The effects of the invasive shrub Lonicera maacki on species richness and soil moisture in the bottomland hardwood forest at the ORWRP

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Abstract

Due to a host of life history characteristics that enable it to out-compete native plants, the Asian shrub *Lonicera maackii* (Rupr.) Maxim. (Amur Honeysuckle) has successfully invaded many natural areas throughout southern and central Ohio. In many places, attempts have been made to remove this exotic shrub in order to restore native plant communities. The purpose of this study was to compare understory species richness and soil moisture in an area cleared of *L. maackii* with an area where *L. maackii* persists. Data was collected by establishing twenty 2 m x 2 m sample plots in the bottomland hardwood forest at the ORWRP in October 2002. Ten plots were located in a section of the forest where *L. maackii* had recently been removed (starting September 2001), and ten were located in an area where *L. maackii* has not been cleared. All plants within the plots were identified and counted; a soil core sample was also taken. Overall understory species richness was higher in cleared areas (Sp. Richness = 25) than in uncleared areas (Sp. Richness = 14), and mean species richness per plot was significantly higher in cleared areas ($p < 0.05$). Plants were then divided into four classifications and species richness estimates were found for woody understory plants, herbaceous plants, vines and trees. For all classifications, species richness was higher in the cleared area of the forest. Mean woody species richness per plot was significantly greater than that of uncleared plots ($p < 0.05$). There was no significant difference between soil moisture levels in the two areas of the forest. Regression analyses showed that there was no correlation between soil moisture and species richness, nor was there a correlation between soil moisture and the number of *L. maackii* individuals present per plot.

Introduction

Originally introduced to North America in 1855, the Asian shrub *Lonicera maackii* (Rupr.) Maxim. (Amur Honeysuckle) has invaded woodlands and marsh edges in 24 of the eastern United States (Trisel and Gorchov, 1994). In the last few decades, *L. maackii* has become the most abundant shrub in many southern Ohio forests, replacing what had previously been relatively open understories containing few native shrubs (Luken and Goessling, 1995; Hutchinson and Vankat, 1997). The Ohio Department of Natural Resources has classified *L. maackii* as one of the thirteen most invasive plant species in Ohio, and much effort has been devoted to eradicating *L. maackii* from nature preserves in south-central Ohio and north-central Kentucky where it tends to dominate and exclude endemic species (Luken and Mattimiro, 1991; ONDR and TNC, 1999).

Studies have shown that this upright, deciduous, multi-stemmed shrub is most successful in invading habitats with high light availability, such as forest edges and disturbed areas with canopy openings (Luken, 1988; DeMars and Runkle, 1992; Hutchinson and Vankat, 1997). Comparing the ages of *L. maackii* shrubs along forest edges in Kentucky with those of shrubs found nearby in the forest interior suggests that radiation occurs opportunistically from the edges into the interior of forests (Luken and Mattimiro, 1991).

Once dominant, *L. maackii* has been shown to decrease the abundance of native tree seedlings and herbaceous plants. Studies performed by Hutchinson and Vankat (1997) show that herb cover, tree seedling density, and tree seedling richness are inversely related to *L. maackii* cover. Collier *et al*. (2001) found that mean species richness and mean species cover was significantly lower in plots under *L. maackii* crowns than in plots located away from the densely growing shrub. When individual taxa were examined, 86% of the herb taxa, 56% of the seed/ bud bank taxa, and 100% of the tree taxa studied were significantly less abundant in plots under *L. maackii* (Collier *et al*., 2001). Total species richness and tree sapling richness and density was also found to decrease as *L. maackii* residence time increased (Collier *et al*., 2001).

