Suppressing Japanese Stiltgrass (*Microstegium vimineum*) with the Grass-Specific Herbicide Sethoxydim

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RESEARCH NOTE

Suppressing Japanese Stiltgrass (*Microstegium vimineum*) with the Grass-Specific Herbicide Sethoxydim

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ABSTRACT: Japanese stiltgrass (*Microstegium vimineum*) is an annual grass native to parts of Asia that has invaded many areas around the world. We conducted a study in Catoctin Mountain Park in Thurmont, Maryland, to determine if low rates of the grass-specific herbicide Sethoxydim were as effective as the label rate for spot treatment (1.5–2.25%) against *M. vimineum*. Sethoxydim E Pro was applied at 0.75%, 1.0%, and 1.5%. Treatments occurred in July 2011, 2012, and 2013. In September of 2011, 2012, and 2013 all treatments had reduced the cover of *M. vimineum* relative to the controls and there was no significant difference between the three treatments or the three groups of plots and no significant effect on other species. In July 2014, *M. vimineum* cover had rebounded substantially and by September 2014, cover of *M. vimineum* in treated plots was not significantly different from the controls.

Index terms: control techniques, grass-specific herbicide, invasive species, *Microstegium vimineum*

INTRODUCTION

Study Species

Microstegium vimineum (Trin.) A. Camus (Japanese stiltgrass) is a C4 warm season annual grass that is native to parts of Asia. It has been reported as invasive in portions of Europe, North America, South America, Oceania, and Asia. The first US report is from Tennessee in 1919 (Merhoff 2010) and the species is now reported in all states from Florida north to New York and Massachusetts and as far west as Texas (USDA, NRCS 2013). By 1995 it had been found in every county in Maryland (Redman 1995). *Microstegium vimineum* reproduces under a wide range of environmental conditions, including high and low light. *Microstegium vimineum* produces a large amount of seed that is viable for at least three years (Williams 1998, cited in Fryer 2011; Tu 2000; Gibson et al. 2002). Seed is spread by numerous vectors (Evans 2010; Merhoff 2010) and can quickly invade disturbed areas. Because of its ability to reproduce in low light conditions, *M. vimineum* has been able to invade many forest interior regions that are generally free of other nonnative plant species. When *M. vimineum* invades an area it may alter ecological processes (Kourtev et al. 1998; Kourtev et al. 1999; Ehrenfeld et al. 2001; Ehrenfeld 2002; Kourtev et al. 2002; Kourtev et al. 2003; Flory and Clay 2010). Deer preferentially avoid eating this species (Griggs et al. 2006; Eschtruth and Battles 2009).

Microstegium vimineum has been present in Catoctin Mountain Park since the 1980s and in significant quantities since at least 1999 (Becky Loncosky, Biologist, Catoctin Mountain Park, National Park Service, pers. comm. 19 April 2013). In 2009 *M. vimineum* cover in Catoctin was estimated at 12% park-wide based on forest vegetation monitoring plots (Schmit et al. 2012). Monitoring data from the same plots (through 2013) suggest that cover has increased to 17%.

Objective

Our objective was to determine if low rates of the grass-specific herbicide Sethoxydim were as effective as the label rate for spot treatment (1.5–2.25%) against the nonnative *M. vimineum*. Sethoxydim E Pro was applied at 0.75%, 1.0%, and 1.5%. If lower-than-label rates are as effective as label rates, we can reduce the amount of chemical applied. Lower chemical application rates both reduce the potential environmental impact of the treatments and save money.

Treatment Options

Broad spectrum herbicides such as glyphosate have been used successfully to treat *M. vimineum* (e.g., Southeast Exotic Pest Plant Council 2013). While effective, they increase the likelihood of collateral damage to nontarget species. By suppressing *M. vimineum* using a grass-specific herbicide at a low rate, we hope to reduce collateral damage.

Sethoxydim

SethoxydimE-Pro(2-[1-(ethoxyimino)-butyl]-5-[2-(ethythio)propyl]-3-hydroxy-2-cyclohexen-1-one) is a postemergent selective, broad spectrum herbicide used to kill grasses (Etigra 2007). Sethoxydim is water-soluble and does not bind well with soils (Tu et al. 2001). Therefore, reducing application rates can reduce potential groundwater impacts.

METHODS

Study Site

Catoctin Mountain Park in Thurmont, Maryland, is a national park unit covering 2350 ha; forest covers 95% of the park. The forest canopy in the park is typically dominated by chestnut oak (*Quercus prinus* L.), red oak (*Quercus rubra* L.), tulip poplar (*Liriodendron tulipifera* L.), and white ash (*Fraxinus americana* L.). Significant amounts of red maple (*Acer rubrum* L.) and sugar maple (*Acer saccharum* Marsh.) are also present (Schmit et al. 2012).

