Background and methods of control for garlic mustard

A Report Prepared for the Sierra Club

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Background

Garlic mustard (Alliaria petiolata) is a native of Europe and was first recorded in the United States in 1868 on Long Island (Nuzzo 1994a). It was likely introduced as an edible green (high in vitamins A and C) and for medicine (Hoffman and Kearns 1992, Nuzzo 1994a). Since that time it has slowly spread or has been introduced westward, but only in the last few decades has it become recognized as highly invasive. For example, the species was first recorded in Illinois in 1918, but was not recognized as a problem in Illinois forests until the 1980's (Nuzzo 1993). When, and especially why, garlic mustard became highly invasive in natural areas is a question that has not been sufficiently untangled, although rising industrial emissions, nutrient deposition, and warmer winters caused by global climate change are all logical candidates.

In North America the species occurs in a wide variety of habitats, from deeply shaded forests, partial shade, forest edges and roadsides, urban gardens and even open habitats (Nuzzo 1994b, McCarthy 1997). In Europe it occurs in similar habitats. It also responds positively to disturbance, and may have higher cover values in soils high in nitrogen and other nutrients that resulted from industrial emissions (Nuzzo 1994a). In Iowa phosphate concentrations were significantly greater in soils supporting high garlic mustard concentrations compared to those with a sparse population (Rosburg et al. 2002). Without control garlic mustard populations may double every four years (Nuzzo 1994a), and at a broader scale it is capable of spreading exponentially across the landscape (Nuzzo 1993). In Iowa, the species is more common in the east than in the west, and is most common in closed canopy woodlands; however, it is also found along roadsides and in old fields equally as often as in open woodlands and savannas (Rosburg et al. 2002), reflecting an ability to invade a wide variety of habitats.

Garlic mustard is one of the greatest threats to Iowa forests in general and to the esthetics and ecological integrity of the entire area that includes Greenwood and Ashworth Parks, and Water Works Park. Because it is not native to the United States, the species is not subject to its native predators, pathogens or competitors, factors that would hold its population in check. Because, as noted above, garlic mustard is capable of explosive

population growth, once garlic mustard is established in a natural woodland, and if it is not controlled, it is capable of displacing the natural woodland understory flora and of suppressing the natural regeneration of trees (McCarthy 1997). Evidence suggests oaks may be particularly susceptible to displacement (Meekins and McCarthy 1999). It has an especially negative impact on the early spring flowering species, the spring ephemerals (Nuzzo 1994a). However, overall decline in species richness and cover may take up to 10 years to become evident for many species, and short-term studies may falsely conclude that garlic mustard has little effect on native vegetation (Nuzzo 1994a).

If left unchecked, garlic mustard will have an obvious and immediate effect on the aesthetics and beauty of the woods and park. Less, obvious, but just as profound will be the longer-term loss of forest integrity and function. If the regeneration of oaks and other tree species is suppressed, over time the ability of the woods to regenerate will be compromised. Although evidence suggests that at least one species of oak may be displaced, this is an area that clearly needs further study. Little is known about the affect on animal populations – songbirds, insects, mammals – as native species are displaced by garlic mustard, and this is another area where further study is clearly called for (Nuzzo 1994a). However, there is evidence that deer avoid garlic mustard in favor of native plants, potentially hastening their displacement (Nuzzo 1994a). As native species are displaced, it is likely that other wildlife species that feed on the plants will affected. For example, in Virginia, populations of a rare butterfly have declined because chemicals in the leaves of garlic mustard appear to be toxic to their larvae (Rowe and Swearingen, 1999).

The spring ephemeral species give the park and woods much of their value, because of their beauty and also because of their important ecological function of holding soil and retaining nutrients in the forest system. Potential for loss of nutrients is high in spring, because higher levels of runoff due to snowmelt and spring rain occur at a time when transpiration and nutrient uptake by many species has not yet begun. Spring ephemerals, which complete their life cycles before or shortly after canopy closure, are growing most rapidly at this time. Most spring ephemerals senesce in late spring, releasing nutrients which can then be accumulated by trees and later-growing herbaceous species (Muller and Bormann 1976, Blank et al. 1980,

Peterson and Rolfe 1982). Thus, spring ephemerals may act as a short-term sink for nutrients at a time of high potential for nutrient loss from the system.

