USDA United States Department of Agriculture

An Assessment of Garlic Mustard in Northern U.S. Forests

Research Note NRS-199

This publication is part of a series that provides an overview of the presence of invasive plant species monitored on an extensive systematic network of plots measured by the Forest Inventory and Analysis (FIA) program of the U.S. Forest Service, Northern Research Station (NRS). Each research note features one of the invasive plants monitored on forested plots by FIA in the 24 states of the Midwestern and Northeastern United States.

Background and Characteristics

Garlic mustard (*Alliaria petiolata*) was introduced by settlers for medicinal and culinary use in the 1800s (Czarapata 2005, Kaufman and Kaufman 2007, Rodgers et al. 2008). In eastern North America this aggressive invader has become one of the most rapidly increasing woodland invasive plant species (Welk et al. 2002), spreading across North America and Canada at a rate of nearly 2,500 square miles per year (Rodgers et al. 2008). It is a unique plant invader in that it can grow in low light levels, such as the forest interior (Fig. 1). Garlic mustard prefers alkaline soils and requires ≥19.7 inches of annual rainfall, >120 frost free days, and adequate cold winters (Welk et al. 2002).

Garlic mustard is an allelopathic herb and its dense growth alters light and nutrient availability, affecting seedlings and the mycorrhizal community. In addition to impacting the plant community, the secondary compounds it contains act as defense mechanisms to reduce herbivory. With increased presence of garlic mustard, the rare West Virginia white butterfly (*Pieris virginiensis*) is also affected due to laying its eggs on this invader instead of on toothwort (*Dentaria* spp.), the host plant of the butterfly larvae, thus posing a serious threat to the butterfly (Kaufman and Kaufman 2007, Rodgers et al. 2008).

Figure 1.—Garlic mustard infestation. Photo by Leslie Mehroff, University of Connecticut, Bugwood.org.

Figure 2.—Garlic mustard seedheads. Photo by Chris Evans, Illinois Wildlife Action Plan, Bugwood.org.

Description

Growth: biennial, year 1 forms a basal rosette of kidney shaped leaves with scalloped edges that stay green throughout winter, year 2 plants bolt and can reach several feet tall. Plants yield a distinct garlic scent when crushed.

Reproduction: ¼-inch diameter flowers (white with 4-petals, small) bloom early in the season and turn into skinny capsules (siliques) that contain many seeds (Fig. 2).

Habitat: occurs in pastures, forests, fields, and along roads and waterways.

Control: various biological, chemical, and mechanical methods, such as hand-pulling and cutting to ground level. Repeated treatment is often necessary due to large seed banks (Czarapata 2005, Kaufman and Kaufman 2007).

Range

Garlic mustard is currently found in 36 states and 5 Canadian provinces: British Columbia, New Brunswick, Nova Scotia, Ontario, and Quebec (Fig. 3) (NRCS 2014).

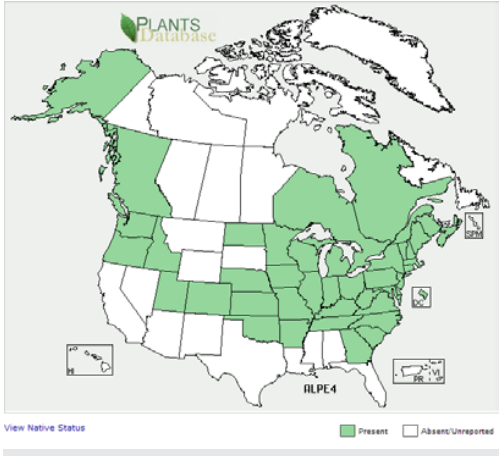

Figure 3.—Garlic mustard presence, U.S. and Canada. (NRCS 2014)

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Garlic Mustard Presence on Phase 2 Invasive Plots

FIA crews visited 7,579 forested Phase 2 (P2) invasive plots across the NRS region between 2008 and 2012. Forty-three invasive plant species (IPS)[1] and one undifferentiated genus (nonnative bush honeysuckles)[2] were monitored. On each of these plots, which were measured in the summer, various attributes were collected including the occurrence and coverage of IPS as well as the standard forest variables measured on P2 plots (e.g., tree diameter, height). Overall, 49.5 percent of forested plots had one or more of the monitored invasives present.

