



VEGETATION MANAGEMENT GUIDELINE

Garlic Mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande]

SPECIES CHARACTERISTICS

DESCRIPTION

Garlic mustard (*Alliaria petiolata*) is a tap-rooted, biennial herb of the mustard family (Brassicaceae) that has the fragrance of garlic throughout the entire plant. During the first year of growth, plants consist of a basal rosette of kidney-shaped leaves that have a wrinkled appearance and remain green throughout the winter. Individual plants that overwinter successfully will produce flowers and then die. Second-year plants bolt in April or June. Plants typically produce one flowering stem, but may produce up to ten stems with the central stem being the largest. The flowering stalks can reach heights between 15 cm - 1.3 m (6 inches - 4 feet) and are glabrous or have a few simple hairs. The cauline leaves are triangular in shape, 3 - 6 cm (1 1/4 - 22 inches) broad and long, have a sharp point and are coarsely toothed.

The inflorescence is a terminal raceme, but flowers can also occur in the leaf axils. The white flowers are small, 6 mm (1/4 inch), have four petals and six stamens B four long and two short, and occur on short, stout petioles that are about 5 mm (1/4 inch) long. Small black seeds approximately 3 mm (c inch) long are dispersed from a long, narrow, 4-angled capsule called a silique that can be up to 6 cm (22 inches) long. If identification of the species is in doubt, the plant's identity should be confirmed by a knowledgeable individual and/or by consulting appropriate manuals or keys.

SIMILAR SPECIES

Garlic mustard is most easily confused with other species in the mustard family. A number of these bloom in early spring and have white flowers with four petals. Garlic mustard is distinguished from other woodland plants in the mustard family by its distinct odor of garlic that can be detected when the leaves are crushed and by its coarsely toothed leaves. In northern Illinois, it is the only tall plant that blooms during the month of April and has white, four-petaled flowers. During the autumn, garlic mustard rosettes may be mistaken for violets (*Viola* spp.), immature white avens (*Geum canadense*) and some members of the saxifrage family which also have heart- or kidney-shaped leaves. Violets and white avens differ from garlic mustard in that they have fibrous root systems and lack the garlic odor. White avens also has hairy leaves. Garlic mustard plants have a white taproot with an As@ shape at the top of the root.

DISTRIBUTION

Garlic mustard is a European native, but is known from northern Africa, Sri Lanka, India, New Zealand and North America. European settlers utilized this plant for its garlic flavor in cooking and as a medicinal herb and may have been responsible for its introduction into North America as early as the nineteenth century. Garlic mustard was first recorded in North America in Long Island, New York in 1868. Herbarium records indicate it was collected in Idaho in 1892 and Oregon in 1959. Today, garlic mustard ranges from Maine south to Georgia and west to

Arkansas and Oklahoma and north to the Canadian border and Alaska. Isolated populations have been documented in Utah and Colorado, and several spreading populations have been reported from the Pacific Northwest. The initial collection of garlic mustard in Illinois was in 1918. By 1991, this exotic species had spread to 42 counties in northern and central Illinois as well as two counties in southern Illinois. As of 2005, there were eight counties in southern Illinois (Alexander, Hardin, Jackson, Johnson, Pope, Saline, Union, and Williamson) with aggressive and problematic infestations of *Alliaria petiolata*. Smaller populations have been reported from Clay, Crawford, Edwards, Jasper, Lawrence, Marion, Richland and Wabash counties.

HABITAT

Garlic mustard prefers moist, shaded soils but occupies a wide variety of habitats including upland and floodplain forests, savannas, wet meadows, pastures, railroads, roadsides and edges of trails. It seems to frequent areas with calcareous soils and is apparently absent from areas with acidic or very poorly drained soils. It grows on sand, loam, and clay soils, and has been found on limestone and sandstone substrates.

Natural and artificial or anthropogenic disturbance seems to be a contributing factor to garlic mustard invasion in Illinois. In degraded oak forests of northern and central Illinois, garlic mustard can be the dominant ground layer vegetation. It also has been reported that high populations of white-tailed deer (*Odocoileus virginicus*) may contribute to the increase of garlic mustard. The white-tailed deer prefer to forage on native vegetation, which leaves the invasive garlic mustard plants undamaged.

