Invasive Plant Species Abundance along Forest Edges in Northwestern Pennsylvania

A report submitted to the Erie National Wildlife Refuge
and the Foundation for Sustainable Forests

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7 September 2020

Allegheny College Department of Environmental Science and Sustainability Publication 2020–2.

Citation: Brown, J., M. McCampbell, A. Adesiji, C. Aldana, D. Antinozzi, A. Arden, H. Baker, L. Benko, R. Bower, B. Capron, I. Chick, A. Fernandez, N. Ferreira, L. Kellett, J. Lovullo, E. Melanfant, E. McNamara, J. Raphael, E. Shanabrook, A. Spiro, A. Terasavage, A. Tolmachoff, E. Vallejo, Z. Wilson, R.D. Bowden. 2020. Invasive plant species abundance along forest edges in northwestern Pennsylvania. Allegheny College Department of Environmental Science and Sustainability Publication 2020-2.

Abstract

Forest edges often serve as entryways for invasive plants to move into forest interiors. This study examined the abundance of the four common invasive plants - multiflora rose, Japanese barberry, native wild grapevine, and honeysuckle - from forest edges into the interior of forests in northwestern Pennsylvania. We counted stem density in transects extending 50 m or 100 m from the forest edge into the intact forest in four forest sites in northwestern Pennsylvania. Multiflora rose and grapevine had significantly higher stem density than barberry or honeysuckle; multiflora rose was found in 8.3 to 54.4% of plots, and grapevine was found in 0.0 to 12.7% of the plots among the four sites. There were no or only weak as no or only weak correlations between the distance from forest edges and stem density. It is likely that since their introduction, they have spread throughout the distance represented by our transects, thus resulting in the lack of an edge effect over a relatively short distance.

Keywords: Invasive plants, Forest management, Multiflora rose, Japanese barberry, Honeysuckle, Grapevine, The Bail Family Forest, Moxie Woods, Foundation for Sustainable Forests, Erie National Wildlife Refuge.

Introduction

Invasive species are defined as alien or non-native organisms whose introduction causes economic or environmental harm (Beck et al. 2008). Invasive plants can cause ecological disruption (Pejchar and Mooney 2009), economic loss (Pimental et al. 2000, 2005), and human health concerns (Mazza et al. 2014). Non-native invasive plants are usually introduced through transportation of ornamental plants or seeds (Lehan et al. 2013), as well as for environmental or social reasons (Food and Agriculture Organization 2015). Whether introduced intentionally or unintentionally, there are negative consequences of invasive plant introduction. Invasive plants alter vegetation composition and community structure by outcompeting native species, reducing biodiversity, and altering the plant species composition (Hejda et al. 2009; Stinson et al. 2006). Invasives can change ecosystem functions by altering geomorphology, hydrology, soil microbiology, biogeochemistry, fire regimes, animal abundance and diversity, and productivity (Gordon 1998, Dukes and Mooney 2004, Ehrenfeld 2003, Jo et al. 2017, Kourtev et al. 2003, Schimel et al. 2016).

In northwestern Pennsylvania, some of the most abundant invasive plants are multiflora rose (*Multiflora rosa),* Japanese barberry (*Berberis thunbergii*), and honeysuckle (*Lonicera japonica*). Although not technically considered to be an invasive plant because it is a native species, wild grape (*Vitus* spp.) is considered to be invasive especially when land use alters light availability that leads to large populations of grapevines. All four of these plants have the ability to outcompete surrounding vegetation by spreading easily, growing quickly, and surviving in low-light environments (Kurtz and Hansen 2013, Dukes and Mooney 2004). Multiflora rose was first introduced to the eastern U.S. in 1866 and has been promoted for erosion control, use as a living fence (Steavenson 1946), rootstock for ornamental roses (Mays and Kok 1988), and crash and snow barriers (Kurtz and Hansen 2013). It often forms dense thickets that restrict the growth of native plants and reduces light and nutrient availability for native plant species (Kurtz and Hansen 2013). Honeysuckle and barberry, native to Asia, were introduced for domestic cultivation. Both can rapidly invade native habitats (Abbey 2017, 2019, Munger 2002) and honeysuckle can inhibit the growth of native plants by altering nutrient cycling (McEwan et al. 2012). Wild grape is found extensively throughout the U.S. (USDA-NRCS 2020) and is valued as a food source for wildlife. When grapevines grow into the forest canopy, they can damage tree branches, especially when laden with ice or snow, break branches due to their weight, and reduce photosynthesis by shading available sunlight (Lenox 2013).

