Response of the invasive shrub, *Lonicera maackii* (Rupr.), to removal efforts in a bottomland hardwood forest of central Ohio

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Abstract

The focus of this study attempts to address the effectiveness of 5.3-ha bottomland forest restoration at the Olentangy River Wetland Research Park in Franklin County, Ohio by examining clip-method removal of northeast Asian shrub *Lonicera maackii* (Rupr.) Herder (Amur Honeysuckle). Species diversity indices and abundance were used to investigate the effects of *L. maackii* removal. Species diversity and abundance of other species were found to increase in areas where removal had occurred. Mean species diversity increased by 20.6% in areas where *L. maackii* had been removed. Species abundance was evaluated according to percent cover of each species present in the sample sites. Mean percent cover of herbaceous vegetation increased by 8.8% and mean percent cover of woody species increased by 15.2% in areas where *L. maackii* had been removed. The results of this study suggest that *L. maackii* removal is having a positive impact in this setting; however, long-term trends remain unexplored.

Introduction

The northeast Asian shrub *Lonicera maackii* (Rupr.) Herder (Amur Honeysuckle) has become a common feature to many forests throughout Ohio and other regions of the eastern United States. The invasive capabilities of this shrub are well documented; however, the effectiveness of management efforts remains largely unexplored.

A trend of accelerated invasive activity has been reported in the United States throughout the last century (Mooney and Drake, 1986; Carlton, 1996). A principle axiom of invasion biology - the belief that invasions are caused by human dispersal and ever-increasing growth rates for human societies that result in environmental disturbances – is commonly used to explain this trend (Elton, 1958). These disturbances allow for invasion by altering historical rates or intensities of resource fluxes, such as space, nutrients, or light, through a system (Sher and Hyatt, 1999). Changes in resource fluxes create new ecological niches that invasive species are often able to inhabit and exploit.

The negative effect invasive species can have on ecosystems have been well documented. System alterations can include the suppression of native species, alterations in water regimes, and changes in nutrient abundance (Mooney and Drake, 1986; Shea and Chesson, 2002). These negative repercussions result from the ability of invasive species to establish monocultures that reduce biodiversity and aesthetic value (Sher and Hyatt, 1999). It has also been shown that these harmful effects can result indirectly from insects and pathogens carried by invaders (Neubert, et al., 2000).

The characteristics of potential invaders, habitat characteristics, resource abundance, and predator dynamics all influence a particular ecosystem's potential for invasion. In order to fully understand invasions it is necessary to consider the combined interactions of these system components (Sher and Hyatt, 1999; Davis et al., 2000; Kolar and Lodge, 2001; Shea and Chesson, 2002). Current efforts to manage invasions include: prevention, early detection, control/removal (Rejm‘anek, 2000; Washitani, 2001), development of invasion classification schemes (Shea and Chesson, 2002), and various modeling approaches (Sher and Hyatt, 1999; Neubert et al., 2000)

Species Background

Lonicera maackii (Rupr.) Herder (Amur Honeysuckle) was originally introduced into North America in the 1890s (Luken and Thieret, 1996). The invasive shrub, which was intended to be used as an ornamental (Luken and Thieret, 1996), now exists in at least 24 states in North America (Trisel and Gorchov, 1994). Its traits consist of extensive shallow root systems, abundant seed production (Deering and Vankat, 1998), the ability to adapt to various levels of light intensity – although it thrives in high levels of light - (Luken and Goessling, 1995; Hutchinson and Vankat, 1997a), and rapid growth. *L. maackii* is also characterized by early development of leaves that are retained later in fall compared to native shrubs (Trisel and Gorchov, 1994; Hutchinson and Vankat, 1997a). Thickets of *L. maackii* are often abundant along forest edges where light is abundant (Luken and Goessling, 1995). The seeds of *L. maackii* are mainly distributed via bird-dispersal (Luken and Goessling, 1995; see Hutchinson and Vankat, 1997b, for an excellent discussion on this topic; Deering and Vankat, 1998).

The devastating effect *L. maackii* can have on ecosystems has caused it to become the focus of many research efforts in areas near its impact. Hutchinson and Vankat found *L. maackii* cover to be inversely related to the density of tree seedling and herb cover. They also found that the same correlation held true for species diversity (1997a). The findings of Luken et al. (1997) suggest that *L. maackii* removal has a positive effect on herbaceous vegetation populations. While investigating the dispersal of *L. maackii*, Hutchinson and Vankat (1997b) showed that higher levels of forest cover and connectivity contribute to the spread of its seeds. This can be attributed to the fact that *L. maackii* relies on birds, which travel primarily along forested terrain, for seed dispersal.

