosc's panicgrass	8
Leersia virginica	Whitegrass	7
Lycopus virginicus	Bugleweed	7
Rubus spp.	Blackberry	7
Vitis vulpina	Frost grape	7
Galium concinnum	Shining bedstraw	6
Galium circaezans	Licorice bedstraw	6
Galium triflorum	Sweet-scented bed straw	6
Muhlenbergia schreberi	Nimblewill	6

Table 4.—Main categories of factors and issues related to management of *M. vimineum* in Connors Hollow watershed. These were elicited from Connor's Hollow watershed stakeholders.

Main category	Subcategory/Issues
Japanese stiltgrass	• Will herbicide affect seed viability?
	• What is the best way to control JSG?
	• Stiltgrass will always be here.
	• Weedwhip treatments in sensitive areas.
	• Herbicide treatments applied 07/14/07.
	• Do we kill stiltgrass first or tree-of-heaven?
Gypsy moth	• Linked to stiltgrass?
	• Applying for spring 2008 spraying.
Awareness	• Most people aren't aware of the JSG problem.
	• JSG is only present from June to September.
Timbering	• Timbering in the late 1980s, no JSG, some TOH.
	• Timber harvested about 5 years ago, JSG came in.
Hemlock woolly adelgid	• Can hemlock recover?
	• Can JSG move into area affected by the HWA?
Wildlife	• How does JSG affect wildlife?
	• At least some cover of JSG. Good?
	• What is the habitat quality of JSG?
	• Bears can be a problem with tree tubes.
Aesthetics	• JSG looks very attractive.
	• Most people would probably like the appearance.
Herbicide control	• Not good to spray herbicides everywhere.
Conservation easements	• Several landowners developing easements.
Deer	• Are there too many? Too few?
	• Chronic wasting disease is nearby.
	• Deer browse line is present.
	• What are deer eating? Understory is barren.
	• Deer are eating TOH sprouts.
Tree-of-Heaven	• Seldom Seen Hunt Club treating TOH.
	• Garlon 3E hack-and-squirt yields good results.
Other invasive species	• In absence of stiltgrass, what will come in next?
	• Other species benefit if stiltgrass is killed?
Different landowners	• Perrier Water Company, Hunt Clubs, Cacapon State Park, Private Individuals, Length of ownership, History of associations with Connors Hollow.
Organizations	• WV Division of Forestry, Westvaco/NewPage Corporations, WVU Extension Service, Cacapon Institute, Potomac Conservancy, WV Division of Agriculture (gypsy moth).

On high sethoxydim plots, *M. vimineum* individuals had damaged terminal shoots (location of flowers). A key question remains: Can the stunting by this graminicide prevent flowering or seed set?

Species richness was high on these plots, with 144 different species identified. Unlike Pomp and others (In press), no clear statistical differences in species richness were established. The general rankings, however, with three of four glyphosate treatments having the fewest species on those plots, suggest more research is needed to find an herbicide that will kill stiltgrass and leave other plants intact when used in restoration projects.

Factors elicited from landowners and members of a local hunting club are an important starting point in integrating herbicide prescriptions with the other factors related to management. For example, deer browsing is a significant biotic pressure that can impede even the most successful *M. vimineum* treatment. Lack of *M. vimineum* might increase browsing of plants hidden by the grass. This interrelationship is only one of many we hope to continue to investigate in our effort to control exotic species in Connors Hollow watershed.

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