Recruitment of experimental garlic mustard and Japanese stilt-grass populations in metro forests

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Abstract

Fragmented forests in the metropolitan landscape are subject to co-invasion by multiple non-native plant species. In the forests of eastern North America, two important herb layer invaders are garlic mustard (*Alliaria petiolata*) and Japanese stilt-grass (*Microstegium vimineum*). We have established a well-replicated, five-year field experiment that includes staged invasions of both species across six forests in a suburban/exurban region. After applying the initial seed addition treatments in Fall 2012, we observed highly variable recruitment among forests and among the approximately twenty 16 m^2 plots per forest per species that had seeds added. We added equal numbers of seeds to each addition plot, but by July 2013 recruitment of garlic mustard ranged from 0-188 plants per plot, and for stilt-grass it was 13-605. Stilt-grass clearly dominated the initial stage of invasion. Recruitment success was highly significantly different among forests for both species. We hypothesized that differences in leaf litter quantity may explain the variation, since it also varied significantly among forests. Indeed, on average, fewer garlic mustard plants recruited in forests where leaf litter samples were, on average, more massive. Mean sample leaf litter mass explained 68% of the variation among forests in mean recruitment of garlic mustard , but did not explain stilt-grass recruitment. Within each forest, regression of the number of plants per plot on leaf litter mass explained a substantial part of the variation in only one of the six forests, and only for stilt-grass, which was negatively affected by greater leaf litter. The next steps are to understand why leaf litter mass differs among forests and how it affects recruitment of these two invaders of the herb layer.

Introduction

Invasive species pose a serious threat to ecosystems worldwide by potentially reducing native plant abundance and diversity, and by altering ecosystem functions. To better understand the process of invasion, it is important to study each stage of the invasion process, beginning with initial recruitment. Not all invasive species survive equally when introduced to a new habitat, and variation in recruitment may be an essential component of their relative success. Environmental heterogeneity, which includes factors such as light availability and leaf litter quality, plays an important role in the crucial life history stage of initial plant recruitment.. Differential environmental factors may be better suited for the recruitment of one species over another, thus those factors greatly influence the species that could potentially invade a new habitat.

Two prominent herb layer invaders found throughout deciduous forests in northeastern United States are Japanese stiltgrass (*Microstegium vimineum*) and garlic mustard (*Alliaria petiolata*). Both species are common co-invaders in New Jersey forest fragments located within an urbanizing landscape. These forests host a variety of native and nonnative plants, and experience great pressure from overabundant white-tailed deer populations. Ultimately, we seek to understand how multiple invasive plant species and deer interact to affect not only native plant community structure, but also the process of invasion itself. For a five-year study in Central New Jersey, we have established replicated, experimental invasions of both *M. vimineum* and *A. petiolata* across six different suburban forests. We observed great variation in recruitment of the two invasive species in the first year. We hypothesized that differences in leaf litter quantity may explain the variation, since leaf litter also varied significantly among forests.

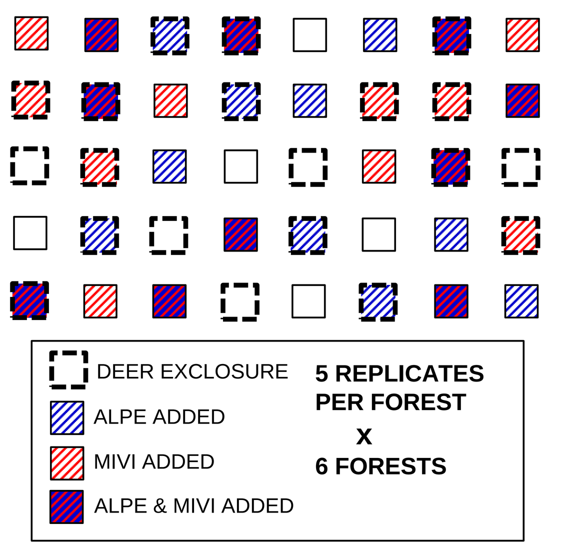
Methods

Experimental sites

- Experiment replicated in six similar forests in suburban, central New Jersey that have *M. vimineum* and *A. petiolata* present, but initially absent in the plot area.

