CHAPTER THREE: PRIORITY INVASIVE PLANT SPECIES

A. Criteria for Selecting High-Priority Invasive Plant Species

Invasive plant species are rapidly transforming ecosystems throughout North America. Ecologists have identified biological invasions as a significant cause of decreasing *biodiversity*—the variation of life forms and functions in an ecosystem—at both local and global scales. The future sustainability of entire ecosystems is now in question, as the combination of global warming, overdevelopment, pollution, and biological invasions will have unpredictable and potentially disastrous effects on biological communities.[1]

The Brodhead Watershed region has experienced incredible human population growth and economic development over the past few decades, coincidental with the establishment of invasive plant species. Therefore, the region is especially vulnerable to swift, and perhaps unforeseen, environmental changes in coming years. We will divide the adverse impacts of invasive plant species, at least those we can foresee, into three categories:

1. **Economic**: Many invasive plant species interfere with the growth of agricultural crops, reducing annual yields and forcing farmers to devote more resources to weed management. Some invasive plants may also promote soil erosion, interfere with water cycles, disrupt landscaping efforts, and even damage paved roads. The cumulative economic costs directly associated with invasive plant species are estimated in the hundreds of millions of dollars every year in the United States.[2]

2. **Ecological**: These impacts are discussed in greater detail above, and include decreasing biodiversity, increasing rates of extinction, and far-reaching effects on ecological webs (such as food chains).

3. **Environmental**: This category clearly relates to ecological impacts, however, it also includes issues of central importance to BWA, such as possible negative effects on water quality, increasing soil erosion and decreasing stream bank stability, changes in ecosystem capacity to process and weather pollution from industry and overdevelopment, and the aesthetic and political devaluation of regional forests and open space.

---

[1] Gurevitch 2004, Dukes and Mooney 1999, Didham 2005, Olden, J. 2004. Ecological and evolutionary consequences of biotic homogenization. *Trends in Ecology & Evolution* 19, no. 1 (1): 18-24.

[2] Pimentel 2004, Weiser 2002, Stutzman 2004, National Invasive Species Information Center 2009.

B. Brodhead Watershed's Regional High-Priority Invasive Plant Species

To designate high-priority invasive plant species in the Brodhead Watershed region, we have considered several factors:

1. **Population Size and Density:** Invasive plant species that are not currently prevalent in the area will be treated as lower priority (See, Table 1). The BWA will continue to monitor these lower-density populations, however, and may in some cases work to remove particularly virulent species before they can expand in the watershed.

2. **Potential Damage:** Some invasive plant species cause more of the economic, ecological, and environmental damages described above than other species. Plants that pose greater threats to the regional economy, ecological communities, and abiotic environment will be given higher priority.

3. **Likelihood of Successful Action:** While some invasive plant species can be removed with relative ease, others have proven very challenging. In order to best use our talents and resources, only those plant populations that we hope to successfully manage will be considered high-priority.

Using this rubric, then, we have designated the priority each species will receive in the management plan as follows:

High Priority: Japanese Knotweed, Multiflora Rose, Japanese Barberry

Medium Priority: Invasive Honeysuckles, Garlic Mustard, Japanese Stiltgrass, Common Reed

Low Priority: Tree of Heaven, Oriental Bittersweet, Russian Olive, Purple Loosestrife, Norway Maple, Spotted Knapweed

The next sections will include information about each of the three high-priority plant species, followed by a brief summary of information on each of the medium-priority plant species. Additional information on all of these invasive plants is available from BWA.[3]

[3] http://www.brodheadwatershed.org/invasivespecies_learnmore.html

C. Multiflora Rose

Multiflora rose, also known as *Rosa multiflora*, is a woody shrub native to Japan, Korea, and parts of China. This plant was probably first introduced to North America in the 1940s by ranchers and farmers who used the plant as a livestock barrier, or "living fence", to replace the less effective native plant, Osage orange (*Maclura pomifera*).[4] Ironically, the very characteristics that appealed to farmers in the 1940s now make multiflora rose an aggressive invasive species. These traits include: arching branches and dense twigs that grow rapidly to as much as eight feet tall, sharp reticulate thorns, temperature hardiness through most of the United States, and large masses of fruit that serve as a food source for birds in winter (thereby quickly spreading with the bird populations). Multiflora rose is now found in almost all of the United States, except for the Rocky Mountain region.

Figure 12. Image of Multiflora Rose from NPS's "Least Wanted" at: http://www.nps.gov/plants/alien/fact/romu1.htm

C1. Multiflora Rose Ecology

In addition to competing for space and resources with native plants, some studies have indicated that multiflora rose has even deeper ecological impacts. For example, many native birds readily eat the fruits of multiflora rose; since multiflora rose's fruits persist through the winter, one study demonstrated that Northern Mockingbirds have been able to extend their winter range north, with cascade effects on the ecosystem.[5] Another study showed that Cedar Waxwings will eat the fruits of multiflora rose instead of the fruits of *Viburnum trilobum*, which relies exclusively on Cedar Waxwings for seed dispersal.[6] Both of these studies serve as clear warnings of the kinds of network-like effects that invasive plant species can have on ecological communities.

In addition to competing for space and resources with native plants, some studies have indicated that multiflora rose has even deeper ecological impacts.

For example, many native birds readily eat the fruits of multiflora rose; since multiflora rose's fruits persist through the winter, one study demonstrated that Northern

---

[4] Steavenson, H. A. 1946. Multiflora Rose for Farm Hedges. *The Journal of Wildlife Management* 10:227- 234.

[5] Stiles 1982.