We established three replicate sets of four 5 × 5-m treatment plots in June 2011. The four treatments consisted of three different herbicide concentrations and one untreated control. A buffer of at least three meters was left between each plot. Plot corners were marked with pin flags and plot edges were marked with string. Plots were treated 15 July 2011, 16 July 2012, and 17 July 2013. Sethoxydim E Pro (active ingredient 13% Sethoxydim) was applied at 0.75%, 1.00% and 1.50%. Methylated Seed Oil (used as a surfactant) was included at 0.50% and a spray indicator was included at 0.50%. Mid-July was chosen because at that time in Catoctin, *M. vimineum* has fully matured but not yet set seed.

The herbicide was applied in a spray-to-wet basis (cover foliage but avoid dripping). Only *M. vimineum* was treated—nontarget species were not sprayed. To allow for absorption and prevent off-site movement, Sethoxydim was not applied when there was a potential for rain within two hours of application. All plots had a 40-m buffer from any standing water to protect groundwater.

In 2011 and 2012, 5.7 L was needed to cover 75 m^2 (the area of three plots of each treatment type; 0.75% = 0.68 kg a.i./ha, 1.0% = 0.90 kg a.i./ha, 1.5% = 1.35 kg a.i./ha). Because less *M. vimineum* was present in 2013, only 3.8 L of mix was needed to cover 75 m^2 (0.75% = 0.45 kg a.i./ha, 1.0% = 0.60 kg a.i./ha, 1.5% = 0.90 kg a.i./ha).

We performed ocular estimates of percent cover in two 0.5 × 1.0-m subsamples for each plot in early summer (15 July 2011, 16 July 2012, 17 July 2013, and 15 July 2014) and late summer (1 September 2011, 15 September 2012, 19 September 2013, and 17 September 2014). Subsamples were located 1 m in from opposite corners (Figure 1). Vegetation over 2 m tall was not included in the cover estimates. September was chosen because the plant is at the end of its aboveground growth phase but still green.

We estimated the percent cover of each of following variables on all of the plots at all of the monitoring dates:

- *Microstegium vimineum*
- native forbs
- native woody vegetation
- native graminoids
- exotic forbs
- exotic woody vegetation
- exotic graminoids
- dead vegetation
- bare ground

Analysis

For the purposes of this study we considered reduction in *Microstegium* cover and increase in the cover of other plant species to be indicators of successful treatment. We were particularly interested in these measures in September 2013, after the last Sethoxydim treatment and in September 2014, one year after treatment ended. We determined the effects of the treatment using linear mixed models with treatment as a fixed variable and plot as a random variable, and either *Microstegium* cover or non-*Microstegium* cover as the response. All statistics and graphics were created using R version 3.0.2 (R Core Team 2013), including the lattice (Sarkar 2008) and nlme (Pinheiro et al. 2013) packages.

RESULTS

Effects on *Microstegium vimineum*

In 2011, all treatments of Sethoxydim reduced *M. vimineum* cover to less than 20% from July to September, while the control plots had 80% cover in both July and September ($P < 0.001$, $F = 1039.3$; Figure 2). There was no significant difference between the three treatments or the three groups of plots, and the initial cover

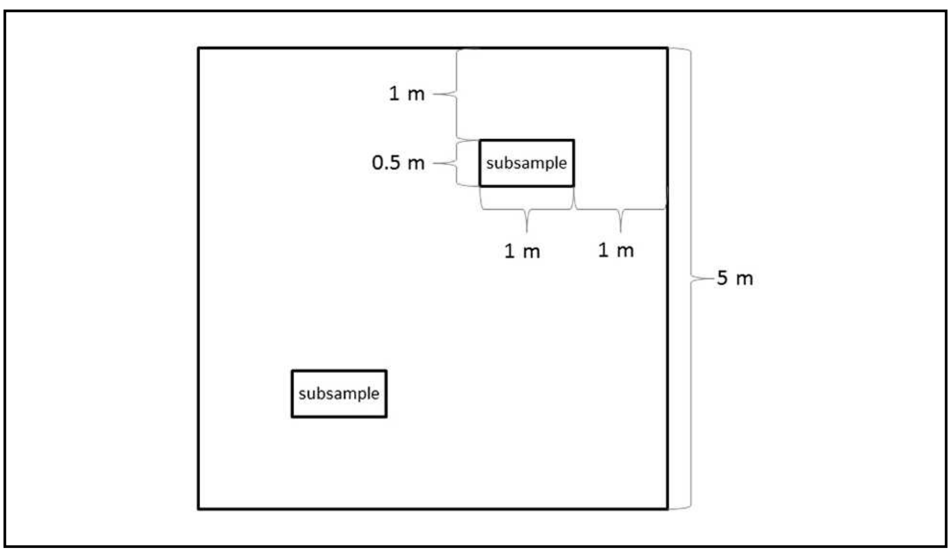

Figure 1. Plot diagram showing sampling locations within treatment plots for *Microstegium vimineum* at Catoctin Mountain Park 2011–2014.

