Vegetation Release Eight Years After Removal of *Lonicera maackii* in West-Central Ohio

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Abstract. ***Lonicera maackii*** **is thought to inhibit growth of herbaceous vegetation and woody seedlings. To determine the extent of this inhibition, in April 1996, *Lonicera* was removed from ten 30 x 30 m areas within Sugarcreek Reserve. Paired 20 x 20 m plots were established, one of each pair in the removal area and one adjacent to that area. These plots varied in history and topographic position. Twenty 1-m² small plots were established in each large plot and sampled for herbaceous vegetation (by species and cover class) and woody seedlings (species and number). Sampling was done summer 1996 and spring 1997. Nine of the paired plots were resampled summer 2003 and spring 2004. Few differences were found between control and treated plots the first year after *Lonicera* removal. Significant differences between control and treated plots were found seven to eight years after treatment in both spring and summer: treated plots had higher species richness, higher cover, and higher tree seedling densities. These results indicate that *Lonicera* removal can enhance ground layer species diversity and cover after a lag period of at least one year.**

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INTRODUCTION

The deciduous shrub *Lonicera maackii* (Rupr.) Herder (bush or Amur honeysuckle; we will refer to it as 'honeysuckle' throughout this report) was deliberately introduced from eastern Asia to the United States in the mid-1800s (Luken and Thieret 1996). It is now naturalized in at least 24 states of the eastern United States and in Ontario, Canada. Many resource managers consider it an undesirable invader of natural areas, detrimental to native tree seedlings (Gorchov and Trisel 2003, Hartman and McCarthy 2004) and herbaceous plants (Luken and others 1997, Gould and Gorchov 2000, Collier and others 2002, Miller and Gorchov 2004). Its impacts may have a lag effect and vary from exclusion to reduced fecundity. Impacts on seed and bud banks can lead to delayed recovery of native species following honeysuckle removal (Collier and others 2002). Honeysuckle is in leaf earlier and later than almost any other associated woody, deciduous plants, reducing light to the ground layer (Luken and Thieret 1996). Dorning and Cipollini (2006) also found leaf and root extracts to have allelopathic properties.

Honeysuckle grows best in the open and in forest edges and gaps; however, it can invade and maintain itself in the forest interior (Luken 1988, Luken and Goessling 1995, Luken and others 1995, Medley 1997). Similarly, clipping stems inhibits its growth more in the forest interior than in the open (Luken and Mattimiro 1991, Luken and Thieret 1996). DeMars and Runkle (1992) studied seven areas within a single, large woodlot in Greene County, Ohio (the Wright State University woods), sampling 100 1-m² plots in each area. They found honeysuckle to be the 15th most frequent taxon (species or genus) of 126 total taxa, the second most frequent nonnative species, and the most frequent nonnative woody species overall, present in 29% of the plots sampled. It was in 91% of plots in a 40-year stand, 69% of plots in a 60-year stand, and 8% of plots in older (uncut) stands, all within the Wright State University woods.

Although honeysuckle fruits are low in nutritional value they are eaten and dispersed by birds (Ingold and Craycraft 1983) and white-tailed deer (*Odocoileus virginianus* Zimm.) (Velland 2002, Nickell 2004). As a result of such dispersal honeysuckle can spread throughout a landscape. This spread may be slow at first while the first immigrants get established, then accelerates as they begin to reproduce (Deering and Vankat 1999). The movement is slow enough that significant relationships between initial establishment site and presence in woodlots can be detected several decades after introduction (Hutchinson and Vankat 1997, 1998). It tends to be more abundant nearer residential areas even in parks where it has existed for many years (Gayek and Quigley 2001, Borgmann and Rodewald 2005).

Honeysuckle is usually more abundant in younger woods than older woods and is often correlated with reduced ground layer cover and species diversity. To help justify that this correlation is causal it is necessary to consider the alternative hypothesis that younger woods inherently have less ground layer cover and species diversity than older woods. Several studies have found younger woods to be lower in species diversity than older woods, especially for forest herbs (DeMars and Runkle 1992, Dzwondo and Loster 1997, Elliot and others 1998, Bossuyt and others 1999, De Keersmaeker and others 2004). Other studies find higher species diversity in younger woods (Howard and Lee 2003). Oliver (1981) and Oliver and Larson (1990) found that many forest successions undergo what they call the 'stem exclusion' stage in which tree seedlings are scarce, excluded by the crowded canopy. This stage occurs about ages 5 - 40 years (with much wider spans in some forests) after stand reinitiation. It is necessary to determine experimentally by looking at a range of stand ages whether honeysuckle itself adds to the impoverishment of its sites.