[6] Drummond 2005; Witmer, M. C. 2001. Nutritional interactions and fruit removal: cedar waxwing consumption of Viburnum opulus fruits in spring. *Ecology* 82, no. 11: 3120–3130.

Mockingbirds have been able to extend their winter range north, with cascade effects on the ecosystem.[7] Another study showed that Cedar Waxwings will eat the fruits of multiflora rose instead of the fruits of *Viburnum trilobum*, which relies exclusively on Cedar Waxwings for seed dispersal.[8] Both of these studies serve as clear warnings of the kinds of network-like effects that invasive plant species can have on ecological communities.

Multiflora rose most successfully invades high-light environments, such as fields and open canopies,[9] and is therefore particularly adept at invading regions with partial deforestation due to construction, logging, fire, disease, flooding, or overgrazing by deer and livestock (See **Figure 13**, below right). Efforts to minimize the invasive success of multiflora rose will thus perfectly complement more broad forest conservationist goals in the Brodhead Watershed.

Figure 13. Multiflora Rose and other invasive plants in lighted area along Paradise Creek in Brodhead watershed

C2. Managing Multiflora Rose

Mechanical removal of multiflora rose is suggested, but care must be taken to avoid injury due to the rose's sharp thorns. Regional efforts have proven effective when stands of multiflora rose are cut to the base, followed by removing the root system,

---

[7] Stiles 1982.

[8] Drummond 2005; Witmer, M. C. 2001. Nutritional interactions and fruit removal: cedar waxwing consumption of Viburnum opulus fruits in spring. *Ecology* 82, no. 11: 3120–3130.

[9] Robertson, D.J., Robertson, M.C. and Tague, T. 1994. Colonization Dynamics Of Four Exotic Plants In A Northern Piedmont Natural Area. *Bull. Tor. Bot. Club* 121:107-118.; Hubner, C.D. 2003. Vulnerability of Oak-Dominated Forests in West Virginia to Invasive Exotic Plants: Temporal and Spatial Patterns of Nine Exotic Species Using Herbarium Records and Land Classification Data. *Castanea* 68:1-14.

although care must be taken to avoid any unnecessary disturbance to neighboring native plants. These removal efforts should be planned in the spring or early summer, before the shrubs develop viable seeds, or else removal efforts may effectively promote the spread of the species.[10]

If labor is unavailable to remove existing stands, the expansion of multiflora rose can be easily controlled by mowing seedlings in the early spring.[11]

Biological control of this species has been widely investigated as a complement to mechanical management methods. A viral rose-rosette disease which rarely spreads to ornamental rose varieties has been suggested by some sources as an optional biological control, but the virus has proven difficult to isolate and characterize, and is thus not yet available for controlled study and use.[12]

An insect, the European rose chalcid wasp, (*Megastigmus aculeatus nigroflavus*), feeds on seeds within the rose hips, and has also been suggested as a means of biological control (Mays & Kok, 1988). Unfortunately, this wasp is not able to reliably overwinter in the Brodhead Watershed region, and thus is not an ideal management tool at this time.

---

[10] Alternatively, if the fruits have turned red (an indication of seed viability), tarps should be laid out near the rose stands during removal and used to collect all plant material. These piles can then be left on an abiotic surface (e.g. asphalt, gravel, stone) and allowed to wilt.

[11] Eckardt, N. 2000. Element Stewardship Abstract for Rosa Multiflora. www.imapinvasives.org/GIST/ESA/esapages/rosamult.html .

[12] Epstein, A. H., Hill, J.H. and Nutter, F.W. Jr. 1997. Augmentation of Rose-Rosette Disease for Biocontrol of Multiflora rose (*R. multiflora*). *Weed Science* 45:172-178; Missouri Botanical Garden. 2009. [Online].www.mobot.org/gardeninghelp/plantfinder/ipm.asp?code=104; Sabanadzovic, S., and N. A Ghanem-Sabanadzovic. 2008. Molecular characterization and detection of a tripartite cryptic virus from rose. *Journal of Plant Pathology* 90, no. 2: 287–293. Note that the virus causing rose-rosette disease has yet to be conclusively identified, and some studies, such as Sabanadzovic 2008, suggest that the virus may be *present* in ornamental roses, but at least currently asymptomatic.