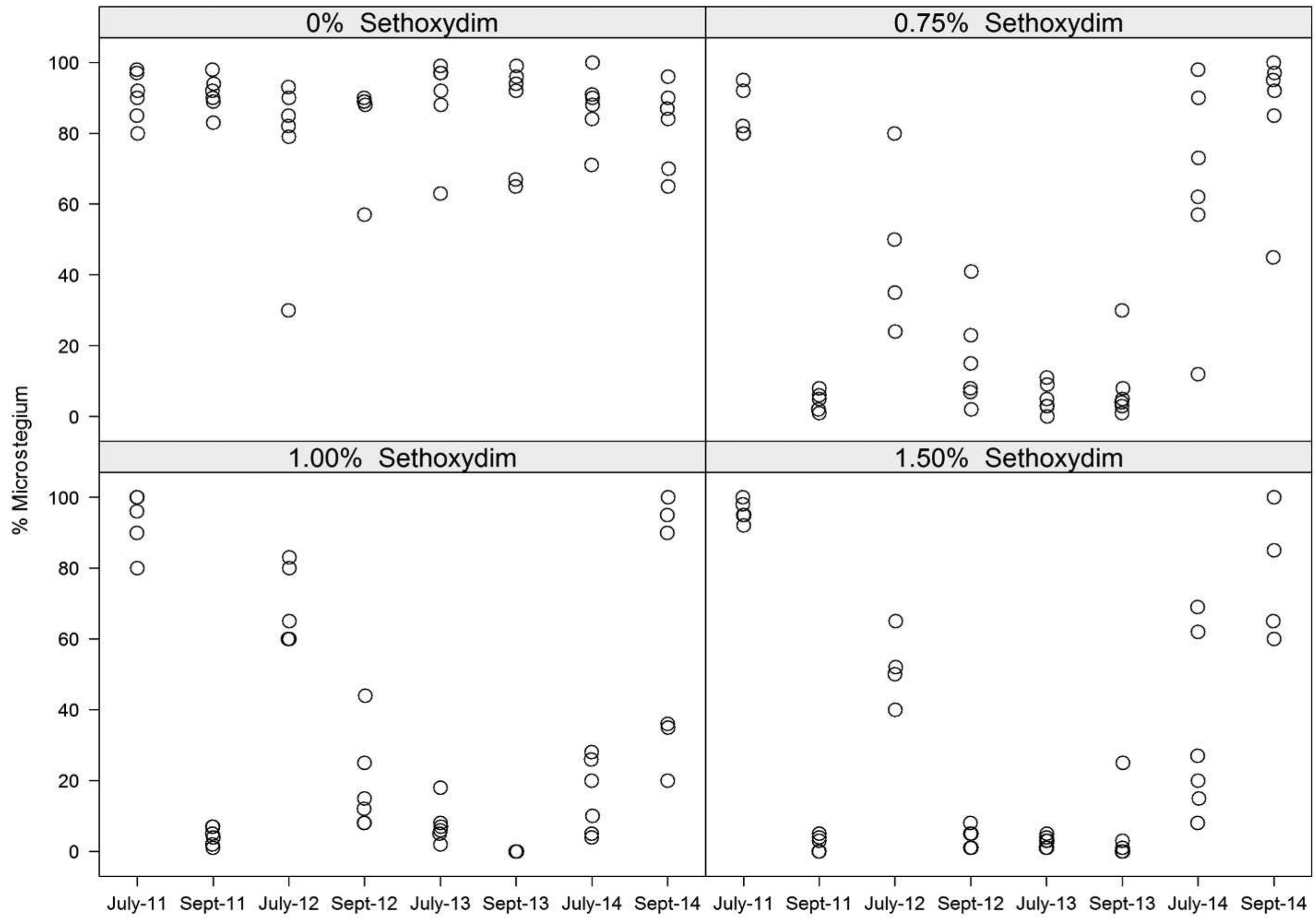

Figure 2. ***Microstegium vimineum*** **cover over time under each treatment. Treatment was done with Sethoxydim E-Pro herbicide for** ***Microstegium vimineum*** **at Catoctin Mountain Park, Maryland, 2011–2014.**

of *M. vimineum* did not have an impact on this result ($P = 0.71$, $F = 0.14$).

By July of 2012, *M. vimineum* cover had rebounded, but by September 2012, all treatments reduced the cover of *M. vimineum* compared to the controls ($P < 0.001$, $F = 54.2$; Figure 2).