Invasive plants often thrive in disturbed areas where sunlight has become readily available (Thuiller et al. 2006). They can be introduced by animals or by humans traversing trails, roads, or forest edges; invasive plants can thrive in forest edges (Meeker and McCarthy 2001), and abundance is positively correlated to the proximity of forest trails (Mortensen et al. 2009). When invasive plants are transported into disturbed areas, they often establish themselves quickly by growing rapidly in the available sunlight and outcompeting native species, frequently creating near monocultures. This tendency requires that forest management needs to consider invasive plant populations, as well as management efforts that may increase light to the forest floor. In areas slated for logging or trail clearing, for example, the response of invasive plants to increased sunlight must be considered so that successful forest regeneration can be ensured. Without such consideration, invasive plants may outcompete native plants and tree seedlings for available sunlight.

Forest land is often managed for a variety of purposes, including wildlife management, timber production, biodiversity, and aesthetic reasons (Campbell and Brown 2012, DeFries et al. 2007). To effectively implement forest management plans, information about the abundance and type of invasives present in the forest sites must be known. Without such knowledge, forest management objectives may be compromised. The purpose of this project was two two-fold. First, we sought to determine the abundance of multiflora rose, Japanese barberry, grapevines, and honeysuckle at two forests managed for long-term sustainable forestry by the Foundation for Sustainable Forests, and at the Erie National Wildlife Refuge, which manages forests for wildlife diversity. Second, we specifically investigated whether invasive plants were more abundant near forest edges or trails and how the abundance of invasive species changed as we moved toward the interior of the forest.

Methods

We worked in three temperate deciduous forest sites in northwestern Pennsylvania (Fig. 1). The Bail Family Forest and Moxie Woods are owned privately by the Foundation for Sustainable Forests (https://www.foundationforsustainableforests.org/) and had been harvested within the last three decades. The third forest is at the Erie National Wildlife (ENWR) Refuge, where two separate forest sites were investigated. The Bail Forest and Moxie Woods are publicly accessible, and are managed for long-term sustainably-harvested timber. The ENWR is publicly owned and managed for biodiversity and wildlife habitat by the United States Fish and Wildlife Service. The average annual precipitation of the region is 112.5 cm and the average annual temperature is 8.7^{o}C (U.S. Climate Data 2020). Precipitation is relatively evenly distributed throughout the year, and the region has an approximate four-month growing season and approximately four months of snow cover. All four sites have a history of agricultural use, with evidence of plowed and unplowed soils. Soils at the four sites are silt loams. Forests are temperate, mixed central hardwoods.

At each site, the abundance of invasives was measured in the fall of 2017 using transects extending from the forest edge and extending into the intact forest. Transects at ENWR and Moxie Woods were 100 m deep and 2 m wide. The ENWR-1 transects began at a former agricultural field. ENWR-2 bordered a gravel road. The Bail and Moxie Woods transects extended into the forest interior from logging access roads. At the Bail Family Forest, transects were 50 m x 2 m. Some transects at Bail were less than 50 m long if another trail interfered with the ability to place a full transect. In these cases, transect lengths were half the distance between the forest edge and the intersecting trail. Seven transects were established at each site.

Transects were established to be representative of conditions at each site. At ENWR, the sites were selected to represent low (ENWR 1) and high (ENWR 2) density conditions of invasives. In the transects, we counted the number and type of invasive at one-meter intervals along the length of the transect as we moved away from the forest edge. Individual stems counted as single plants; where there were clusters of stems or vines arising from a common location, the cluster was counted as a single entry.

Species and site comparisons were analyzed using ANOVA; differences among sites or species were evaluated using Tukey's multiple comparison tests (SigmaPlot ver. 12.5).

Results

Multiflora rose was the most abundant invasive plant species (Table 1) and differed significantly in density among the four sites ($p<0.004$). Plant density ranged more than 10-fold among sites (from 0.105 ± 0.034 stems m^{-2} at ENWR 1 to 1.158 ± 0.339 stems m^{-2} at ENWR 2. Grapevines were the next most common plant, followed by honeysuckle and barberry. Grapevines also differed significantly among sites ($p<0.001$); Bail had more grapevines than ENWR 1 and Moxie ($P<0.005$). Barberry and honeysuckle were not abundant at the sites.