Decreases in native species abundance under *L. maackii* are related to several factors. First, the dense growth of the shrub, which commonly reaches four to five m in height, often shades out native plants growing below it (Collier *et al*., 2001; Hutchinson and Vankat, 1997). *L. maackii* is also in leaf earlier in the spring and later in the fall than any native woody deciduous species, thus further decreasing the light available to native species (Trisel and Gorchov, 1994). Another characteristic which contributes to this invasive shrub's success is its lack of coevolved biological control agents such as pathogens and herbivores (Trisel and Gorchov, 1994). There is also evidence to suggest that *L. maackii* exhibits alleopathy and inhibits seed germination and seedling growth in some native species (Hutchinson and Vankat, 1997; Trisel, 1997 cited in Collier et al. 2001). *L. maackii* also has an extensive shallow root system that may reduce nutrient and moisture levels in the upper soil and negatively impact native species (Hutchinson and Vankat, 1997). In his 1997 Ph.D. dissertation, Trisel found that two native tree species suffered reduced survival under *L.*

maackii due to root competition (Collier et al. 2001).

Like many other forested areas in central Ohio, the bottomland hardwood forest at the Olentangy River Wetlands Research Park in Columbus, Ohio has been successfully invaded by *L. maackii*. Beginning in September 2001, measures have been taken in 2001 and 2002, with the assistance of volunteers, to remove *L. maackii* shrubs from a portion of this forest corridor which buffers the Olentangy River. The purpose of our study was to determine if understory species richness was greater in the area where *L. maackii* had been cleared than in the area where *L. maackii* had not been removed. To do this we established sample plots in the cleared and uncleared areas, and identified and counted all of the plant species within them. Soil core samples were also taken at each sample plot in order to study the relationship between *L. maackii* presence and soil moisture levels. Due to its extensive root system and dense canopy cover, we hypothesized that lower soil moisture would occur in areas where *L. maackii* had not been removed.

Methods

The study was conducted in Franklin County, Ohio at the Olentangy River Wetland Research Park. Located north of the Ohio State University campus in Columbus, the site is bordered on the north and east by the Olentangy River. Running between the river and the constructed wetlands is a 730 m long swath of bottomland hardwood forest. The forest encompasses 5.2 ha and varies in width from 25 m to 90 m. In the northern part of the forest, several attempts have been taken to eradicate *L. maackii* stands. Shrubs were cleared from the northwestern edge of the forest in September 18 and October 18, 2001 and May 3, 2002. On September 24, 2002, more shrubs were removed further east of the original cleared area. Honeysuckle was removed by chopping the shrubs at the base and carrying the material out of the forest. The City of Columbus or other authorized person then applies herbicide to the remaining stump.

Sampling was performed in late autumn (October 27-28, 2002) in a 97 m long section of the forest were *L. maackii* had been cleared, and a 197 m long section to the southeast where *L. maackii* had not been cleared (Fig 1). Species richness estimates for areas with and without *L. maackii* were obtained by establishing twenty sample plots. Ten of the 2m x 2m plots were placed at random within the area of the forest that had been cleared of *L. maackii*, and ten in the area that had not been cleared. All of the plants within the plots were identified and counted, and the diameter at breast height (dbh) of the trees within the plots was recorded.

A soil core sample, which reached one foot into the soil profile, was taken at each plot for soil moisture data. Percent soil moisture was determined gravimetrically by weighing the soil samples while wet, drying samples in an oven at 50°C for 48 hours, and reweighing.

Vegetation data were analyzed to determine understory species richness in the cleared and uncleared areas. Canopy trees were not included in this species richness estimate.