LIFE HISTORY

Garlic mustard is typically a biennial herb with a 2-year generation time. Seeds germinate in early spring, approximately February of March in southern Illinois and April 1 in northern Illinois. Usually, first year plants develop basal rosettes by early summer and overwinter in the rosette stage. Second year plants bolt and bloom the following year. Flowering usually occurs in April in Southern Illinois and May or June in the remainder of the state. The flowers can be cross pollinated by a number of insects, but most populations of garlic mustard appear to be autogamous (self-fertilized), with self-pollination occurring before the flowers open and before the stigma is exposed. The flowering plant will die and turn light brown or tan after the seeds mature, usually in August. Seeds will disperse after the silique bursts.

Seed dispersal is thought to be mostly by mechanical means. Dispersal by wind is limited. The seeds apparently do not float well, but will attach to moist surfaces. Long range dispersal is accomplished by seeds becoming attached to birds, mammals, white-tailed deer, horses, boots and clothing, as well as mowers and other equipment. The sturdy stalks can remain standing for several months.

Garlic mustard reproduces exclusively but prolifically by seed. Large plants can produce up to 150 fruits. Each fruit can contain up to 24 seeds, but the average is around 15 seeds. On average, each plant produces about 360 seeds; however, large multiple-stemmed plants can produce more than 8,000 seeds depending upon soil and growing conditions. The number of seeds in the seedbank can be as high as 22,000 per m². In an Ohio study, seedlings averaged 19,060 per square meter in some wooded areas.

Garlic mustard seeds require a cold stratification for germination. Studies in Illinois and Kentucky indicate the seeds usually have an 8-month dormancy period, but a 20-month dormancy period has been reported from studies in Canada. Most of these seeds germinate within the first or second year, but they can remain in a seed bank from 2-7 years.

EFFECTS UPON NATURAL AREAS

Garlic mustard was found within 58 (30%) dedicated nature preserves and 18 (31%) state parks throughout the state of Illinois in 1993. However, with the exponential rate of population growth corroborated by field observations, it is likely that these percentages have risen dramatically over the last 13 years. Garlic mustard poses a devastating threat to the natural areas that it invades. It is allelopathic and therefore inhibits other native plant species. As a result, wildlife that depends on native plants for pollen, nectar, fruits, and seeds will also be negatively impacted by the absence of their host plants. Many natural areas that are known for their exceptional display of spring wildflowers may also be devastated by garlic mustard invasion. Canadian farmers report that garlic mustard taints the taste of cow's milk.

CONTROL RECOMMENDATIONS

Long-term control of garlic mustard will be successful only after the seedbank has been depleted. In order to accomplish this, it is imperative that appropriate control methods are implemented during the correct stage of the plant's life cycle. Since garlic mustard is a prolific seed producer and its seed remains viable in the seed bank for many years, control efforts will be needed for several years to eradicate even small populations. Control measures should be done on a yearly basis until the seed bank has been destroyed.

RECOMMENDED PRACTICES IN NATURAL COMMUNITIES OF HIGH QUALITY

Initial effort in areas of light infestation

Hand pulling is an appropriate management tool for small infestations of garlic mustard. Hand pulling can be done at any time when the soil is not frozen. It is important to remove stems and roots from the site to prevent the plants from re-sprouting and the seeds from maturing. Pulled plants should be bagged and burned or otherwise disposed of.

Initial effort in areas of heavy infestation

CHEMICAL CONTROL

A 0.7% active ingredient solution of Triclopyr formulated as a triethylamine salt (Trade name Garlon 3A, Tahoe 3A is an effective control for garlic mustard and often exhibits immediate results. Garlon 3A and Tahoe 3A are broadleaf specific herbicides that will not harm most grasses and sedges. Garlon 3A and Tahoe 3A may be applied in either spring or fall. Apply enough herbicide to thoroughly wet the leaves, but **do not spray so heavily that herbicide drips off the target species**. Herbicides should be applied while backing away from the treated areas in order to avoid contacting the wet herbicide. By law, herbicides only may be applied in

accordance with label instructions and by licensed herbicide applicators or operators when working on public properties.

Spot treatment of individual plants with an amine formulation of 2,4-D (Trade name Platoon) is an effective control when applied as 0.5% active ingredient solution. To reduce vapor drift, use an amine formulation of 2,4-D rather than an ester formulation.