Because honeysuckle is a management concern and its removal usually involves cutting and the use of herbicides (Nyboer 1992, Hartman and McCarthy 2004) it is important to document its inhibitory effects, particularly for its treatment in natural areas. Doing so experimentally helps determine how honeysuckle directly impacts the ground layer. It also is necessary to monitor management activities to determine whether or not they are successful and for how long.

This study attempts to contribute to our knowledge of honeysuckle management by determining the immediate and long-term (seven to eight year) consequences of honeysuckle removal on ground layer species diversity and cover and on tree seedling densities for one park in west-central Ohio. It does so for sites with different histories and topographic locations to indicate whether those factors influence honeysuckle's impacts.

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METHODS

Ten pairs of plots were established during spring and early summer of 1996 in Sugarcreek Reserve, Greene County, Ohio. Each pair contained an experimental plot (honeysuckle removed from an area 30 x 30 m) and a control plot (honeysuckle present). Plots were picked subjectively to include a range of stand ages and topographic positions (Table 1). Young areas had a maximum tree size of approximately 25 cm dbh (diameter at breast height = 137 cm) and mostly were abandoned from agriculture about 1967, when the park was created. Medium-aged stands had a maximum tree size of about 50 cm dbh and were abandoned from agriculture before the park became established. Old areas contained trees > 50 cm dbh and had no historic evidence of having been cleared. Honeysuckle was cut at the base and each stump was painted with the herbicide Round-Up (1:10 dilution with water) in April 1996. All vegetation sampling was done after honeysuckle was removed. Within each control plot and each experimental plot 20 1-m x 1-m plots were sampled randomly from a 20 x 20 m grid. Species, percent cover and, if woody, number of plants present were recorded. Maximum honeysuckle height over each plot, including leaves from stems not rooted in the plot, was measured with largest stems recorded as $\geq$ 2 m tall. Percent cover values followed the ranges $\leq$ 5 %, 6 – 25 %, 26 – 50 %, 51 – 75 %, and 76 – 100 %. Sampling occurred mid-June through August 1996 and May 1997. Nine of those plot pairs were resampled seven years after treatment, in summer (July 21-August 4), 2003, and spring (May 19-June 8), 2004 (the tenth plot could not be relocated). Because few of the 1 x 1 m plot flags remained, new sets of small plots were sampled. Differences between earlier and later samples combine differences in data recorders, exact plot locations, and year-specific weather. These factors should affect both plots in each pair similarly, however, so differences in vegetation change from 1996 - 1997 to 2003 - 2004 between plots of the same pair should be related to the treatment.

Statistical analyses were conducted using PC-SAS 9.1 (SAS Institute 2004). A repeated measures analysis of variance was used to test changes with treatment, time and interactions for both spring and summer samples. Dependent variables were the average number of species and sum of species cover values per 1-m^2 plot. Honeysuckle was excluded from these analyses. These analyses used average values for each of the eighteen 20 x 20 m plots. In addition, an analysis of variance based on all 360 1-m^2 plots evaluated the main effects and interaction of plot pairs and treatment for each season for 2003 - 2004. T-tests were used to determine significant differences between treatments for each pair of 20 x 20 m plots. Dependent variables for these tests were species richness, total cover, and number of woody seedlings. Again, honeysuckle was excluded from the data. For each year-season combination, taxa (species or genera) present in $\geq$ 20% of the 1-m^2 plots were examined for statistically significant differences between treatments. A chi-square test was used to compare the number of treatment plots (out of 180 total) in which the taxon was found with the number of control plots (also out of 180) in which it was found. Nomenclature follows Gleason and Cronquist (1991).

RESULTS

Honeysuckle was removed spring 1996 but then reinvaded the

Table 1

Characteristics of sites (paired plots) in Sugarcreek MetroPark. Significant differences between treatments after seven years are indicated with E if the experimental plot had a higher value, C if the control plot had a higher value, and a dash if the difference was not signifianct.

			Spring			Summer		
Site	Stand age*	Topography	# of Taxa	Percent Cover	Seedling Density	# of Taxa	Percent Cover	Seedling Density
1	Medium	Flat upland	-	-	-	E	-	-
2	Medium	Upper slope	E	-	E	-	-	E
3	Medium	Flat lowland	-	E	C	E	E	-
4	Young	Flat upland	E	E	-	E	E	-
5	Medium	Mid slope	E	E	-	E	E	E
6	Medium	Mid slope	E	E	E	E	E	E
7	Young	Flat upland	E	-	E	E	-	E
8	Old	Flat upland	E	E	-	E	E	-
9	Old	Flat upland	E	E	-	E	E	-

*Young: maximum tree size of 25 cm dbh, last farmed about 1967
Medium: maximum tree size of 50 cm dbh, last farmed several years before 1967
Old: maximum tree size > 50 cm dbh, no evidence of having been farmed