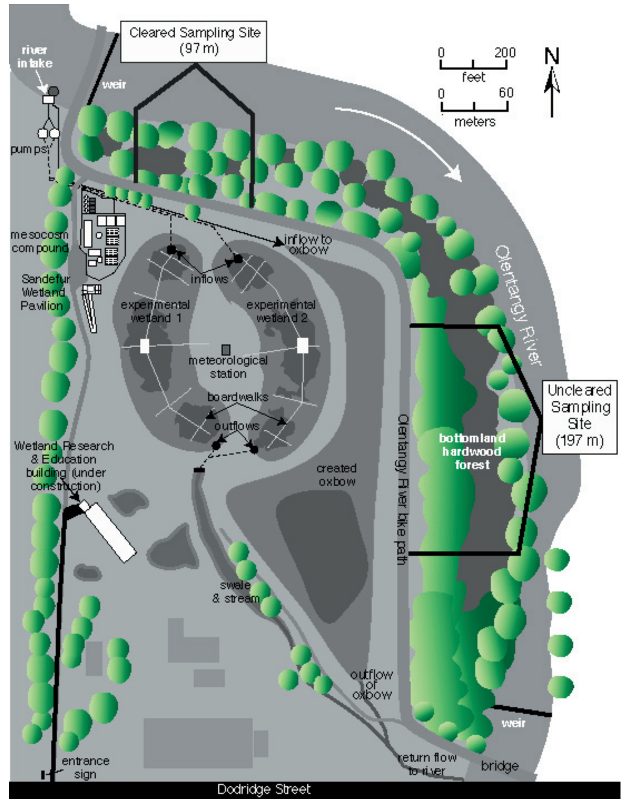

Figure 1. Study site at the Olentangy River Wetlands Research Park. The bottomland hardwood forest runs along the Olentangy River and borders the site to the north and east. The areas where sampling took place are indicated.

Mean understory species richness per plot was determined for cleared and uncleared areas and compared using the Student's t-test. To better understand the effects of *L. maackii* presence on forest vegetation, taxa were divided into four categories: woody seedlings, saplings, and shrubs; herbaceous plants; vines; and trees. The number of species in each category was then found for the cleared and uncleared areas. The Shannon-Wiener diversity index [$H = -£(p_k)\ln(p_k) / \ln(s)$] was also used to estimate the diversity of understory vegetation in the two areas.

During sampling we observed that distribution of the shrub throughout the forest was patchy, and *L. maackii* was more dominant along the forest edge. In addition to comparing the mean soil moisture of cleared and uncleared plots, we also compared soil moisture levels in plots where L. maackii naturally did not occur to those where it did. Because *L. maackkii* was already resprouting in many parts of the cleared area, we hoped that this comparison would reveal more about the shrub's effects on soil moisture, and possibly indicate the role that soil moisture content played in *L. maackii* establishment. Mean percent soil moisture was calculated for plots where *L. maackii* had been cleared, and for plots where it had not been cleared. The two means were then compared using a student's t-test. Regression analysis was performed to determine if there was a correlation between species richness and percent soil moisture in both cleared and uncleared areas.

To determine if soil moisture levels were different in these areas where *L. maackii* naturally did not occur, percent soil moisture in five plots (2 in cleared area; 3 in uncleared area) was compared to the 15 other plots using a Mann-Whitney U test.

Results

Even though *L. maackii* had been removed from the area, eight of the ten plots in the cleared area of the forest contained young *L. maackii* saplings that were sprouting from previously cleared stumps. Only two plots in this area were naturally devoid of *L. maackii*. Three of the ten plots located in the uncleared area were devoid of *L. maackii*. There were 28 *L. maackii* individual plants indentified in the cleared plots and 25 in the uncleared plots (Table 1). This showed significant honeysuckle resprouting has occurred in the 2002 growing season.

Species richness and diversity

Total understory species richness in the areas that had been cleared of *L. maackii* was 25, versus 14 in the uncleared areas. Species richness per plot ranged from 3 to 6 in cleared areas, and 1 to 5 in uncleared areas. The mean species richness per plot in cleared areas (4.4 ± 0.3 species, ave ± SE) was significantly greater ($p = 0.0086$, $p < .05$) than the mean species richness in uncleared areas (2.9 ± 0.4 species) (Fig. 2).

Species richness was higher in uncleared areas for all four categories—woody seedlings, saplings, and shrubs; herbaceous plants; vines; and trees (Table 1; Fig. 3). Understory woody species richness was ten in cleared areas and two in uncleared areas. A student's t-test also showed a statistically significant difference ($p = 0041$, $p < 0.05$) between the mean woody species richness per plot in cleared areas (2.0 ± 0.365 species) versus uncleared areas (0.7 ± 0.153 species).

