Does Topography Affect the Colonization of *Lonicera maackii* and *Ligustrum vulgare* in a Forested Glen in Southwestern Ohio?[1]

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Abstract. *Lonicera maackii* (Amur honeysuckle) and *Ligustrum vulgare* (Common privet) are two exotic shrubs that have naturalized throughout the eastern and midwestern United States. This study examines the influence of topography on the level of invasion of *Lonicera maackii* and *Ligustrum vulgare* in a second growth forested glen in southwestern Ohio (Glen Helen, Yellow Springs, OH). The topographic positions compared were east-facing slope, bottomland, and west-facing slope using twelve 100 m transects through each of the three habitats for a total of 36 transects. *L. maackii* and *L. vulgare* plants were counted in ten 3 × 3 m quadrats along each transect for a total of 120 quadrats per topographic position.

Two-way analysis of variance compared interaction between topography and numbers of plants in three size classes (small, medium, large). Average density of *L. maackii* for all size classes was 1136 plants/ha. East-facing slopes were most heavily invaded with 497 plants/ha; there were 238/ha in the bottomland; 401/ha on the west-facing slopes. East- facing slopes are close to town, one of the original sources of seed. West-facing slopes are surrounded by farmland, fence rows, and farmhouses, a second source of seed. West-facing slopes have significantly fewer large *L. maackii* and *L. vulgare* than east-facing slopes but it may only be a matter of time until they are as heavily colonized as the east-facing. For now, the native species of the bottomland are able to compete successfully against *L. maackii*. Without management, however, colonization of *L. maackii* in the bottomland may progress. *L. vulgare*, overall, is not as invasive in this woodland setting as *L. maackii*.

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INTRODUCTION

One of the main threats to biodiversity in the world is the human-caused disturbance and destruction of natural habitats. This alteration of ecosystems opens plant communities to invasion by exotic, non-native species (Baker 1986; Crawley 1986; Hobbs 1989; Hobbs and Huenneke 1992). Invasion is a natural biological process that has occurred throughout evolutionary time; recent human population growth however, has accelerated this process (Mooney and Drake 1989; Huenneke 1997; Woods 1997; Becher 1998).

Invasive plants produce significant changes in the structure, composition, and functioning of the ecosystems they invade (Bazzaz 1986; Vitousek 1986, 1990; Cronk and Fuller 1995; Woods 1997). Human introduction of plants has been going on for hundreds of years and continues to accelerate. While many of these species are not invasive, and some, in fact, are quite desirable from a horticultural viewpoint, a number of introduced plants have become naturalized and are replacing native plant species in forested ecosystems (Mack 1985; Woods 1993; Hutchinson and Vankat 1997, 1998).

Lonicera maackii has become the dominant shrub in many forests and open areas in Ohio and adjacent states (Luken 1988; Luken and Goessling 1995; Luken and Thieret 1996; Hutchinson and Vankat 1997). The story of *Lonicera maackii* is similar to that of other Eurasian deciduous shrubs; the bush honeysuckles, *Lonicera maackii, L. morrowii* (Morrow Honeysuckle), *L. tatarica* (Tatarian honeysuckle), the buckthorns, *Rhamnus frangula* (Glossy buckthorn) and *R. cathartica* (European buckthorn), *Elaeagnus umbellata* (Autumn Olive), and *Rosa multiflora* (Multiflora rose) were originally introduced for their floral, fruit, and foliage displays and subsequently became invasive problems (Luken and Thieret 1996).

Patterns of invasion and colonization have generally been examined at broad regional scales (Baker 1986; Luken and Thieret 1996; Nuzzo 1993). Two studies have examined patterns of invasion and colonization in individual stands (Deering and Vankat 1999; Brothers and Spingarn 1992). The primary objective of our research was to test the hypothesis that density of the invasive shrubs *Lonicera maackii* (Amur honeysuckle) and *Ligustrum vulgare* (Common privet) is topographically dependent. We hypothesized that the level of invasion would be greater on the east-facing slopes compared to the west-facing slopes. In Glen Helen the ravine is well defined with good forest cover. We also tested whether Amur honeysuckle and privet have lower densities in the bottomland, presumably due to competition from a well established native plant community (Rejmanek 1989) and to continuous canopy cover. We compared the overall densities of Amur honeysuckle and Common privet with each other.