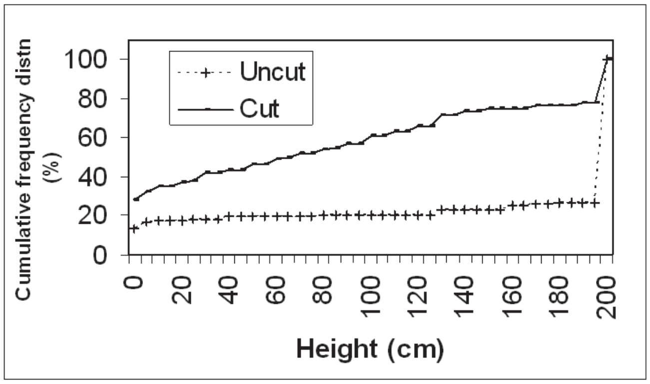

FIGURE 1. Cumulative frequency distributions of *Lonicera maackii* height in 2004 for all 180 plots in each of the uncut (control) and cut (experimental) treatments.

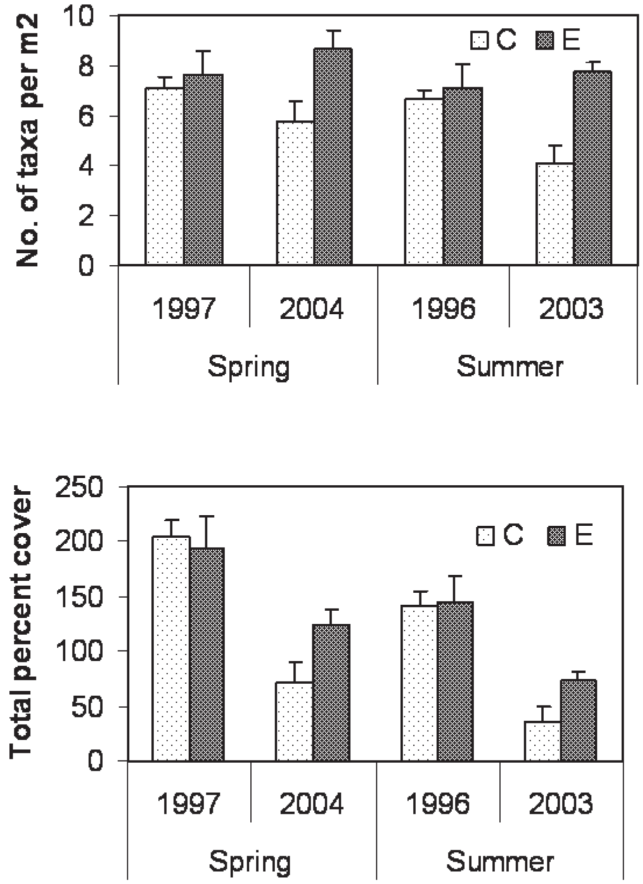

FIGURE 2. Number of taxa (a) and total percent cover per m^2 (b) in all plots sampled in both time periods and for both spring and summer. C=control (*Lonicera maackii* not cut); E=experimental (*L. maackii* cut). Bars indicate standard errors. *L. maackii* not included in either data set.

experimental plots as seedlings or sprouts. In general, however, the removal was still effective eight years later (Fig. 1). In 2004 honeysuckle was absent from 28% of the 1-m^2 experimental plots and 13% of the control plots. It was $\leq$ 1 m high in 61% of the experimental plots versus only 21% of the control plots. It was $\geq$ 2 m high in only 22% of the experimental plots versus 73% of the control plots.

The difference between the mean numbers of species per m^2 in the 400 m^2 control plots and in the experimental plots increased over time for both the summer and spring samples (Fig. 2A). This relationship was not significant for the spring samples ($P = 0.06$ for treatment, $P = 0.08$ for year and treatment interactions, $P = 0.83$ for year) based on the nine plot averages for each treatment although the tendency ($0.05 < P < 0.10$) was for more species to be in the experimental plots and for the difference between treatments to be greater in 2004 than in 1997. For the summer samples, more species were in the experimental plots ($P < 0.01$ for treatment), similar numbers of species were present in 1996 and 2003 ($P = 0.16$ for year) and differences between treatments were greater in 2003 than in 1996 ($P = 0.02$ for year and treatment interactions). For the total percent cover of plants per m^2 the difference between the control plots and experimental plots increased over time (Fig. 2B). Only the overall difference between years was significant, for both spring ($P = 0.19$ for treatment, $P = 0.13$ for year and treatment interactions, $P < 0.01$ for year) and summer ($P = 0.24$ for treatment, $P = 0.29$ for year and treatment interactions, $P < 0.01$ for year).