Spot application of 1.0% active ingredient solution of glyphosate (Trade name Accord, Glyphomax, Roundup, Rodeo, Touchdown) is an effective control for garlic mustard. In northern Illinois, treating garlic mustard with Roundup successfully reduced flowering plant density and seedling frequency and reduced seedling production by 85%. A more recent study found that Roundup reduced the presence of garlic mustard without negatively affecting native species. In fact, some of the native species had a positive response to the single-year reduction of garlic mustard. Application of glyphosate is most appropriate during the dormant season when garlic mustard is green, but the surrounding native vegetation is inactive. Glyphosate may be applied in either spring or fall. Plants treated with glyphosate can take several days to exhibit effects of the herbicide, so patience is required. For controlling seed production, a spring application may be more appropriate. However, depending on the area under control, it may be more desirable to apply glyphosate during the fall season in order to avoid damaging the native spring ephemerals that may have emerged, but have not bloomed.

MECHANICAL

Cutting plants that are flowering but have not set seed at ground level resulted in 99% mortality and contributed no seeds to the seedbank. Cutting at 4 inches (10 cm) above ground level produced 71% mortality and reduced total seed production by 98%. Cutting is equally effective whether using hand or gas-powered devices. Gas-powered string trimmers may be most desirable as they offer greater control and less damage to nontarget species.

BURNING

In fire-adapted communities, prescribed burning can be a useful tool for reducing seed production of garlic mustard and stimulating growth of native plants. Prescribed burning may be most effective when initiated during late spring in order to reduce rosettes and any newly emerged seedlings. These fires should be of sufficient intensity to thoroughly and evenly burn the infested sites. Any plants that are not burned should be treated using methods described in the guideline. Prescribed burning will reduce leaf litter and may aid in germination of garlic mustard seeds. It is not uncommon for the density of garlic mustard plants to increase following Burning; this increase in density is probably the result of seed germination, so if follow-up treatments are diligently employed the seed bank can be more rapidly depleted.

Spot treatment using propane torches is also an effective control for garlic mustard. These torches can be attached to 20 lb. propane tanks and mounted on backpack frames. This arrangement allows the applicators greater mobility as they move through infested areas. Torching is most effective when used in spring when plants are in the rosette or bolting stages and before plants have set seed. However, this treatment is not as effective during the fall season when the plant is in a rosette stage. Before employing the torch, a review of local burning ordinances is recommended. Torching may also result in ground fires if fuels are available.

Torching should always be conducted while adhering to fire safety standards and complying with all applicable air quality and burning requirements.

RECOMMENDED PRACTICES ON BUFFER AND SEVERELY DISTURBED SITES

Same control practices as recommended for high quality natural communities.

BIOLOGICAL CONTROL METHODS

Investigations into biological controls for garlic mustard have been ongoing since 1998. During that period, trials have been conducted on 69 weevils (Curculionidae) that feed on various parts of the garlic mustard plant. Four weevils in the genus *Ceutorhynchus* (Coleoptera: Curculionidae) are considered as possible biocontrol agents. These species attack the rosette root crown (*C. scrobicollis*), stems (*C. roberti*, *C. alliariae*) and seeds (*C. constrictus*) of garlic mustard. Preliminary results suggest the rosette-feeder reduces overwintering survival and the stem and seed feeders reduce seed output that, together, should be particularly effective. Demographic modeling suggests that rosette mortality and reduction of seed output are the most important factors for controlling garlic mustard. Modeling further suggests *C. scrobicollis* will have the most significant impact on garlic mustard, but releases of a single control agent are not likely to control garlic mustard throughout its full range and combinations of agents that simultaneously reduce rosette survival and seed production will be required to suppress the most vigorous garlic mustard populations.

INEFFECTIVE, FAILED, NOT RECOMMENDED PRACTICES

Low intensity fires that do not burn thoroughly and evenly are not effective in controlling garlic mustard. Executing a management method during one year without following through in subsequent years will not control garlic mustard. This is a highly invasive plant that requires regular monitoring and active management on a yearly basis in order to exhaust the seed banks.

