Ohio Invasive Plant Assessment Protocol

Botanical Name: *Alliaria petiolata*
Common Name: Garlic Mustard
Family Name: Brassicaceae
Assessment conducted by: OIPC Team

Step I Outcome: **Invasive**
Step II Score: **63**
Step II Outcome: **Invasive**

Step I

Directions: Place an "X" in the Score column next to the selected answer to each of the four questions.

		Score	Notes	References
1. Is this plant known to occur in the state and listed as "noxious" on any federal or Ohio Department of Agriculture plant list?	Yes. *Place on invasive plant list, no further investigation needed.* ***STOP***			
	No. *Continue on to question 2.*	x		
2. Has this plant demonstrated widespread dispersion and establishment (i.e. high numbers of individuals forming dense stands) in natural areas across two or more regions in Ohio?[a]	Yes. *Place on invasive plant list, no further investigation needed.* ***STOP***	x	1,3&4=>widespread distribution in all 5 regions, but population sizes not given.	1,3,4
	No. *Continue on to question 3.*			
3. Does this plant form self-replicating populations outside of cultivation in Ohio and is it documented to alter the composition, structure, or normal processes or functions of a natural ecosystem?	Yes	x	10=> species outcompetes native plants, "alters habitat suitability for native birds, mammals, and amphibians and might affect the populations of these animals."	1,3,4,10
	No			
	Unknown			
4. Is the plant listed as invasive in an adjoining state or a nearby state east of the Mississippi within the USDA Plant Hardiness zones 5-6?[b,c]	Yes	x	IN, MI,PA [also in KY but not counted here]	5,6,7,8,33
	No			
	Unknown			

If the answer was yes for both questions 3 and 4, the plant is placed on the invasive plant list and no further research is needed. Stop here. If the answer is no for both questions 3 and 4, the plant is not considered invasive and no further investigation is warranted. Otherwise, proceed to Step II.

Step II: Invasion Status

Directions: Place the appropriate numerical score (or "U") in the Score column next to the selected answer to each of these 18 questions.

	Score	Notes	References
1. Current Invasion in Ohio - plant is not found in natural areas (**0 pts.**) - plant is found in natural areas but only because it persist from previous planting in that location (e.g. old home sites) (**0 pts.**) - plant is only expanding from sites of previous planting (**1 pt.**) - plant occurs in natural areas away from site of planting (**3 pts.**) - Information unknown (**U**)	3		1,3,4
2. State Distribution[a] - plant is not naturalized in any region of Ohio (**0 pts.**) - plant is naturalized in only one region in Ohio (**1 pt.**) - plant is naturalized in two regions in Ohio (**2 pts.**) - plant is naturalized in three regions in Ohio (**3 pts.**) - plant is naturalized in four regions in Ohio (**4 pts.**) - plant is naturalized in five regions in Ohio (**5 pts.**) - Information unknown (**U**)	5	Regions 1,2,3,4,5	1,3,4
3. Regional/US Distribution - plant is not considered to be a problem in any other state (**0 pts.**) - plant has been reported as a widespread problem in another non-neighboring state within the USDA Plant Hardiness Zones 5-6 (**1 pt.**)			

- plant has been reported to be a widespread problem in 1-2 adjoining states (**3 pts.**) - plant has been reported to be a widespread problem in 3 or more adjoining states (**5 pts.**) - plant has been reported to be a widespread problem in similar habitat outside the US (**1 pt.**) - Information unknown (**U**)	5	IN, MI,PA [also in KY but not counted here]	5,6,7,8,33
Step II: Biological Characters			
4. Vegetative Reproduction - no vegetative reproduction (**0 pts.**) - reproduces readily within the original site (**1 pt.**) - has runners or spreading rhizomes that root easily (**3 pts.**) - fragments easily and fragments can be easily dispersed (**4 pts.**) - has runners or spreading rhizomes that root easily AND fragments easily and fragments can be easily dispersed (**5 pts.**) - Information unknown (**U**)	0	No evidence	9
5. Sexual Reproduction - no sexual reproduction (**0 pts.**) - infrequent sexual reproduction (**1 pt.**) - frequent sexual reproduction, but high variation among years in seed production (**3 pts.**) - frequent sexual reproduction (one or more events per year) (**5 pts.**) - Information unknown (**U**)	5	9=> Species is biennial and has prolific seed set in Ohio. 15=> an obligate biennial producing overwintering rosettes in the first year, blooming from early spring through July of the second year, and producing fruit from June through September, after which the plant dies. 31=> reproduces only sexually.	9,15,18,31
6. Number of Viable Seeds or Propagules per Plant - few (0-10) (**1 pt.**) - moderate (11-1,000) (**3 pts.**) - prolific (>1,000) (**5 pts.**) - Information unknown (**U**)	5	165-8,000 seeds/plant, estimated seed production (seeds/m2) for Ohio: 19,060 - 38,025. 15=> as many as 9500 to 107,000 seeds per m2. 31=> "One plant can produce more than 3500 seeds (Susko and Lovett-Doust 2000), with population seed production varying from around 9500 seeds per m2 in northern Illinois (Nuzzo 1993b) to more than 107,000 seeds per m2 in Ontario (Cavers et al. 1979)."	9,10,11,15,31
7. Flowering Period - one month or less per year (**0 pts.**) - two months (**1 pt.**) - three to five months (**2 pts.**) - longer than five months (**3 pts.**) - Information unknown (**U**)	1	9=> Early April - Early June. 15=> blooming from early spring through July of the second year	9,15
8. Dispersal Ability - low potential for long-distance seed/propagule dispersal (>1km) (**0 pts.**) - medium potential for long-distance seed/propagule dispersal (**3 pts.**) - high potential for long-distance seed/propagule dispersal (**5 pts.**) - Information unknown (**U**)	5	Transported by rodents, birds, deer, and humans.	9,10
9. Generation Time - long juvenile period (>5 or more years for trees, 3 or more years for other growth forms) (**0 pts.**) - short juvenile period (<5 years for trees, <3 years for other forms) (**3 pts.**) - Information unknown (**U**)	3	2 years	9,10,11
10. Establishment - unable to invade natural areas (**0 pts.**) - can only colonize certain habitat stages (e.g. early successional habitats) (**1 pt.**) - aggressively colonizes and establishes in edge habitats (**3 pts.**) - aggressively colonizes and establishes in intact and healthy natural areas (**6 pts.**)		14=> in OH: "The phytochemical profile of A. petiolata was distinct from those of four closely related and/or abundant Brassicaceaeous species native to North America." 16=> garlic mustard is being attacked by a powdery mildew	