METHODS

Site Description

The research was conducted in Glen Helen, a 400 ha (1000 acre) nature preserve located in Miami Township in the north central part of Greene County, OH, adjacent to the town of Yellow Springs (Fig. 1). The study area is

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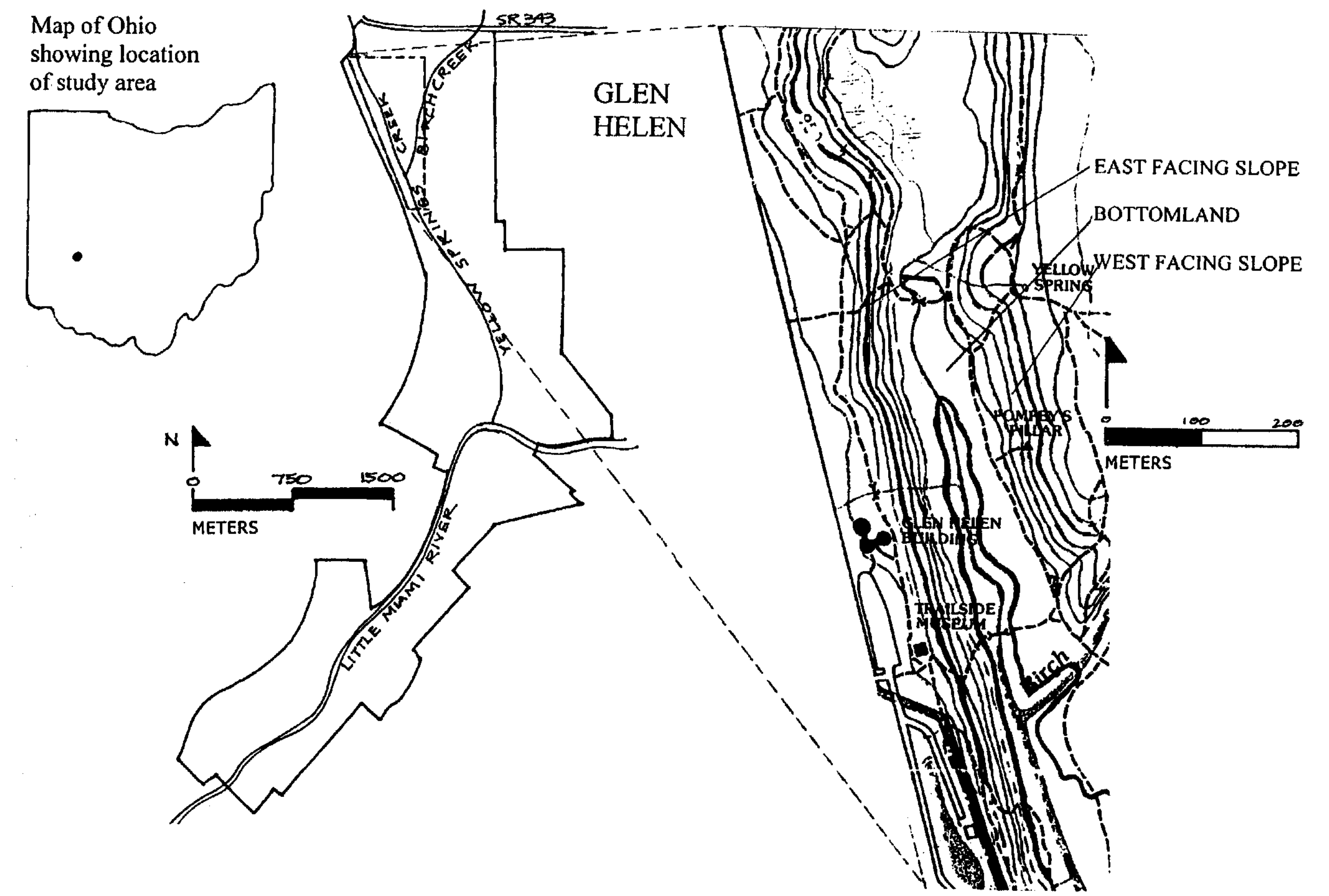

FIGURE 1. Map of study area in Glen Helen, Yellow Springs, OH. Topography section shows topographic positions.

in the North Glen, an area of mixed mesophytic forest (Anliot 1973). Elevations in the uplands above the study area are 290 m (950 ft) above msl (mean sea level). Bottomland or valley floor elevations are 273 m (900 ft) (Anliot 1973).