Experimental design

- 16 m^2 plots; 40 per forest.
- Staged novel invasions.
- Randomly assigned treatments.
- 5 replicates per forest.
- Seeds of *A. petiolata* and *M. vimineum* added. to plots November – December 2012.
- Deer exclosures constructed March – April 2013.



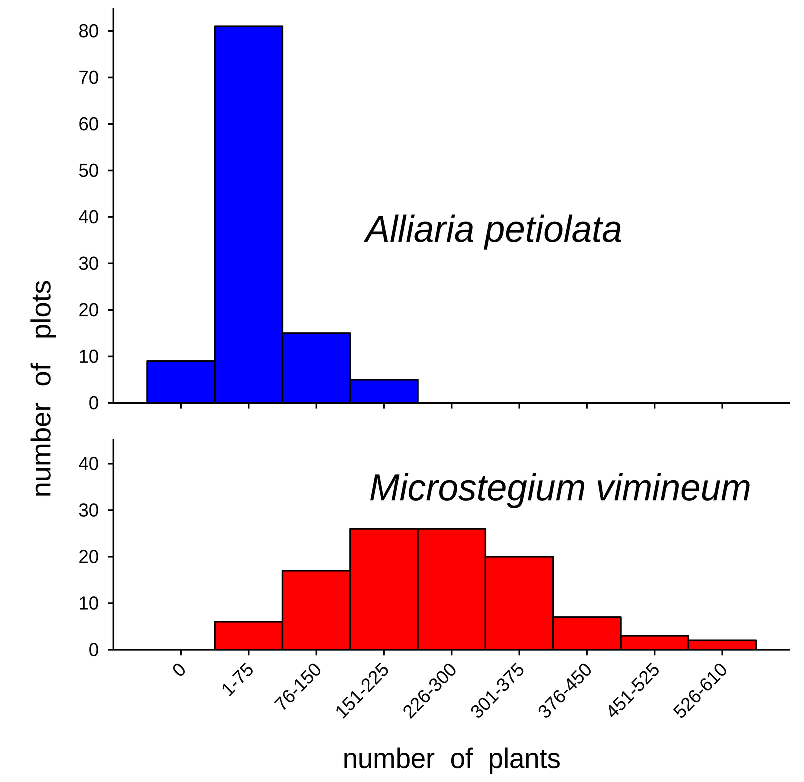
M. vimineum and *A. petiolata* counts

- Counted the total number of *M. vimineum* present in MIVI-added and ALPE/MIVI-added plots in all of the forests, in July 2013.
- Counted the total number of *A. petiolata* present in ALPE-added and ALPE/MIVI-added plots in all of the forests, in July 2013.

