Removal of *Lonicera maackii* (Amur Honeysuckle) at Litzsinger Road Ecology Center using different glyphosate treatments.

Introduction

Invasive plant species are introduced from a different continent, colonize a new area, increase in density, and rapidly expand their range. Invaders threaten a system's biodiversity when a single species becomes dominant. They can dramatically and permanently alter a community's structure, function, and composition. Invasive species must be managed to stop new invaders from entering the system and to reclaim invaded communities (Myers and Bazely 2003).

The loss of biodiversity in a system correlates to the establishment of invasive species (Donlan and Martin 2003). In the islands of Mauritius and Hawaii, an invasive species (*Psidium cattleianum*) altered the habitat in such a way to push out all native plant species (Cronk and Fuller 1995). Native plant diversity is reduced by *Lonicera maackii* invasion. The reduction of growth and reproduction of perennial herbs was associated with shading out the understory before native herbs emerge in the spring (Miller and Gorchov 2004). *L. maackii* reduces available light, heat, soil moisture and pH, limiting the recruitment of native tree seedlings (Hartman and McCarthy 2004). The shrub has also been associated with reduced tree seedling density in Ohio forests due to above ground competition (Gorchov and Trisel 2003). Eradication of invasive plant species is the best way to give native biota a chance recovery time in disturbed places (Zavaleta *et al* 2001).

L. maackii is a deciduous, multi-stemmed shrub native to Asia. The leaves are opposite and entire, with a dark green upper surface and lighter green lower surface (Dirr 1998). The leaves expand early in March and persist until November (Miller and Gorchov 2004). White tube flowers bloom in May and turn yellow (Vegetation Management Guideline 2005). The fruit is a red berry that ripens during June and July (Kurz 1997). The berries are eaten by birds, which are the main seed dispersers for this plant. *L. maackii* was introduced to North America in the late 1800s and has been used as an ornamental landscape plant. Now shrubs invade woodlands, wetlands, and prairies (Vegetation Management Guideline 2005).

L. maackii is a successful forest habitat invader because it shades the forest floor early in spring before native flora emergence, and the leaves stay green until November. Seed dispersal by bird consumption, attaining heights of 20 feet in the shade, and resprouting after repeated clipping also contribute to the dominance of *L. maackii* in a community. Invasion poses a threat to native fauna. Breeding sites for birds can become eliminated, and higher nest predation was found in American robins that nested in exotic shrubs, including *L. maackii*, versus those that inhabit similar native shrubs. Higher nest predation rates can contribute to decreasing populations of songbirds (Schmidt and Whelan 1999). Invader plants can also impact systems by altering soil chemistry, geomorphological processes (sedimentation or erosion), fire regime (frequency and intensity), and hydrology (water run-off) (Cronk and Fuller 1995).

The development of a plant community is modified by *L. maackii* understory dominance. Removal of the shrub provides a window for other plants to become established. Removal of a dominant invader produces an effect similar to the resource availability boost after a natural disaster, such as tree-fall gaps. Tree-fall gaps in deciduous forests increase light available on the forest floor, and indigenous herbs respond positively. The light increase was found to have a positive effect on native tree seedling density. Gap formation was found to have a significant and positive influence on total plant density (Luken *et al.* 1997).

Removal of *L. maackii* is one step in the process of improving native flora in the woodland area of Litzsinger Road Ecology Center. *L. maackii* readily resprouts after stems are cut. I looked at the effects of different glyphosate treatments on stump resprout ability. Resprouting in woody plants occurs in response to biomass removal, and how well a plant persists depends on the development of stem buds and availability of stored carbohydrates. *L. maackii* resprout rates remain high in forests, even though shrubs have lower productivity than those growing in full sun. Even in forests, large numbers of *L. maackii* stems sprout annually from the woody base. *L. maackii* regenerates most of its former shrub after clipping. Clipping alone can induce mortality if done at least once a year for many years (Luken and Mattimiro 1991). Cutting stem bases and treating the stump with undiluted glyphosate within thirty seconds while translocation from the damaged sapwood is still occurring is an effective method for killing woody plants (Cronk and Fuller 1995). Some land managers recommend stems be cut at the base and a diluted 20% glyphosate solution applied immediately to the stump to prevent resprouting (Vegetation Management Guideline 2005). The treatments can be done from late summer to dormant season.

Removal was planned for the last week of June and was completed from the 27th through 29th. The cut stumps were treated with full strength (41%) glyphosate solution immediately, half strength (20%) glyphosate solution immediately, or full strength glyphosate solution 24 hours after cutting stems. The control plots with stumps cut but no glyphosate applied were expected to resprout at a greater growth rate and greater number of stems per shrub than all other treatments. Stumps where glyphosate was applied one day after cutting were expected to resprout but at a lower growth rate and with less stems per stump. No growth was expected from stumps in plots where stems were cut and either full or half strength glyphosate was applied immediately.