Garlic mustard was the second most commonly observed invasive species, after multiflora rose. Garlic mustard was found on 644 plots (8.5 percent) and found in 18 of the 24 states (Fig. 4). The six states where garlic mustard was not observed on FIA plots were Maine, New Hampshire, North Dakota, Rhode Island, South Dakota, and Vermont. However, garlic mustard has been found in all the NRS states except Rhode Island and South Dakota (NRCS 2014). Seven states had garlic mustard on more than 16 percent of the plots with Ohio having the highest percentage of plots with garlic mustard (29.2 percent). Additional information about the species monitored and county level occurrence maps for the NRS region from 2005 through 2010 can be found in Kurtz 2013.

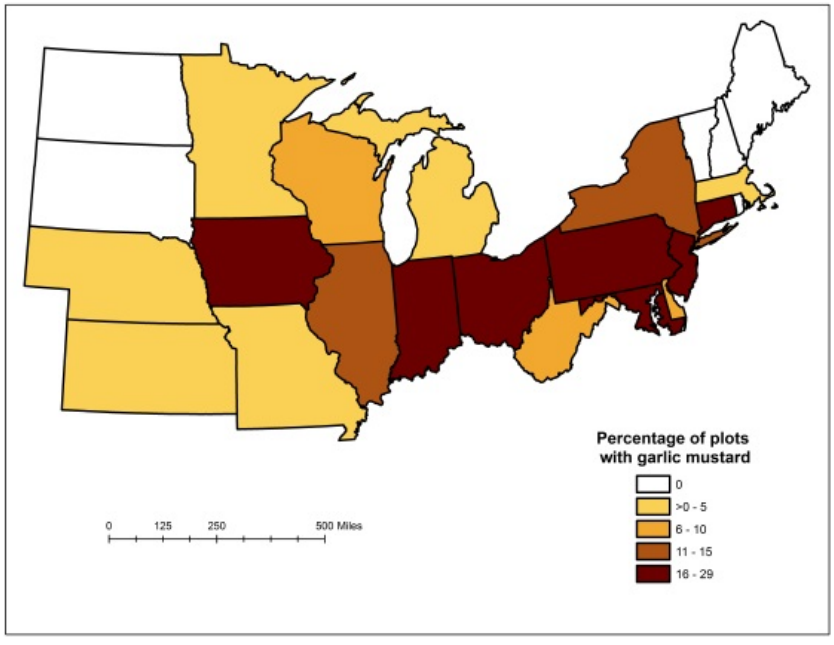

Figure 4.—Inventory reporting area showing percent of Phase 2 Invasive plots with garlic mustard, 2008-2012.

Garlic mustard in flower.
Photo by Chris Evans, Illinois Wildlife Action Plan, Bugwood.org.