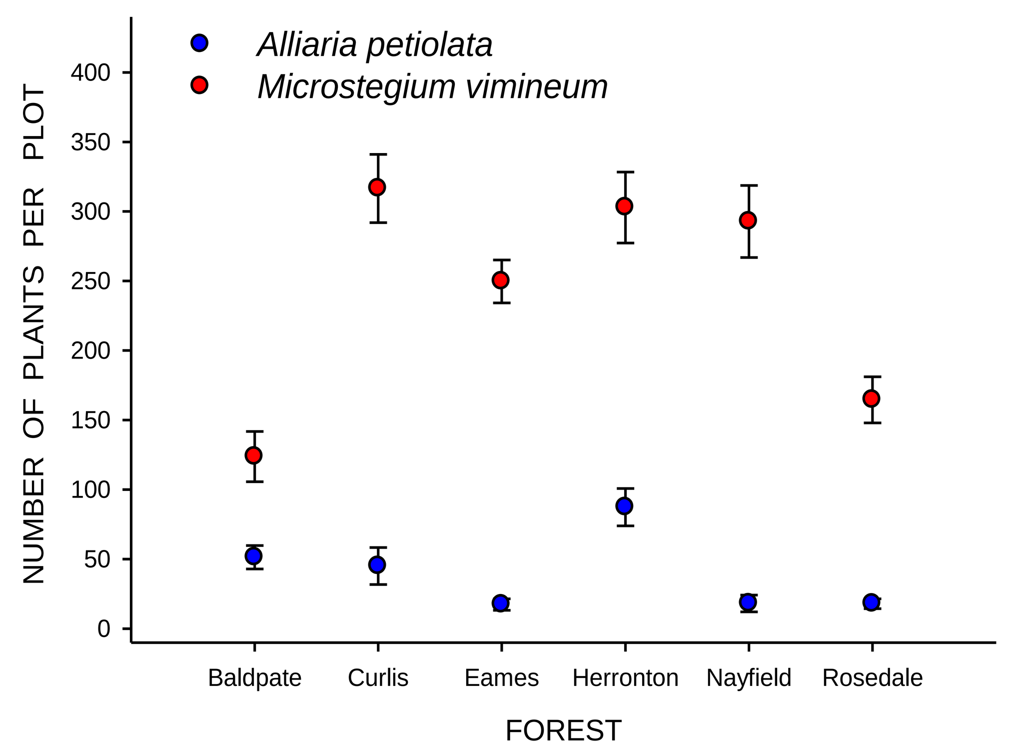
Leaf litter

- Collected 4 samples of leaf litter from each plot in each forest, in Summer 2013.
- Dried at 60 C°.
- Calculated the mean dry mass of litter per plot.

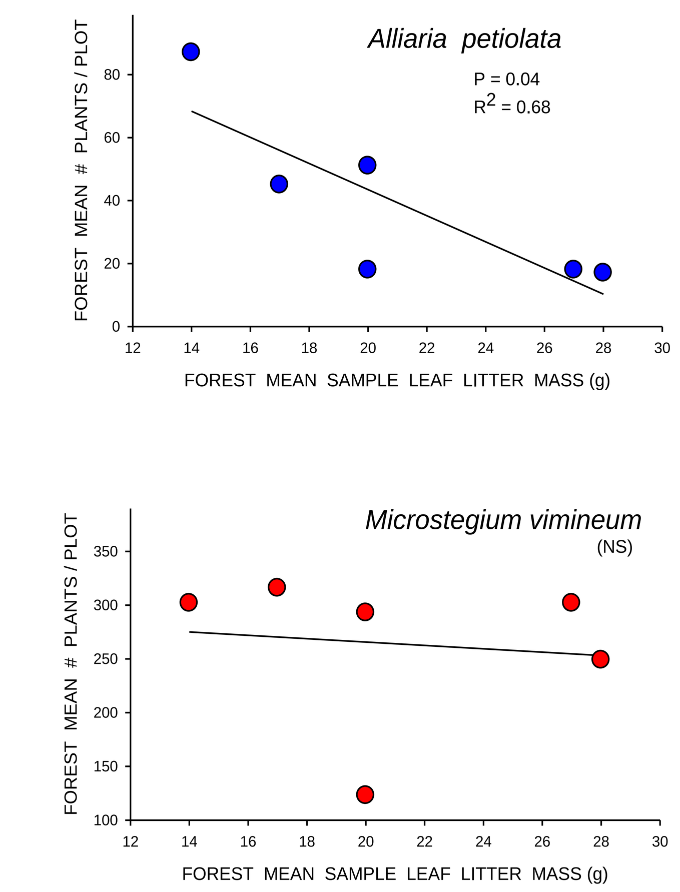
Results



1 Frequency distributions of the number of *A. petiolata* and *M. vimineum* individuals per plot in July 2013, the first summer after fall seed additions (pooled across all forests). ***Microstegium vimineum* generally had much higher recruitment than *A. petiolata*, even though equal numbers of seeds per plot were added.**



2 Mean (+ SE) plants per plot in each forest, for both *A. petiolata* and *M. vimineum*. **Recruitment of both species varied significantly among the forests** [ANOVA: ALPE, $F_{(5, 104)}$=9.45, P<0.0001; MIIVI, $F_{(5, 101)}$=13.04, P<0.0001].