Step II	- Information unknown (**U**)	6	fungus in southwestern Ohio. 17=> "displays defense traits that are strongly inducible by jasmonic acid across populations, that jasmonate induction is substantially costly to growth with little variation among populations, and that costs of induction increase with decreased soil nutrient availability." 19=> garlic mustard grew rapidly and reached maximum cover earlier than most native groundcover species. 21= species exhibits phenotypic plasticity. 31=> can spread across the landscape at a rate of 6400 square kilometers per year.	,10,11,14,16,17,19,21,3
	Step II: Ecological Importance			
	11. Impact on Ecosystem Processes			
	- no known effect on ecosystem-level processes (**0 pts.**)			
	- moderate effects on ecosystem-level processes (e.g., changes in nutrient cycling)(**3 pts.**)	6	Species can alter species composition because it can outcompete native species - growing season starts before most native plants and deer find it unpalatable. It is potentially allelopathic. MAY AFFECT GROWTH OF MORELS (ESHBAUGH COMM.) 15=> ectomycorrhizal fungi association is negatively correlated with Garlic Mustard invasion. 16=> likely has impacts on nutrient cycling but still not fully understood [as of 2011]. 23=> "native populations of Pilea pumila with a long history of coexistence with garlic mustard developed more diverse symbiotic AMF communities." 26=> "over time, microbial communities can develop resistance to [garlic mustard] but at the cost of lower richness." 27=> "populations of A. petiolata from areas with a greater density of interspecific competitors invest more in a toxic allelochemical under common conditions. Furthermore, populations of a native competitor from areas with highly toxic invaders are more tolerant to competition from the invader, suggesting coevolutionary dynamics between the species." 28=> "populations of a native annual, Pilea pumila, shift from being maladapted to adapted to their local soil community with increasing history of invasion by Alliaria petiolata, an invader known to alter microbial communities." 29=> garlic mustard can displace resident understory species; "oak forest understories may be more vulnerable to A. petiolata invasion and that A. petiolata may negatively affect oak regeneration." 31=> "The consequences of garlic mustard invasion include the loss of biological diversity, ripple effects through higher trophic levels, and changes in the function of soil microbial communities."	),11,15,16,23,26,27,28,
	- causes long-term, substantial alterations in the ecosystem (e.g., changing fire regime of an area, changing hydrology of wetlands) (**6 pts.**)			
	12. Impact on Rare Organisms			
	- no known negative impact on Ohio State-listed or federal-listed plants or animals (**0 pts.**)			
	- negatively impacts listed species, such as through displacement or interbreeding (**3 pts.**)	3		Need citation
	13. Impact on Native Animals			
	- no known negative impact on animals (**0 pts.**)			