Within sites, the density of each invasive varied greatly (Fig 2). For example, at ENWR 2, multiflora rose ranged from 0.00 ± 0.00 to 2.93 ± 1.51 stems m^{-2}. Similarly, grapevine density ranged from 0.00 to 0.58 stems m^{-2}.

In addition to having the highest stem density, multiflora rose at ENWR 2 occupied a substantial portion of the plots, with 54 % of plots containing rose (Table 2). Grapevine was most common at Bail, with 12.7% of plots containing grapevines. Honeysuckle and Japanese Barberry were not abundant, and were most common at Moxie Woods, with 0.2% of plots containing stems.

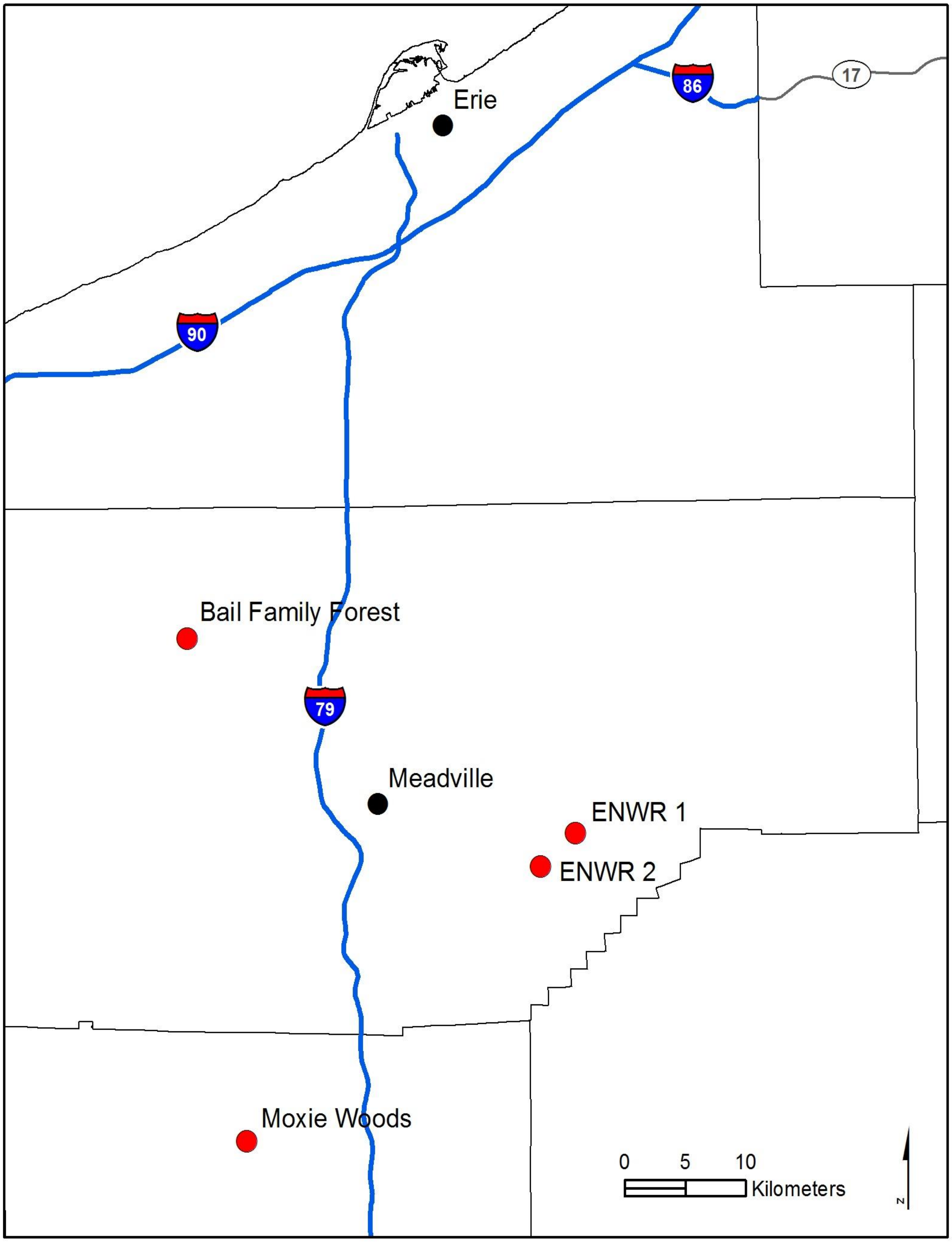


Fig. 1. Locations of invasive plants study sites in northwestern Pennsylvania. (ENWR: Erie National Wildlife Refuge).