For the 2003 - 2004 samples, for both spring and summer, most paired plots differed significantly from each other (Table 1). The number of species per 1 m^2 was significantly greater in the experimental plot for seven of nine pairs in the spring and eight of nine pairs in the summer. Total percent cover per 1 m^2 was significantly higher in the experimental plots for six of nine spring pairs and six of nine summer pairs. The number of woody seedlings per 1 m^2 was low in all samples but significantly higher in the experimental plots for four pairs each, spring and summer. For all three dependent variables the main effects and interaction of treatment and plot pair were significant ($P \leq 0.01$). Patterns of paired plot relative values and significance did not have any apparent relationship to plot age or topographic position (Table 1): significantly higher values were found in experimental plots of each age and for both uplands and slopes.

Individual taxa varied in frequency with treatment and time (Table 2). Only three taxa showed significant differences in the first spring after honeysuckle removal and only two in the first summer; four of those taxa were more frequent in the control plots. Seven to eight years later a very different outcome was apparent: five species each in spring and summer were significantly more frequent in the experimental plots; no species were significantly more frequent in the control plots.

DISCUSSION

Honeysuckle often resprouts vigorously after cutting, necessitating the application of herbicides onto the cut stumps for most management applications (Nyboer 1992, Hartman and McCarthy 2004). It is unclear how long the effects of a cutting and herbicide treatment persist. In the present study honeysuckle was present in most plots eight years after treatment but at low frequencies and low heights. In part this prolonged benefit of treatment occurs because of the limited resources for honeysuckle under a closed canopy, where its growth and productivity are restricted (Luken 1988, Luken and Mattimiro 1991). Cutting also rapidly decreases the seed bank of honeysuckle (Luken and Mattimiro 1991).

The delayed response of species to honeysuckle removal has been found by other studies. Luken and others (1997) found several species did not reappear until the second or third year after honeysuckle removal. Several factors may be involved in this delay. For some species, honeysuckle does not affect their survival as much as their growth and fecundity (Gould and Gorchov 2000, Miller and Gorchov 2004). Therefore, a simple index of presence or the use of broad cover classes, such as used in the present study, could obscure more immediate responses of increased growth and reproductive effort. Honeysuckle also inhibits the germination of several herb species, though not itself, by allelopathy (Dorning and Cipollini 2006). It is uncertain how long this effect lasts but it could delay the reinvasion of the site by some species. A long-term presence of honeysuckle can also deplete the bud and seed banks of the site, restricting the number of species able to respond quickly (Collier and others 2002). The slow dispersal capabilities of many forest herbs also can lead to long delays before the ground layer vegetation has recovered (Ehrlen and Eriksson 2000, Matlack 2005, Flinn and Vellend 2005).

Is the dearth of tree seedlings and paucity of herbaceous cover in young forests with honeysuckle due to inhibition by honeysuckle or to other factors associated with young forests, such as the development of crowded canopies? A stem exclusion stage has been noted as typical of many forest developments (Oliver 1981, Oliver and Larson 1990). Therefore, some impacts sometimes attributed to honeysuckle may be due to other factors. However, the results of the present study indicate that honeysuckle does indeed suppress the growth of other species. Tree seedlings and herbaceous plants in general were found at greater densities and frequencies where honeysuckle had been removed in both young and old forested stands.

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Table 2

*Taxa frequency values (%) out of 180 plots sampled. Taxa listed were found in ≥20% of plots for given season (SU=summer, SP=spring) and year. C=control (uncut); E=experimental (cut). Significant differences between treatments for the same year and season are based on chi-square tests: * for P≤0.05; ** for P≤0.01.*

Taxa	SP 97 C	SP 97 E	SP 04 C	SP 04 E	SU 96 C	SU 96 E	SU 03 C	SU 03 E
Acer negundo	-	-	21	25	37	33	-	-
Alliaria petiolata	60	56	59	54	59	49	46	56*
Boehmeria cylindrica	-	-	28	31	-	-	-	-
Circaea lutetiana	-	-	-	-	29	25	-	-
Claytonia virginica	18	22	-	-	-	-	-	-
Daucus carota	19	27	-	-	-	-	-	-
Eupatorium rugosum	-	-	21	27	-	-	17	52**
Galium aparine	68	57*	21	28	-	-	-	-
Geum sp.	60	99*	19	62**	61	56	19	54**
Impatiens sp.	-	-	22	34**	28	17*	-	-
Osmorhiza sp.	41	27*	-	-	-	-	-	-
Parthenocissus quinquefolia	20	21	32	47**	65	66	27	52**
Prunus serotina	21	23	-	-	-	-	-	-
Rosa multiflora	-	-	12	31**	19	22	-	-
Sanicula gregaria	-	-	14	52**	24	17	22	35**
Solidago sp.	-	-	-	-	26	28	-	-
Toxicodendron radicans	17	24	-	-	22	28	-	-
Viola sp.	47	46	34	38	54	42*	32	34

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