The valleys of Glen Helen are enclosed by limestone cliffs and talus slopes. These are the result of the Wisconsin ice sheet, which advanced and retreated a number of times over southwestern Ohio, the last glacier having left this area about 16,000 years ago (Anliot 1973). The gorges of the Little Miami River, Yellow Springs Creek, and Birch Creek follow these carved valleys, cutting their channels into the glacial deposits (Anliot 1973).

The orientation of the Glen is 20° west of north. The Yellow Springs Creek runs south, making the valley slopes predominantly either east- or west-facing. Birch Creek, a tributary of Yellow Springs Creek, runs southwest into Yellow Springs Creek approximately 100 m southeast of Trailside Museum. The bottomland or valley floor is 75 to 100 m (about 500 ft) wide in the study area (Fig. 1). The principal soils developed under forest vegetation and are well-drained loam over calcareous till. The talus slopes are mostly lithosols (Anliot 1973).

Vegetation of the Study Site

In the Glen, the vegetation of the forested uplands is primarily oak-sugar maple. The Glen contains one of the best remaining examples of oak-sugar maple forest in Ohio (Anliot 1973). Chinquapin oak (*Quercus muhlenbergii*) is the major canopy dominant. Some of the largest of these trees are 250 years old. Chinquapin oak is typically found on calcareous soils and appears to reach its maximum development on limestone outcrops. Red oaks (*Quercus rubra*) are next in importance. Other canopy trees include hickories (*Carya* spp.), sugar maple (*Acer saccharum*), and, occasionally, black oak (*Quercus velutina*). Prior to the 1900s, grazing and some selective logging took place in some of the upland areas (Anliot 1973).

On the east- and west-facing talus slopes, typical trees are basswood (*Tilia americana*), sugar maple, slippery elm (*Ulmus rubra*), chinquapin oak, red oak, hornbeam (*Carpinus caroliniana*), white ash (*Fraxinus americana*), green ash (*Fraxinus pennsylvanica*), black walnut (*Juglans nigra*), and tulip poplar (*Liriodendron tulipifera*). Sugar maple is predominant. Also found are redbud (*Cercis canadensis*), hackberry (*Celtis occidentalis*), and black cherry (*Prunus serotina*). Blackhaw viburnum (*Viburnum prunifolium*), wild hydrangea (*Hydrangea arborescens*), and spicebush (*Lindera benzoin*) are common shrubs.

On the floodplains, the willow (*Salix* spp.) – cottonwood (*Populus deltoides*) – sycamore (*Platanus occidentalis*) community is dominant along the larger waterways. Bur oak (*Quercus macrocarpa*), silver maple (*Acer *saccharinum*), black walnut, Ohio buckeye (*Aesculus glabra*), and black maple (*Acer saccharum* subsp. *nigrum*) also occur in the bottomlands. Common shrubs or small trees are box-elder (*Acer negundo*), spicebush, prickly-ash (*Xanthoxylum americanum*), bladdernut (*Staphylea trifolia*), wafer-ash (*Ptelea trifoliata*), and pawpaw (*Asimina triloba*) (Anliot 1973; Case and others 1999).

In Glen Helen, the steepness of the talus slopes prevented them from being cultivated or easily timbered. More important for the preservation of the glen, however, are its scenic features including cascades and many springs, the most famous being the Yellow Spring, so called for its high iron content that stains the limestone around the spring a deep yellow-orange (Anliot 1973; pers. obs.).

Brief History of Glen Helen

As the town of Yellow Springs developed, Glen Helen also developed, and over the years, Yellow Springs Creek was dammed to create a lake (now filled in with trees due to the broken dam), and a hotel and several spas were built in Glen Helen. All are gone now.

Given more than two centuries of human impact in the Glen (Leuba 1972), it is not surprising that Anliot (1973) found a number of herbaceous and woody exotics naturalized or adventive in the Glen and adjacent John Bryan State Park. He listed 188 species out of the 872 in his survey (22%) for the entire 770 hectares (1900 acres) that were not native to Ohio. *Lonicera maackii* was not listed in Anliot's 1960-62 survey as being present in Glen Helen at all. He noted it only as "rare in the fields in John Bryan State Park" (Anliot 1973, p 118). He lists *Ligustrum vulgare* as "frequent in moist disturbed woods" (Anliot 1973, p 102).

