IWPF000354

Comparative Life History Studies of *Microstegium vimineum*, an invasive exotic in southern Illinois.

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Final Report submitted to the Illinois Department of Natural Resources
Natural Heritage Division, Wildlife Preservation Fund Program

June 30, 2001

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Table of Contents

Summary

1. The comparative life history of *Microstegium vimineum* an invasive exotic grass was investigated in four populations in southern Illinois.
2. The objective of the study was to determine the generality of poor production and fecundity of a population of *M. viminium* that was observed at Dixon Springs State Park in the drought year of 1999. A second set of observations of this population were made in 2000 at Dixon Springs State Park, and compared with observations made at three additional populations at Bell Smith Springs, Cove Hollow and Lusk Creek Canyon.
3. Recovery and reestablishment of the Dixon Spring population following the drought of 1999 was vigorous, which was not unexpected based upon the longevity of the seed bank. The location within the site of the most vigorous plants in 2000 was not the same as in 1999. Survivorship of *M. vimineum* across all populations was 40 – 50%, with 90% of surviving individuals flowering. Performance of *M. vimineum* varied significantly within- and among populations and was related to soil texture and chemistry, and overhead canopy cover.
4. Our study illustrates the pernicious nature of this exotic plant. Although as an annual it has to reestablish each year, it has a sufficiently large seed bank and a highly plastic response to local microhabitat conditions that likely ensures its persistence once it has invaded a site.

List of Tables

List of Figures

Figure 2. Frequency distribution of spikelet numbers per individual *Microstegium vimineum* across all sites. Top panel is a box-whisker plot of frequency distribution.

Figure 3. Number of spikelets on *Microstegium vimineum* plants from four populations in southern Illinois during 2000. Upper panel: among sites on two sample dates (box-plot showing the median (central line), 25th and 75th percentiles, 90th percentile (upper bar), and individual values beyond the 90th percentile). Lower panels: among transects and within sites (mean plus 1 se bar).

Figure 4. Principal Component Axis 1 scores for plants from four sites in southern Illinois sampled on days 294 and 321 (left panels), and along five transects (right panels).

Introduction

Invasive exotic species make up 28% of the Illinois flora and are one of the most pernicious threats to the integrity of natural areas in the state (Illinois Department of Energy and Natural Resources 1994). Understanding their basic population biology is a first step for developing methods of control and integrated pest management for these species.

Microstegium vimineum (Trin.) A. Camus (Eulalia, Japanese grass, stiltgrass, Nepal microstegium) is one of the 25 exotic weeds considered to pose the greatest threat to Illinois forests (Illinois Department of Energy and Natural Resources 1994). A native of Asia, *M. vimineum* was first discovered in the United States in 1919 in Knoxville Tennessee and is now widespread east of the Mississippi (Hunt & Zaremba 1992; Redman 1995; Ehrenfeld 1999). *Microstegum vimineum* is also spreading as an exotic invader to countries other than the United States, e.g., Turkey (Scholz & Byfield 2000). In southern Illinois it is reported in Pope, Union, Saline, Johnson, Hardin, Alexander, Gallatin, Williamson, and Massac Counties (Mohlenbrock & Voigt 1959; Mohlenbrock & Schwegman 1969; Shimp 1996). It is of special concern in a number of State Parks, and Illinois Natural Area Inventory Sites.

M. vimineum is annual grass which spreads into shady stream-side forest habitat. It also spreads rapidly into disturbed areas but can invade undisturbed upland areas by forming satellite populations brought in by animals or flooding. On fertile mesic sites it can replace competing ground vegetation within 3-5 years (Tennessee Exotic Pest Plant Council and Great Smoky Mountains National Park 1997).

A putative perennial form of *M. vimineum* has been reported in New Jersey (Ehrenfeld 1999; Mehrhoff 2000), but has not been observed in Illinois.

There is insufficient life history information on this species to allow the development of an adequate management plan. Illinois currently has no control method listed in the Illinois Vegetation Control Manual for *M. vimineum*.

In 1999, we measured seed production, seed rain and viability, and seed bank persistence, in a population of *M. vimineum* at Dixon Springs State Park (Spyreas *et al.* 2000). We found that this population was severely affected by late-summer drought, and plants in only 0.01% of the population flowered. Those plants that did flower were significantly larger than those that did not flower. Seed production was very low and of seed produced only 50% were viable. We suspect that such poor production and fecundity to be atypical of such a pernicious exotic.

Project Objectives

The overall objective is to assess the generality of the poor production and fecundity of *M. viminium* observed in the drought year of 1999. To do this we measured plant performance and reproduction at the site studied in 1999 as well as at four additional sites.

Materials and Methods

Site Description

The primary site for this study was Dixon Springs State Park in Pope County. This park lies within the Illinois Shawnee Hills Physiographic Region, and is characterized by plant communities ranging from mature secondary Oak-Hickory forest, to early successional woods. We chose to work in an early successional dry/mesic woods encompassing the east half of the park where infestation of *M. vimineum* infestation is particularly heavy.

Intermittent streams dissect the area, which is gently sloping. Poor soil horizon development indicates historical agricultural use, followed by abandonment 35 years ago. The area is dominated by young *Quercus velutina, Q. stellata*, and *Carya* spp., with an overstory of *Juniperus virginiana, Cornus floridia, Diospyros viriginiana*, and *Sassafras albidum*. Typical shrubs and vines include *Symphiocarpus orbiculatus, Lonicera japonica, Toxicodendron radicans,* and *Vitis* spp.