Methods

Litzsinger Road Ecology Center (LREC) was established as an urban nature reserve in Ladue, Missouri in 1990. It is comprised of 34 acres including restored prairie, bottomland hardwood forest, and the intermittently flowing Deer Creek. The Center is surrounded on all sides by urban development and is an ecological island. There is 14 acres of bottomland hardwood forest, about half of which is located east of Deer Creek (Ochs 1993). The study area resembles mesic bottomland forest, once extensive in Missouri. Mesic bottomland forests are characterized by level or gently sloping higher elevations of stream flood plains. The Soil Conservation Service mapped LREC soils as Wilbur silt loam, nearly level and moderately well drained. Flooding is common, and soil permeability is moderate with slow surface runoff. It is not known when the forest was last logged (Ochs 1993).

Bottomland communities characteristically have a dense tree canopy, well developed understory with tall vines, and a diverse herbaceous ground layer. The canopy of the woodland in the study area is tall and closed after mid-June when trees have fully leafed-out. *Acer negundo* (box elder), *Aesculus glabra* (Ohio buckeye), and *Platanus occidentalis* (sycamore) are common large trees in the study area. Unfortunately, the understory is completely dominated by *L. maackii* (Amur honeysuckle). A few individuals of privet were also found and treated during the study. The ground layer is dominated by *Euonymus fortunei* (wintercreeper), and *Laportea canadensis* (wood nettle) is extensive (Ochs 1993). The study area also consists of *Toxicodendron radicans* (poison ivy), *Parthenocissus quinquefolia* (Virginia creeper), *Vitus riparicum* (wild grapevine), *Alliaria petiolata* (garlic mustard), *Hemerocallis lilioasphodelus* (tiger lily), and two individuals of *Arisaema draconitum* (green dragon).

Study plots were located in LREC bottomland mesic forest on the east side of Deer Creek near the bridal trail creek crossing. Plots were adjacent and did not border the creek bank. The plots were located between the bridal trail (west) and the railroad right-of-way (east). Five study plots were set up as 15 m x 15 m squares, and flag tape tied to rebar corner posts was used to mark plots. Each plot was divided into four subplots (7.5 m x 7.5 m squares) and flag tape was used to mark subplots. Plots were numbered 1-5 and subplot treatments were assigned in the same order in each plot. An initial count of the number of shrubs per subplot, notes on species composition, and observations about *L. maackii* distribution were recorded (Fig 2). *L. maackii* distribution varied among the plot area. In the plots near the bridal trail there were numerous smaller stemmed *L. maackii* shrubs per subplot. In the plots near the railroad right-of-way there were fewer, much larger stemmed *L. maackii* shrubs per subplot. Treatments were evenly spaced through the plots because *L. maackii* shrubs were densely spaced with smaller stems toward the western border and widely spaced with larger stems toward the eastern border. Control subplots (CON) were cut near the base and the stump was not treated with glyphosate. Full strength immediately subplots (FSI) had stems cut near the base and full strength (41%) glyphosate immediately applied with a sponge bottle to the cut stump. Half strength immediately subplots (HSI) had stems cut near the base a half strength (21%) glyphosate solution immediately applied to the cut stump with a squirt bottle. Full strength next day subplots (FSND) were treated by cutting stems near the base and returning to apply full strength glyphosate the next day. After a subplot was cut and glyphosate applied if needed, the brush was hauled across the plot boundary. Subplot 2HSI did not contain *L. maackii* individuals, so this subplot was relocated adjacent to 1HSI. This spot was chosen because it was not too close to the creek and contained many *L. maackii* individuals. Removal began on June 27 when plots 3, 4, and 5 were treated (Fig.1). On June 28 these plots were completed and two FSND subplots were cut. On June 29 these two subplots were treated along with completing removal in plots 1 and 2.

Subplots were observed weekly for new growth from cut stumps. Observations of the understory and ground layer species were taken after *L. maackii* shrubs were removed.

New shoots that emerged from the stumps were counted and measured for each stump in each subplot. Analysis was performed with ANOVA (Microsoft Excel) to determine whether the mean value for the number of stems per stump and the longest stem per stump varied significantly across treatment types. Each subplot treatment was analyzed using a t-test (Microsoft Excel) to determine whether CON subplots had a higher mean number of new stems per stump and higher mean value for longest new growth stem than all other subplot treatments. T-tests were used to determine whether FSND subplots had significantly higher means for new stems per stump and tallest new growth stem than both of the same day treatments (FSI and HSI).