The focus of this study sought to examine the effectiveness of current *L. maackii* removal efforts at the bottomland hardwood forest at the Olentangy River Wetland Research Park in Franklin County, Ohio. It is hypothesized that effective restoration will be evidenced by the following (1) greater species diversity and (2) an increased abundance of other species.

Methods

Study area

The site for this study was a bottomland hardwood forest located between The Ohio State University's Olentangy River Wetland Research Park (ORWRP) and the Olentangy River in Columbus, Ohio (Figure 1). The site is approximately 730 m long and ranges from 18 to 60 m wide. Until recently, the 5.3 hectare site was segregated from the Olentangy River by a man-made embankment. In 2000, four breeches were cut in this embankment allowing periodic flood events to enter the bottomland hardwood forest from the Olentangy River.

In September 2001, annual voluntary efforts of restoration were initiated to control the established invasion of *L. maackii* by means of shrub clipping. This technique consists of clipping the shrub at ground level followed by removal of debris from the area. Initial restoration efforts began at the northwest corner of the forest. Subsequent efforts have progressed in a linear fashion heading east and south. At the time of this study the extent of removal had reached the approximate region of the division line shown on Figure 1.

Sampling and analysis

The site was divided into two sections of treatment: Control and removal (Figure 1). At the time of data collection, no known *L. maackii* removal had occurred in the control area. During the last three years, *L. maackii* removal is known to have occurred throughout the removal area. After inspection of the entire study site, 4 x 4 m quadrats were set up along cardinal axes in areas that were believed to be characteristic of the respective treatment areas. The relative location of each quadrat was determined first, by noting the perpendicular distances to the bike path and Olentangy River respectively while traveling from the northwest corner of each quadrat, and second, by noting the distance to the ORWRP bike path entrance along the adjacent bike path. Five quadrats were set up in each treatment area for a total of ten quadrats. Vegetation in each quadrat was identified, and cover values were visually estimated for each species. In addition, living *L. maackii* plants were counted, as were *L. maackii* plants that had been clipped. Averages and standard deviations were calculated in order to determine mean % changes in species diversity and % cover of various species

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.

using a 90% confidence interval. Statistical analyses were conducted according to small sample size methods laid out by Miller and Miller (1995). The Shannon-Weaver Index was used to measure species diversity in each quadrat (According to Shannon and Weaver, 1949). Higher values for the Shannon-Weaver Index correlate to a higher level of uncertainty of species prediction corresponding to greater species diversity. The natural log of the number of species present in a site is the highest index value attainable with this method.

Results

Species diversity

The mean percent of *L. maackii* cover in the control area was approximately 50.0% compared to 11.4% in the removal area. These numbers resulted in a decrease of 77.2% for mean % cover of *L. maackii* (Table 1). The values observed in the control sites were subject to a significant amount of variability with a standard deviation of 30.4 (58% of the average value). The average number of species present in control quadrats was approximately 6.8 compared to 8.2 in areas with removal. The result was a 20.6% increase in mean species diversity for areas with *L. maackii* removal (Table 2). Values obtained using the Shannon-Weaver Index supported these findings. Index values for the control sites ranged from 0.26 to 1.68 with an average value of 0.94 (Table 3). Index values for the removal sites ranged from 1.57 to 2.01 with an average value of 1.75 (Table 4).

Ground Cover

L. maackii removal had positive effects on some herbaceous species and negative effects on others. The mean percent cover of *Vitaceae Parthenocissus quinquefolia* (Virginia creeper) increased from 0.8% in control sites to 5.6% in removal sites (Table 5). The mean percent cover of *Alliaria petiolata* (garlic mustard) decreased from 3.2% in control sites to 1.0% in removal sites (Table 6). The overall affect of *L. maackii* removal on mean percent cover of total herbaceous vegetation was an increase of 8.8% following restoration efforts (Table 7).

Woody Species

Similarly, *L. maackii* removal suggested positive effects on some woody species and negative effects on others, although further investigation is recommended to account for perennial vegetation that may have been established prior to removal efforts. The mean percent cover of *Asimina triloba* (Paw-paw) increased from 0.2% in control sites to 5.6% in removal sites (Table 8). The mean percent cover of *Acer negundo* (Box elder) was 4.4% in control sites and 0.2% in removal sites (Table 9). The overall effect of *L. maackii* removal on the mean percent cover of total woody species was an increase of 15.2% following restoration efforts (Table 10).