Field Work

During the summer of 1999, we ran twelve 100 m transects through each of three distinct topographic positions, east-facing slopes, bottomland, and west-facing slopes, for a total of 36 transects. We counted all *Lonicera maackii* and *Ligustrum vulgare* plants in ten 3 × 3 m quadrats equally spaced along each transect. This made a total of 120 quadrats per habitat. Within each quadrat, we counted the two species in three size classes: small (less than 1 m tall, age 1-2 years), medium (1-3 m tall, age 3-5 years), and large (over 3 m tall, age 6-30 years). In the field, we used size (height) as the determining factor. Age was estimated, based on clipping stems and roots and counting rings of two plants per size class before we began setting up our quadrats.

Transects on the east-facing slopes were parallel to each other and to the cliff walls. The westernmost transect was at the base of the east-facing limestone wall. Parallel transects were then run across the slopes, across the bottomlands, and across the west-facing slopes to the top of the west-facing limestone walls. The northern end of the first transect (it was on an east-facing slope) began approximately 75 m south of the old dam and the southernmost transect ended about 500 m south of the Trailside Museum. All slope transects were on the talus slopes below the east- and west-facing vertical cliffs and overhangs. Bottomland transects were run through the floodplains of Yellow Springs Creek and Birch Creek. Transects on the west facing slopes ran either parallel to Birch Creek or parallel to Yellow Springs Creek. The combined area of the sample plots was 3240 m^2 or 0.32 ha (Fig. 1).

RESULTS

Statistical analysis was by two-way analysis of variance (ANOVA) with the sources of variation being (a) topography (east-facing slopes, bottomland, and west-facing slopes) and (b) size class (small, medium, large). Transect means were used in these analyses. Density values were converted from # plants/area sampled (90 m^2 for each transect) to # plants/ha.

Total density of *L. maackii* on the east-facing slopes was 497 plants/ha, 238/ha in the bottomland transects, and 401/ha on the west-facing slopes. The total density of *L. maackii* for all size classes was 1136 plants/ha (Table 1).

TABLE 1

Mean density of Lonicera maackii *(Amur honeysuckle) per hectare. Density was converted from # plants/area sampled (90 m^2 per transect). Means are presented (± 1 SE).*

Topography	Small* (1-2 yr)	Medium* (3-5 yr)	Large* (6-35 yr)
East facing slope	620 (212)	407 (75)	463 (128)
Bottomland	250 (90)	315 (114)	148 (65)
West facing slope	694 (209)	315 (100)	194 (58)

*Small = <1 m tall; Medium = 1-3 m tall; Large = >3 m tall.

Mean density of *Lonicera maackii* plants in different age classes was significantly different among transect areas, as was the effect of topography on density. However, there was no significant interaction of topography and age class. Comparison among transect density means results in $LSD_{.05} = 0.036$, $MSR_{.05} = 0.058$, and $P = 0.049$. LSD is the Least Square Difference; MSR is the Minimum Significant Range (Table 2).

For *Ligustrum vulgare*, mean density is significantly different among transect areas, as was the effect of topography on density. For *L. vulgare* also, there was no significant interaction of topography and age class. Comparison among transect density means for *Ligustrum vulgare*: $LSD_{.05} = 0.0628$, $MSR_{.05} = 0.1003$, and $P < 0.01$ (Table 3).

DISCUSSION

Comparisons of Density of *Lonicera maackii* between Topographic Positions

The numbers of *L. maackii* on the west-facing slopes show a normal trend, a reverse J-curve, for a colonizing

TABLE 2

Two-way analysis of variance for Lonicera maackii *using transect density means.*

ANOVA Source of Variation	df	MS	F	P-value
Age class	2	61.88	3.11	0.05
Topography	2	60.57	3.05	0.05
Interaction	4	22.13	1.11	0.35
Within	99	19.88		
Total	107			

species: high numbers of small plants aged 1-2 years (694/ha), half as many medium 3-5 years old (315/ha), and much fewer large 6-35 years old (194/ha) (Table 1).

The east-facing slope also follows the trend for a colonizing species, with 620/ha small shrubs and 407/ha medium sized shrubs. However, there are more large shrubs than expected (463/ha). This could be a reflection of relative age, as *L. maackii* came from town (from the west) down onto these east-facing slopes before it began to move in from the farm fields and houses (from the east). The only significant difference in overall density of *L. maackii* between the east- and west-facing slopes is in the large size class. The east-facing slope has 463 large shrubs/ha while the west-facing slope has only 194/ha (Table 1).