Garlic mustard is a biennial. After germination the seedlings form a rosette during the first year, which may continue to grow in winter when the ground is free of snow and temperatures are above freezing (Cavers et al. 1979). Plants that survive the first year produce flowers the second year, and die following fruit set. Depending on the size each plant, it is capable of producing 100s of seeds. Seeds may stay dormant in the seed bank for up to five years, although the proportion that is viable is low by the fourth year (Hoffman and Kearns 1992, Nuzzo 1994a). New populations are spread largely by humans, as they become lodge in boots, pants cuffs, and tires (Nuzzo 1992), and often appear in new areas first along trails and roads. Roadside mowing also helps promote its spread by moving seeds to new areas of suitable habitat (Nuzzo 1993). Seeds of garlic mustard also appear to disperse naturally along streams and rivers (Nuzzo 1993). The overpopulation of deer, which consume and ultimately remove understory species and disturb the soil through hoof action, have also been implicated in spread of garlic mustard, but this has not been quantified (Nuzzo 1994a).

Garlic Mustard in Greenwood, Ashworth and Waterworks Parks

A comprehensive formal survey of the vegetation of these parks have not been conducted; however, through extensive informal monitoring by Jo Hudson, and an intensive survey conducted in a small area of Ashworth Park (Mabry 2002) we know that there are extensive populations of garlic mustard in many areas of waterworks, and populations in Greenwood and Ashworth Parks that range from patchy to extensive. The areas of heaviest infestation of garlic mustard occur where there has been extensive human disturbance or near these disturbed areas (for example, parkland bordering Foster Drive and 52nd St. residences, and in and adjacent to the Rose Garden). Fortunately, there are also many areas in Greenwood and Ashworth Parks that are entirely and nearly entirely free of garlic mustard. The distribution, or extent of infestation-free areas in Water Works Park is entirely unknown.

Control of Garlic Mustard

Experience increasingly suggests that garlic mustard control is possible, and feasible, although an intensive coordinated effort is needed to achieve it. The most effective means of controlling garlic mustard is to monitor woodlands regularly and prevent populations from becoming established. As a biennial, the plant can only persist by producing seeds, which persist in the soil for up to five years. Thus, once a population is established, the goal of control measure is to prevent the plant from producing seeds. If these efforts are maintained in successive years, the seed bank will be depleted, and the population effectively controlled.

There is no known biological control, and while this possibility is being researched, there is none on the immediate horizon (Rowe and Swearingen 1999, Nuzzo 1994a). Therefore, current control options fall into three categories: burning, mechanical removal and herbicide application.

Burning

Use of prescribed fire has been effective in controlling garlic mustard if specific conditions are met. Rosette density (second year plants about to flower) was not affected by low intensity fires, defined as those with flame length up to 3 cm and the burn frequently extinguished within the experimental plot. In fact, rosette density increased following low intensity fire. In contrast, rosette density was very significantly decreased by mid intensity fires, defined as those with flame lengths up to 15 cm and burning through the majority of the plot (Nuzzo 1991). The decrease was more striking if there was a second year burn (89 percent reduction). The results were similar for fires initiated in the spring and fall.

Seedling (first year newly germinated plants) frequency was also reduced by fire, but only by a spring fire of mid-intensity, and if it was conducted while seeds are germinating. If seeds germinate after the fire, seedling establishment may actually increase because it is easier for seedlings to establish when they do not have to push

through a dense litter layer (Nuzzo 1994b), and fire will need to be supplemented by another method to control seedlings.

A fire management strategy that is equally effective against seedlings and rosettes is problematic. Slow mid-intensity fires are effective against the root crowns of rosettes, but when the leaf litter is removed by these fires, it may favor establishment of seedlings by exposing bare soil. On the other hand, a thin litter layer kept moist by snowmelt is sufficient to protect root crowns from fire (Nuzzo 1994b).