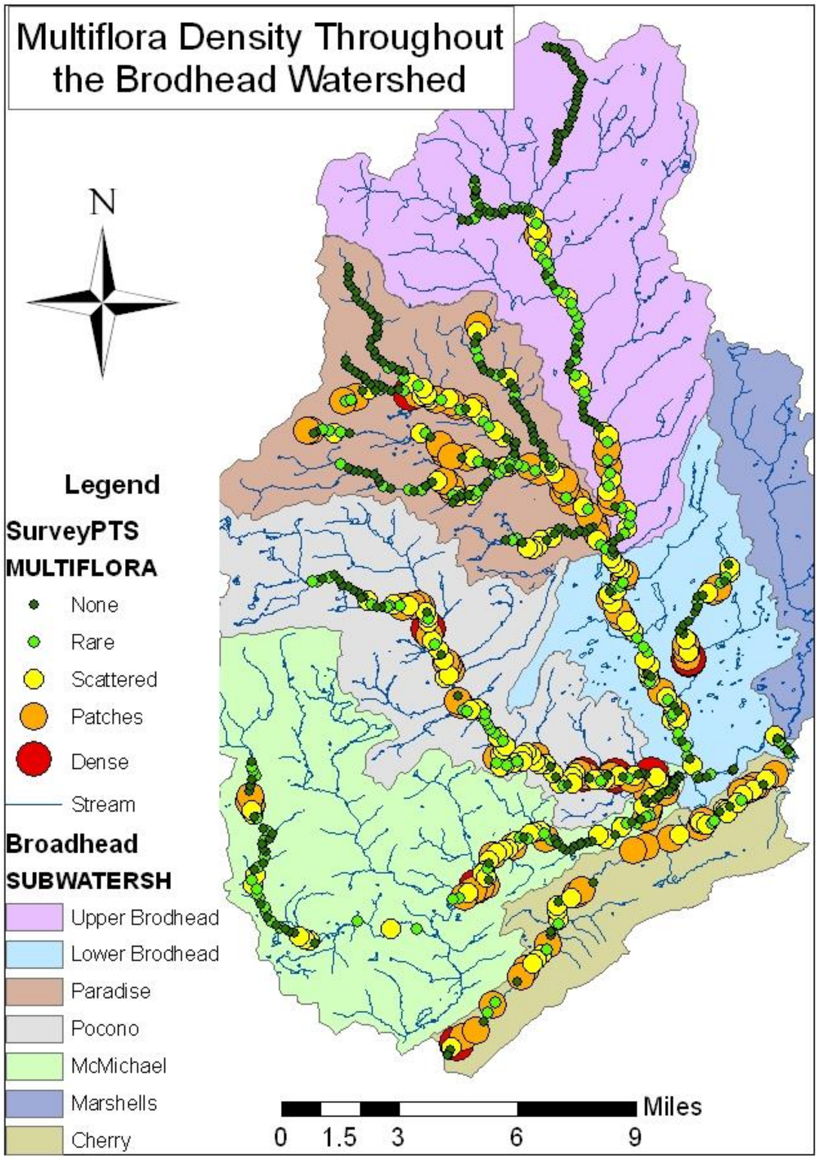


Figure 14. The density of *Rosa multiflora* populations along streams in the Brodhead Watershed.

D. Japanese Barberry

Japanese barberry (*Berberis thunbergii*), native to Asia, is a spiny shrub with clustered simple leaves and yellow wood.[13] Individual plants are typically between three and six feet tall. In this region, Japanese barberry produces leaves in the early spring, followed by pale-yellow six-petaled flowers in April, and finally slightly oblong bright red fruits in August that last through the winter. Some ornamental varieties have also become invasive in the Brodhead Watershed region; their summer foliage ranges from deep purple to a light yellow green. Japanese barberry can grow in many different environments; in New York, New Jersey, and Pennsylvania, it is typically found invading the under-story of deciduous forests.[14] Once Japanese barberry invades, it often forms extensive, virtually pure stands in the under-story, as found in parts of the Brodhead Watershed region (see survey results with a density score of 4). *B. thunbergii* appears to do particularly well in disturbed habitats.[15] Introduced as a deer-resistant ornamental plant, Japanese barberry is currently found from North Carolina and Tennessee north to Nova Scotia and as far west as Montana, with its range continuing to expand.[16]

D. Japanese Barberry

D1. Japanese Barberry Ecology

Once Japanese barberry invades an ecosystem, it can have manifold and complex impacts on the entire ecological community, and promotes changes in soil chemistry, microbial activity, litter composition and thickness, presence of invasive arthropods and earthworms, herbivore and frugivore preferences, and the expansion of other invasive plants.

Figure 15. Japanese Barberry in winter

Turkeys eat the fruits of this plant during the winter, along with *Rosa multiflora* fruits, when their native foods are not available.[17] This likely contributes to the spread of Japanese barberry.[18]

Importantly, recent studies have suggested that blacklegged ticks, which carry Lyme disease and can cause human infection, are more densely populated in stands of Japanese

---

[13] Rhoads, A.F. and Block, T.A. 2007. The Plants of Pennsylvania: An Illustrated Manual, 2nd Edition. University of Pennsylvania Press, Philadelphia. 1042 p.

[14] Ehrenfeld, J.G. 1997. Invasion of deciduous forest preserves in the New York metropolitan region by Japanese barberry (*Berberis thunbergii* D.C.).

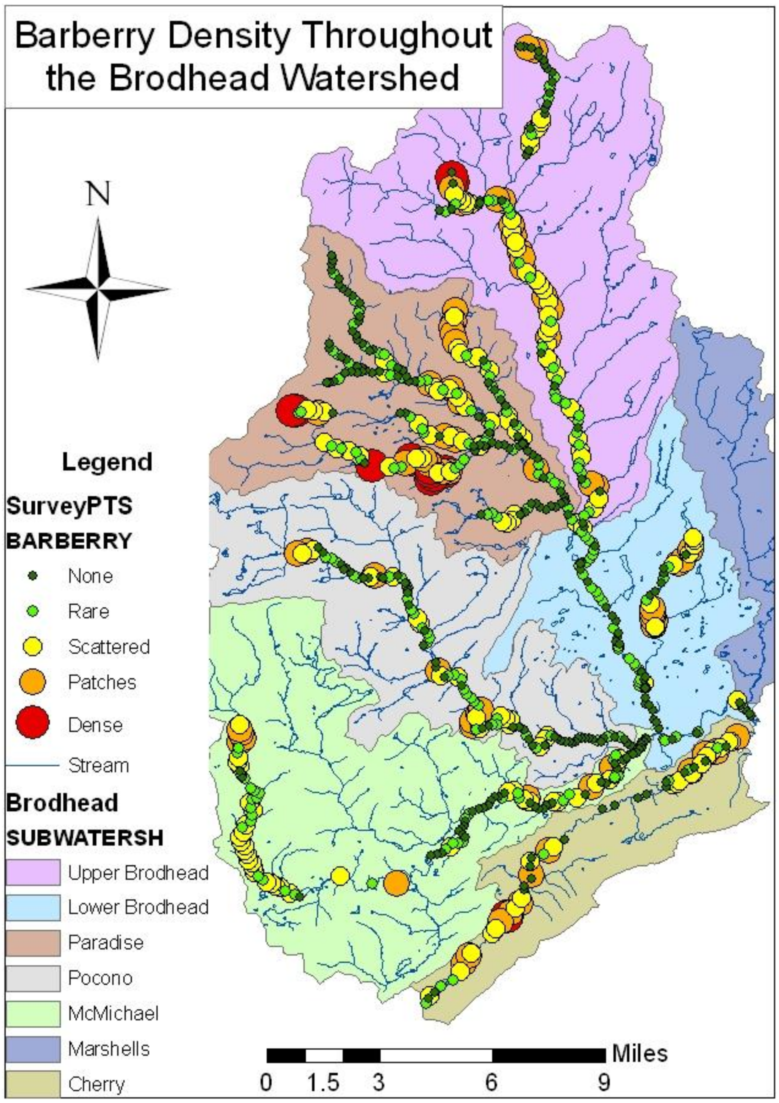
[15] Searcy, K. B., Pucko. C., McClelland, D. 2006. The distribution and habitat preferences of introduced species in the Mount Holyoke Range, Hampshire Co., Massachusetts, *Rhodora.* Vol. 108 (933).