Table 1. Density (mean ±SE) of invasive plant species at forest sites in northwestern Pennsylvania.

	Plants m^{-2}			
	Bail	Moxie	ENWR 1	ENWR 2
Multiflora Rose	0.157 (0.075)	0.617 (0.191)	0.105 (0.034)	1.158 (0.339)
Japanese Barberry	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.013 (0.013)
Honeysuckle	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)	0.000 (0.000)
Grapevine	0.095 (0.042)	0.002 (0.002)	0.000 (0.000)	0.005 (0.003)

Table 2. Percent of forest plots at each site in northwestern Pennsylvania containing invasive plants.

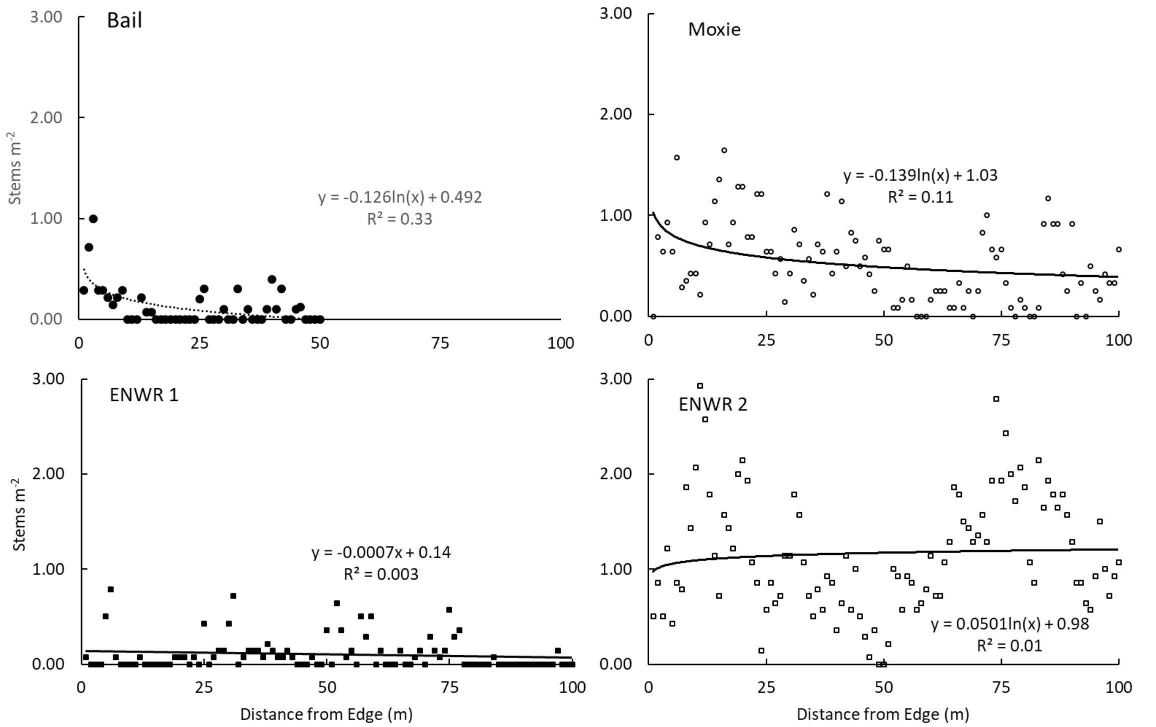
	% of plots occupied by invasive species			
Plant	Bail	Moxie	ENWR 1	ENWR 2
Multiflora Rose	11.9	35.3	8.3	54.4
Barberry	0.0	0.2	0.0	0.2
Honeysuckle	0.0	0.2	0.0	0.0
Grapevine	12.7	0.5	0.0	0.9

There was no correlation between plant abundance and proximity to forest edges (Fig. 2) for any of the species at any of the sites. Most r^2 values ranged from < 0.001 to 0.33 (Fig. 2). Transect data did not display any clear pattern of abundance. In some cases (e.g. multiflora rose at Moxie Woods), plant density was relatively uniform across the site. In other cases (multiflora rose at ENWR-2) some areas along the transects showed densities nearly twice those of the site mean. Barberry was most abundant nearer the edge at ENWR-2, but at the same site, the highest grapevine densities occurred farthest from the edge.