The distribution of *M. vimineum* at this site is represented by a dense core population within the interior of the park. This 'core' is immediately surrounded by small, isolated peripheral patches. Additionally, a few small, widely scattered satellite patches occur further south along the entrance trail towards the park entrance, away from the large interior core populations. Plant taxa associated with *M. vimineum* at this site are listed by Spyreas *et al.* (2000).

Three additional populations were located at Bell Smith Springs, and Lusk Creek, in Pope County, Illinois, and Cove Hollow in Jackson Hollow, Illinois.

Bell Smith Springs. This site located in the greater Shawnee Hills is characterized by a large, permanent stream. The sandy streamside where *M. vimineum* occurs is adjacent to very steep sandstone bluffs on both sides. The *M. vimineum* populations were large and well established at this site. The plant could not spread up the sides of the bluffs and steep slopes, though it had established itself anywhere the water reached high enough to disperse seed, seemingly outcompeting the native flora on these steep slopes. It was growing on rock outcrops with Ferns (*Asplenium platyneuron*, *Woodsia obtusa*), mosses and liverworts. The study populations were in dense vegetation growing on the banks and sand bars of the stream. *Microstegium vimineum* was growing with a diverse and flora including *Andropogon gerardii*, *Sambucus canadensis*, *Alnus serrulata*, *Corylus americana*, *Panicum clandestinum*, *Platanus occidentalis*, *Salix* spp., *Cassia marilandica*, *Perila frutescens* and *Polygonum* spp. Trees were not well established within this ravine.

Cove Hollow. A mesic, cove forest in the Ozark section of the Shawnee. A ravine stream enters into a dammed lake. The forest is dominated by *Fagus grandifolia*, *Acer saccharum*, *Quercus rubra*, *Juglans nigra*, and *Lindera benzoin* in the valley and *Platanus occidentalis*, and *Acer rubrum* nearer the stream. *Microstegium vimineum* populations occur in the rocky stream bed. Populations are generally of scattered patches, and the plant does not show signs of leaving the cobble/sand streambed and invading the relatively undisturbed upland mesic forest. The scouring action in the ephemeral stream bed likely sustains the populations of *M. vimineum*.

Lusk Creek. This was a creek habitat similar to that of Cove Hollow. The stream was ephemeral, very rocky and surrounded by sandstone bluffs. The area and it's surrounding forest were not as mesic as Cove hollow as the soil was not as deep and rich.

Associate species included *Lindera benzoin* and *Zizia aurea*. *Microstegium vimineum* did not appear to be spreading out of the creek bed here, the population was not that large and generally consisted of scattered patches.

Field Methods

At each site, five transects were randomly located within *Microstegium vimineum* populations. At Dixon Springs, one of these transects (transect A) was located within the high density flowering patch of our 1999 survey. Each transect was 3 - 5 m in length. Along each transect, ten plants were selected using a stratified random approach and tagged with colored wire, giving a total of 50 marked plants per population. The Dixon Springs population was marked May 18, 2000 (day 138 of 2000), the Cove Hollow population on June 24 (day 175), Bell Smith Springs on July 22 (day 203), and Lusk Creek on September 10 (day 253). The number of leaves, tillers and total plant length (sum of length of all branches) was recorded at the time of initial marking and subsequently for a total of 3 – 5 observations per plant. The most extensive set of measurements were made on the Dixon Springs plants, which were measured on days 138, 196, 238, 294, and 321. Measurements at the other populations were on days 175, 237, 294, and 321 at Cove Hollow, days 203, 272, 294, and 321 at Bell Smith Springs, and days 253, 294, and 321 at Lusk Creek. By November 17, 2000 (day 321), all populations had flowered and individual plants were starting to senesce. Where possible, the reason for mortality was noted when plants were found to be dead. On October 21 (day 294), two plants were selected at random from each transect at each site and collected for additional measurements. The remaining plants (up to 8 per transect) were collected on day 321. In addition to leaf number, tiller number and length, the number of inflorescences, spikelets, nodes and seeds, and biomass (dry weight after drying for > 24 hr at 80 ° C) of the whole plant and seed were recorded at days 294 and 321.

A composite soil sample was taken from each transect in October, 2000. Eight-ten samples were collected from 2 – 10 cm depth along each transect using a soil corer and composited to obtain an approximately 250 g sample. The samples were sent to A&L Laboratories (Memphis, TN) for analysis of pH, extractable P, K, Ca, Mg, percentage organic matter, cation exchange capacity, and texture (hydrometer method).

Overhead tree canopy cover was estimated in mid-summer above each transect at the Bell Smith Springs and Lusk Creek sites using a spherical densiometer.

An unbalanced design (variable numbers of plants per sample date) precluded a statistical analysis of the measurements taken on marked plants through the course of the field season. A conservative approach was taken to examining these data by simply plotting means and standard errors of mean plant performance at each sample date (day of 2000). The measurements made on plants collected on days 294 and 321 were analyzed using a three-way ANOVA testing the effects of site (df = 3), transect nested within site (df = 14), date (df = 1) and the site by date interaction on log transformed dependent variables, including reproductive allocation (RA) calculated as seed biomass/total plant biomass. Because of the unbalanced design, a Type III Sum of Squares was calculated (Shaw & Mitchell-Olds 1993). Only a single plant survived on transect D at Cove Hollow and so these data were excluded from analysis. The soils data were analyzed using a 1-way ANOVA with site as the treatment. The Tukey-Kramer all pairs test was used to compare means for significant treatment effects. A Principal

Components Analysis on the correlation matrix of the morphological variables was used to obtain an integrated measure of plant performance. Significance of axes extracted using PCA was tested using Parallel Analysis (Franklin *et al.* 1995). All statistical analyses were conducted using SAS Version 8.0 and JMP Version 4.0.4 (SAS Institute Inc 1999).