[16] Kaufman, S.R. and Kaufman, W. 2007. Invasive Plants: Guide to Identification and the Impacts and Control of Common North American Species. Stackpole Books. Mechanicsburg, P.A. 458 p.

[17] Vander Haegen, W. M., Dodge, W.E. and Sayre, M. W. 1988. Factors affecting productivity in a Northern wild turkey population. *The Journal of Wildlife Management* 52: 127-133.

[18] Swearingen, J. M. 2009. Japanese Barberry, PCA Plant Conservation Alliance's Alien Plant Working Group, Least Wanted. http://www.nps.gov/plants/alien/fact/beth1.htm

barberry and oriental bittersweet (another invasive found in the Brodhead Watershed region, though considered low priority at this time by BWA). This probably occurs because deer do not typically forage on Japanese barberry stands, allowing the tick populations to grow with minimal disruption.[19]



[19] Elias, S. P., Lubelczyk, C.B., Rand, P. W., Lacombe, E. H., Holman, M.S. and Smith, R. P. Jr. 2006. Deer browse resistant exotic-invasive understory: an indicator of elevated human risk of exposure to *Ixodes scapularis* (Acari: Ixodidae) in Southern Coastal Maine woodlands. J. *Med. Entomol. 46(6):1142-1152.*

Figure 16. The density of *Berberis thunbergii* plants along streams in the Brodhead Watershed.

Exotic European earthworms were found in higher densities beneath *Berberis thunbergii* and *Microstegium vimineum* in forests in 3 parks in New Jersey[20] as well as higher soil pH, available nitrate and net potential nitrification when compared to soils under native blueberries (*Vaccinium* spp). They also concluded that the ecosystem effects may inhibit restoration, primarily due to the high nitrate concentrations in the soil. Exotic earthworms from Asia (*Amynthas hawayanus*) have been shown to significantly increase both carbon and nitrogen flux and significantly decrease the organic matter content of the O horizon in soils.[21]

Studies in mesic hardwood forests in the Chippewa and Chequamegon National Forests, in Minnesota and Wisconsin showed extensive invasion by exotic earthworms (species of *Dendrobaena*, *Aporrectodea* and *Lumbricus*) and predicted that less than 3% of mesic hardwood forests in the area were free from exotic earthworm invasion.[22] The mesic hardwood study also looked at human disturbance as a factor in earthworm invasion, primarily as distance from roads, cabins and fishing access as potential earthworm introduction sites. They found road and cabin distance were good predictors of invasive earthworm presence.

Kourtev, et. al[23] showed a distinct change in microbial soil characteristics beneath Japanese barberry and Japanese stilt grass (*Microstegium vimineum*) compared to native blueberries.

In conclusion, the changes in soil characteristics in combination with drivers like high white-tail deer abundance, spread by turkeys and ruffeled grouse, exotic earthworm presence and human disturbance co-occur with *Berberis thunbergii* presence.

D2. Managing Japanese Barberry

Japanese barberry responds well to mechanical removal, if the below-ground roots are completely removed.[24] Above-ground stems have sharp thorns, so care needs to be taken when removing the plants manually. Regional efforts with volunteer groups

---

[20] Kourtev, et. al, 1999

[21] Burtelow, A.E., Bohlen, P.J. and Groffman, P. M. 1998. Influence of exotic earthworm invasion on soil organic matter, microbial biomass and denitrification potential in forest soils of the northeastern United States. Applied Soil Ecology 9: 197-202.

[22] Holdsworth, et. al, 2007

[23] Kourtev, P.S., Ehrenfeld, J.G. and Haggblom, M. 2002. Exotic plant species alter the microbial community structure and function in the soil. *Ecology* 83: 3152-3166.

[24] A pilot project at Hickory Run State Park, using volunteers, showed significant reduction of Japanese Barberry after 2 spring mechanical removals, and native plant species recovered in the area treated, including the fly-poison lily (*Amianthium muscitoxicum).*

were most effective when stems were removed with long-handled bypass loppers, followed by removing stumps and roots with a pickaxe.

