WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
(December 1999)

Scientific Name: *Alliaria petiolata* (Bieb.) Cavara & Grande
SY=*Alliaria alliaria* (L.) Britt.
SY=*Alliaria officinalis* Andrz. *ex* Bieb.
SY=*Erysimum alliaria* L.
SY=*Sisymbrium alliaria* (L.) Scop.

Common Name: garlic mustard

Family: Brassicaceae

Legal Status: Class A

Description and Variation: Garlic mustard is considered an obligate biennial herb in North America (Cavers et al. 1979; Nuzzo 1991), although it is also described as a winter annual in other areas of its range. The seeds of garlic mustard overwinter the first year. Germination and growth of the basal rosette begin early the following spring. These rosettes have stalked, reniform (kidney shaped) leaves. The leaves range from 2 to 8 inches long, and the leaf margins are coarse, round and irregularly toothed. The rosette overwinters the second year. The flowering stalk bolts early in the spring, and garlic mustard stands an erect 3 feet tall. The usually single stalk is sometimes slightly branched. The upper leaves are alternate, and their shape is deltoid (triangular), with the leaves gradually becoming narrower and smaller and sessile. At this time the basal rosette often withers. The overall plant is sparsely pubescent with simple hairs.

The white flowers have four sepals, four petals about 6 mm long (twice as long as the sepals) and tetradynamous stamens (4 tall and 2 short stamens). Small nectaries are found at the base of the stamens (Cruden et al. 1996 as cited in Anderson et al. 1996). The inflorescence is usually a terminal raceme, with occasional axillary racemes. The fruit is a linear, 4-angled silique, from 1 to 2 ½ inches long, containing a single row of seeds. The black seeds are oblong, and grooved, with an impermeable seed coat. Seed production ranges from 194 to 8,000 seeds per plant, and seed production is density dependent. The white taproot is slender, and forms an "s" shaped curve just below the crown (Nuzzo). Axillary buds are found at the root crown, and along the upper part of the "s". The new leaves and the root have a strong garlic odor. This odor fades as the plant matures.

During the rosette stage, garlic mustard resembles several native plants found in the shaded forest understory: *Viola* ssp., and several plants in the Saxifrage family, including *Tellima grandiflora* (fringecup) and *Tolmiea menziesii* (piggy-back plant). A distinguishing characteristic of the saxifrage are the presence of long hair, particularly on the leaf stems - which mature garlic mustard does not have.

Economic Importance:

Detrimental: The biology of this plant is invasive – it is broad-niched, with a short life cycle, and it can self-pollinate (Bazzaz 1986 as cited in Anderson et al. 1996). Garlic mustard can enter and establish in a relatively stable forest understory habitat, and replace the existing vegetation. This exotic species is a winter annual/biennial, with vegetative growth starting early in the season, outcompeting native and beneficial species that are still dormant at this time of year. Since garlic mustard is able to self pollinate, one plant has the capability to take over an entire site. By forming monospecific stands, garlic mustard disrupts and threatens native ecosystems, causing increased concern for resource managers. Natural areas that are managed, or preserved, are at risk of garlic mustard outcompeting and replacing the existing vegetation (Anderson et al. 1996). Once established, garlic mustard is difficult to eradicate. There are no known natural predators. The infestation size of garlic mustard can double in four years. In areas of high disturbance the population size can increase from 214% (flood zone) to 1000% (canopy loss in forest windstorm), in 2 years (Nuzzo). The geographic range across North America, and the expanded range of habitat type of garlic mustard is increasing. In Europe, *Alliaria* is the host plant for the *Alliaria* mosaic virus (Cavers et al. 1979) and several viruses affecting horticultural and agricultural crucifers (Nuzzo). Canadian farmers report that when cattle eat the rosettes of garlic mustard, the milk is tainted and has a bad taste to it (Cavers et al. 1979).