Herb species richness was 12 in cleared areas and ten in

Table 1. Species classification and occurrence in cleared and uncleared areas of bottomland forest. (UNK indicates unknown species).

Species	Class	Individuals in cleared area	Individuals in uncleared areas
Amur Honeysuckle	woody	28	25
Box elder	woody & tree	tree= 2, woody= 2	tree= 2
Bristly Greenbriar	vine	2	1
Buckeye	tree	1	2
Canada goldenrod	herb	4	5
Cottonwood	tree	0	1
Fall phlox	herb	0	28
Grape	vine	3	2
Grasses	herb	8	4
Ground Ivy	herb	11	18
Hackberry	tree	2	0
Long Bristled Smartweed	herb	6	0
Paw paw	woody & tree	tree= 6, woody= 9	0
Poison ivy	vine	1	0
Tall Larkspur	herb	0	5
UNK B	herb	21	10
UNK C	herb	1	0
UNK E (ginger)	herb	3	53
UNK F (laurel)	woody	1	0
UNK H (aster)	herb	31	0
UNK I (Ranunculus)	herb	81	37
UNK J	woody	1	0
UNK M	woody	1	0
UNK N	woody	19	0
UNK O	woody	1	0
UNK P	woody	2	0
UNK Q (bittercress)	herb	7	0
UNK R	woody	11	0
UNK S	herb	1	0
UNK U	herb	0	15
UNK W (violet)	herb	0	13
UNK X	woody	0	1

Figure 2. Mean understory species richness of plots in the area where L. maackii was removed vs. the area where L. maackii is present.

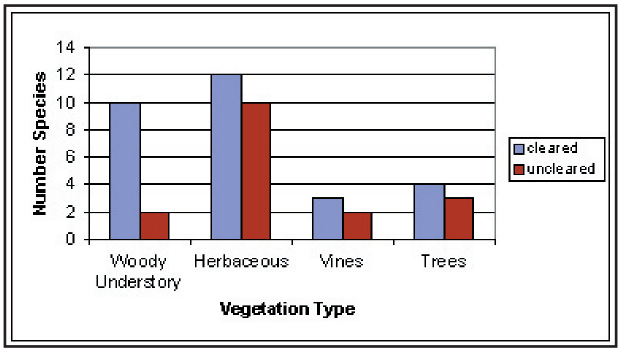

Figure 3. Species richness in the area of the forest that was cleared of L. maackii vs. the uncleared area where L. maackii persists. Species where broken down by vegetation type into four classification groups: woody understory (seedlings, saplings, and shrubs), herbs, vines, and trees.

uncleared areas, and mean herb species richness per plot was equal for cleared (1.9 ± 0.6 species) and uncleared areas (1.9 ± 0.4 species). Species richness for vines was 3 in cleared areas and 2 in uncleared areas. Tree species richness was 4 in cleared areas and 3 in uncleared areas.

Shannon-Weaver diversity was slightly greater in the uncleared areas (H = 0.834) than in the cleared areas (H = 0.761).

Soil moisture

No statistically significant difference ($p = 0.104$, $p > 0.05$) was found between the mean percent soil moisture in plots where *L. maackii* had been cleared (21.61% ± 0.71), and the mean in plots where it had not been cleared (20.25% ± 0.90). Regression analysis revealed that soil moisture did not account for a significant proportion of species richness variation in cleared ($r^2 = 0.042$, $p > 0.05$) (Fig. 4a) and uncleared areas ($r^2 = 0.020$, $p > 0.05$) (Fig. 4b). Regression analysis was also used to explore the relationship between number of *L. maackii* individuals per plots and percent soil moisture. Abundance of *L. maackii* was not correlated with percent soil moisture ($r^2 = 0.045$, $p > 0.05$) (Fig 4c).