Removed portions should be piled upon tarps and carried to a removal site on the tarp so that viable root segments and seeds are not spread. Burning wilted vegetation at a designated removal site should contain any infestation. After mechanical removal, the site needs to be revisited annually for several years to remove any regrowth or seedlings. Controlled burns can be used to kill barberry in fire-resistant communities, but this option is not typically useful in the Brodhead Watershed region.

E. Japanese Knotweed

Japanese knotweed (*Fallopia japonica*) is the most prevalent and likely most detrimental invasive plant species growing along streams in the Brodhead Watershed. It grows in dense stands along the entire Brodhead Creek, much of the Pocono Creek, and the lower Paradise Creek, as well as many of the tributaries of these streams. Presently, there is almost no Japanese knotweed growing along the Cherry Creek, McMichael Creek, and Marshalls Creek, although some smaller stands were found in the surveys of each of these subwatersheds. Where Japanese knotweed was found in high density, virtually no native plants were found growing contiguously, even before Japanese knotweed begins its above-ground growth in late spring. The Brodhead Watershed Association therefore considers management of Japanese knotweed to be a top priority.

E. Japanese Knotweed
E1. Origin and Spread

Japanese knotweed (*Fallopia japonica*, previously *Polygonum cuspidatum* or *Reynoutria japonica*) was first introduced to North America and Europe from East Asia in the 19th century at horticultural fairs as an ornamental plant. In Europe, Japanese knotweed now covers many of the continent's streambanks, spreading primarily through asexual (clonal) reproduction. Indeed, even a small fragment of Japanese knotweed can regenerate into a whole new plant when washed downstream or carried off by a passing animal.

Figure 17. Path hacked through streamside strand of *Fallopia japonica* (Japanese Knotweed) at ESSA site on McMichael Creek.

Once an individual plant has established itself, it can spread over large areas through underground rhizomes (which are modified stems), so that to the unsuspecting above-ground observer, a single organism appears to be literally dozens of separate stalks. Given this situation, ecologists in Europe first suggested that Japanese knotweed's incredible ability to quickly invade a variety of ecosystems was caused by its relatively high success with asexual reproduction compared to native plants.

E2. Regional Plans for Optimal Results

Management plans in Europe have been designed based on the assumption that Japanese knotweed reproduces clonally; this assumption has proven incorrect in North America, however, and thus management plans from Europe are far less effective when applied in the United States. In fact, broad genetic variation has been found among Japanese knotweed populations in the United States,[25] and mounting evidence suggests that sexual reproduction is not uncommon,[26] sometimes resulting in drastic new varieties and hybrid forms.[27] Moreover, even genetically similar Japanese knotweed plants can exhibit a wide array of traits and responses to stress.[28]

Figure 18. *Fallopia japonica* (Japanese Knotweed) plants streamside in the Brodhead watershed

Following these findings, ecologists now urge the development of regional management plans tailored to the interactions between the local variety(ies) of Japanese knotweed and the regional ecosystems and environments.

---

[25] Gammon, M. A, J. L Grimsby, D. Tsirelson, and R. Kesseli. 2007. Molecular and morphological evidence reveals introgression in swarms of the invasive taxa Fallopia japonica, F. sachalinensis, and F. xbohemica (Polygonaceae) in the United States. *American Journal of Botany* 94, no. 6: 948.

[26] Perhaps the wide array of climates in the United States have facilitated seed viability; or native relatives of *Fallopia japonica* in the North America may be better suited to hybridization. See

[27] Grimsby, J. L, D. Tsirelson, M. A Gammon, and R. Kesseli. 2007. Genetic diversity and clonal vs. sexual reproduction in Fallopia spp.(Polygonaceae). *American Journal of Botany* 94, no. 6: 957; Bailey, J. P, K. Bímová, and B. Mandák. 2009. Asexual spread versus sexual reproduction and evolution in Japanese Knotweed sl sets the stage for the "Battle of the Clones". *Biological Invasions* 11, no. 5: 1189–1203.

[28] Richards 2008

E3. Herbicides NOT Effective against Japanese Knotweed

Unfortunately, after more than a decade of intense research in the United States, most scientists agree that Japanese knotweed cannot be permanently removed from North America, short of some drastic environmental catastrophe. In some regions, the threat posed by Japanese knotweed to streambanks and stream ecologies—for Japanese knotweed has the potential to devastate aquatic communities[29]—outweighed the possible damage caused by herbicides, and herbicidal management plans were enacted. While Japanese knotweed did temporarily die back after herbicidal treatment, environmental managers found that even after years of treatment with potent herbicides, Japanese knotweed consistently grew back. Surprisingly, stands were often larger and more resilient after herbicide applications than when the eradication plan was first put into action. Well-designed scientific experiments have recently corroborated these upsetting results, demonstrating that even the most sophisticated regimens and techniques for herbicidal application will not be useful to any serious effort to manage Japanese knotweed and restore native plant communities.[30]

E4. Mechanically Controlling Japanese Knotweed

Without herbicides for chemical control, the only remaining options for removing Japanese knotweed are biological or mechanical control. There are no known agents of biological control for Japanese knotweed, although some ecologists continue to explore this possibility.

Recommendation. BWA therefore suggests mechanical methods for removing Japanese knotweed. This can be a labor-intensive process: any seed heads and flowers must be removed first, followed by all above-ground stalks, and finally below-ground rhizomes and roots. During removal, plants cannot be divided into any small fragments; all portions of the plant must be collected and either dried and burned (following local ordinances) or composted. Until the plants have completely dried or decomposed, they must be protected from any mechanism that could transport portions away, such as wind, heavy rain, birds, or foraging mammals, since this would allow for the establishment of new stands. Once a Japanese knotweed stand has been removed, the area should be replanted with native alternatives.[31] Still, Japanese knotweed is very likely to return, so the process will need to be repeated over several years to yield any successful results.