Beneficial: A winter herb used in salads and as a garlic or onion substitute for recipes (Post 1995). It is high in Vitamins A and C. Contains antiseptic properties and was used to clean wounds and abrasions.

Habitat: In its native range, garlic mustard is considered weedy, and takes advantage of disturbed areas. This species is often found in open disturbed forests and along fence rows.

In North America, garlic mustard is found in a wide variety of habitats, to include: forest edges, shaded roadsides, urban areas, riparian areas, flood plains, along hiking trails, waste areas and in dry, sunny areas along railroads. Garlic mustard grows on sand, loam, clay soils, limestone and sandstone substrates, drained peat soil and in well fertilized sites (Nuzzo).

In Washington, garlic mustard is found in the shaded forest understory of several parks in the Seattle area of King County. Associated shade tolerant species include: *Tolmiea menziesii* (piggy-back plant), *Tellima grandiflora* (fringecup), *Geranium robertianum* (herb Robert), *Lapsana communis* (nipplewort) and *Hedera helix* (ivy).

Geographic Distribution: Garlic mustard is native to Europe, and is more common in northern Europe. It has since spread to North Africa, India, New Zealand, Canada and the US. This plant was first collected in the United States from Long Island, NY in 1868. It may have been brought over for food, or for medicinal use. The largest North American populations are in New England and in the Midwest, where this species is known from 30 states and 3 provinces. Herbarium collections from the western states indicate sporadic populations, and early collections of garlic mustard are recorded from Idaho (1892) and Portland, OR (1959). Garlic mustard is found in western Canada, where it is established in Victoria, BC and Vancouver (Cavers et al. 1979 and White et al. 1993 as cited in Nuzzo). However, Roy Cranston, Provincial Weed Specialist, BC,

indicates that he is unaware of this species in the Victoria, or Vancouver area. There is an unconfirmed siting in the Okanogan (Vernon) area. (Personal correspondence 7/99).

History: Garlic mustard was identified and first reported to the Washington State Noxious Weed Control Board in the spring of 1999, when it was recommended, by Sarah Reichard, to be listed as a Class A noxious weed. No herbarium specimens were found from the University of Washington or from Washington State University. At this time, the known locations of garlic mustard are limited to King County, with field infestations at the Woodland Park Zoo, Carkeek Park and Golden Gardens. An additional roadside site was identified in Snohomish County.

Growth and Development:
After a period of dormancy, germination occurs from late February or early March and lasts until May. Germination can occur in light or under the dark forest canopy. The seedlings develop into basal rosettes by mid summer, and garlic mustard overwinters as a basal rosette. The rosettes will continue to grow during the winter months, when temperatures are above freezing and when there is no snow (Cavers et al. 1979). The following spring, these plants bolt, producing usually one flowering stalk. Some vigorous plants produce up to 12 flowering stalks. Depending on the site, flower production begins in May, and seed production occurs from June to October. (Anderson et al. 1996; Nuzzo; Post 1995). The seeds gradually drop from the mature siliques (Cavers et al. 1979).

Seeds remain dormant for 8 – 20 months, then germinate within 2 years. The seeds can remain viable for 5 years. The seeds are grooved. These grooves trap air, allowing the seeds to float for short distances. The populations are never constant because of the differing germination rates of the seeds (Post 1995).

Germination rates range from 48% - 100% (Lhotska 1975 as cited in Anderson et al. 1996), but seedling mortality is high, with only 7.5% seedling survival. The survival rates from seedling to mature plant range from 1% (Nuzzo 1993b) to 2% - 4% (Cavers et al. 1979). Summer drought can cause 95% mortality of first year rosettes (Nuzzo). High density rates may help to offset the high seedling mortality rates, and it may help with competitiveness during the second year of growth (Anderson et al. 1996). There is little mortality during the second growing season.