- documented direct or indirect negative effects on animal taxa (**3 pts.**)	3	The rare Pieries virginiensis (the West Virginia white butterfly) lays eggs on this species. Garlic mustard often "fatally inhibits" larval growth. 13=> Invaded areas contained nearly three times more springtails than uninvaded areas, possibly reflecting increased leaf decomposition in invaded sites. 20=> "Presence of A. petiolata was attributed to decreased population decline of Pieris napioleracea (mustard white butterfly) a rare, native butterfly found in the northeastern United States [50]. The authors reported that although females would oviposit on A. petiolata plants, the plant did not support larval growth, thus decreasing population persistence." 22=> in northeastern OH: "Plots invaded by garlic mustard showed reduced leaf litter depth, and an increased abundance of nonnative Amynthas earthworms" but did not appear to impact ant communities.	2,9,13,20,22
14. Impact on Native Plants			
- no known negative effects on native plants (**0 pts.**)			
- negatively impacts some native plants (increasing their mortality and/or recruitment of certain taxa) (**3 pts.**)		Thought to be a severe threat to many spring ephemerals and the animals that depend on them. 12,31=> species is allelopathic. 14=> "Allelopathic effects ...have been demonstrated against other plants and arbuscular and ectomycorrhizal fungi." 15=> "Garlic Mustard, while being outcompeted by Acer negundo L. (Box Elder), has been shown to outcompete seedlings of another native tree, Quercus prinus L. (Chestnut Oak), compete equally with some native annuals such as Impatiens capensis Meerb. (Jewel Weed) (Meekins and McCarthy 1999), and reduce seed germination of the native perennial Geum laciniatum Murray (Rough Avens) (Prati and Bossdorf 2004). McCarthy (1997) also found that removal of Garlic Mustard resulted in an increase in cover of annuals, tree seedlings, and vines over the course of three years." 18=> in MN, there was little evidence that garlic mustard was negatively impacting other plant species. 24=> although garlic mustard is allelopathic, "certain microbial taxa inhibit the process, possibly by degrading the allelochemicals." 25=> "impact of A. petiolata on soil microbial communities varied among individuals due to variation in their allelochemical concentrations. The differential impacts translated into varied effects on native tree growth...". 29=> "Garlic mustard had a negative effect on the final biomass, number of leaves, and relative growth rate in height of damesrocket [Hesperis matronalis]. Survival of damesrocket was not negatively affected by interspecific competition with garlic mustard; however, garlic mustard showed higher mortality because of intraspecific competition." 31=> "In soil from which garlic mustard had been experimentally removed 45 d earlier, the abundance of entomopathogenic fungi was restored to levels found in soil with no history of garlic mustard." 32=> garlic mustard and deer interact to differentially affect different plant species.	1,12,14,15,18,24,25,29
- impacts native plants to such an extent that community structure is greatly altered (**6 pts.**)	6		
15. Hybridization			
- no known instances of hybridization with other plant species (**0 pts.**)			
- can hybridize with native Ohio plants or commercially-available species, but seeds are inviable (**1 pt.**)	0	No evidence	
- can hybridize with native Ohio plants or commercially-available species, producing viable seed (**3 pts.**)			

16. Population Density

- occurs only as small, sporadic populations or individuals (**1 pt.**)
- typically forms small, monospecific patches (**3 pts.**)
- is a dominant plant in area where population occurs (absolute cover 15-50%) (**4 pts.**)
- forms an extensive, monospecific stand (absolute cover >50%) (**5 pts.**)

5	9=> has potential to dominate the herb layer	9

17. Role in Succession in Natural Areas

- successional information is unknown (**0 pts.**)
- is an early successional species that temporarily invades a disturbed site but does not persist as the site matures (**0 pts.**)
- readily invades disturbed sites and persists, but does not interfere with succession (**1 pt.**)
- readily invades disturbed sites, persists and interferes with succession of native plants (**4 pts.**)

1	It may alter succession in forests, but more evidence is needed for a positive answer. It is able to invade mature forests with minimal disturbance.	9

18. Number of Habitats Invaded

Forestlands: Floodplain forest, hemlock-hardwood forest, mixed mesophytic forest, beech-maple forest, oak-maple forest, oak-hickory forest.
Grasslands: Alvar*, beach-dune community*, bur oak savanna*, slough-grass-bluejoint prairie*, sand barren*, big bluestem prairie, little bluestem prairie
Wetlands: Bog*, fen*, twigrush-wiregrass wet prairie*, marsh, buttonbush swamp, mixed shrub swamp, hemlock-hardwood swamp*, maple-ash-oak
* Considered a rare plant community in Ohio by ODW's Biodiversity Database Program.
† – Xeric limestone prairies or cedar glades and post oak openings are unique to the Interior Low Plateau Region of Adams, Highland and Pike counties, and are not included in Schneider and Cochrane (1997)

- not found in any natural habitats in Ohio (**0 pts.**)
- only found in 1 broad category (**1 pt.**)
- found in 2 broad categories or 2 rare habitat types (**3 pts.**)
- found in 3 broad categories or 3 rare habitat types (**4 pts.**)
- found in 4 or more rare habitat types (**5 pts.**)

1	9=>Bluestem prairies, Oak savanna N. floodplain forest , Oak-hickory forests, Ash-Elm forest, Beech-Maple, ; 11=>open fields, inundated mesic communities, forests, dry and sandy forests	9,11

Total Score: **63**

Number of Unknowns: **0**

Outcome: **Invasive**

Total Points	Assessment Decision
4 or more U	Insufficient Data
0-34	Not Known to be Invasive
35-44	Pending Further Review
45-80	Invasive