Results

The marked plants of *M. vimineum* differed in survivorship among populations (Fig 1d). The population at Dixon Springs, which was monitored throughout the season, exhibited a constant rate of mortality with just over 50% (23 of 50) of the marked plants surviving until the end of the growing season (day 321). By contrast, although marked at different times, the other three populations each showed an initial high rate of mortality. At Cove Hollow, mortality was most marked with only 30% (12 of 50) of the marked plants surviving until day 321. The cause of mortality varied among individuals. At Dixon Springs, most plants appeared to die due to browsing. At Cove Hollow, all of the plants on at least one transect were washed away by floodwater, whereas of the 10 plants along a second transect, 5 individuals were dead, one was missing, two survived only as a stem, and one was found uprooted and lying on an adjacent rock on day 237. At Bell Smith Springs, all of the plants on transect A were destroyed through vandalism sometime between two periods of observation.

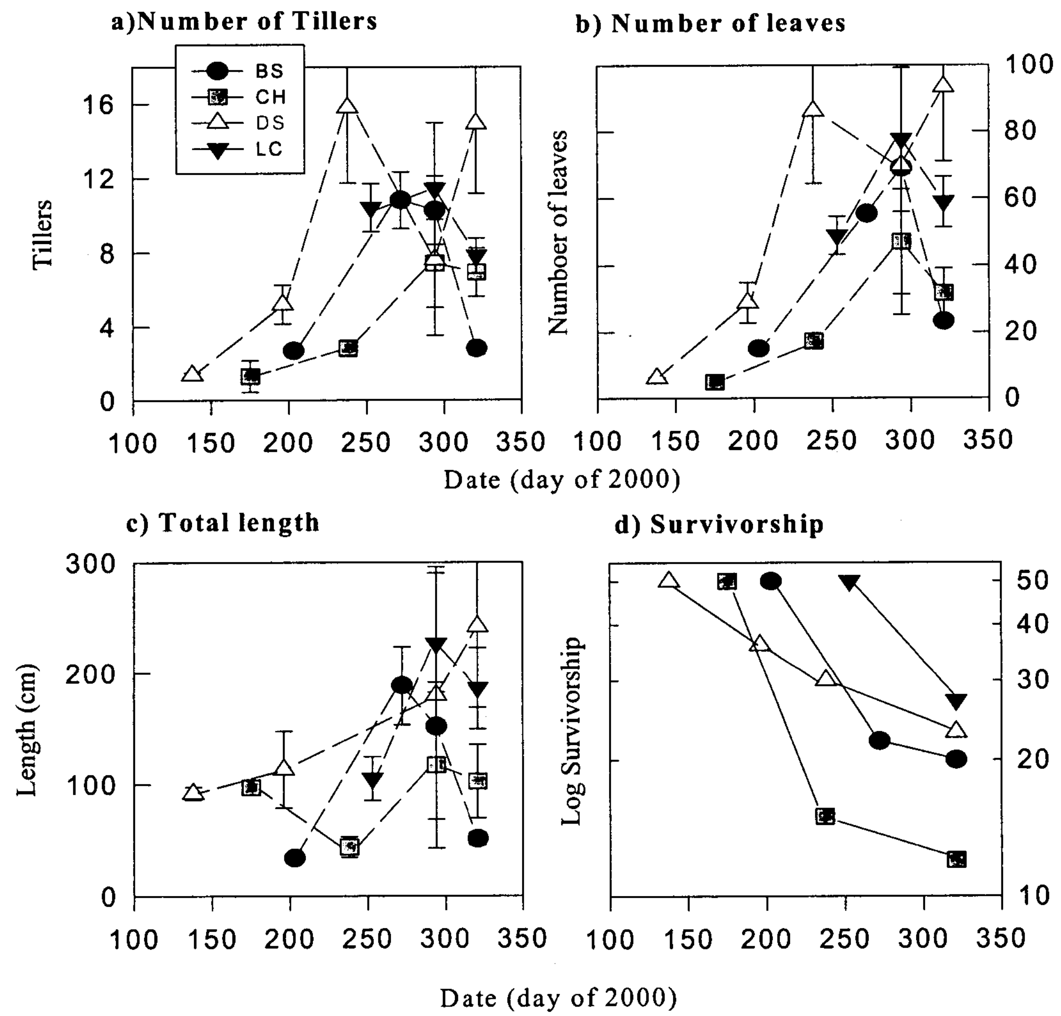


Figure 1. Growth (a,b, & c) and survivorship (d) of *Microstegium vimineum* at four sites in southern Illinois in 2000.

Through the course of the growing season, the marked plants of *M. vimineum* increased in size in terms of numbers of tillers, numbers of leaves and total plant length (Fig 1, abc). The plants at Bell Smith Springs, Cove Hollow, and Lusk Creek showed a die back between days 294 (October 21) and 321 (Nov 17), whereas the plants at Dixon Springs had still not started to senesce by the date of the last observation. The individuals at Dixon Springs were generally the largest, whilst those at Cove Hollow grew the slowest, and remained the small (Table 1). Although small, the plants at Cove Hollow had flowered as well as plants at the other sites, producing an equivalent amount of seed per individual as the large plants at Dixon Springs. Consequently, the RA of the Cove Hollow plants was substantially larger than that of the plants at the other sites.