Use of propane torches to burn small (cotyledon-stage) seedlings has recently been discovered to be a highly effective and rapid way to eliminate large numbers of seedlings (Kearns 2003).

Herbicide Application

Two chemicals have been most effective in controlling garlic mustard: Round-up (glyphosate) and Basagran (bentazon). Round-up applied at 1, 2 and 3 percent concentrations to dormant rosettes in the late fall or early spring reduced rosette cover by up to 95 percent (Nuzzo 1991, Nuzzo 1994b). Round up applied to seedlings after germination also significantly reduced their populations (Nuzzo 1991).

To avoid loss of native species, Round up should only be applied in the narrow window in the spring and fall when native plants are dormant, but the rosettes are green and photosynthesizing. Garlic mustard and native plants that emerge after application are not affected by the herbicide because it is not residual in the soil (Nuzzo 1994b, 1996). There is some concern about the affect of round-up on semi-evergreen native species such as Phlox divaricata, Asarum canadense and some sedge species; however, in central Iowa phlox and ginger generally are not semi-evergreen and go fully dormant and further study has shown them to be unaffected by dormant season application of glyphosate (Nuzzo 1996). I have observed some individuals of Blephila hirsuta, Carex blanda and C. jamesii remain semi-evergreen, at least in years where winters are not severe. However, because some individuals in the population are fully dormant, the overall

populations of these species should be able to withstand chemical treatment. This was supported by an Illinois study that found that 1 and 2 percent dormant season application of glyphosate resulted in no significant reduction of herbaceous or woody vegetation cover (Nuzzo 1996), but the impacts should also be tested in Iowa.

Although it needs more testing before widespread use, it appears that Basogram, a post-emergent contact herbicide used to control mustards in agricultural fields, offers some promise to extend the period that herbicide can be applied into summer because it had little impact on native herbaceous species and less impact on grasses than roundup, although it is listed as selective for some species of sedge (Nuzzo 1994b, 1996). A field test of Basogram applied to garlic mustard during the summer growing season showed that it was nearly as effective in killing first-year rosettes as Round up. However, garlic mustard seedlings were not affected by the herbicide treatment (Nuzzo 1994b). Basogram applied at the rate of 0.56 kg/ha during the dormant season had no effect on native understory vegetation, although its effectiveness during the dormant season in controlling garlic mustard needs further study (Nuzzo 1996).

2,4-D, Garlon, and Blazer are not recommended for garlic mustard control because they are much less effective than Roundup and Basogram, and/or because of their negative effect on native species (Nuzzo 1994a, 1994b).

Cutting

Cutting is the most time consuming and labor intensive method of control. However, it is probably the most effective way of preventing garlic mustard from producing seeds. Plants cut at ground level had 99 percent mortality (Nuzzo 1994b). Plants cut at 10 cm above the ground only experienced 71 percent mortality but seed production was still reduced by 98 percent (Nuzzo 1994b). Using a weed whip would speed up removal by cutting, but may damage native plants if they are not able to resprout following cutting (Nuzzo 1994). Because garlic mustard seeds can mature on the plant if the plant is pulled after flowering has began (Solis 1998), and because seeds may retain viability even under

composting pressure, pulled plants must be bagged and hauled to a landfill, adding to the labor and cost of control by this method.

Pulling plants out of the ground may be a quicker option for control than stooping and cutting plants at ground level. However, when the soil is dry, stems break at or just below the root crown, which can then resprout. In addition, some workers believe that disturbing the soil with pulling creates conditions that favor germination of more garlic mustard seedlings and may damage native plants (Nuzzo 1994a), although I was not able to locate any data that addressed these concerns.

