Weed Risk Assessment for *Euonymus fortunei* (Turcz.) Hand.-Mazz. (Celastraceae) – wintercreeper

Maryland Department of Agriculture

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Version 1

Upper left: Wintercreeper flowers. Lower left: Wintercreeper fruits (Source: Carole Bergmann) Center: Wintercreeper climbing a tree. (Source: Sylvan Kaufman). Upper right: Wintercreeper aerial stems on a tree trunk. (Source: Carole Bergmann) Lower right: Wintercreeper growing over the ground in a forest. (Source: Sylvan Kaufman)

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Introduction The Maryland Department of Agriculture regulates terrestrial ornamental invasive plants under the authority of Md. AGRICULTURE Code Ann. § 9.5-101 et seq. Invasive Plant Prevention and Control. An invasive plant is defined as "a terrestrial plant species that a) did not evolve in the State, and b) if introduced within the State, will cause or is likely to cause, as determined by the Secretary: economic harm; ecological harm; environmental harm; or harm to human health."

Maryland's Invasive Plant Advisory Committee (IPAC) was established by legislative mandate in October 2011. The IPAC's primary responsibility is to advise the Secretary of Agriculture on regulating the sale of invasive plants, and on preventing them from entering Maryland or from spreading further in the state. IPAC evaluates the risk potential of plants already present in Maryland, newly detected in the Maryland or the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

IPAC evaluates the potential invasiveness of plants using the weed risk assessment (WRA) process developed by the Plant Protection and Quarantine (PPQ) Program of the US Department of Agriculture's Animal and Plant Health Inspection Service (Koop et al. 2012). PPQ's risk model uses information about a species' biological traits and behavior to evaluate its risk potential (Koop et al. 2012).

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States, or for any specific region in the United States. In the PPQ process, the geographic potential of the species is evaluated separately so that risk managers can make decisions appropriate for their regions. With respect to Maryland's evaluation process, we use PPQ's Geographic Information System overlays of climate to evaluate the potential for a plant to establish and grow in Maryland. The PPQ weed risk assessment also uses a stochastic simulation to evaluate how the uncertainty associated with the assessments affects the model's predictions. Detailed information on the PPQ WRA process is available in the document, *Guidelines for the USDA-APHIS-PPQ Weed Risk Assessment Process* (APHIS PPQ 2015), which is available upon request.

IPAC uses a second tool, the Maryland Filter, to assign plant species that score as highly invasive either Tier 1 or Tier 2 status. Maryland regulations define Tier 1 plants as "invasive plant species that cause or are likely to cause severe harm within the State" and Tier 2 plants as "invasive plant species that cause or are likely to cause substantial negative impact within the State." The Maryland Filter considers the actual and potential distribution of a species in Maryland, its threat to threatened and endangered ecosystems and species in the state, the difficulty of control of the species, and whether added propagule pressure would be likely to increase its persistence and spread significantly. IPAC then

recommends regulations to reduce the risk of the Tiered invasive plants in Maryland.

Euonymus fortunei (Turcz.) Hand.-Mazz. – wintercreeper

Species Information

Family: Celastraceae

Synonyms: *Eleaodendron fortunei* Turcz., *Euonymus radicans* Siebold ex. Miq., *Euonymus japonicus* var. *acutus* Rehder, *Euonymus japonicus* var. *radicans* Siebold ex. Miq., *Euonymus kiautschovicus* Loes. (ARS 2015).

Common names: wintercreeper, climbing euonymus, spreading euonymus, dwarf euonymus (ARS 2015).

Botanical description: *Euonymus fortunei* is an evergreen, shade-tolerant vine that forms a groundcover and climbs using aerial rootlets. Ascending stems eventually produce bird-dispersed fruits and plants can also reproduce from stem sections (Hutchison 2006).

Initiation: This plant is listed on the MD Department of Natural Resources (DNR) Do Not Plant List, a policy document available from MD DNR, which lists approximately 90 plant species that may not be planted on DNR land or for DNR projects.

Foreign distribution: *Euonymus fortunei* is native to China, Japan, Taiwan, Korea, India, Indonesia, Laos, Philippines, and Vietnam (Flora of China Editorial Committee 2013). It also naturalizes in Ontario, Canada (USDA PLANTS 2015) and Chile (Teillier et al. 2003) and has occasionally been found outside cultivation in New Zealand (Howell and Sawyer 2006).

U.S. distribution and status: Zouhar (2009) lists *Euonymus fortunei* as naturalized in numerous states in the U.S., mainly concentrated in Midwestern and southeastern states. It is listed as invasive in numerous national parks mostly in the southeast and Mid-Atlantic regions (Invasive Plant Atlas 2015) and is controlled in these regions (Invasive Plant Atlas 2015). The plant is widely cultivated in the United States (Dave's Garden 2015) and is hardy in zones 5-8 (Dirr 2009)

WRA area[1]: Entire United States, including territories.

Summary Statement

Euonymus fortunei received a score of High Risk under the PPQ WRA model because it forms dense mats on the ground and climbs trees, causing damage to habitat structure and community composition. The species received a ranking of Tier 1 in the Maryland Filter analysis because it immediately threatens Maryland threatened and endangered plant species in at least two locations.

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted [definition modified from that for "PRA area"] (IPPC, 2012).