[1]Amur honeysuckle (*Lonicera maackii*), autumn olive (*Elaeagnus umbellata*), black locust (*Robinia pseudoacacia*), Bohemian knotweed (*Polygonum xbohemicum*), bull thistle (*Cirsium vulgare*), Canada thistle (*Cirsium arvense*), Chinaberry (*Melia azedarach*), common barberry (*Berberis vulgaris*), common buckthorn (*Rhamnus cathartica*), common reed (*Phragmites australis*), creeping jenny (*Lysimachia nummularia*), dames rocket (*Hesperis matronalis*), English ivy (*Hedera helix*), European cranberrybush (*Viburnum opulus*), European privet (*Ligustrum vulgare*), European swallow-wort (*Cynanchum rossicum*), garlic mustard (*Alliaria petiolata*), giant knotweed (*Polygonum sachalinense*), glossy buckthorn (*Frangula alnus*), Japanese barberry (*Berberis thunbergii*), Japanese honeysuckle (*Lonicera japonica*), Japanese knotweed (*Polygonum cuspidatum*), Japanese meadowsweet (*Spiraea japonica*), leafy spurge *(Euphorbia esula*), Louise's swallow-wort (*Cynanchum louiseae*), Morrow's honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), Nepalese browntop (*Microstegium vimineum*), nonnative bush honeysuckle (*Lonicera* spp.), Norway maple (*Acer platanoides*), Oriental bittersweet (*Celastrus orbiculatus*), princesstree (*Paulownia tomentosa*), punktree (*Melaleuca quinquenervia*), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea*), Russian olive (*Elaeagnus angustifolia*), saltcedar (*Tamarix ramosissima*), showy fly honeysuckle (*Lonicera xbella*), Siberian elm (*Ulmus pumila*), silktree (*Albizia julibrissin*), spotted knapweed (*Centaurea stoebe* L. ssp. *micranthos*), tallow tree (*Triadica sebifera*), Tatarian honeysuckle (*Lonicera tatarica*), tree of heaven (*Ailanthus altissima*)

[2]The 43 IPS and one undifferentiated genus (nonnative bush honeysuckles) are hereafter referred to as "invasive species", "invasive plants", "invasives", or "IPS".

The percentage cover of garlic mustard is shown in two figures: Figure 5 illustrates cover at the state level, and Figure 6 focuses on the plot level. It is important to use caution when looking at overall state averages (Fig. 5) as states with a small number of occurrences are driven by a low number of plots. For states with few observances (e.g., Massachusetts), Figure 6 is more informative since individual plot values can be assessed. These maps, along with Figure 4, reveal important information related to the presence and abundance of garlic mustard in the NRS region. Over time these maps will allow us to assess change and spread.

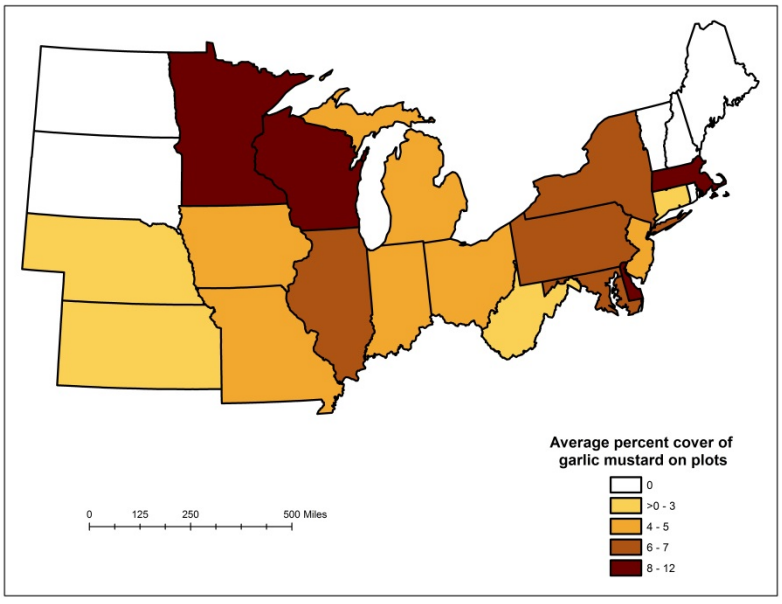

Figure 5.—Average percentage cover[3] of garlic mustard on Phase 2 invasive plots, 2008-2012.

[3]Average percentage coverage is based on subplot data and is calculated for the portion of the plot which is forested. Each FIA plot consists of four circular 1/24-acre subplots located at the corners and center of an equilateral triangle that is 208 feet on a side.