Discussion

Species Diversity

The results of this study supported the hypothesis that removing the invasive shrub *L. maackii* will result in greater species diversity. The observed trend proved significant as evidenced by the results of the Shannon-Weaver Index for diversity. Such a finding is further supported throughout literature discussing the invasive potential of *L. maackii*. Collier et al. (2002) found that the presence of *L. maackii* causes diminished diversity and abundance of native plants in forests of southwestern Ohio and surrounding areas. Hutchinson and Vankat (1997a) reported a similar trend while noting a large degree of variability in their data; this was also the case in this study. The degree of variation in the data presented here may have resulted from the notable presence of first-year shoots of *L. maackii*. These nascent plants would not have properly established themselves to accomplish the negative effects associated with *L. maackii*, yet their scattered abundance could be enough to affect the data obtained for diversity.

Species Abundance

Results of this study also supported the hypothesis that *L. maackii* removal will increase species abundance. This can be largely attributed to the diminished competition for nutrients and water in areas where *L. maackii* has been removed. Herbaceous and sapling woody vegetation obtain the majority of their nutrients from the upper portion of the soil. *L. maackii*, which has an extensive root system,

Table 1. Mean Percent Cover of *Lonicera maackii* Using a 90% Confidence Interval

Treatment	Ave. % Cover of *L. maackii*	Std. Dev.	Error (+/-)	% Error
Control	50.0	30.4	29.0	58
Removal	11.4	5.1	4.9	43

Mean % cover of *L. maackii* was 77.2% lower for areas of removal.

Table 2. Mean Species Richness Using a 90% Confidence Interval

Treatment	Mean # Species	Std. Dev.	Error (+/-)	% Error
Control	6.8	3.6	3.4	50
Removal	8.2	1.9	1.8	22

% increase of mean sp. richness was 20.6% greater for areas with *L. maackii* removal.

Table 3. Percent Cover and Diversity Index for Species in Control Area Sites

Site #	Species	% Cover	Shannon-Weaver Index
1	Lonicera maackii	0.50	0.68
	Populus deltoides	0.02	
	Acer negundo	0.07	
	Alliaria petiolata	0.03	
2	Lonicera maackii	0.25	0.26
	Acer negundo	0.02	
8	Lonicera maackii	0.15	1.68
	Asimina triloba	0.01	
	Alliaria petiolata	0.01	
	Eupatorium maculatum	0.01	
	Acer negundo	0.05	
	shrub spp. #1	0.03	
	Vitaceae Parthenocissus quinquefolia	0.01	
	woody spp. #1	0.05	
	grass	0.01	
9	Lonicera maackii	0.85	0.98
	Alliaria petiolata	0.02	
	Phlox divaricata	0.10	
	Trifolium repens	0.01	
	Vitaceae Parthenocissus quinquefolia	0.01	
	Vitis vitera	0.02	
	Conioselinum chinense	0.01	
	weed spp. #1	0.02	
	Aster spp.	0.02	
	grass	0.05	
10	Lonicera maackii	0.75	1.12
	Vitaceae Parthenocissus quinquefolia	0.02	
	Alliaria petiolata	0.10	
	Aster spp.	0.02	
	weed spp. #1	0.05	
	Eupatorium maculatum	0.01	
	Acer negundo	0.08	
	ivy spp. #1	0.02	
	shrub spp. 2	0.01	

Table 4. Percent Cover and Diversity Index for Species in Removal Area Sites

Site #	Species	% Cover	Shannon-Weaver Index
3	Lonicera maackii	0.10	1.57
	Geranium maculatum	0.05	
	Vitaceae Parthenocissus quinquefolia	0.15	
	Asimina triloba	0.15	
	Populus deltoides	0.02	
	Smilax spp.	0.01	
	Acer spp.	0.01	
4	Lonicera maackii	0.05	1.74
	Vitaceae Parthenocissus quinquefolia	0.10	
	Asimina triloba	0.05	
	Geranium maculatum	0.01	
	Alliaria petiolata	0.01	
	Ulmus rubra	0.05	
	Vitis vitera	0.01	
	Ulmus americana	0.01	
5	Lonicera maackii	0.02	1.68
	Smilax spp.	0.01	
	Solidago spp.	0.01	
	Asimina triloba	0.03	
	Vitis vitera	0.01	
	Alliaria petiolata	0.01	
6	Lonicera maackii	0.05	2.01
	Alliaria petiolata	0.02	
	grass spp. #1	0.01	
	Vitaceae Parthenocissus quinquefolia	0.02	
	Solidago spp.	0.01	
	Asimina triloba	0.05	
	Vitis vitera	0.01	
	Eupatorium maculatum	0.02	
	Aster spp.	0.02	
7	Lonicera maackii	0.15	1.77
	Eupatorium maculatum	0.01	
	Alliaria petiolata	0.01	
	Vitis vitera	0.05	
	Allium tuberosum	0.01	
	Catalpa spp.	0.02	
	Smilax spp.	0.01	
	Conioselinum chinense	0.01	
	Vitaceae Parthenocissus quinquefolia	0.01	
	shrub spp. #1	0.02	

Table 5. Mean Percent Cover of *Vitaceae Parthenocissus quinquefolia* Using a 90% Confidence Interval

Treatment	Mean % cover of *V. P. quinquefolia*	Std. Dev.	Error (+/-)	% Error
Control	0.8	0.8	0.8	100
Removal	5.6	6.6	6.3	112

Mean % cover of *V. P. quinquefolia* increased by 600% in areas with *L. maackii* removal.