The plants collected on days 294 (2 plants per transect) and day 321 (remaining plants) exhibited a high correlation among the 8 morphological variables (Spearman's Rank correlation r = 0.46 – 0.91, n = 103 – 115, P all < 0.0001). Of these surviving plants, 103 of 115 (90%) produced an inflorescence with no significant difference among populations (χ^2 = 1.91, NS at 3 df).

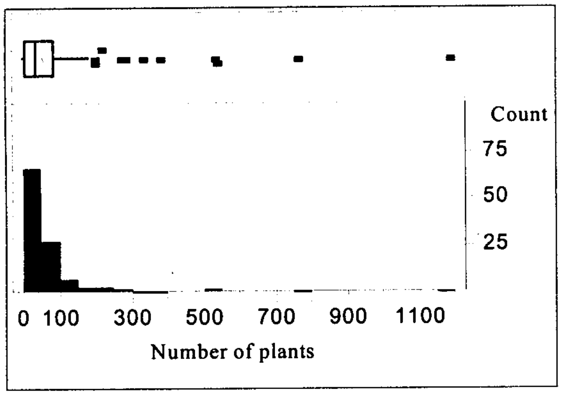
Table 1. Mean size of *Microstegium vimineum* plants across four sites in southern Illinois in 2000. BS, Bell Smith Springs, n = 28; CH, Cove Hollow, n = 19; DS, Dixon Springs, n = 31; LC, Lusk Creek, n = 37 (36 for seed biomass and RA).

Variable	BS	CH	DS	LC
Length (cm)	79.8 ± 12.7	107.9 ± 33.1	228.8 ± 61.0	197.0 ± 32.3
Tillers	4.9 ± 0.8	7.1 ± 1.2	13.0 ± 3.0	8.7 ± 1.18
Nodes	34.6 ± 4.4	28.6 ± 4.4	66.0 ± 13.6	54.7 ± 7.4
Leaves	36.3 ± 5.6	37.3 ± 7.4	87.2 ± 19.9	63.9 ± 7.9
Infloresences	5.1 ± 1.4	9.1 ± 2.74	30.9 ± 9.4	16.7 ± 2.4
Spikelets	36.3 ± 12.3	71.3 ± 39.1	98.1 ± 40.1	105.2 ± 19.1
Seeds	2.3 ± 1.0	42.3 ± 26.3	48.1 ± 16.0	16.2 ± 3.1
Seed Biomass (g)	0.003 ± 0.001	0.17 ± 0.16	0.04 ± 0.01	0.02 ± 0.003
Plant Biomass (g)	0.54 ± 0.8	0.31 ± 0.1	1.22 ± 0.34	1.21 ± 0.23
RA	0.004 ± 0.002	0.51 ± 0.45	0.06 ± 0.01	0.03 ± 0.01

ANOVA on the measurements from days 294 and 321 indicated significant site, transect, date, or site by date interactions for all of the variables measured (Table 2). Site by date interactions were significant for 8 of 10 variables reflecting the end of season die back of plants observed at three of the sites. This trend can be seen clearly in terms of numbers of tillers and leaves of plants from Bell Smith Springs (Fig 1 a,b,c), and also occurred for the number of nodes, spikelets (Fig 3) and other reproductive characters (inflorescences, seed, RA).

The number of spikelets per plant served as a useful and representative measure of overall plant performance (Spearman's R = 0.63 – 0.89, P < 0.0001, n = 114 for morphological variables; R = 0.29, P = 0.0015, n = 113 for RA). There were 81.7 ± 14.6 spikelets per plant, ranging from 0 to a maximum of 1192 on a plant at Dixon Springs. The frequency distribution of spikelet production was markedly left-skewed (skewness = 4.5) with 34 of 114 plants producing 10 or few spikelets (Fig 2). Spikelet number varied significantly among all sites, interacting with transect number and date (Table 1, 2; Fig 3). Spikelet production was the most variable at Dixon Springs where the largest number of spikelets were produced on plants along Transect B located in a shady ravine. The flowering patch from 1999 (Patch 3 of 1999, transect A in this report) also produced a relatively large number of spikelets (Spyreas *et al.* 2000). Plants at Lusk Creek were less variable than those at Dixon Springs (Fig 3), and produced a larger number of spikelets per plant.

Fig 2. Frequency distribution of spikelet numbers per individual *Microstegium vimineum* across all sites. Top panel is a box-whisker plot of frequency distribution.



A Principal Components Analysis of 112 plants for which a complete set of 10 morphological measurements were available extracted a single significant component.

Table 2. F-values from ANOVA on final measurements. Dependent variables represent counts unless indicated otherwise. RA = reproductive allocation. All variables were log transformed prior to analysis. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. Model df = 113, except seed characters where df = 112, PCA axis 1 df = 110. Site df = 3, transect nested in site df = 13, date df = 1, site* date df = 3.