For both small and large size classes, two-way ANOVA showed significant differences in the density of *L. maackii* between the bottomland and the slopes. Fewer *L. maackii* in both small and large size classes were in the bottomland (250 small/ha and 147 large/ha) than on both the east-facing slopes (640 small plants/ha and 463 large plants/ha) and west-facing slopes (694 small/ha and 194 large/ha). Native species in the bottomland are holding their own against *Lonicera maackii* for now. Continuous canopy cover and distance from seed source may be other factors in keeping numbers of *Lonicera maackii* in the bottomland down.

Numbers of medium sized plants of *Lonicera maackii*, 1-3 m tall, aged 3-5 years, did not differ significantly with topography (Table 1).

TABLE 3

Two-way analysis of variance for Ligustrum vulgare *using transect density means.*

ANOVA Source of Variation	df	MS	F	P-value
Age class	2	313.86	5.26	<0.01
Topography	2	561.91	9.42	<0.01
Interaction	4	81.68	1.37	0.25
Within	99	59.67		
Total	107			

Density of *Lonicera maackii* in Glen Helen Compared to a Woodlot Near Oxford, Ohio

In a 1.2 ha woodlot near Oxford, OH, Hutchinson and Vankat (1998) found *L. maackii* at 2586 plants/ha. Their oldest shrubs were 17 years. 89.2% of their shrubs were 1-5 years old, 9.3% were 6-10 year old shrubs, and older shrubs were only 1.5%. In Glen Helen, where counting technique was the same, small individuals (1-2 years old) made up 46% of the census, medium sized individuals (aged 3-5 years) were 30%, and large individuals (over 6 years old) were 24%. Grouping the 6-10 year and older shrubs together, Deering and Vankat (1999) got 10.8%. This compares to 24% large sized (6-35 year old) shrubs in Glen Helen.

Colonization of *L. maackii* in Glen Helen probably began in the mid 1960s. Though the Glen Helen colony is about twice the age of the *L. maackii* colony in the Oxford woodlot (35 years:17 years), there are only about 50% more *L. maackii* plants in Glen Helen. It may be inferred that because the Glen Helen colony consists of more medium and large *L. maackii* than the Oxford woodlot, the rate of increase in the Glen Helen population has slowed.

Comparison of Density of *Ligustrum vulgare* between Topographic Positions

The distribution of *Ligustrum vulgare* in the Glen also reflects the trend of an establishing species. In all three topographic positions, small plants are numerous. There are fewer medium, and very few large shrubs. Far fewer small (1-2 yrs. old) privet were on the east-facing slope (259/ha) than on the west-facing slope (1269/ha) or in the bottomland (1037/ha) (Table 4). This may be due to the extreme rockiness of the east-facing slope. Even though the west-facing slope is characterized as a talus slope, in fact it is less rocky than the east-facing slope, and less steep overall, with a slightly deeper soil profile. Another factor in the lower numbers of small privet on the east-facing slope may be competition from the dense shade of the large *L. maackii.*

West-facing slopes and bottomland have about half as many medium-sized privet plants as small privet plants. East-facing slopes have approximately one-third as many medium sized plants as small plants. There are only 83 medium-sized *L. vulgare*/ha on the east-facing slopes compared to 602/ha on the west-facing slopes and 713/ha in the bottomland.

Over all three topographic positions, the number of large plants of privet is very small, especially compared to the high numbers of small plants. Ramets and genets were counted in small privet plants. A genet is the whole plant that has arisen from a seed; a ramet is a clonally produced part of a plant with its own roots and potentially independent existence. Only 28 large privet plants/ha were on the east-facing slopes, 148/ha in the bottomland, and 19/ha on the west-facing slopes. The

TABLE 4

Mean density of Ligustrum vulgare *(Common privet) per hectare. Density was converted from # individuals/area sampled (90 m² per transect). Means are presented (± 1 SE).*

Topography	Small* (1-3 yr)	Medium* (4-6 yr)	Large* (7-16 yr)
East facing slope	259 (139)	83 (28)	28 (15)
Bottomland	1037 (515)	602 (196)	148 (60)
West facing slope	1269 (251)	713 (240)	19 (12)

*Small = <1 m tall; Medium = 1-3 m tall; Large = >3 m tall.

deep shade of the forest may prevent *Ligustrum vulgare* from reaching its normal height and width.