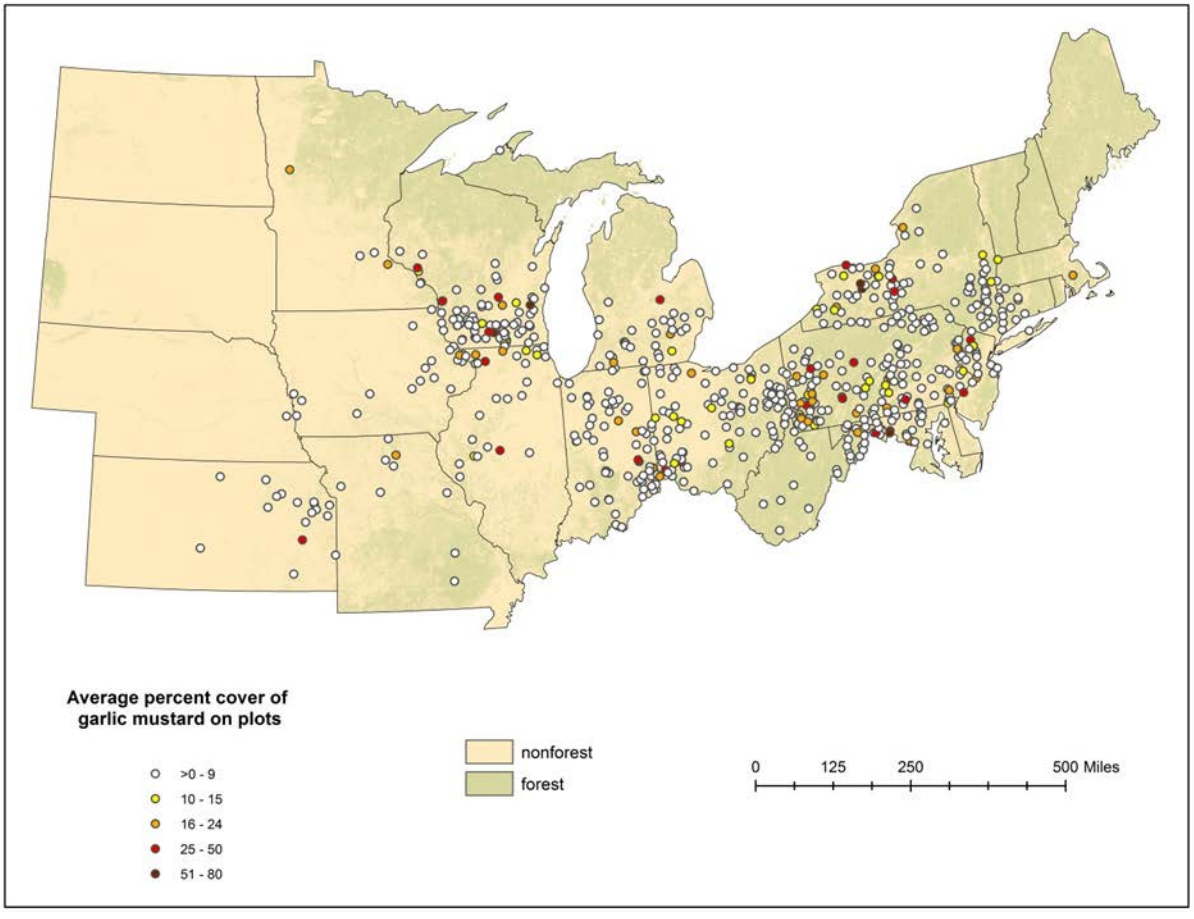

Figure 6.—Average percentage cover of garlic mustard on Phase 2 Invasive plots where it occurred, 2008-2012.

Characteristics of Plots with Garlic Mustard

Garlic mustard was more common on plots near roads. There was a significant difference ($p<0.01$) in the distance to the nearest road for plots with and without garlic mustard (Fig. 7). Roads are a conduit for seed dispersal and alter light and nutrient availability, as well as drainage. Vehicles traveling on roads carry propagules of many exotics, which become dispersed along these roads. Roads have been found to be important vectors for IPS (Kurtz and Hansen 2013, Lundgren et al. 2004, Predick and Turner 2008). Due to the effects of roads and fragmentation, it is important to keep forest land intact.