REFERENCES

- Alaska Natural Heritage Program. 2004. Nonnative plant species of Alaska - Garlic mustard, *Alliaria petiolata* (Bieb.) Cavara & Grande. Environmental and Natural Resources Institute, University of Alaska Anchorage, Anchorage, Alaska.
- Blossey, B., V. Nuzzo, H. Hinz, and E. Gerber. 2001. Developing biological control of *Alliaria petiolata* (M. Bieb.) Cavara and Grande (Garlic mustard). *Natural Areas Journal* 21:357-367.
- Carlson, A.M., D.L. Gorchoy. 2004. Effects of herbicide on the invasive biennial *Alliaria petiolata* (Garlic Mustard) and initial responses of native plants in a southwestern Ohio forest. *Restoration Ecology* 12:559-567.
- Carroll, C.J. and J. White. 1997. Integrated pest management for Garlic mustard, *Alliaria petiolata* (M. Bieb.) Cavara & Grande. Pp 6-12. *In: Integrated pest management methods*

- for control of invasive exotic plant species at Midwein National Tallgrass Prairie. Ecological Services, Urbana, Illinois.
- Davis, A.S., D.A. Landis, V. Nuzzo, B. Blossey, E. Gerber, and H.L. Hinz. 2006. Demographic models inform selection of biocontrol agents for garlic mustard (*Alliaria petiolata*). Ecological Applications 16: 2399-2410.
- Davis, A.S., Landis, D.A., Schemske, D.W., Evans, J.A. 2006. Matrix population models to inform *A. petiolata* biocontrol agent selection [abstract]. Weed Science Society of America Meeting. 45:36.
- Driesche, V. R., et. al. 2002. Biological control of invasive plants in the eastern United States, USDA Forest Service publication FHTET-2002-04, 413 p.
- Kelly, C., D. Eagan, E. Padley, K. Kearns, and C. Matula. 2006. Garlic mustard-A major threat to Wisconsin's woodlands. Univ. of Wisconsin-Extension, WDNR.
- Kleinstei, D. Columbia University. October 2001 (10/17/06). Introduced species summary project.
- Mohlenbrock, R.H. 1980. The Illustrated Flora of Illinois: Flowering Plants - Willows to Mustards. Southern Illinois University Press, Carbondale. 286 pp.
- Mohlenbrock, R.H. 2002. Vascular flora of Illinois. Southern Illinois University Press, Carbondale.
- Nuzzo, V. 1991. Experimental control of garlic mustard (*Alliaria petiolata* (Bieb.) Cavara & Grande) in northern Illinois using fire, herbicide, and cutting. Natural Areas Journal 11:158-167.
- Nuzzo, V. 1993. Current and historic distribution of garlic mustard (*Alliaria petiolata*) in Illinois. The Michigan Botanist 32:23-33.
- Osborne, T. L. Y. and B. Steffan. 2005. Occurrences of garlic mustard (*Alliaria petiolata*) in eleven southern Illinois counties. Unpublished manual for IDNR and USDA Forest Service Participating Agreement.
- Rowe P. and J.M. Swearingen. 2005. Weeds gone wild: Alien plant invaders of natural areas. Available at: <http://www.nps.gov/plants/alien/>
- Stinson, K.A., S. A. Campbell, J.R. Powell, B.E. Wolfe, R.M. Callaway, G.C. Thelen, S.G. Hallett, D. Prati, and J.N. Klironomos. 2006. Invasive plant suppresses the growth of native tree seedlings by disrupting belowground mutualisms. PLoS Biology 4: e140: 727-731.
- USDA, NRCS. 2007. The PLANTS Database (<http://plants.usda.gov>, 26 February 2007). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.
- Whitman, M. 2006. Garlic Mustard: Odiferous Invader. Wild Ones Native Plants, Natural Landscapes, reprinted from Wild Ones Journal July/August 2006. Available at: http://www.columbia.edu/itc/cerc/danoffurg/invasion_bio/inv_spp_summ/Alliaria_petiolata.htm

PERSONAL COMMUNICATIONS

- Edgin, B, 2006. Illinois Nature Preserves Commission, Newton, Illinois.

Lindsay, B. 2006. Division of Natural Heritage, Illinois Department of Natural Resources, Ferne Clyffe State Park, Goreville, Illinois.

Shimp, Elizabeth, L. 2006. Shawnee National Forest Botanist. Region 9, Vienna, Illinois.