CONCLUSION

Level of Invasion of *Lonicera maackii* on East-facing Slopes Compared to West-facing Slopes

The east-facing slopes are heavily invaded by *L. maackii*. The density of large size *L. maackii* on the east-facing slopes far exceeds that of the west-facing slopes (463/ha compared to 194/ha on the west-facing slopes). We believe that this is largely due to a combination of topography and proximity of the east-facing slopes to the town of Yellow Springs, one of the earliest sources of seed.

Our hypothesis that the difference in success of colonization (density) is due to topography alone is debatable. The only current measure of the lower level of invasion on the west facing slopes is the lower numbers of older plants of both *Lonicera maackii* and *Ligustrum vulgare*. It could be argued that it may be only a matter of time (assuming lack of management) before the west-facing slopes are as heavily colonized with *Lonicera maackii* as those facing east. The high numbers of juvenile *L. maackii* on the west-facing slopes may become the future high numbers of large *L. maackii*.

Lonicera maackii in the Bottomland

There are fewer *L. maackii* in the bottomland than either slope for two reasons. The first is that the native plant understory there is relatively dense with large stands of pawpaws and many other native shrubs. "Wet habitats do not provide open space for invaders because of fast growth and high competitiveness of resident species" (Rejmanek 1989). Also, the forest canopy is intact. We believe, however, that without management, the honeysuckle will, over time, become more predominant in the bottomland. Thousands of seedlings occur along the sunny banks of the Yellow Springs Creek. The narrower, far shadier Birch Creek has none. However, if a significant treefall were to occur, creating an opening in the canopy cover, in the bottomland area near Birch Creek, the conditions would be favorable for more honeysuckle to become established and for the honeysuckle that is already there to spread and grow more quickly. However, for the time being, due to the deep shade and existing plant community, *L. maackii* is suppressed in the bottomlands.

In the watershed of Yellow Springs Creek, honeysuckle is generally spreading from west to east. As treefalls occur, new invasions are establishing over a patchy area through the bottomlands and up the west-facing slopes. Some areas in the Glen, in the bottomlands, on the west-facing slopes, and in the uplands, are far enough away from the town to the west and the fence rows of the farm fields to the east to be still relatively free of *Lonicera maackii*. We encourage active management of small new invasions in these areas.

Level of Invasion of *Ligustrum vulgare*

Significantly fewer privet in all sizes classes are on the east-facing slopes than on the bottomland or west-facing slopes. This could be due to the rockier conditions of the east-facing slopes. It may also be partially due to competition from the high density of the large *L. maackii* on the east-facing slopes.

In the case of *Ligustrum vulgare*, our hypothesis that colonization would be more successful on the east-facing slopes than on the west-facing is not supported. The level of invasion was actually higher on the west-facing than on the east-facing slopes, except for the large size class, which is so small on both slopes as to be negligible.

Our observations and counts do not reflect Haragan's (Randall and Marinelli 1996) description of privet as "extremely aggressive," forming "dense, impenetrable thickets that crowd out more desirable plants." In Glen Helen, many native spring wildflowers and summer perennials growing among stands of privet, especially in the moist seeps which privet seems to prefer, were observed.

L. vulgare has been in the woods longer than *L. maackii*. Anliot lists it in his 1960-62 survey as "frequent in moist disturbed woods" (Anliot 1973). The 1960 *Encyclopedia of Gardening* describes *Ligustrum vulgare* as a "native of the Mediterranean region that has become naturalized in the Eastern United States" (Everett 1960). Though naturalized, we observed that *L. vulgare* in the woods of Glen Helen is a far smaller plant than *L. maackii*. A 2.4 m (8 ft) tall *L. vulgare* for example is only about 1 m (3 ft) wide. The 30 cm (1 ft) *L. vulgare* juveniles have no branching at all. A *L. maackii* shrub at 2.4 m (8 ft) tall is at least 2.4 m wide even in the shade. A 30 cm (1 ft) *L. maackii* plant is also about 30 cm across. Overall, we believe that the deep shade of the forested environment keeps privet small. Also due to the shade, even in seeps where it is tall, *L. vulgare* is still not broad.

From the lack of vigor of all privet we observed on the west-facing slopes, we believe dryness and deep shade are the controlling factors inhibiting the colonization of privet. The very few privet on the west-facing slopes that grow above 1.5 m (5 ft) are scrawny and struggling. Those on the east-facing slopes generally stay

1.5 m or less, due to competition from *L. maackii* or from native shrubs. Though privet will continue to colonize, we believe it will be found primarily in moist areas and never become the problem *Lonicera maackii* is.

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