---

[29] Lecerf, A, D. Patfield, A. Boiche, M.P. Riipinen, E. Chauvet, and M. Dobson. 2007. Stream ecosystems respond to riparian invasion by Japanese knotweed (Fallopia japonica). *Canadian Journal of Fish and Aquatic Science* 64: 1273-1283.

[30] Hagen and Dunwiddie 2008, Green 2003, Machado 2007 pers. comm. Herbicides that only affect above-ground portions of Japanese knotweed have almost no long-term effect, since a large portion of a plant's resources are stored in underground rhizomes. On the other hand, herbicides which are translocated to storage tissue in the rhizomes, such as glyphosate, are apparently unable to reach all of an individual plant's rhizomatic nodes—even at high concentrations—allowing for regrowth and recovery in the following year. See Price 2002.

[31] Some reference to BWA lists of native alternatives; the Brooklyn B.G. book; etc.

E5. The BWA Japanese Knotweed Management Strategy

At the time this report is being completed, the BWA has been focusing on educating local landowners, fishing clubs, municipal workers, and volunteer organizations on the threat posed by Japanese knotweed invasion and the best techniques for its removal. Since eradication is not a feasible option in the Brodhead Watershed,[32] the BWA emphasizes preventing Japanese knotweed from invading the Cherry Creek watershed and the McMichael and Marshalls' Creek subwatersheds any further, and on

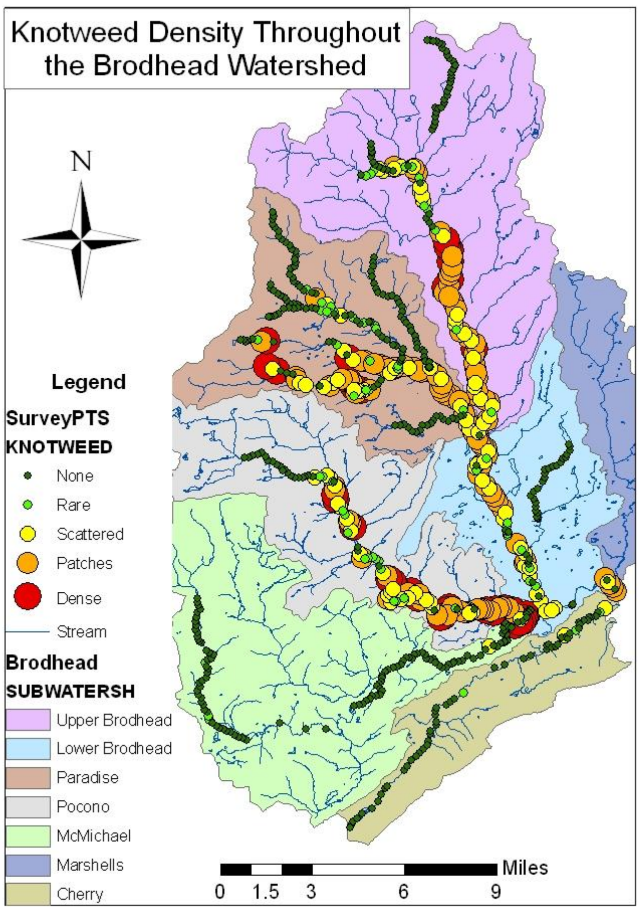


Figure 19. The density of *Fallopia japonica* plants along streams in the Brodhead Watershed.

---

[32] As in general, eradication is not optimal from any standpoint—economic, environmental, or ecological. See Eisworth 2002.

curtailing its continued spread in the already heavily-invaded regions. As the public becomes more involved, the BWA plans to compile information on the relative success of different techniques for mechanical removal, and continue to conduct demonstration sites when funding and labor are available. [33]

Recommendation. Future surveys should be conducted to determine the extent of Japanese knotweed's spread or decline as the Monroe County community is mobilized to manage this invasive species. The BWA's Japanese knotweed management plan is therefore a long-term, continuous project. Success will be measured not by the amount of Japanese knotweed eradicated, but by the quality of local ecologies where community members have struggled against Japanese knotweed's expansion.

F. Medium-Priority Invasive Plant Species: Other Invasive Plants

Figure 20. Lonicera spp (Invasive Honeysuckles)

F1. Invasive Honeysuckles

Several species of invasive honeysuckles (*Lonicera spp.*) are found in the Brodhead Watershed, and are typically difficult to distinguish without a naturalist's assistance. The invasive species are now more common than native species in the Brodhead Watershed region, and include species that grow as shrubs, as well as Japanese honeysuckle (*Lonicera japonica*), which forms long vines.

[33] A discussion of one of the BWA's unsuccessful knotweed removal efforts can be found in Appendix A (McMichael Steambank Demonstration Project Discussions, pp. 53-56).

Recommendation. Established shrubs can be removed by cutting the entire plant to the base and removing any accessible underground growth; check the site for three to five years after initial removal to prevent any regrowth. Removal is most easily accomplished in spring, when the plants are easily identifiable but have not yet produced fruits.