In July of 2013, the plots treated with Sethoxydim still had greatly reduced cover compared to the controls ($P < 0.001$, $F = 183.3$) and cover remained low in September of 2013 ($P < 0.001$, $F = 88.4$).

Between the start of the study in July of 2011 and the survey in September of 2013, there was a 78% to 93% reduction in *M. vimineum* cover across all three treatments ($P < 0.0001$, $t < -11.4$; Table 1). Control plots lost 4.8% over the same period ($P = 0.30$, $t = -1.05$; Figure 2). In July 2014, however, cover of *M. vimineum* in the 0.75% ($P < 0.0001$, $t = 5.48$) and 1.5% ($P = 0.01$, $t = 2.88$) treatments was significantly higher than July 2013. There was no significant difference for the controls or the 1.0% treatment. By September 2014, cover of *M. vimineum* for all treatments was not significantly different from the controls ($F = 1.16$, $P = 0.35$, $R^2 = 0.15$).

Effects on Other Plants

The initial reduction of *M. vimineum* cover was associated with increases in cover of non-*M. vimineum* species, both native and exotic.

By September 2013, there were nonsignificant losses of non-*Microstegium* cover in the control and 1% plots, and significant increases in the 0.75% ($t = 2.82$, $P < 0.02$) and 1.50% ($t = 2.16$, $P < 0.05$) treatment plots (Table 2). By September 2014, however, the impact of treatment had changed. The control and 0.75% treatment plots had less non-*Microstegium* cover than when the study began, but the 1.00% amd 1.50% treament plots had more, although this was only signficant for the 1.00% treatment ($t = 2.19$, $P < 0.05$; Table 3).

When analyzed separately, both native and non-*M. vimineum* nonnative species increased in cover in the treatment plots, and decreased in cover on the controls, but in no case were these changes statis-

Table 1. Statistical results: net change in *M. vimineum* cover at Catoctin Mountain Park, Maryland, July 2011–Sept 2014.

Term	Coefficient	Std. Error	DF	*t* value	*P* value
Intercept	-8.3	10.2	20	-0.82	0.42
0.75%	6.7	14.4	20	0.46	0.65
1.00%	-23.3	14.4	20	-1.62	0.12
1.50%	-11.3	14.4	20	-0.79	0.44

anova statistics: Treatment *F* value 1.68, *P* value 0.20

Table 2. Statistical results: net change non-*M. vimineum* cover July 2011–Sept 2013 at Catoctin Mountain Park, Maryland.

Term	Coefficient	Std. Error	DF	*t* value	*P* value
Intercept	-8.3	4.3	20	-1.95	0.065
0.75%	17.0	6.0	20	2.82	0.011
1.00%	6.7	6.0	20	1.11	0.28
1.50%	13.0	6.0	20	2.16	0.043

anova statistics: Treatment *F* value 3.05, *P* value 0.052

Table 3. Statistical results: net change non-*M. vimineum* cover July 2011–Sept 2014 at Catoctin Mountain Park, Maryland.

Term	Coefficient	Std. Error	DF	*t* value	*P* value
Intercept	-4.2	8.1	20	-0.51	0.61
0.75%	3.0	11.5	20	0.26	0.80
1.00%	25.2	11.5	20	2.19	0.04
1.50%	11.5	11.5c	20	1.00	0.33

anova statistics: Treatment *F* value1.93, *P* value 0.16

tically significant with the exception of a marginally signficiant increase in native plant cover in 2014 in the 1% treament plots (data not shown).

DISCUSSION

Applying Sethoxydim for *M. vimineum* at Catoctin Mountain Park at half the label rate (0.75%) appears just as effective as the full label rate (1.5%). Reduced chemical use reduces the risks to groundwater, decreases the likelihood of collatoral damage to desirable plants, and saves money.

During the year of treatment, all treatments reduced the cover of *M. vimineum* relative to the controls and there was no significant difference between the three treatments or the three groups of plots. There were only a few other species before or after treatment, so treatments had no significant effect on other species.

One year of treatment is insufficient to control this species at any of the tested rates; a second year of treatment appears to offer better control than just one year. However, if a seed source is nearby, annual treatments are needed. *Microstegium vimineum* plants on the edges of plots were more dense and taller than plants in the middle of plots. We used a 3-m buffer but it appears that 3 m was insufficient.

If we assume 17% of Catoctin Mountain Park is covered with *M. vimineum,* then approximatley 400 ha of the 2350-ha park are covered in *M. vimineum*. *Microstegium vimineum* control in one year on all 400 ha would be impractical, so site prioritization is needed. In addition, our results suggest that many years of follow-up treatments are needed to achieve effective control.

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