Reproduction:
In North America, garlic mustard is considered an obligate biennial herb, that reproduces by seed. Garlic mustard is capable of cross-pollination and self-pollination, producing individual plants that are genetically similar and interfertile. Most populations of garlic mustard are autogamous, with self-pollination occurring before the flowers open and before the stigma is exposed. Local populations exhibit variations in pollination and breeding systems, probably due to genetic differences in the floral biology. (Anderson et al. 1996). All rosettes that overwinter produce a flowering shoot, regardless of the rosette size. Flowers are produced in the spring of the second growing season, and the seeds ripen and disperse throughout the summer and early fall. An average plant produces about 350 seeds per plant, but a robust plant can produce up to 8,000 seeds. Seed production per site ranged from 9,533 seeds/m^2 to 107,580/m^2 (Anderson et al. 1996). The

seeds are seldom wind dispersed, and often fall close to the parent plant. Pedestrians, animals, and vehicles transport seeds.

Response to Herbicide: Herbicides are effective. Round-up® (glyphosate) at rates of 1%, 2% and 3% concentrations to rosettes in late fall or early spring reduced adult cover by 95% (Nuzzo). (These rates are from the Midwest.) Roundup and an amine formulation of 2,4-D can be applied in spring and fall. Basagram (bentazon) is highly effective for mid-summer control of first year rosettes growing in dense stands. No known chemical control for seedbank (Haber 1997). Please refer to herbicide labels for site specific control information.

Response to Cultural Methods: Prescribed burnings for large sites are a control option, and burning for 2 consecutive years is recommended, and effective. This will reduce the rosette populations. But, fires as a management tool are not always an option, and they do have their drawbacks – namely regeneration of flowering stalks from the root crown if the fires are not hot enough, which leads to higher seed production, and high rates of seedling survival after a fire (Nuzzo).

Response to Mechanical Methods: Depending on the size of the infestation, hand pulling is an effective control for this short lived mustard. Mature plants are easily pulled. The rosettes tend to snap off at the root (personal observation). Another option is to cut the flowering stalk to only a few inches above the ground, just before the plant produces flowers. Remove these stems from the site. The site should be monitored for 2 to 5 years, until the seed bank is eliminated.

Biocontrol Potentials: The preliminary research for a potential biological control project of garlic mustard was initiated by Bernd Blossey in April 1998. A literature review reported 69 insects and 7 fungi as natural predators. 26 of those species were collected, 17 species were reared, and 6 species were selected as potential biocontrol agents: *Ceutorhyitchus alliariae* and *C. roberti*, shoot-mining weevils that attack rosettes and bolting plants; *Ceutorhynchus constrictus* larvae destroys seeds; *Phyllotreta ochripes*, a flea beetle larvae found mining the root and root crown; *Ophiomyia alliariae* a shoot-mining agromyzid; and a weevil, *Ceutorhynchus scrobicollis* (Hinz, H.L. and E. Gerber 1998).

Several viruses do affect *Alliaria*, but only under certain conditions – and they did not affect plants growing in a natural environment (Nuzzo).

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**** References available from the Washington State Noxious Weed Control Board Office in Kent.***

Rationale for Listing:

Garlic mustard is a shade tolerant, invasive species with the capability to establish in our state. This exotic species has a history of invading and establishing, at a very fast rate, in the forested habitat of the New England area and Midwestern states, causing expensive and long-term management problems of natural areas. The biology of garlic mustard makes it difficult to control once it has reached a site: it is self-fertile, it has a high seed production rate, it is short lived, it outcompetes native vegetation with early spring germination and it can establish in a relatively stable forest understory. The fact that is it self-fertile means that one plant can occupy a site, produce a seed bank and establish an infestation of garlic mustard.

Prevention is often mentioned as the recommended control method for garlic mustard. At this time, the known distribution of garlic mustard in our state is very limited. By listing this species as a Class A noxious weed, and requiring eradication, we have the potential to contain the spread of garlic mustard, and to remove any existing populations.