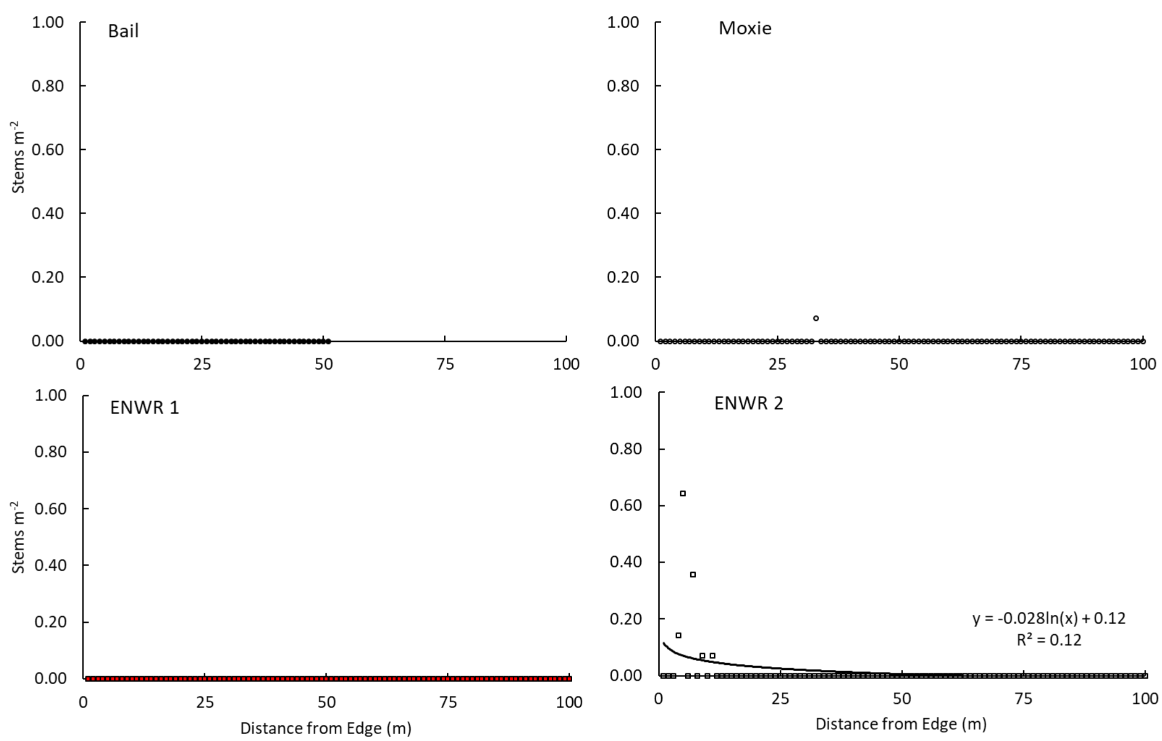
Discussion

The abundance of multiflora rose is likely linked to active and intentional planting, its ability to survive in shaded conditions, and its propensity to spread rapidly. Multiflora rose grows best in full sunlight but can also survive well in the shade of the forest interior, which allows it to flourish in the intact forest. All four of our sites had essentially full canopy closure in the overstory, yet we found that plants were distributed relatively uniformly throughout each site. Multiflora rose is a prolific seed producer, with small, rounded seed-containing fruits that animals eat and spread to other areas of the forest in their excrement. Each shrub is capable of producing up to 1 million seeds per year that remain viable for up to 20 years (USDA Forest Service 2006). Thus, through active transport of seeds by animals, this plant is likely spread extensively throughout the forest interior. Each stem is also able to root where it touches the ground (a process known as layering) that results in a new plant (Steavenson 1946), also enhancing its spread.