A Mann-Whitney U test revealed that there was no significant difference between the percent moisture between

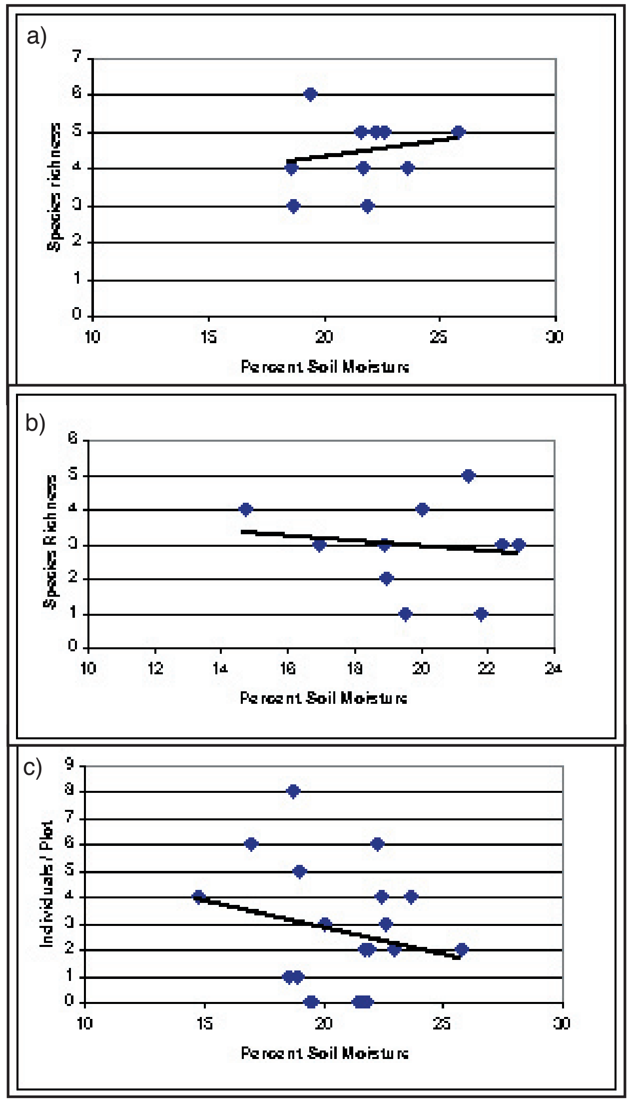

Figure 4. Linear regressions between: a) soil moisture and species richness in the cleared area of the forest ($r^2 = 0.042$); b) soil moisture and species richness in the uncleared area of the forest ($r^2 = 0.020$); c) soil moisture and number of L. maackii individuals present per plot ($r^2 = 0.045$).

individual plots where *L. maackii* occurred and did not occur ($U = 49$, $U_{0.05(2)5,15} = 61$).

Discussion

Overall species richness was higher in areas where honeysuckle has been removed than in areas where honeysuckle still persists and dominates. Twenty-five plant species were observed in the understory of cleared areas while only 14 species were found in the understory of uncleared areas. There was also a significant difference in the mean species richness found in cleared and uncleared plots. When taxa were broken down into categories, cleared areas showed higher species richness in herbs; woody seedlings, saplings, and shrubs; vines; and trees. The most significant difference in species richness was observed for understory woody species: species richness was ten in cleared areas and two in uncleared areas, and mean woody species richness per plot was significantly greater in cleared areas. In both cleared and uncleared areas, *L. maackii* was one of the woody species included in this species richness estimate. Cleared areas had nine woody species other than *L. maackii* present in the understory while uncleared areas had only one other woody species present. These results support studies performed by Collier et al. (2001) which showed lower species richness and abundance of tree seedlings under L. maackii canopies, and those of Hutchinson and Vankat (1997) which found a negative relationship between *L. maackii* cover and tree seedling density and species richness. Decreased success of woody species in areas dominated by L. maackii have been attributed to decreased light availability (Trisel and Gorchov, 1994), decreased water and nutrient levels in the soil (Hutchinson and Vankat, 1997), alleopathy (Hutchinson and Vankat, 1997), and pollinator competition. *Lonicera maackii* flowers earlier and for a longer period than many native shrubs, and may compete for pollinators, thus reducing the seed set of native shrub species (Trisel and Gorchov, 1994; Williams, 1997). While higher in cleared areas, differences in species richness of herbs, vines, and trees were less pronounced.