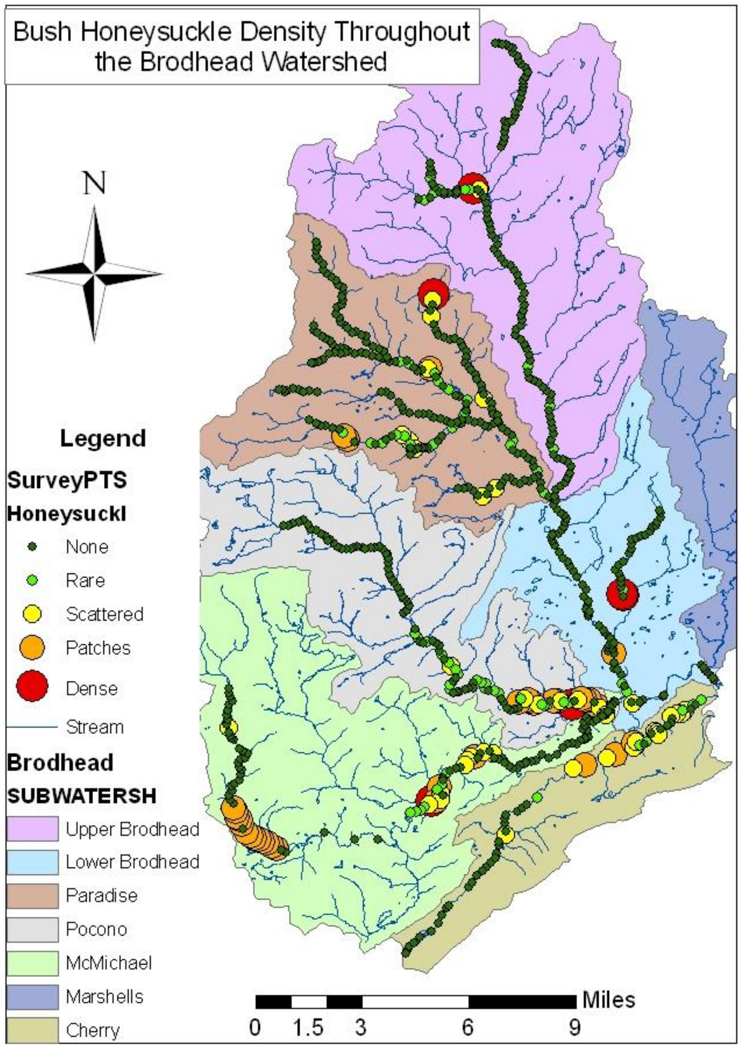


Figure 21. The density of invasive honeysuckles along streams in the Brodhead Watershed.

F2. Garlic Mustard

Garlic mustard (*Alliaria petiolata*), **Figure 22** (below right), is a biennial herbaceous plant named for the pungent, garlicky smell produced by its leaves. Unlike many other invasive plant species, garlic mustard often spreads in completely undisturbed ecosystems, colonizing and then replacing native species.

Regional efforts to eradicate garlic mustard have not been fruitful.

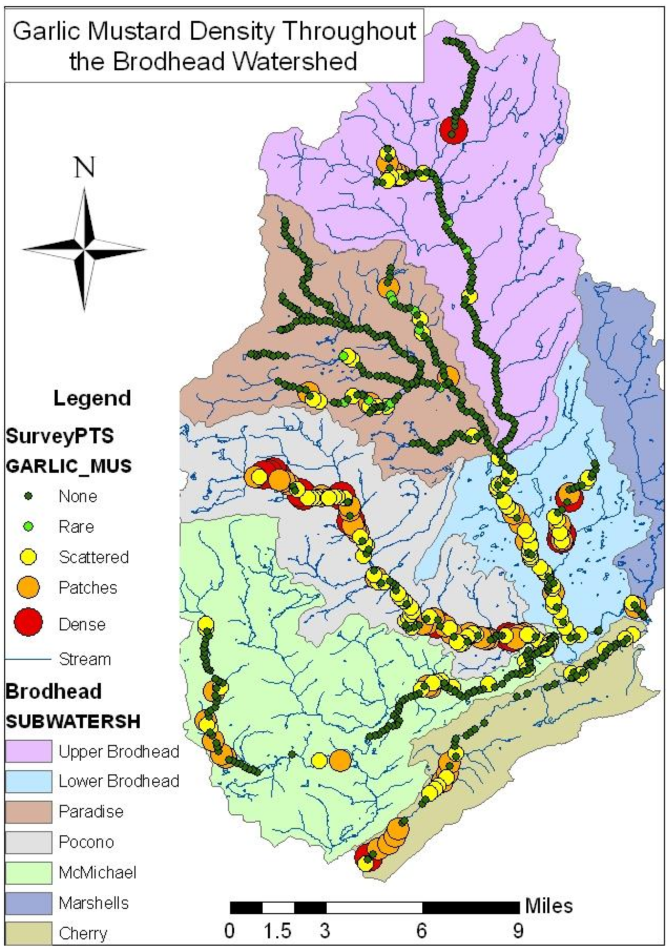


Figure 23. The density of garlic mustard plants along streams in the Brodhead Watershed.

Recommendation. BWA suggests a moderate management plan, removing garlic mustard mechanically when it begins to invade a given site. When garlic mustard is first noticed at a site, manually pull the plants before seed production to remove both the whole organism; this is easily accomplished when the soil is moist. If a large patch of garlic mustard is targeted, mow in the spring and again later in the year if regrowth occurs. After removal, try replacing with native under-story plants to prevent future colonization.

F3. Japanese Stiltgrass

Japanese stiltgrass (*Microstegium vimineum*), which appears on the left bank in **Figure 24** (below center) is an annual grass that begins above-ground growth in late spring and reaches heights of one to two feet by August.

The BWA survey found Japanese stiltgrass growing in nearly all conditions, but it is especially dominant in the forest understory.