Multiflora rose



Japanese Barberry



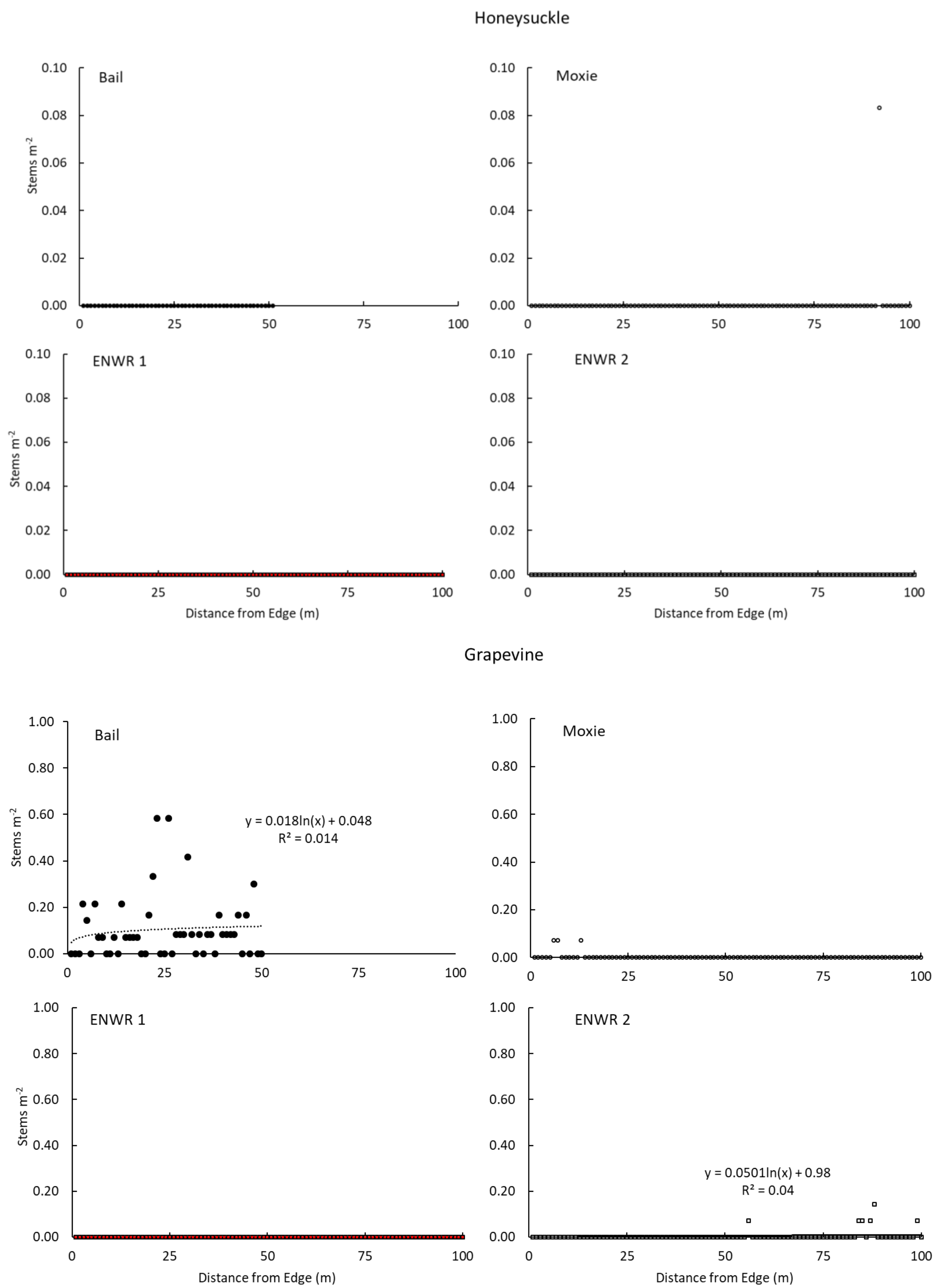


Fig. 2. Invasive species abundance versus distance from forest edge at four northwestern PA sites (note differences in y-axis scale among species).