Written for the Illinois Nature Preserves Commission by:

Victoria Nuzzo
Native Landscapes
124 Dawson Ave.
Rockford, IL 61107

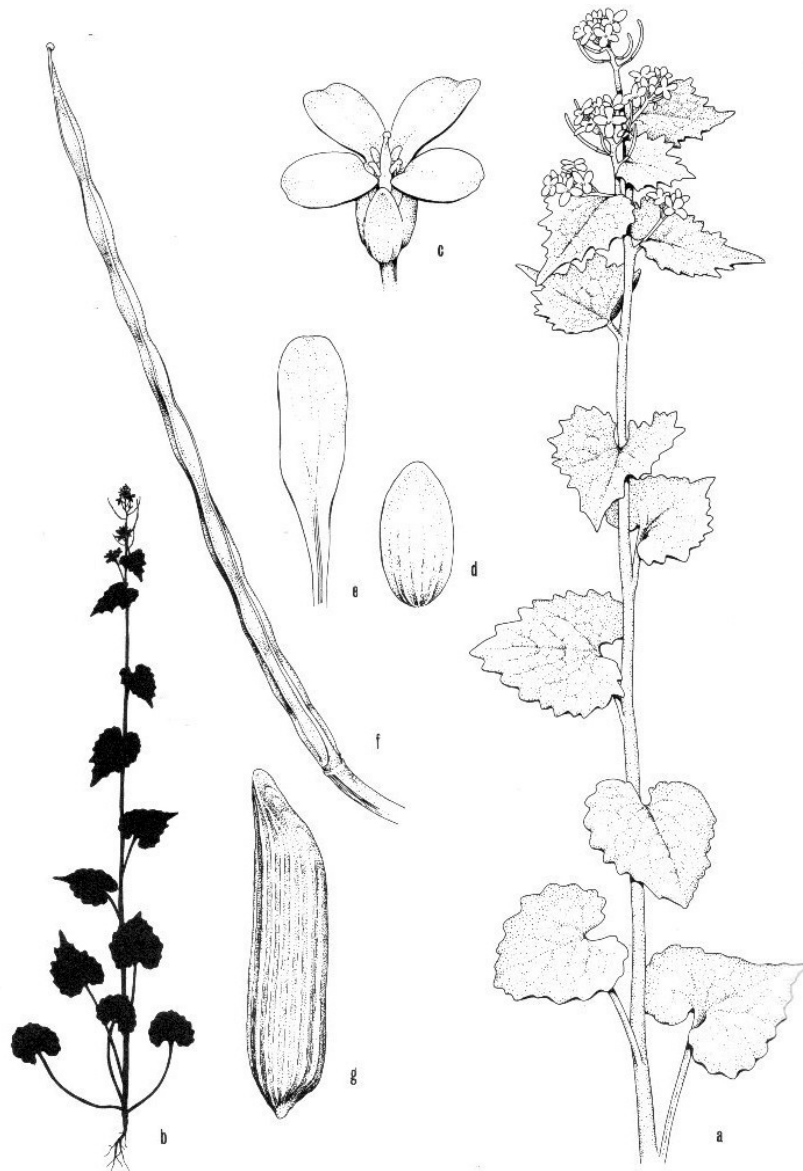
and

Jill Kennay and George Fell
Natural Land Institute
320 S. Third Street
Rockford, IL 61108

Revised by:

Leslie Rodman
Illinois Department of Natural Resources
Ferne Cliffe State Park
Goreville, IL 62939

Equal opportunity to participate in programs of the Illinois Nature Preserves Commission (INPC), Illinois Department of Natural Resources (IDNR) and those funded by the U.S. Fish and Wildlife Service and other agencies is available to all individuals regardless of race, sex, national origin, disability, age, religion or other non-merit factors. If you believe you have been discriminated against, contact the funding source's civil rights office and/or the Equal Employment Opportunity Officer, IDNR, One Natural Resources Way, Springfield, Ill. 62702-1271; 217/785-0067; TTY 217/782-9175.



Alliaria officinalis (Garlic Mustard). a. Upper part of plant, X $\frac{1}{4}$. b. Habit (in silhouette), X $\frac{1}{8}$. c. Flower, X5. d. Sepal, X10. e. Petal, X6. f. Fruit, X2 $\frac{1}{2}$. g. Seed, X25.