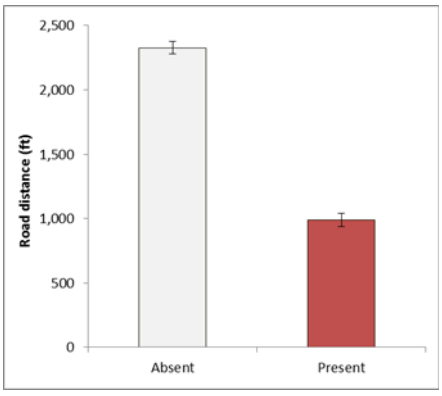

Figure 7. —Average distance to the nearest road for plots with or without garlic mustard, 2008-2012.

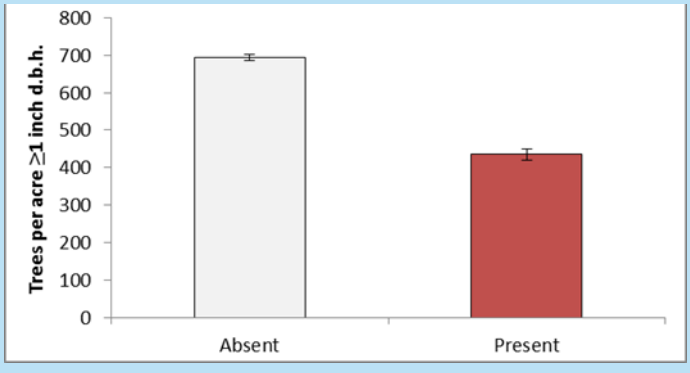

Figure 8.—Trees per acre ≥1 inch d.b.h. with or without garlic mustard.

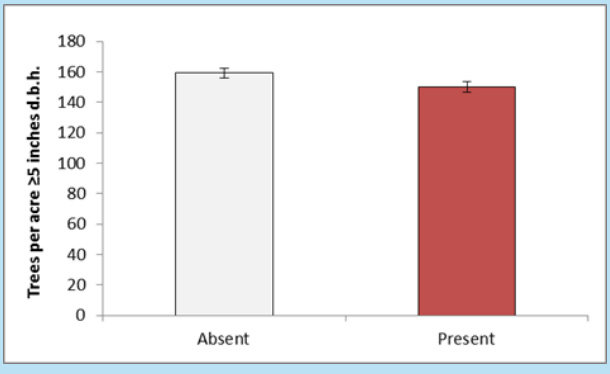

Figure 9.—Trees per acre ≥5 inches d.b.h. with or without garlic mustard.

Tree cover also differs for plots with garlic mustard. The current data (2008-2012) suggest that there were fewer trees per acre ≥1 inch d.b.h. (Fig. 8; $p<0.01$) when garlic mustard was present. However, there was no significant difference in the number of trees per acre in the larger diameter class (Fig. 9). This suggests the difference is in the smaller diameter trees, those with a d.b.h. <5 inches. Since the study has been ongoing for only a short period of time (2007 implementation across all of the NRS region), it is difficult to assess whether the invasive plants are influencing tree regeneration and growth or if the invasive plants are establishing where there is low tree cover and less competition. Continued research on this issue is important because these plants can out-compete native species and without adequate understory regeneration to replace the aging overstory, the future of the forest remains in question. These preliminary investigations suggest there is a difference between plots with and without garlic mustard; future studies will need to be evaluated to determine the effects these species are causing.

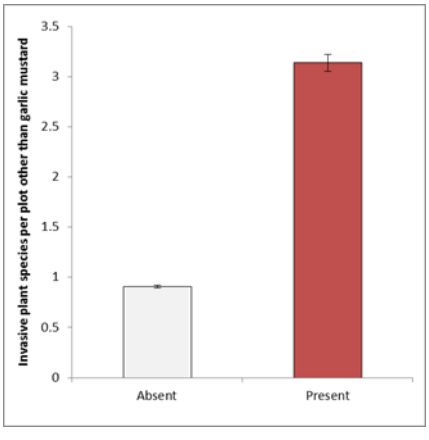

Figure 10.—Number of invasive plant species other than garlic mustard on plots with or without garlic mustard.