Dependent variable	Site	Transect nested in Site	Date	Site * Date
Length	5.04**	6.95***	2.10	2.07
Tillers	1.74	5.99**	2.62	7.95**
Nodes	2.56	3.23**	0.09	3.30**
Leaves	3.28**	4.83***	6.10**	5.05**
Inflorescences	6.78**	6.05**	24.32***	9.73***
Spikelets	7.96***	4.24***	43.78***	5.90**
Seeds	12.39***	2.97**	11.98***	2.81*
Seed biomass	2.54	1.19	3.44*	4.88**
Plant biomass	6.40**	6.07***	2.56	1.45
RA	3.89*	0.90	6.06*	5.17**
PCA Axis 1	4.02**	5.92****	4.68*	4.31**

All the morphological variables had large positive loadings (> 0.695) indicating that plants assigned high factor loadings had large values for all the variables. The scores from this first axis thus provide an integrated measure of plant performance. This component accounted for 74% of the variation in the data (Eigenvalue = 6.67) and was significantly related to the interaction between site and date ($F_{3,110}$ date*site = 4.31, P = 0.0069; Table 2). A plot of the mean first axis scores by site and date reinforces the view obtained from separate analyses of each morphological variable (Fig 4). Large axis 1 scores indicate that the plants at Lusk Creek on day 294 were larger than plants from all other sites at both sample dates. Bell Smith Springs plants were also relatively large, but became the smallest group of plants by day 321. The plants at Dixon Springs were the smallest of all the plants on day 294, but were the largest plants on day 321. The Cove

Hollow plants were the smallest plants on day 294, and increased in size only slightly by day 321. Significant variation in size occurred among transects within sites ($F_{13,110}$ = 5.92, P < 0.0001) reflecting within habitat variation. This was clearly illustrated with the plants at Dixon Springs which spanned the range of PCA axis 1 scores (Fig 4). The plants on transect A and B were the largest, whereas those on transects D and E were much smaller by comparison.

Soils among the four populations were generally sandy or silty loams, with low amounts of clay. The stream-side soils from the Bell Smith Springs and Lusk Creek populations were noticeably high in sand (55 – 85% at Bell Smith Springs, 64 – 87% at Lusk Creek). There were significant differences in soil pH and exchangeable cations among the sites (Table 3). The soils from Dixon Springs were the most acidic and had the highest Cation Exchange Capacity, K, and Mg. Ca levels were highest at Bell Smith Springs, while soil P was highest at Cove Hollow. Percentage organic matter was low ranging 0.9 – 2.8 % without a significant difference among sites.

Mean plant performance per transect (i.e., PCA axis 1 score, Fig 4) was negatively related to the % silt and CEC of the soil (Spearman Rank Correlations, R = -0.67, -0.55, P = 0.02 for both, DF = 17, 12, respectively), positively related to % sand (R = 0.69, DF = 12, P = 0.01) and showed a trend towards a negative relationship with overhead tree canopy cover (R = - 0.61, DF = 9, P = 0.08).