Grapevines were most prominent at the Bail Family forest, and seemed to be most abundant in areas that were canopy gaps. This would align with the recent logging history of this site. Bail forest was also heavily logged in the past. In addition to creating skid trails, logging creates canopy gaps that provide intolerant invasive plants with increased amounts of sunlight that contributes to rapid growth (Woods 1989, Padmanaba and Sheil 2014). As an intolerant species, grapevine responds rapidly to canopy gaps (Smith and Lamson 1986), and thus if not controlled, can rapidly exploit forest openings. It is possible that grapevines were not controlled after the last harvest, and due to their ability to grow rapidly in open areas, grape plants that existed in the understory prior to forest harvest had light conditions favorable for growth into the overstory.

Honeysuckle and barberry presently do not constitute a large concern at these sites. Barberry was found only at ENWR 2, which among the four sites, was closest to an active local gravel road. We did not determine the age of the plants, so we do not know how long the plants had been at the site.

Differences in invasive abundance among the sites may be explained in part by the land use history of each site. The lack of pit and mound topography at ENWR 2 suggests that it was plowed previously for agricultural use and then reverted to forest following agricultural abandonment. Parts of Moxie Forest were also used for agriculture. Past agricultural land-use carries long-term impacts on plant community composition and structure (Bellemare et al. 2002, Mosher et al. 2009). Post-agricultural landscapes often allow invasive species to invade and exert dominance following agricultural abandonment (Glitzenstein et al. 1990).

The lack of a clear relationship between the proximity of edges created by human disturbances and plant abundance contrasts with results found in other studies (e.g. Mortensen et al. 2009, Thuiller et al. 2006). Wind dispersal of seeds is most prevalent at the edge of a forest and declines with distance into the forest interior (Cadenasso and Pickett 2001). Animals, however, can exert influences deeper into the forest by dispersing seeds via excrement or seed attachment (Sakai et al. 2001). All four of the invasive plants that we studied can produce large amounts of seeds, and may well have been distributed uniformly over time throughout our study area. We also note that our transects did not extend deeply in the forest sites, and most forest birds or mammals that would inhabit our sites would not be limited by the distances represented in our transects.

Management Recommendations

Multiflora rose has the highest potential to influence vegetation dynamics in these forests. Typical control methods include excavating plants by the roots, repeated cutting the plants, or herbicide treatments (Johnson et al. 2007, Bish and Bradley 2015). A focused herbicide, such as metsulphuron, is an effective spot control when applied directly to foliage (Derr 1989). However, that would only be effective at the ENWR 1 site and the Bail forest where plant density would render hand treatment a viable option. The ENWR 2 and Moxie sites have too high a density to make spot control feasible. In this case, glyphosate can be applied more broadly with a backpack sprayer. However, with that method, other native plants can often be killed along with the target species. In addition, ENWR 2 and the Bail Family Forest have portions of the site in close proximity to streams; glyphosate can be toxic to aquatic organisms (Annett et al. 2014).

Introduction of rosette disease is an alternative option that is gaining considerable attention (Amrine 1996). Using goats has also been shown to be effective. Browsing by goats in Appalachian forests resulted in drastic reductions in rose cover, height, and stem density (Linginbuhl et al. 1998, 2000). Honeysuckle, though not extensive in our sites, was also reduced dramatically in these studies.

Grapevines may create problems at the Bail Family Forest, and may alter forest regrowth and tree vigor if not controlled. High densities of grapevines can physically damage trees and reduce photosynthesis (Smith 1989). They can be controlled through cutting, herbicides, and silvicultural operations that control light, best accomplished prior to forest harvest (Smith 1989, Trimble and Tryon 1979). No harvest is planned immediately at this site; removal of grapes by cutting stems may be sufficient to reduce the vine population because low light in the understory will reduce regrowth of cut or new vines. If regrowth is halted by low light conditions well in advance of harvest operations, then treatment with herbicides is probably not needed.

Overall, we found a considerable range in the density of invasive plant species that may influence forest growth, regeneration, and plant species diversity among sites. Quantifying plant density is important to determining whether or not control measures, which can be costly and time intensive, are warranted.

Acknowledgements

We appreciate the assistance of Melissa Althouse, Biologist with the US Fish and Wildlife Service, Vicki Muller, Director of the Erie National Wildlife Refuge, Annie Maloney, Director of the Foundation for Sustainable Forests, and Guy Dunkle of Firth Maple Products, in providing valuable guidance for this project. We also thank Chris Shaffer for GIS support.

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