Since Japanese stiltgrass typically grows alongside native plants, produces seeds which can remain viable in the soil for several years, and has generally proven difficult to remove, BWA has decided not to focus our attention on managing this plant species at this time.

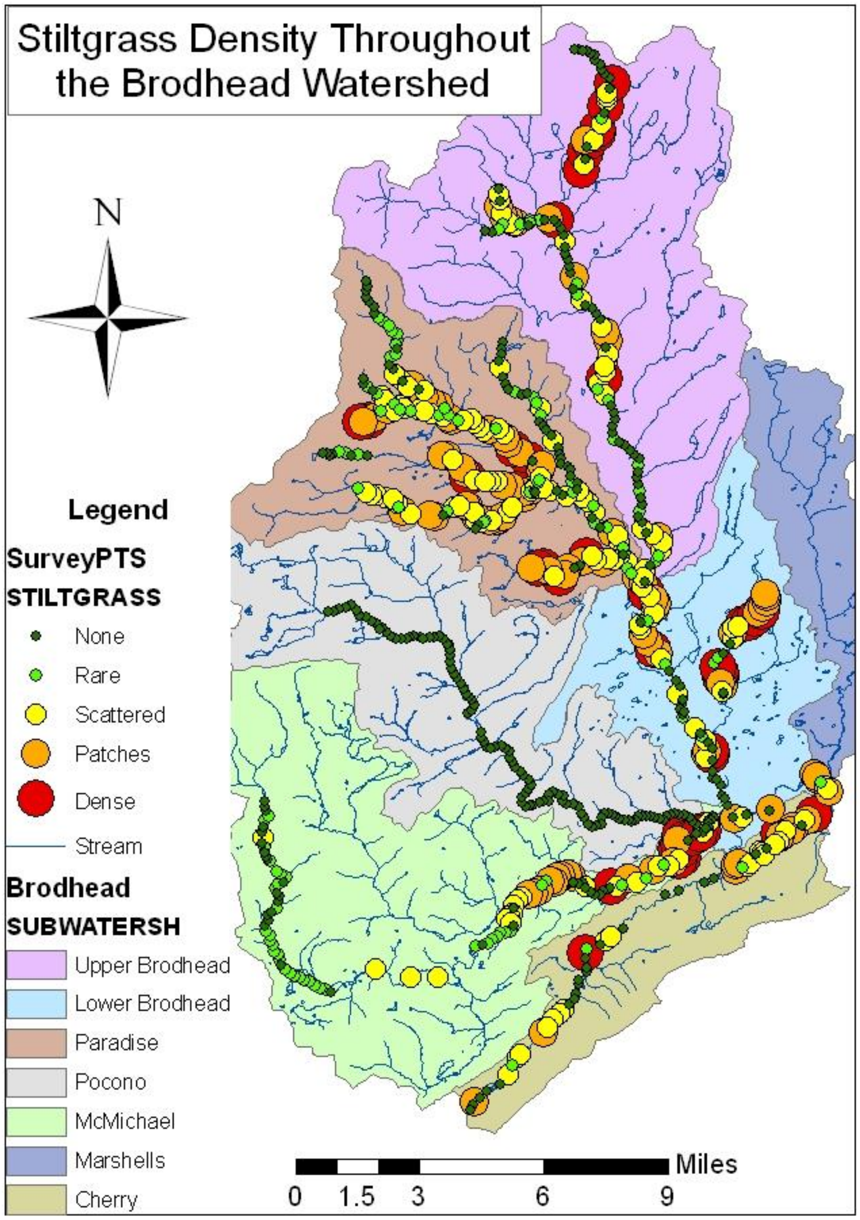


Figure 25. The density of Japanese stiltgrass along streams in the Brodhead Watershed.

Recommendation. In cases where Japanese stiltgrass has only recently invaded, where its presence poses a particular threat to a rare native plant species, or where it interferes with a scenic landscape, Japanese stiltgrass can be removed mechanically. Either manually pull the plants as they appear in late spring, repeating for several years if necessary, or mow large stands of the grass during flowering (but before producing seeds; typically this is late summer in our region) to most effectively damage the populations.

F4. Common Reed

Common reed (*Phragmites australis*), shown on **Figure 26 (**below), is a tall wetland grass that grows up to 15 feet in height.

The invasive species has native counterparts (*Phragmites spp.*) found in North America, although these native species are increasingly displaced by the invasive *P. australis*.[34] While common reed is not extremely prevalent in the Brodhead Watershed, it has thoroughly invaded other watersheds in the northeastern U.S. The BWA seeks to prevent a similar invasion in this watershed by removing the few common reed stands our surveys found. Common reed stands spread through underground stems (rhizomes), much like Japanese knotweed; removal efforts must therefore not only remove aboveground portions of the plants, but also completely remove underground growth.

Although not a major focus of this study an plan, during the summer of 2009 -- at the request of the Stroud Regional Open Space and Recreation Commission staff -- the BWA authorized a student intern to explore the difficulty of removing a patch of stiltgrass from an area near on the region's parks and adjacent to the Brodhead Creek.

---

[34] Meyerson, Laura A., David V. Viola, and Rebecca N. Brown. 2009. Hybridization of invasive Phragmites australis with a native subspecies in North America. *Biological Invasions* 12, no. 1 (2): 103-111.

Figure 27, below, unfortunately a somewhat unclear image, shows volunteers working on the western edge of the Brodhead Creek in East Stroudsburg to remove the common reed.

Recommendation. Mechanical methods have proven effective in removing stands of common reed, so long as the entire stand is removed and the area is revisited annually to check for any regrowth.

The next section of this report contains what we have termed the "Action Plan" for managing invasive plant species in our watershed.