Integrating Biological Control and Native Plantings to Restore Sites Invaded by Mile-A-Minute Weed, *Persicaria perfoliata*, in the Mid-Atlantic USA

E. Lake¹, Kiri Cutting² and J. Hough-Goldstein²

¹Department of Biology, USDA-ARS, Invasive Plant Research Laboratory, Fort Lauderdale, FL 33314  ellen.lake@ars.usda.gov
²Department of Entomology & Wildlife Ecology, University of Delaware, Newark, DE 19716  kiri@udel.edu  jhough@udel.edu

Abstract

Successful biological control can significantly reduce the competitive ability and population density and/or distribution of an invasive weed. However, in some cases the target weed is replaced by other nonnative weeds. If this "invasive treadmill effect" occurs, the biodiversity of the site will not improve. Mile-a-minute weed, *Persicaria perfoliata* (L.) H. Gross, is an annual vine from Asia that has invaded natural areas in the eastern U.S. The host-specific weevil *Rhinoncomimus latipes* Korotyaev was approved for release in 2004, and is showing considerable success. However, in some sites the suppressed mile-a-minute weed has been replaced by other invasive species, such as Japanese stiltgrass, *Microstegium vimineum* (Trin.) A. Camus. Two integrated weed management experiments were conducted to determine best practices for breaking the invasive treadmill cycle and restoring native plant communities at sites invaded by mile-a-minute weed. In one experiment, sites received a combination of the biological control weevil, plantings of competitive native vegetation, and a pre-emergent herbicide application. Native plantings consisted of plugs of flat-top goldentop, *Euthamia graminifolia* (L.) Nutt., and seedlings of Dutch elm disease tolerant American elm, *Ulmus americana* L. Integrating these treatments decreased mile-a-minute seedling numbers and prevented Japanese stiltgrass from becoming the dominant vegetation at sites where this weed was abundant. The sites with the greatest pressure from invasive species had a higher percentage of native cover when herbicide and planting treatments were combined compared to the control. In the second experiment, sites were seeded with a mix of native warm and cool season grasses and forbs, with and without weevils, which were excluded using a systemic insecticide. This fully factorial experiment showed reduced mile-a-minute weed cover and greater native plant richness in the treatment with both restoration seeding and biocontrol than for either treatment alone. The results of these experiments suggest that integration of control methods can suppress mile-a-minute weed and help restore a diverse native plant community.
Introduction

Mile-a-minute weed, *Persicaria perfoliata* (L.) H. Gross, is a temperate annual vine of Asian origin that has invaded natural areas in the eastern U.S. Seeds of *P. perfoliata* were accidentally imported into a nursery in York County, PA, in the 1930s (Moul, 1948) and the plant has subsequently spread to sites throughout much of the eastern U.S. from Massachusetts to North Carolina and west to Ohio (EDDMapS, 2011). A biological control program was initiated by the U.S. Forest Service in 1996 (Wu et al., 2002). The host-specific weevil *Rhinoncomimus latipes* Korotyaev, originally collected in China, was approved for release in North America in 2004 (Hough-Goldstein et al., 2008). This weevil develops at least three to four overlapping generations during the growing season in the mid-Atlantic region of the U.S., increasing in population size and dispersing to new patches (Lake et al., 2011). It can reduce populations of mile-a-minute weed substantially within one to three years (Hough-Goldstein et al., 2009).

The primary mechanism for mile-a-minute weed suppression is through release of apical dominance and production of “stacked” nodes in response to adult and larval (internal) feeding, resulting in shorter vines, which are less competitive with surrounding vegetation (Hough-Goldstein et al., 2008). In some areas, the resident plant community is diverse and consists of mostly native species, and as mile-a-minute is suppressed, these desirable plants become dominant. At other sites, however, additional non-native invasive plant species are replacing mile-a-minute, a phenomenon that has been termed the “invasive species treadmill” (Thomas and Reid, 2007).

One possible way to enhance plant competition, increase the effectiveness of the biocontrol agent, and at the same time avoid the invasive species treadmill effect is through restoration planting using native species. Two different experiments were conducted to test the effects of restoration planting on mile-a-minute weed populations. The first studied the impact of planting a vigorous native perennial, flat-top goldentop (*Euthamia graminifolia* (L.) Nutt.), with and without use of a pre-emergent herbicide, along with release of the biocontrol agent. In the second experiment, a seed mix of native grasses and forbs was tested with and without the biocontrol weevil.

Methods and Materials

For the first experiment, 6.1 x 6.1 m plots of *P. perfoliata* were treated with post-emergent herbicide, cleared of woody and herbaceous debris, and plantings were established in October 2008 (details in Lake, 2011). Treatments included a low-density planting of 100 *E. graminifolia* plugs per plot; a high-density planting of 400 *E. graminifolia* plugs per plot; a low-density planting of *E. graminifolia* plus 25 Dutch elm disease-tolerant elm tree seedlings in each plot; and a control treatment with no planting (Fig. 1). These treatments were replicated at three different sites in southeastern PA (the Laurels, Waterloo Mills, and Crosslands). In April, 2009, a pre-emergent herbicide was applied to half of each treatment plot, randomly assigned. Although the biocontrol weevil was already present at all sites in low numbers, 500 additional weevils obtained from the rearing facility at the NJ Department of Agriculture Phillip Alampi Beneficial Insect Laboratory in Trenton, NJ were added to each plot in June, 2009. Plots were monitored in five 1 m$^2$ quadrats randomly and permanently established within each half of each plot (Fig. 1). The plant community in these plots was assessed in the fall of 2010.