Although species richness was higher in areas that had been cleared of *L. maackii*, diversity estimates were slightly higher in the area where *L. maackii* still dominated (H = 0.834 in uncleared areas and H = 0.761 in cleared areas). The results indicate that individuals are spread out more evenly across taxa in uncleared areas. The cleared site had a greater number of species that occurred only once or twice (Table 1).

Estimates of species richness and diversity may have been affected by the fact that a portion of the study area had just been cleared of *L. maackii* a month before the sampling took place. The timing of the study may also have affected species richness and diversity estimates. Collier *et al*. (2001) found that mean species richness both below and away from *L. maackii* was highest in the spring and declined steadily as fall approached.

In comparing the mean percent soil moisture in plots where *L. maackii* had been cleared (21.6 ± 0.7%) to the mean in plots where it had not been cleared (20.25 ± 0.90%), no statistical difference was found. These results do not support our original hypothesis that soil moisture would be lower in areas dominated by *L. maackii*. The sampling technique employed was designed to obtain average soil moisture of the entire area; not to examine more localized effects on soil moisture. In our study, soil core samples were taken at random points in an area where *L. maackii* was common. Even in plots that contained *L. maackii*, soil core samples may not have been taken close to the shrubs. If soil core samples had been taken below *L. maackii* crowns and compared with those taken away from *L. maackii* there may have been more pronounced differences in soil moisture levels.

An important observation noted during the study was that significant resprouting of L. maackii was occurring in the cleared area (Note: resprouts were again sprayed with herbicides in this cleared area in December 2002, after this study). The fact that *L. maackii* had regenerated in areas that had been cleared may also have minimized differences between soil moisture in the two areas. Soil moisture data may also have been different if sampling occurred at a different time. Because *L. maackii* extends its leaves earlier in the spring and retains foliage longer in the fall than native species, there may have been lower soil moisture levels in areas dominated by *L. maackii* if sampling had occurred later in autumn or in the spring.

Regression analysis revealed that there was no correlation between number of *L. maackii* individuals per plot and percent soil moisture. This could be due to a variety of factors, but the best explanation may be that number of individuals reflects nothing about the size and productivity of these individuals. More information about the relationship between *L. maackii* presence and soil moisture could have been obtained by calculating the total biomass of *L. maackii* in plots, instead of just number of individuals, and running a regression to see if it accounts for variation in soil moisture levels. We would expect lower soil moisture levels as biomass increases.

The results also indicated that there was no significant difference in soil moisture levels between areas where *L. maackii* naturally did not occur and areas where it did. In term of establishment, this may indicate that other factors, such as light availability, play a larger role in *L. maackii* colonization than soil moisture. Regression analysis showed that soil moisture did not account for a significant proportion of species richness variation in cleared or uncleared areas. We expected to see a relationship between species richness and moisture. DeMars and Runkle (1992) found lower species richness and lower soil moisture content in study area dominated by *L. maackii* and other woody stemmed shrubs.

While no relationship between soil moisture and *L. maackii* presence was established by the study, results did show significant differences in species richness between cleared and uncleared areas of the forest. Most significant are the results showing that cleared areas have greater woody understory species richness. Negative effects on seedling and sapling success may lead to great changes in canopy composition in the future. These results, coupled with the fact that observed *L. maackii* abundance was actually higher in cleared areas than uncleared areas and that infrequent clipping leads to denser *L. maackii* growth (Luken & Mattimiro, 1991), indicate that continued *L. maackii* removal will be important in maintaining the community composition of the bottomland hardwood forest.

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