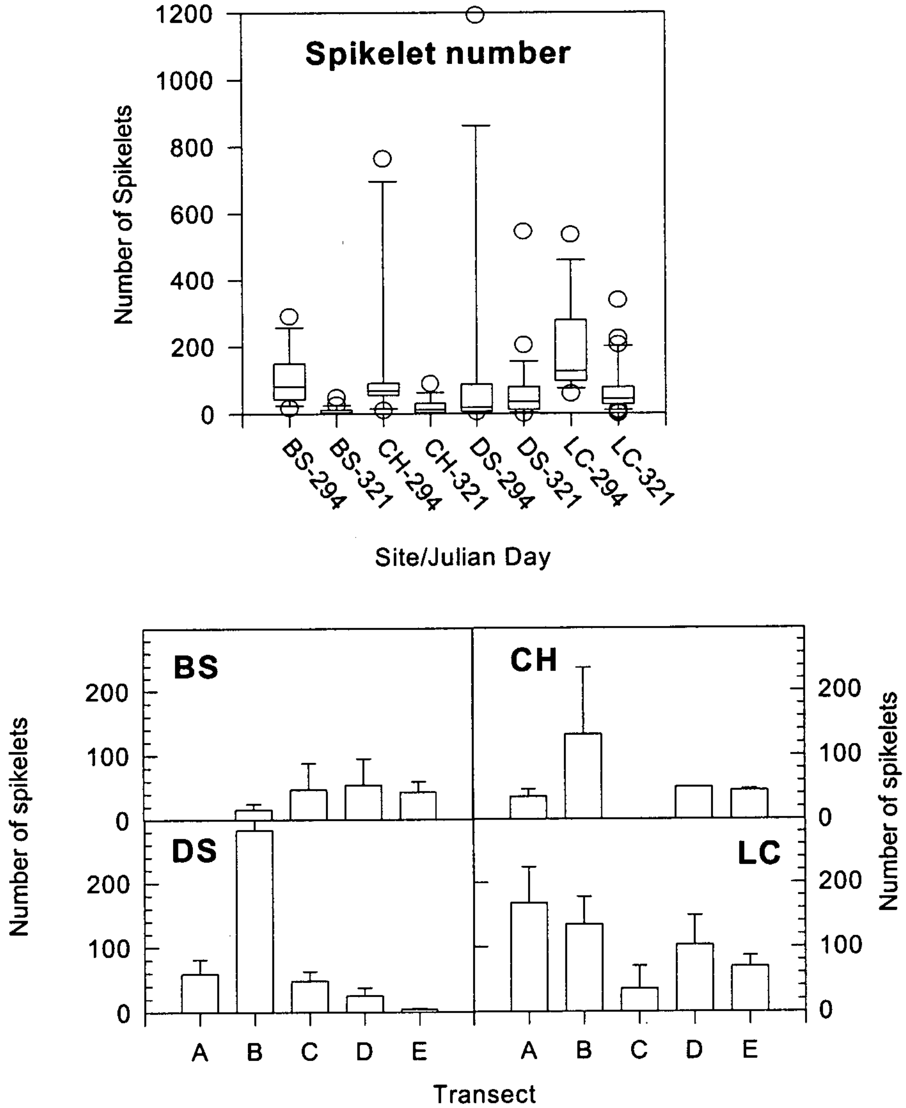


Figure 3. Number of spikelets on *Microstegium vimineum* plants from four populations in southern Illinois during 2000. Upper panel: among sites on two sample dates (box-plot showing the median (central line), 25th and 75th percentiles, 90th percentile (upper bar), and individual values beyond the 90th percentile). Lower panels: among transects and within sites (mean plus 1 se bar). BS = Bell Smith Springs, CH = Cove Hollow, DS = Dixon Springs, and LC = Lusk Creek.

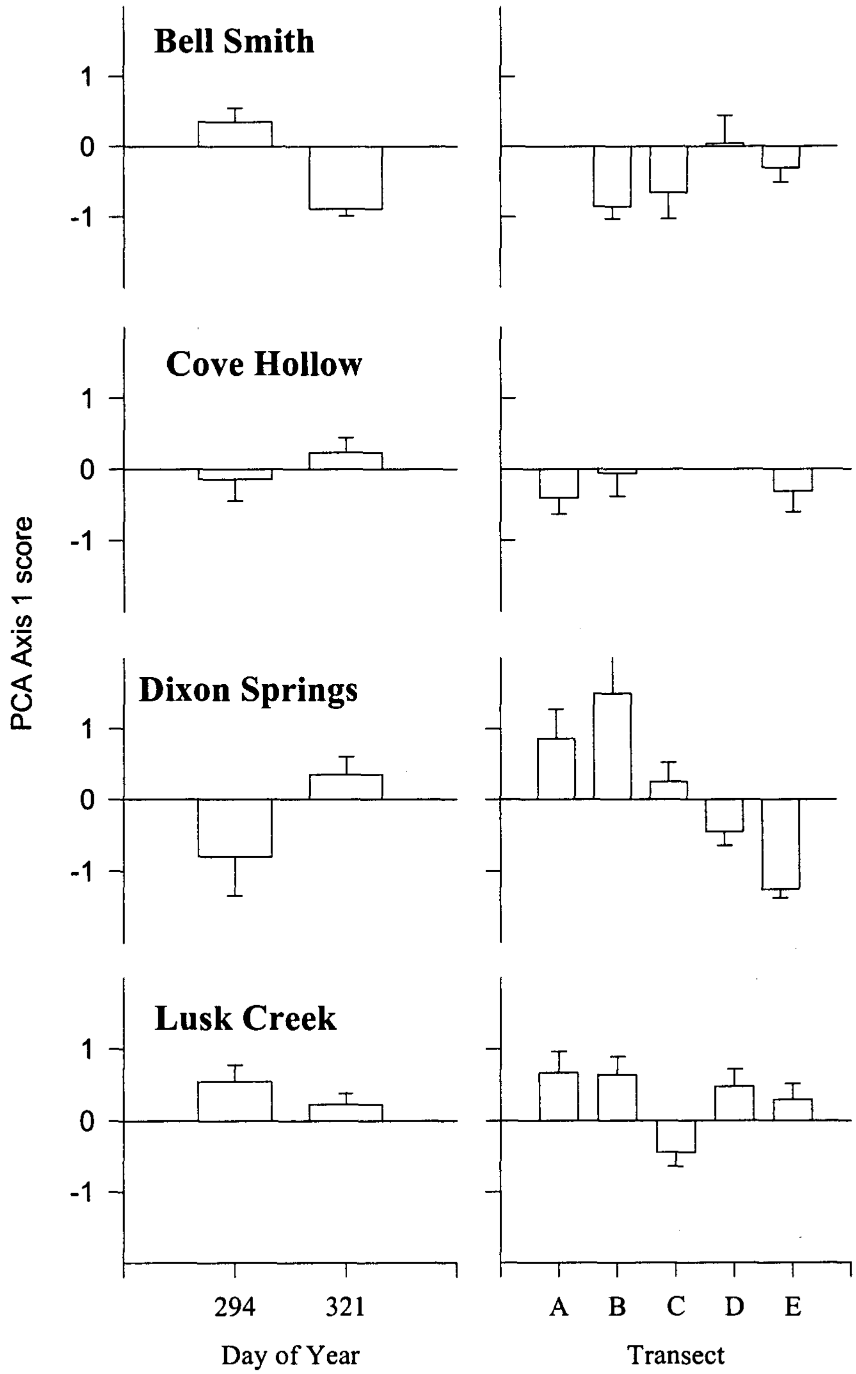


Figure 4. Principal Component Axis 1 scores for plants from four sites in southern Illinois sampled on days 294 and 321 (left panels), and along five transects (right panels).

Table 3. Analysis of soils collected from *Microstegium vimineum* plots. Site coding indicates site and transect; e.g., LCA = Lusk Creek transect A. At DS, the patches surveyed by Spyreas *et al.* (2000) are identified as P1, P2, etc. P3 is transect A of this report. Units are $\mu g\ g^{-1}$ for exchangeable cations. Texture, L = loam, LS = loamy sand, SL = sandy loam, SyL = silty loam. Analysis for pH calculated after back transforming to H^+ ion concentration. Site means in a column sharing the same letter are not significantly different at P = 0.05 (all pairs Tukey-Kramer test). Tree canopy cover (%) data available only from BS and LC.