The second experiment was conducted at a single site on the grounds of Longwood Gardens in Kennett Square, PA (details in Cutting, 2011). At this site, four treatments consisting of combinations of weevils and no weevils, with and without a native seed mix, were applied to 2 x 2 m plots of *P. perfoliata* with five replicates, beginning in April, 2009. The seed mix consisted of a combination of three native perennial grasses, big bluestem (*Andropogon gerardii* Vitman), Canada wildrye (*Elymus canadensis* L.), and switchgrass (*Panicum virgatum* L.); and two native perennial forbs (both Asteraceae), blackeyed Susan (*Rudbeckia hirta* L.) and oxeye sunflower (*Heliopsis helianthoides* (L.)). Weevils were present in low numbers at this site, but were supplemented by releasing 100 weevils per plot in weevil treatments in May 2009. Additional weevils were allocated to plots, with insect numbers standardized by percent mile-a-minute cover in each plot in August 2009, May 2010, and June 2010 (Cutting, 2011). Weevils were excluded from plots to produce a no-weevil treatment using a soil drench with the systemic insecticide, dinotefuron (Safari*
The percent cover of mile-a-minute, number of weevils, and seed production were monitored weekly within the entire plots. Plant species richness was evaluated twice each season. A destructive harvest to obtain *P. perfoliata* biomass occurred at the end of year two.

**Results and Discussion**

For the *E. graminifolia* planting experiment, mile-a-minute seedling counts for spring, 2009, were significantly lower on the side of the plots where the pre-emergent herbicide had been used (Fig. 2A). This was expected, because the pre-emergent herbicide kills seeds that are in the process of germinating, while having no effect on live vegetation. However, this difference persisted in 2010 (Fig. 2B) and 2011 (Fig. 2C) even though no additional herbicide was used and the original herbicide would no longer have been active. Mile-a-minute seedling numbers were much lower in all of the plots in both the herbicide and no-herbicide treatments in 2010 compared to 2009, and this was also true of mile-a-minute cover during the growing season (data in Lake, 2011). Although a no-weevil control was not included in this experiment, it is likely that the mile-a-minute weed in these plots was suppressed by the weevils, as has occurred in other studies (Hough-Goldstein et al., 2009). Mile-a-minute was most effectively suppressed in this experiment where it was initially reduced by the pre-emergent herbicide (Fig. 2).

A total of 127 plant species from 48 families were identified in these plots in the fall of 2010, and more than 60% of plant species at each site were native. At one of the sites (the Laurels) most of the vegetation cover consisted of native plants. At this site, weevils plus pre-emergent herbicide use effectively restored native vegetation, and the planting treatments had no additional effect. At the other two sites, however, native plant cover was higher in the treatments with restoration plantings compared to the control plots, both where herbicide had been applied and where no herbicide had been applied (Fig. 3A). Native

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**Figure 1.** *Euthamia graminifolia* restoration experiment site design. Each of three sites had four planting treatment plots as shown. The inset illustrates the herbicide and no herbicide treatment areas and the five monitoring quadrats that were established randomly and permanently within each herbicide and planting treatment combination.

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a pre-emergent herbicide (which killed germinating Japanese stiltgrass seeds as well as mile-a-minute seeds) along with restoration planting prevented the reinvasion of stiltgrass, resulting in 80-90% native plant cover with virtually no Japanese stiltgrass (Fig. 3).

In the native seed mix experiment, integrating the biocontrol weevils with restoration seeding significantly reduced mile-a-minute weed cover compared with the control, to about 20% by the second year (2010). In plots where weevils were excluded using dinotefuron, mile-a-minute cover remained at about 80% (Fig. 4). The treatments with weevils but no seed mix produced intermediate mile-a-minute cover in 2010. Two additional measures of plant productivity, mile-a-minute seed cluster production and dry biomass showed similar results (Fig. 5) to mile-a-minute cover. Native plant species richness in 2010 was highest in the weevil plus seed mix treatment (Cutting, 2011).

Conclusions

For both experiments, an integrated weed management approach was more effective than the biological control weevil alone for suppressing mile-a-minute weed and restoring the native plant community. The use of a pre-emergent herbicide in the *E. graminifolia* planting experiment improved the establishment of planted perennial vegetation and helped to prevent Japanese stiltgrass from taking over where mile-a-minute weed had been suppressed. In both experiments, enhanced competition via native restoration plantings improved the effectiveness of the biocontrol agent and increased native plant biodiversity following suppression of the target weed. Where practical and necessary, depending on the resident plant community, both selective herbicides and restoration planting should be considered for use in conjunction with biological control of invasive weeds.

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Figure 2. *Persicaria perfoliata* spring seedling counts (mean ± SEM) in (A) 2009, (B) 2010 and (C) 2011. Counts were conducted in 0.5 m² of the 5 monitoring quadrats in each herbicide and planting treatment combination at three sites. There were significantly more seedlings in the no herbicide than herbicide plots in 2009 (*P* = 0.0001), 2010 (*P* = 0.0056), and 2011 (*P* = 0.0040), but no significant differences by planting treatment.
Figure 3. Cover (mean ± SEM) of (A) native plants, including *Euthamia graminifolia* (significantly higher in the herbicide than no herbicide plots, $P < 0.0001$) and (B) Japanese stiltgrass (significantly lower in the herbicide than no herbicide plots, $P < 0.0001$), at Crosslands and Waterloo Mills, Fall of 2010.
Figure 4. Cover (mean ± SEM) of *Persicaria perfoliata* in (A) 2009 and (B) 2010, native seed mix experiment. Means for the last date within each year followed by the same letter are not significantly different (two-way ANOVA, Tukey’s test).
Figure 5. Dry biomass (mean ± SEM) of *Persicaria* *perfoliata* harvested from the native seed experiment in 2010 (*P* = 0.0039). Means with the same letter are not significantly different (Tukey’s test).
References