Table 6. Mean Percent Cover of *Alliaria petiolata* Using a 90% Confidence Interval

Treatment	Mean % Cover of *A. petiolata*	Std. Dev.	Error (+/-)	% Error
Control	3.2	4.0	3.8	118
Removal	1	0.7	0.7	67

Mean % cover of *A. petiolata* decreased by 68.8% in areas with *L. maackii* removal.

Table 7. Mean Percent Cover of Herbaceous Species Using a 90% Confidence Interval

Treatment	Mean % cover of Herbaceous species	Std. Dev.	Error (+/-)	% Error
Control	11.4	12.1	11.6	102
Removal	12.4	6.4	6.1	49

Mean % cover of herbaceous species increased by 8.8% in areas with *L. maackii* removal.

Table 8. Mean Percent Cover of *Asimina triloba* Using a 90% Confidence Interval

Treatment	Mean % Cover of *A. triloba*	Std. Dev.	Error (+/-)	% Error
Control	0.2	0.4	0.4	213
Removal	5.6	5.6	5.4	96

Mean % cover of *A. triloba* increased by 2700% in areas with *L. maackii* removal.

Table 9. Mean Percent Cover of *Acer negundo* Using a 90% Confidence Interval

Treatment	Mean % Cover of *A. negundo*	Std. Dev.	Error (+/-)	% Error
Control	4.4	3.4	3.2	73
Removal	0.2	0.4	0.4	213

Mean % cover of *A. negundo* decreased by 95.5% in areas with *L. maackii* removal.

Table 10. Mean Percent Cover of Woody Species Using a 90% Confidence Interval

Treatment	Mean % cover of woody species	Std. Dev.	Error (+/-)	% Error
Control	6.6	4.7	4.5	69
Removal	7.6	6.7	6.4	84

Mean % cover of woody species increased by 15.2% in areas with *L. maackii* removal.

exceedingly depletes these resources from this layer of soil (Collier, et al., 2002) resulting in the diminished abundance of native vegetation.

The impacts of *L. maackii* are not limited to below-ground competition. In fact, a study conducted by Gorchov and Trisel (2003) found that above-ground competition *of L. maackii* had a greater impact on surrounding vegetation. This is primarily a result of competition for light. The development of *L. maackii* consists of rapid vertical growth (exceeding 1 m by age 3) and high rates of stem recruitment and branching (Deering and Vankat, 1998). This branching characteristic allows *L. maackii* to intercept the majority of light by growing over-the-top of surrounding vegetation, especially herb, weed, and young woody species.

A factor greatly influencing this study was the time of year at which it was conducted. All data was gathered throughout the month of October. By that time of year, many plants in Ohio have reached the end of their growing season. This illustrates a characteristic of *L. maackii* contributing to its abilities as an invader. Much of the vegetation encountered in this study, especially woody species, was in the process of loosing their leaves, and moving toward a state of dormancy. At the same time, all *L. maackii* plants were still in full leaf. Trisel and Gorchov (1994) reported similar observations during a study near Oxford, Ohio. The extended growing season of *L. maackii* proves to be a well-suited adaptation for this plant. The spread of *L. maackii* takes place primarily through bird-dispersal (Deering and Vankat, 1998). By making seeds available for a greater portion of the year the plant becomes a primary food source for many bird species. The timing of this study has another implication. It is quite possible that species diversity and abundance data were skewed by the fact that some species may not have been present since their growing season had come to a natural end. As a result, species diversity and abundance values were underestimated.

An important consideration to be factored into a management plan is the reproductive life history of this shrub. *L. maackii* plants are not capable of reproduction until they reach approximately three years of age (Deering and Vankat, 1998). Numerous first-year shoots of *L. maackii* were observed throughout the study site including removal areas. For removal efforts to be successful, it is necessary to return to areas of removal during subsequent years in order to remove newly sprouting plants before they are capable of reproduction. The great magnitude of seed production and tenacious survival strategies exhibited by *L. maackii* create the need for continual and persistent management efforts. Without such persistent management, restoration is not likely to be successful. Additional research is required to investigate the long-term and seasonal effects restoration efforts will have on *L. maackii* populations and the subsequent effect these efforts will have on the native environment.

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