Recommendations for Greenwood and Ashworth Parks

No single control method is likely to work alone; instead, a coordinated range of controls timed to season, and based on the density of garlic mustard and number of volunteers available is an approach that has been used with success elsewhere in Iowa and other Midwestern states. For example, the Indian Creek Nature Center has used spring fires to reduce large populations, followed up by spraying, pulling or cutting the remaining isolated clumps (Jo Hudson, personal communication). Similarly, Jaye Maxfied of Driftless Land Stewardship LLC, a natural resources management company based in Glen Haven, WI, has successfully used a combination of torching seedlings with a propane torch, along with fall and spring spraying, spring pulling, and burning (communication to the Iowa Native Plant Society).

Specifically, for Greenwood and Ashworth Parks I recommend that

• New infestations should be prevented by monitoring all park areas in early spring and late fall when the native vegetation is dormant and the green rosettes of garlic mustard are highly visible. The visible rosettes should be burned with propane, sprayed or pulled, the areas marked and monitored for second year rosettes, which should also be cut or pulled.

• Existing populations that are very sparse should be controlled by cutting or pulling second year rosettes, new seedlings can probably most effectively be controlled using a propane torch..

• Areas where populations are too dense to pull over a period of a few days or that are so extensive that native vegetation is starting to be displaced will need a combination of efforts, that occur in 4 stages through the year. 1) spring controlled burns of sufficient intensity can be initiated, although **it is important to note that low intensity burns will likely do more harm than good**. If controlled burn is not an option, then dormant season application of herbicide should be substituted. Effective application rates for glyphosate are 1-2 v:v concentrations, and bentazon at 0.56 kg/ha, or 0.5 #AI/acre (Nuzzo 1996). 2) spring burning should be followed by burning seedlings after they emerge in late spring or early summer using a propane torch 3) pull or cut adult plants that have flowered during May and June 4) spray or pull rosettes in the fall after the native vegetation has gone dormant.

These more intensive efforts will need to be continued for at least 4-5 successive years in order to deplete the seed bank. It is unlikely that garlic mustard will be totally eliminated in the park even after five years and monitoring and control should be included as a part of the routine park maintenance; however, it can be effectively controlled, preserving the native understory, tree regeneration and ecological function of this beautiful and valuable urban park.

References

Blank, J.L., Olson, R.K. and Vitousek, P.M. 1980. Nutrient uptake by a diverse spring ephemeral community. Oecologia 47: 96-98.

Cavers, P.B., Heagy, M.I, Kokron, R.F. 1979. The biology of Canadian weeds. 35. Alliaria petiolata (M. Bieb.) Cavera and Grande. Canadian Journal of Plant Science 59: 217-229.

Hoffman, R. and Kearns, K. 1992. Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants. Bureau of Endangered Species, Department of Natural Resources, Madison, WI.

Kearns, K. 2003. Garlic mustard control: the latest thoughts. Newsletter, Iowa Native Plant Society 9: 1, 7.

Mabry, C.M. 2002. Vascular plant inventory and ecological assessment of Ashworth Park in the mountain bike trail area. Final Report to the City of Des Moines, Park and Recreation Department.

McCarthy, B. 1997. Response of a forest understory community to experimental removal of an invasive nonindigenous plant (Alliaria petiolata, Brassicaceae). In: Luken, J.O. and Thieret, J.W. (eds.). Assessment and Management of Plant Invasions. Springer, New York, NY.

Meekins, J.F. and McCarthy, B.C. 1999. Competitive ability of Alliaria Petiolata (garlic mustard, Brassicaceae, an invasive nonindigenous forest herb. International Journal of Plant Science 160: 743-752.

Nuzzo, V.A. 1991. Experimental control of garlic mustard [Alliaria petiolata (Bieb.) Cavera & Grande] in northern Illinois using fire, herbicide and cutting. Natural Areas Journal 11: 158-167.

Nuzzo, V.A. 1993. Current and historic distribution of garlic mustard (Alliaria petiolata) in Illinois. The Michigan Botanist 32: 23-33.

Nuzzo, V.A. 1994a. Element stewardship abstract for Alliaria petiolata garlic mustard. The Nature Conservancy, Arlington, VA. (http://tncweeds.usdavis.edu).

Nuzzo, V.A. 1994b. Response of garlic mustard (Alliaria petiolata Bieb. [Cavera and Grande]) to summer herbicide treatment. Natural Areas Journal 14: 309-310.