Figure 1. Configuration of subplots and treatment dates.

			5 CON 6/27	5 FSI 6/27	4 CON 6/27	4 FSI 6/27
			5 HSI 6/27	5 FSND 6/27,28	4 HSI 6/27	4 FSND 6/27,28
	1 CON 6/29	1 FSI 6/29	2 CON 6/29	2 FSI 6/29	3 CON 6/27	3 FSI 6/27
2 HIS 6/28,29	1 HSI 6/29	1 FSND 6/28,29	2 HSI 6/29	No treat- ment	3 HSI 6/27	3 FSND 6/27,28

Results

New growth from stumps occurred during the third week after cutting. At that time, new growth occurred in four CON plots and three FSND plots. In the FSND plots, it was apparent that the stumps were missed when glyphosate application occurred. Residue from the blue dye used in the glyphosate solution was not present on these stumps. Resprouting was not seen in subplot 4CON and blue dye residue was apparent on stumps that were mistakenly treated. On stumps that resprouts did occur, the buds or stems were opposite from the bark. The new growth was light green and growing upward from the top, sides, and basal area of stumps.

For the mean number of stems per stump in plots, ANOVA analysis showed that there was a significant difference between the four treatments ($F_{3, 16} = 3.82$ with $p = 0.03$). T-test analysis was performed between CON versus all other treatments and between FSND and all other treatments (Table 1). T-tests were not performed for FSI versus HSI because no growth occurred in either treatment. The CON subplots had a significantly greater number of new stems per stump than all other treatments, and the null hypothesis was rejected. A significant difference was found between the numbers of stems per stump in the CON subplots than in all other treatment subplots. There is no significant difference between the stumps in the FSND subplots and any other treatments. The null hypothesis failed to be rejected. No new growth was expected in the FSI and HSI subplots, and the null hypothesis failed to be rejected in consequence.

For the mean longest stem per stump, ANOVA analysis showed that there was a significant difference between the four treatments ($F_{3, 6} = 6.04$ with $p = 0.0059$). T-tests were done to determine where the difference occurred (Table 2). The same pairs were tested as those tested for mean number of stems per stump. One-tail P-values were assessed because CON subplots showed more growth and more sprouts than all other treatments. One-tail P-values were assessed for the FSND subplots which were expected to have more new growth than FSI and HSI subplots. For mean longest stem per shrub, there is a significant difference between growth in the CON and all other subplots. There is no significant difference between growth in the FSND and all other subplots.

Figure 2. Initial mean number of shrubs per subplot treatment.

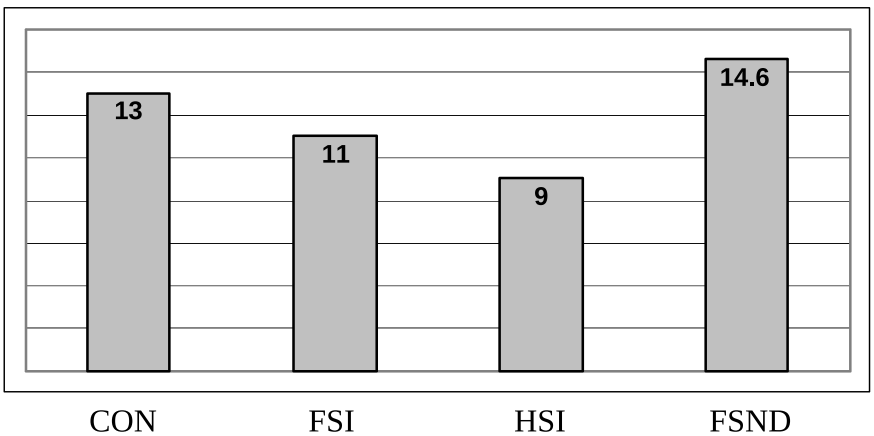

Table 1. Results for mean number of new stems counted per stump.

		T- stats			P-values (T<=t) one-tail		
Treatment	mean	FSI	HSI	FSND	FSI	HIS	FSND
CON	6.394	3.725	3.725	-0.53771	0.01019	0.01019	0.309649
FSND	8.3	-2.044	-2.044		0.055224	0.055224	
FSI	0						
HIS	0						

Table 2. Results for longest measured stem per stump (cm).