Site	pH	P	K	Ca	Mg	CEC (meq/ 100g)	OM (%)	Texture	Canopy cover (%)
BSA	4.7	7	74	342	67	4.1	1.3	LS	84
BSB	6.5	6	123	1471	160	7.9	2.8	SL	89
BSC	6.7	4	85	1377	167	7.3	2.2	SL	90
BSD	6.5	6	69	1046	117	5.6	1.8	LS	87
BSE	6.4	6	59	569	156	3.9	1.0	LS	78
Site mean	5.4^{B}	5.8 ± 0.5^{B}	82.0 ± 11.1^{AB}	961 ± 221^{A}	133.4 ± 18.7^{AB}	5.8 ± 0.8^{AB}	1.8 ± 0.3		
CHA	5.3	12	79	717	130	5.8	1.2	SyL	
CHB	5.8	14	57	865	122	5.5	0.9	SL	
CHC	4.9	14	74	629	120	6.4	1.4	SL	
CHD	4.7	8	69	266	79	3.7	1.2	SyL	
CHE	5.5	17	81	740	123	5.5	1.2	L	
Site mean	5.1^{AB}	13.0 ± 1.5^{A}	72.0 ± 4.3^{B}	643 ± 146^{AB}	114.8 ± 9.1^{B}	5.4 ± 0.4^{AB}	1.2 ± 0.1		
DS P1	4.3	7	81	183	75	4.4	1.6		
DS P2	4.5	7	105	337	194	7.3	1.4		
DS P3	5.3	12	203	727	193	7.0	1.8		
DS P4	4.9	2	112	568	334	9.1	1.8		
DS P5	4.5	7	69	224	119	4.7	1.0		
DS P6	4.5	7	123	483	216	9.2	1.2		
DS P7	4.5	7	100	427	318	10.4	1.2		
DS B	5.4	6	148	647	253	6.8	1.4		
DS C	4.6	9	117	349	201	7.0	2.2		
DS D	4.4	3	126	381	189	8.6	1.3		
DS E	4.5	7	101	343	171	6.9	1.3		
Site	4.6^{A}	6.7 ± 0.8^{B}	116.8 ± 10.8^{A}	424 ± 51^{B}	205.7	7.4 ± 0.6^{A}	1.5 ± 0.1		

mean					$\pm 22.9^{A}$				
LCA	5.0	12	32	148	46	1.7	1.1	LS	62
LCB	4.4	6	44	215	58	3.7	1.0	SL	72
LCC	4.3	13	47	398	49	6.1	2.5	SL	71
LCD	5.0	9	29	230	53	2.3	1.2	SL	80
LCE	5.2	8	31	509	70	4.0	1.8	LS	71
Site mean	4.6^{AB}	6.6 ± 0.1^{AB}	36.6 ± 3.7^{B}	300 ± 66.5^{B}	55.2 ± 4.2^{B}	3.6 ± 0.8^{B}	1.5 ± 0.3		
$F_{3,25}$	4.16	8.54	10.94	6.47	9.45	6.25	1.52		
P	0.018	0.0006	0.0001	0.0026	0.0003	0.0031	NS		

Discussion

Our study demonstrates significant variation in performance of *Microstegium vimineum* among the four sites we surveyed and along five transects within each site. *Microstegium vimineum* invades shady riparian corridors both in southern Illinois and elsewhere (Barden 1987), as well as a variety of other habitats including roadsides, lawns, and damp fields (Fairbrothers & Gray 1972). Records from the Illinois Natural History Survey for this species include lowland/mesic woods, bottomland fields and stream channels (R. Phillipe, personal communication). Our survey confirms experimental studies (Winter *et al.* 1992; Horton & Neufeld 1998; Williams 1998; Claridge 2000) indicating that *M. vimineum* shows a plastic response to varying habitat conditions.

Our 1999 study from Dixon Springs State Park (Spyreas *et al.* 2000) showed that *M. vimineum* is susceptible to late season drought. The same population in 2000 was vigorous and flowered profusely. A single small patch of plants flowered in 1999, and this same flowering patch performed similarly in both years (e.g., 69.5 ± 18.5 and 59.2 ± 22.5 spikelets per plant in 1999 and 2000, respectively). However, flowering was widespread throughout the *M. vimineum* population at Dixon Springs in 2000, and was, indeed, more vigorous among plants along a different transect (transect A, with 283.6 ± 143.0 spikelets per plant).

As an annual, *Microstegium vimineum* has to reestablish each year. Evidently, *M. vimineum* had little problem reestablishing, at least at Dixon Springs, even following a poor seed year. This is not unexpected as a persistent seed bank with a longevity of ~ 7 years was demonstrated in our last report (Spyreas *et al.* 2000). The widespread flowering and seed set in 2000 will serve to recharge the seed bank across all existing populations.

Previous studies suggest that disturbance is necessary to allow establishment of *M. vimineum* (Barden 1987). It is also sensitive to a lack of soil moisture (Williams 1998) and is usually found along stream courses and riparian corridors (Barden 1987); the habitat in which we find it in southern Illinois. The highly disturbed nature of the streambed site at Lusk Creek provides adequate soil moisture and allows establishment of *M. vimineum* at the expense of other species less well adapted to disturbance. However, the scouring and frequent flooding appears to be limiting survivorship and performance at this site. Consistent with other annuals (Watkinson 1997), highest mortality of *M. vimineum* was early in the season (Fig 1) and only 40 – 50% of individuals survive to flowering. Nevertheless, even seemingly established plants, such as the mid-season plants we first marked at Lusk Creek, are susceptible to mortality when growing in a highly disturbed streambed.