Nuzzo, V.A. 1996. Impact of dormant season herbicide treatment on the alien herb garlic mustard (Alliaria petiolata [Bieb.] Cavera and Grande) and groundlayer vegetation. Transactions of the Illinois State Academy of Science 89: 25-36.

Muller, R.N. and Bormann, F.H. 1976. Role of Erythronium americanum Ker. in energy flow and nutrient dynamics of a northern hardwood forest system. Science 193: 1126-1128.

Peterson, D.L. and Rolfe, G.L. 1982. Nutrient dynamics of herbaceous vegetation in upland and floodplain forest communities. American Midland Naturalist 107: 325-329.

Rosburg, T., Mottl, L. and Dornbush, M. 2002. A quantitative analysis of the habitat preferences and distribution of the invasive woodland species Alliaria petiolata in Iowa. Final Report to the Iowa Science Foundation, Iowa Academy of Science, Cedar Fall, IA.

Rowe, P. and Swearingen, J. M. 1999. Garlic mustard. Native Plant Conservation Alliance, Alien Plant Working Group, Bureau of Land Management, Washington, D.C. (http://www.nps.gov/plants/alien/fact/alpe1.htm).

Solis, K. 1998. Update: new results indicate flowering garlic mustard should be bagged and destroyed (Wisconsin). Restoration and Management Notes 16: 223-224.

Appendix 1. Precision Backback Sprayer

Precision Backpack Sprayer

By Loren Lown

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Whenever a herbicide is used, non-target species may be damaged. This is of special concern when working in a natural system where invasive alien species are still a minor component, or where there are rare native species.

I have attempted to address this problem by building a more efficient delivery system to lessen the chances of accidental damage. Success or failure of herbicide treatment depends on many factors, not least of which is the skill and knowledge of the applicator. Application of the wrong chemical or under the wrong environmental conditions can lead to unfortunate and unforeseen results. My applicators are under strict orders never to spray when conditions are not right, never spray at or next to a species they can't identify, always use the least powerful chemical alternative, follow labels, and always limit personal exposure. Caution must be invoked; all personal safety concerns and label requirements should be considered.

I begin with a larger backpack sprayer. I use a five-gallon capacity sprayer because there are times and sites where you may want to carry the full sprayer rather than making many trips back for refills. My sprayer can carry less and usually does. Any major brand such as Solo or Smith will do. I use the 5 gallon D B Smith purchased from Forestry Suppliers (FS) for $99.50. If you plan on using the sprayer for multiple applications including solvent-based material, then you need to ensure the unit you purchase has seals and hoses appropriately resistant to solvents. You will end up quickly replacing them if you use solvent-based herbicides with neoprene components.

I begin by removing the “wand” type handle from the sprayer and discarding it. They are usually cheap, leaky, and short-lived junk. Replace the wand with a Gunjet 30L, a trigger style unit ($53.75 FS). This tool has nylon seals and remains leakproof for years. Attach a brass extension tube and control rod ($19.43 for an 18” or $24.00 for a 24”, Sprayer Specialties, Grimes, IA) to the Gunjet and fit a brass adjustable conejet nozzle ($16.25 FS) to the end. You can adjust the length of the extension to your applicator’s height. Extensions are also available in longer lengths. The resulting unit extends your reach almost to the ground, even if you are tall. You can now spray herbicide on a cut stump or a herbaceous target from close distance, under most wind effects, and with a substantial reduction in off-target spray or drift.

It has been my experience that cheap sprayers are just that, cheap and disposable. A quality unit that is well maintained will last for years and reduce the applicator’s exposure to the poison we are using.

Once again the skill, timing, and material choice of your applicator will determine your success and whether or not there is unintended damage. I have used this modified unit in woodland and prairie remnants with no visible, unintended results. I believe this modified sprayer is considerably less damaging than other less precise application methods. It can be a helpful tool for natural area managers.

(If you have questions, you can reach Loren at <LLown@co.polk.ia.us>).