		T- stats			P-values (T<=t) one-tail		
treatment	mean	FSI	HSI	FSND	FSI	HSI	FSND
CON	6.925	3.408	3.408	1.207	0.013539	0.013539	0.146974
FSND	4.7	-2.38	-2.38		0.037871	0.037871	
FSI	0						
HIS	0						

Discussion

Effective treatments for removing *L. maackii* at LREC include cutting the stems and applying either full or half strength glyphosate immediately to the stump. Error occurred in the FSND treatment. In three out of five subplots, shrubs were cut but missed herbicide treatment during application. The dense cover of wintercreeper made stumps hard to find the next day. Control plots showed glyphosate application was essential to prevent the cut stumps from resprouting within three weeks.

Simulating a natural forest response to tree falls can be done by removing a dominant invader in an area (Luken *et al.* 1997). Forming gaps rather that clear-cutting the shrub layer is beneficial to the native flora and fauna. The flush of *L. maackii* seedlings in the gap can be controlled with foliar spraying, prescribed burn, or hand pulling (Batcher and Stiles 2000). There is a large area of LREC woodland that remains essentially unused for education programs. Removing the invasive plant species is a step to restore beautiful woodland to be used as outdoor classroom space. Eradicating Amur honeysuckle is an essential first step in the restoration, because removal allows managers access to the area for controlling other invaders and planting with desirable natives. Completion of a plan to remove all the invaders in the study area will change the system and allow native species to thrive. Once vegetation in the area can support fauna, another gap can be created in the woodland area east of Deer Creek. This process can be repeated until the woodland supports a diverse native flora. The management process, forest succession, and ecological impacts can be studied by students. Future generations would then be left with beautifully restored woodland to study forest system ecology.

Sources

Batcher MS and Stiles SA. 2000. Element Stewardship Abstract for *Lonicera maackii* (Rupr.) Maxim (Amur honeysuckle) (*Lonicera morrowii* A. Gray (Morrow's honeysuckle) *Lonicera tatarica* L. (Tatarian honeysuckle) *Lonicera x bella Zabel* (Bell's honeysuckle). The Nature Conservancy. URL: http://tncweeds.ucdavis.edu/esadocs. Last modified 8/2000.

Cronk QCB and Fuller JL. 1995. Plant Invaders; The threat to natural ecosystems. Chapman & Hall. London, UK.

Dirr M.A. 1999. Manual of Woody Landscape Plants 5th ed. Stipes Publishing. Champaign, IL. p 580.

Donlan CJ and Martin PS. 2003. Role of Ecological History in Invasive Species Management and Conservation. Conservation Biology 18 (1): 267-269.

Gorchov DL and Trisel DE. 2003. Competitive effects of the invasive shrub, *Lonicera maackii* (Rupr.) Herder (Caprifoliaceae), on the growth and survival of native tree seedlings. Plant Ecology 166: 13-24.

Hartman KM and McCarthy BC. 2004. Restoration of a Forest Understory After the Removal of an Invasive Shrub, Amur Honeysuckle (*Lonicera maackii*). Restoration Ecology 12 (2); 154-165.

Kurz D. 1997. Shrubs and Woody Vines of Missouri. Conservation Commission of the State of Missouri. pp 146-147.

Luken JO and Mattimiro DT. 1991. Habitat-Specific Resilience of the Invasive Shrub Amur Honeysuckle (*Lonicera maackii*) during repeated clipping. Ecological Applications 1(1): 104-109.

Luken JO, Kuddes LM, and Tholemeier TC. 1997. Response of Understory Species to Gap Formation and Soil Disturbance in *Lonicera maackii* Thickets. Restoration Ecology 5 (3): 229-235.

Miller KE and Gorchov DL. 2004. The invasive shrub, *Lonicera maackii*, reduces growth and fecundity of perennial forest herbs. Oecologia 139: 359-375.

Myers JH and Bazely DR. 2003. Ecology and Control of Introduced Plants. Cambridge University Press, Cambridge, UK.

Ochs C. 1993. An Ecological Survey of the Litzsinger Road Ecology Center, 1992. URL: http://www.litzsinger.org/research/ochs.pdf.

Schmidt KA and Whelan CJ. 1999. Effects of Exotic *Lonicera* and *Rhamnus* on Songbird Nest Predation. Conservation Biology 13 (6): 1502-1506.

Vegetation Management Guideline for Bush Honeysuckles: Morrow's and Amur Honeysuckle (*Lonicera morrowii* Gray and *L. maackii* (Rupr.) Maxim). 2005. Conservation Commission of Missouri.
URL: http://mdc.mo.gov/nathis/exotic/vegman/six.htm. Last modified 9/ 2004

Zavaleta ES, Hobbs RJ, and Mooney HA. 2001. Viewing invasive species removal in a whole-ecosystem context. Trends in Ecology & Evolution 16 (8): 454-459.