Soils varied significantly among sites, although all were acidic, sandy or silty loams with low levels of organic matter. Kourtev *et al* (1998) found soils with these characteristics to be typical of *M. vimineum* dominated plots in hardwood forests of New Jersey. They suggested a feed-back between the presence of this exotic plant and the soil mediated by the presence of earthworms. Our study suggests that performance of *M. vimineum* improves with decreasing availability of soil cations (negative relationship with cation exchange capacity) and silt, and increased sand and light. The relationship with light (overhead tree canopy cover) is consistent with Winter *et al* (1992) who showed that *M. vimineum* performs well down to 5% light levels. Performance of *M. vimineum* is limited in nutrient stressed environments (Claridge 2000), but the light environment appears to be more frequently limiting (Barden 1987; Winter *et al.* 1992; Horton & Neufeld 1998).

Literature Cited

Barden, L. (1987) Invasion of *Microstegium vimineum* (Poaceae), an exotic, annual shade-tolerant, C-4 grass, into a North Carolina floodplain. *American Midland Naturalist*, **118,** 40-45.

Claridge, K. D. (2000) The plasticity of resource allocation as an indicator of plant spread in an exotic invasive, *Microstegium vimineum*. M.S. thesis, University of Memphis.

Ehrenfeld, J. G. (1999) A rhizomatous, perennial form of *Microstegium vimineum* (Trin.) A. Camus in New Jersey. *Journal of the Torrey Botanical Society*, **126,** 352-358.

Fairbrothers, D. E. & Gray, J. R. (1972) *Microstegium vimineum* (Trin.) A. Camus (Gramineae) in the United States. *Bulletin of the Torrey Botanical Club*, **99,** 97-100.

Franklin, S. B., Gibson, D. J., Robertson, P. A., Pohlmann, J. T. & Fralish, J. S. (1995) Parallel analysis: a method for determining significant principle components. *Journal of Vegetation Science*, **6,** 99-106.

Horton, J. L. & Neufeld, H. S. (1998) Photosynthetic responses of *Microstegium vimineum* (Trin) A. Camus, an exotic C4, shade-tolerant grass, to variable light environments. *Oecologia*, **114,** 11-19.

Hunt, D. & Zaremba, R. (1992) The northeastern spread of *Microstegium vimineum* (Poaceae) into New York and adjacent states. *Rhodora*, **94,** 167-170.

Illinois Department of Energy and Natural Resources. (1994) *The changing Illinois environment: critical trends. Volume 3: Ecological resources*. Illinois Department of Energy and Natural Resources, Springfield, IL.

Kourtev, P. S., Ehrenfeld, J. G. & Huang, W. Z. (1998) Effects of exotic plant species on soil properties in hardwood forests of New Jersey. *Water, Air and Soil Pollution*, **105,** 493-501.

Mehrhoff, L. J. (2000) Perennial *Microstegium vimineum* (Poaceae): an apparent misidentification? *Journal of the Torrey Botanical Society*, **127,** 251-254.

Mohlenbrock, R. & Schwegman, J. (1969) New and unusual grass and sedge records for Illinois. *Transactions of the Illinois State Academy of Science*, **62,** 100-101.

Mohlenbrock, R. H. & Voigt, J. W. (1959) *A Flora of Southern Illinois*. Southern Illinois University Press, Carbondale & Edwardsville.

Redman, D. E. (1995) Distribution and habitat types for Nepal Microstegium [*Microstegium vimineum*(Trin.) Camus] in Maryland and the District of Columbia. *Castanea*, **60,** 270-275.

SAS Institute Inc. (1999) *The SAS system for Windows*, Cary, North Carolina.

Scholz, H. & Byfield, A. J. (2000) Three grasses new to Turkey. *Turkish Journal of Botany*, **24,** 263-267.

Shaw, R. G. & Mitchell-Olds, T. (1993) ANOVA for unbalanced design: an overview. *Ecology*, **74,** 1638-1645.

Shimp, J. P. (1996) Vegetation analysis and vascular flora of three Research Natural Areas (RNAs) Barker Bluff, Dennison Hollow, and Panther Hollow in southeastern Illinois. M.S. thesis, Southern Illinois University at Carbondale.

Spyreas, G., Benedict, J. & Gibson, D. J. (2000) *Life history studies on Microstegium vimineum, an invasive exotic in southern Illinois*, pp. 34. Final Report to the Illinois Department of Natural Resources. Southern Illinois University, Carbondale.

Tennessee Exotic Pest Plant Council and Great Smoky Mountains National Park. (1997) *Tennessee Exotic Plant Management Manual.*

Watkinson, A. R. (1997) Population dynamics. *Plant Ecology* (ed. M. J. Crawley), pp. 359-400. Blackwell Scientific Publications, Oxford.

Williams, L. D. (1998) Factors affecting growth and reproduction in the invasive grass *Microstegium vimineum*. M.S. thesis, Appalachian State University, Boone, NC.

Winter, K., Schmidtt, M. R. & Edwards, G. E. (1992) *Microstegium vimineum*, a shade adapted C-4 (carbon pathway) grass (comparison of growth with *Digitatia sanguinalis* and *Sporobolus airoides*). *Plant Science Letters*, **24,** 311-318.