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1995

Seedling Distribution and Potential Persistence of the Exotic Shrub *Lonicera maackii* in Fragmented Forests

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ABSTRACT.—Successful invasion of eastern deciduous forests by the exotic shrub *Lonicera maackii* (Rupr.) Maxim. is well-documented, but little is known about seed germination or seedling establishment in this species. Our research suggested that most seeds are dispersed in a nondormant condition. After 88 days, mean cumulative germination percentages of untreated seeds ranged from 54–81% in light and from 31–55% in dark. Seedling density and light availability declined in parallel along transects extending from forest edges to forest interiors. Mean seedling densities ranged from 5–328 seedlings/m². Gap formation in forest interiors was not as conducive to seedling establishment as was the presence of edges. Still, this invasive shrub can establish seedlings throughout a wide range of light environments in fragmented forests.

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INTRODUCTION

Invasion of forests by exotic trees and shrubs is well-documented in many geographic areas (Myers, 1983; Luken, 1988; Harrington *et al.*, 1989; Huenneke and Vitousek, 1990; Woods, 1993). Because most of these biological invasions are relatively recent there is little information on long-term population trends. Determining whether an exotic woody plant is transient or persistent requires information on regeneration potential (*see*, for example, Chilvers and Burdon, 1983; Huenneke and Vitousek, 1990).

For native shrubs persisting in the forest understory, there are well-established relationships between canopy disturbance and demography of either stems or seedlings. A number of native shrubs show increased stem density, lateral extension, and growth in the event of a canopy gap (Ehrenfeld, 1980; Huenneke, 1983; Tappeiner and Alaback, 1989; Dickinson *et al.*, 1993). Others express light-stimulated seed germination (Hughes and Fahey, 1991). The large variety of regeneration mechanisms leading to long-term persistence of shrubs suggests a lengthy history of natural selection in the light-limited forest understory (Canham and Marks, 1985).

We studied seed germination and seedling distribution of the exotic shrub *Lonicera maackii* (Rupr.) Maxim. (Caprifoliaceae) within the discrete boundaries of fragmented forests. *Lonicera maackii* is an upright, deciduous, multi-stemmed shrub native to northeastern Asia. It was introduced to North America as a potential landscape species (Dirr, 1983). Since then, the species has naturalized and assumed a dominant position in a large variety of plant communities growing on calcareous soils. Throughout a region bounded by southern Ontario, Illinois, Tennessee and the New England states (Pringle, 1973; Luken, 1988), disturbed plant communities in or near urban areas are most commonly invaded by this shrub. *Lonicera maackii* has high potential for long-term persistence in forests as a result of annual stem release from the shrub base (Luken, 1988). However, root sprouts do not generally

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15

grid. The scale of measurement corresponded to the largest light flecks found on the forest floor.

Seedling response to shrub removal.—Seedling densities were measured in artificially created canopy gaps in an effort to assess how seedling establishment responds to shrub death. In June 1990, 20 circular plots (28.3 m²) were established in the interior of a forest patch. These plots were centered on sugar maple trees as part of a larger study to assess the effects of shrub removal on tree growth. In 10 of these plots, all adult *Lonicera maackii* shrubs were cut at the tops of the shrub base and biomass was piled outside the plots. All *Lonicera maackii* seedlings were pulled from these plots. *Lonicera maackii* shrubs and seedlings were not disturbed in the remaining 10 plots. In May 1993, all plots were relocated and adult *Lonicera maackii* shrubs, *L. maackii* seedlings and tree seedlings were counted.

RESULTS

Seed germination.—In warm moist conditions with light, seeds began to germinate in 18 days; germination was delayed in the dark but was not completely inhibited (Fig. 1). After 88 days, mean cumulative germination percentages ranged from 53.7–81.3% in light and from 31.3–55.0% in dark. Seeds in light had significantly ($n = 6$, paired t test, $P < 0.01$) higher germination than seeds in dark. Inhibition of germination did occur in the dark as indicated by the numbers of seeds germinating after petri dishes were removed from the aluminum foil and allowed to sit on the laboratory bench (Fig. 1). There were no significant differences in the final cumulative germination percentages between open-grown and forest-grown seeds for a particular light treatment ($n = 3$, rank sum test, $P < 0.05$).

Seedling distribution.—Mean *Lonicera maackii* seedling densities along the transects increased from 5–328 seedlings/m² from interiors to forest edges (Fig. 2B). The trend in seedling density along transects (Fig. 2) was closely associated with the trend in PPFD ($r = 0.88$, $n = 10$, $P < 0.001$).

Counts of seedlings in the forest interior in September indicated a density range of 0–11 seedlings/m² and mean density = 3/m², $SE = 0.4$. A McGinnies index of 1.88 indicated a slight tendency toward aggregated distribution (McGinnies, 1934), although quadrat-level densities were low and did not approach densities measured within 6 m of forest edges.

Seedling response to shrub removal.—Three yr after shrubs were clipped and seedlings pulled, seedling density in removal plots was $\bar{x} = 18$, $SE = 7$ seedlings/m² vs. $\bar{x} = 8$, $SE = 2$ seedlings/m² in reference plots. A rank sum test ($n = 10$) indicated no significant ($P > 0.05$) effects of shrub removal on *Lonicera maackii* seedling density. There was no significant ($P > 0.05$) relationship between *Lonicera maackii* seedling density and adult shrub density ($r = -0.47$ for removal plots and $r = 0.09$ for reference plots, $n = 10$). Neither was there a significant ($P > 0.05$) relationship between *Lonicera maackii* seedling density and tree seedling density ($r = 0.04$ for removal plots and $r = 0.58$ for reference plots). Densities in removal plots did not approach densities measured within 6 m of forest edges.