Analyzing plots with and without garlic mustard shows that plots without garlic mustard tend to have fewer invasives present than plots with garlic mustard ($p<0.01$; Fig. 10). On average, plots with garlic mustard have two additional IPS present (versus plots without garlic mustard). This may reflect that suitable habitat for this species is also suitable for other invaders.

Monitoring IPS is important to determine status, trends, distribution, and population size, as well as to detect new populations. The trends discussed in this research note are valuable and need to be reported in the future to help elucidate important factors related to the presence of the monitored invasives as well as to find out the impacts these species are causing on biota and ecosystems. This research offers nonbiased data to land managers and other concerned individuals to help understand the implications of these species and to assist in making well-informed management decisions.

*Note: the error bars in figure 7 through 10 show a 68% confidence interval for the observed mean.

Citation for this Publication

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FIA Program Information

Bechtold, W.A.; Patterson, P.L., eds. 2005. **The enhanced Forest Inventory and Analysis Program: national sampling design and estimation procedures**. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.

Smith, W.B. 2002. **Forest inventory and analysis: a national inventory and monitoring program**. Environmental Pollution. 116: 233-242.

U.S. Forest Service. 2012. **Forest inventory and analysis national core field guide, Vol. 1: field data collection procedures for phase 2 plots, ver. 6.0**. Available at www.fia.fs.fed.us/library/field-guides-methods-proc/ (verified 21 Apr 2014).

Other References

Czarapata, E.J. 2005. **Invasive plants of the upper Midwest: an illustrated guide to their identification and control.** Madison, WI: The University of Wisconsin Press. 215 p.

Kaufman, S.R.; Kaufman, W. 2007. **Invasive plants a guide to identification and the impacts and control of common North American species.** Mechanicsburg, PA: Stackpole Books. 458 p.

Kurtz, C.M. 2013. **An assessment of invasive plant species monitored by the Northern Research Station Forest Inventory and Analysis Program, 2005 through 2010**. Gen. Tech. Rep. NRS-109. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 70 p.

Kurtz, C.M.; Hansen, M.H. 2013. **An assessment of multiflora rose in northern U.S. forests**. Res. Note NRS-182. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5 p.

Lundgren, M.R.; Small, C.J.; Dreyer, G.D. 2004. **Influence of land use and site characteristics on invasive plant abundance in the Quinebaug Highlands of southern New England.** Northeastern Naturalist. 11(3): 313-332.

Predick, K.I.; Turner, M.G. 2008. **Landscape configuration and flood frequency influence invasive shrubs in floodplain forests of the Wisconsin River (USA).** Journal of Ecology. 96:91-102.

Rodgers, V.L.; Stinson, K.A. Finzi, A.C. 2008. **Ready or not, garlic mustard is moving in: *Alliaria petiolata* as a member of eastern North American forests.** BioScience. 58(5): 426-436.

Natural Resources Conservation Service. (NRCS). 2014. **The PLANTS database.** Greensboro, NC: U.S. Department of Agriculture, Natural Resources Conservation Service, National Plant Data Team. Available at http://plants.usda.gov (Accessed: 21 Apr 2014).

Welk, E.; Schubert, K.; Hoffmann, M.H. 2002. **Present and potential distribution of invasive garlic mustard (*Alliaria petiolata*) in North America.** Diversity and Distributions. 8: 219-233.

Additional Invasive Plant Information

Alien Plant Invaders of Natural Areas (PCA, National Park Service): http://www.nps.gov/plants/alien/factmain.htm

Invasive and Exotic Plants: http://www.invasive.org/species/weeds.cfm

Invasive Plant Atlas of New England: http://www.eddmaps.org/ipane/

Invasive Plant Atlas of the United States: http://www.invasiveplantatlas.org/index.html

Midwest Invasive Plant Network: http://mipn.org/

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