3 Regressions of the mean number of plants per plot in each forest on the mean sample leaf litter mass in each forest (n = 16-20 plots per forest). ***Alliaria petiolata* recruitment was significantly lower in forests with greater leaf litter mass, and leaf litter mass explained 68% of the variation among forests. In contrast, variation in *M. vimineum* recruitment among forests was not explained by the forest's mean leaf litter mass.**

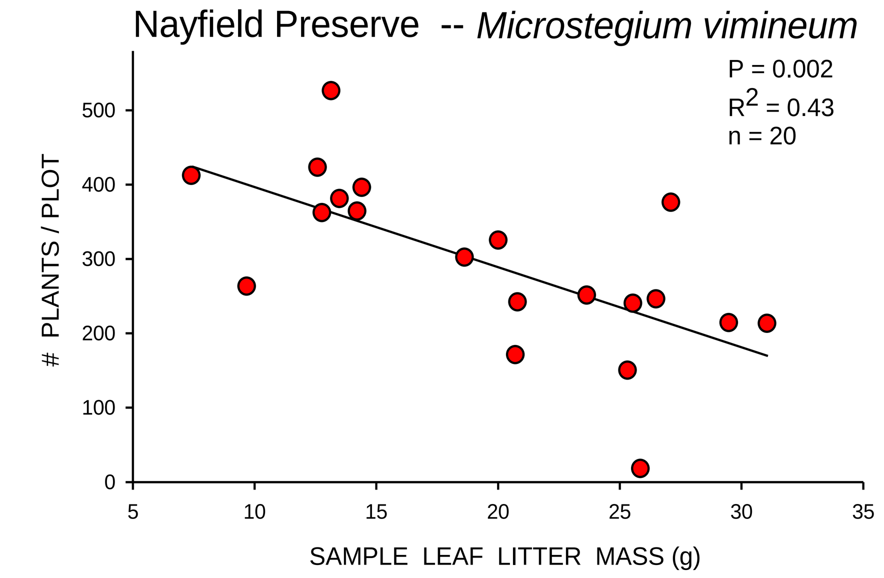
Alliaria petiolata

Microstegium vimineum

4 **Recruitment of the two invasive species within forests was not influenced by leaf litter mass, except in Nayfield Preserve. *Microstegium vimineum* had lower recruitment in plots with greater leaf litter, explaining 43% of the variation in recruitment among plots.**

Regressions of number of plants per plot on leaf litter mass per plot, within forests

		A. petiolata		*M. vimineum*	
Forest	**n**	**R^2**	**P**	**R^2**	**P**
Baldpate	17	0.136	0.12	0.068	0.31
Curlis	17	0.016	0.62	0.027	0.53
Eames	20	0.0004	0.93	0.031	0.46
Herronton	17	0.064	0.33	0.013	0.66
Nayfield	20	0.0003	0.94	**0.43**	**0.002**
Rosedale	16	0.008	0.74	0.018	0.12



Discussion

When different non-native plant species invade a forest together, their initial success at recruitment may have a profound influence on which species come to dominate. Because non-native plant species have become very common members of the flora in metropolitan forests, these differences in recruitment could end up having lasting effects on the overall community structure of forests in urbanizing landscapes. Our results indicate that the invasive plant *Microstegium vimineum* gains an initial advantage over the co-occurring invasive plant *Alliaria petiolata*, by recruiting many more individuals from seed. Whether this initial advantage has a legacy in future years remains to be seen as our experiment progresses.

We observed great variation in recruitment for both species, both among plots within forests and among forests. We have begun to investigate the mechanisms for this variation, starting with the possible effect of leaf litter quantity. Litter may be a physical barrier that stops seeds from properly being planted into the soil, preventing germination. Seeds with less mass may essentially sit on top of the leaf litter and never have a medium within which to grow, whereas heavier seeds should be able to more easily fall through the leaf litter. Deeper leaf litter also may prevent rain from reaching the soil. We found, however, that on a per-forest basis, it was *A. petiolata*, which has heavier seeds, that showed a negative relationship with leaf litter quantity, although within forests the relationships were not significant. This suggests that leaf litter quantity is a blunt instrument regulating *A. petiolata* recruitment, with much lower recruitment in forests with a generally greater quantity of leaf litter. We will be investigating earthworm abundance in these forests as well, which can have dramatic effects on leaf litter quantity. *Microstegium vimineum* recruitment only responded to leaf litter quantity in one of the forests. That particular forest is more dominated by *Acer rubrum* (red maple) than the other forests, so we will be investigating whether red maple litter has a specific negative effect on this invasive species.

Metropolitan forest with empty understory

Acknowledgements

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