DISCUSSION

Canham and Marks (1985) identified three classes of seed storage and germination in woody plants. *Lonicera maackii* would best be placed in the class characterized by minimal delay between dispersal and germination and a lack of persistent seed bank. Most seeds of *Lonicera maackii* do not have well-developed dormancy mechanisms, and some seeds have been observed germinating during warm wet periods in winter after dispersal is complete (Luken, pers observ). In addition, seed banks are not persistent as indicated by long-term shrub removal experiments (Luken and Mattimiro, 1991). Although *Lonicera maackii* fruits are eaten by birds in late winter when more preferred food sources are exhausted (Ingold

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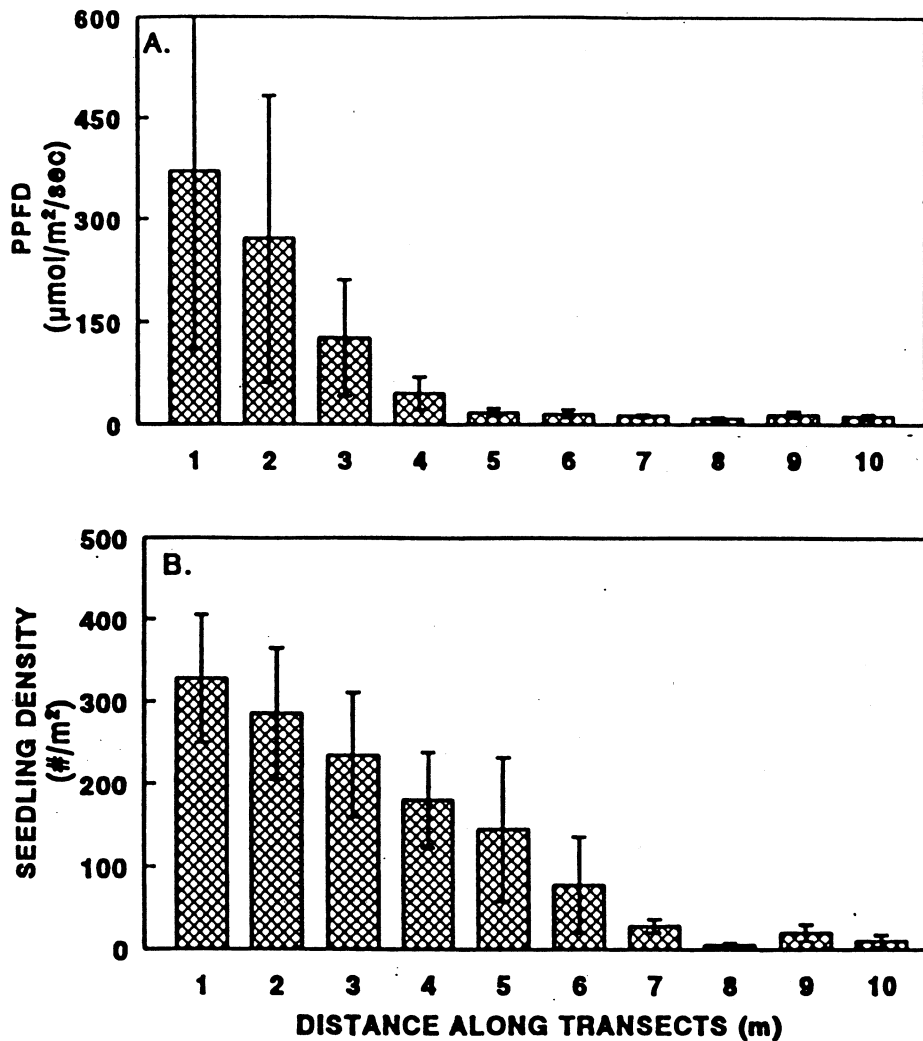


FIG. 2.—Trends in photosynthetic photon flux density (A) and *Lonicera maackii* seedling density (B) along transects extending from forest edges to forest interiors. Means are presented with standard errors, n = 4

grown than forest-grown shrubs (Luken and Mattimiro, 1991). Thus it is likely that seed inputs are also greater in the forest edge as compared to the forest interior. Alternatively, low light conditions or the spectral quality of light in the forest interior may limit seed germination through physiological effects on the embryo or secondary dormancy (Baskin and Baskin, 1989). Previous research on highly disturbed, fragmented forests suggests that forest edges are conducive to seedling establishment of several tree species (Luken *et al.*, 1992) and a number of exotic plants (Brothers and Spingarn, 1992). Such edges also are conducive to regeneration of this exotic shrub.

Light levels in forest interiors beneath both shrub and tree canopies can be reduced to 1% of full sun. Under these conditions seedling establishment occurs to the extent that minimum mean seedling densities exceed mean adult shrub densities by a factor of six. Contagious distribution of these seedlings may be related to micro-site effects (Tappeiner and Alaback, 1989) or to clumped patterns of seed input (Hughes and Fahey, 1991). The ability of these suppressed seedlings to survive and eventually replace adult shrubs may depend on one or more of the following traits: shade tolerance and growth responses to

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SUBMITTED 14 FEBRUARY 1994

ACCEPTED 7 SEPTEMBER 1994

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