1. *Euonymus fortunei* analysis

Establishment/ Spread Potential

Euonymus fortunei grows as a vine and subshrub forming a dense mat on the ground as well as growing into trees (Miller et al. 2010; Hutchison 2006; Schwegman 1996). Plants set fruit when they grow up in to trees (Swearingen et al. 2010). Fruits are dispersed by birds and other animals (Zouhar 2009; Swearingen et al. 2010; Miller et al. 2010). *Euonymus fortunei* is shade tolerant (Zouhar 2009; Remaley 2009; Wang and Ma 2004; Dirr 1998). *Euonymus fortunei* has established outside of cultivation in Canada, Chile, and New Zealand (USDA PLANTS 2015; Teillier et al. 2003; Howell and Sawyer 2006).
Risk score = 14 Uncertainty index = 0.23

Impact Potential

In natural areas, *Euonymus fortunei* is considered a weed and controlled (Texas Invasive Species Institute 2014; Zouhar 2009; Swearingen et al. 2010; Salihu et al.1999) because it alters habitat structure and species diversity (Swedo et al. 2008; Smith and Reynolds 2012; Schwegman 1996). Dense mats alter soil communities and affect native plant communities (Swedo et al. 2008; Smith and Reynolds 2012). Vines climbing into trees smother the canopy (Schwegman 1996). It is likely to affect both endangered species and ecosystems (Andre and Wait 2006; Jaquart et al. 2005; NatureServe Explorer 2014). We found no impacts on anthropogenic or agricultural systems.
Risk score = 2.3 Uncertainty index = 0.08

Geographic Potential

Based on three climatic variables, we estimate that about 64 percent of the United States is suitable for the establishment of *Euonymus fortunei* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *Euonymus fortunei* represents the joint distribution of Plant Hardiness Zones 5-13, areas with 10 to more than 100 inches of annual precipitation, and the following Köppen-Geiger climate classes: Steppe, Humid subtropical, Marine west coast, Humid continental warm summers and Humid continental cool summers. Note that in this weed risk assessment it was not clear if the occurrence of *Euonymus fortunei* reported from Panama is a wild or cultivated plant. The Köppen-Geiger climate class for this occurrence is Tropical rainforest. Because *Euonymus fortunei* is a temperate zone plant, for this prediction, we assumed that this environment is not suitable for it.

The area estimated likely represents a conservative estimate as it uses only three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. *Euonymus fortunei* occurs in a wide range of forest types, forest margins, and forest openings (Zouhar 2009). In its native range *Euonymus fortunei* is, "[c]ommon in woodlands, scrub, and forests, often cultivated in gardens; near sea level to above 3400 m." (Flora of China Editorial Committee 2013).

Entry Potential We did not assess the entry potential of *Euonymus fortunei* because it is already present in the United States (ARS 2015).

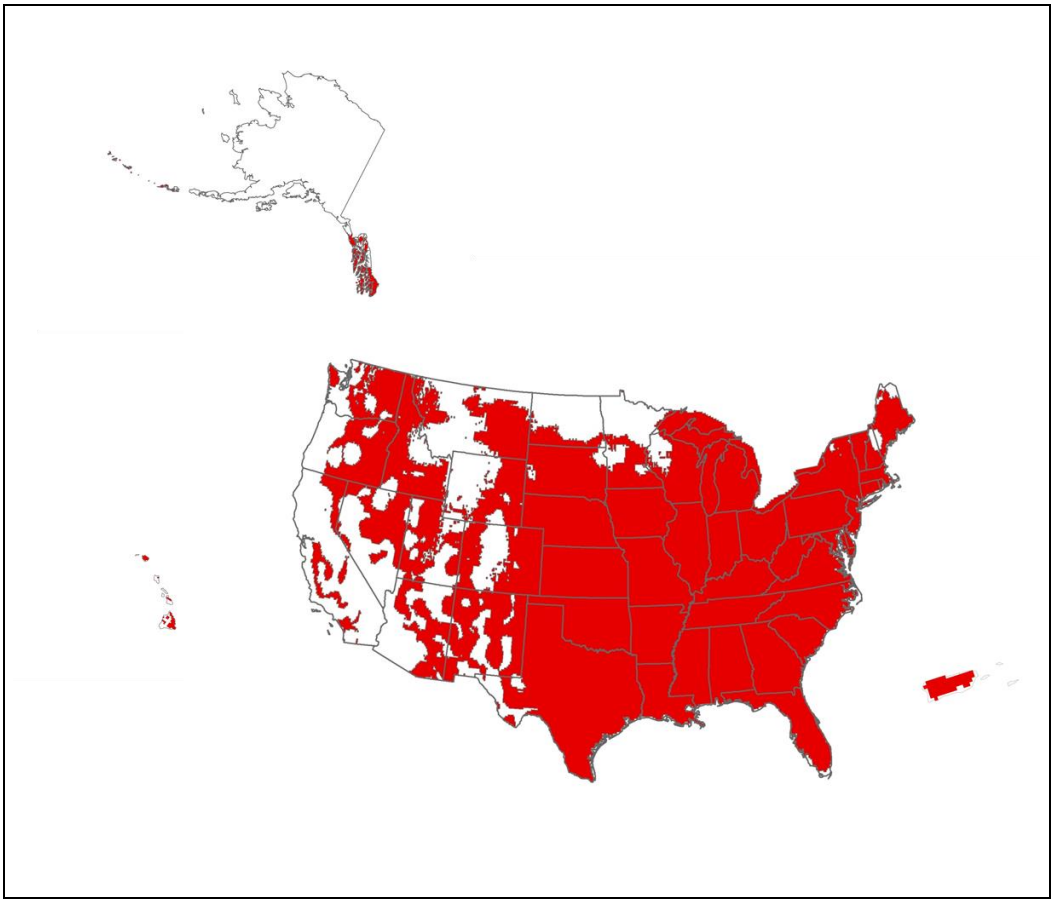

Figure 1. Predicted distribution of *Euonymus fortunei* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 63.4%
P(Minor Invader) = 34.9%
P(Non-Invader) = 1.7%

Risk Result = High Risk

Secondary Screening = Not applicable

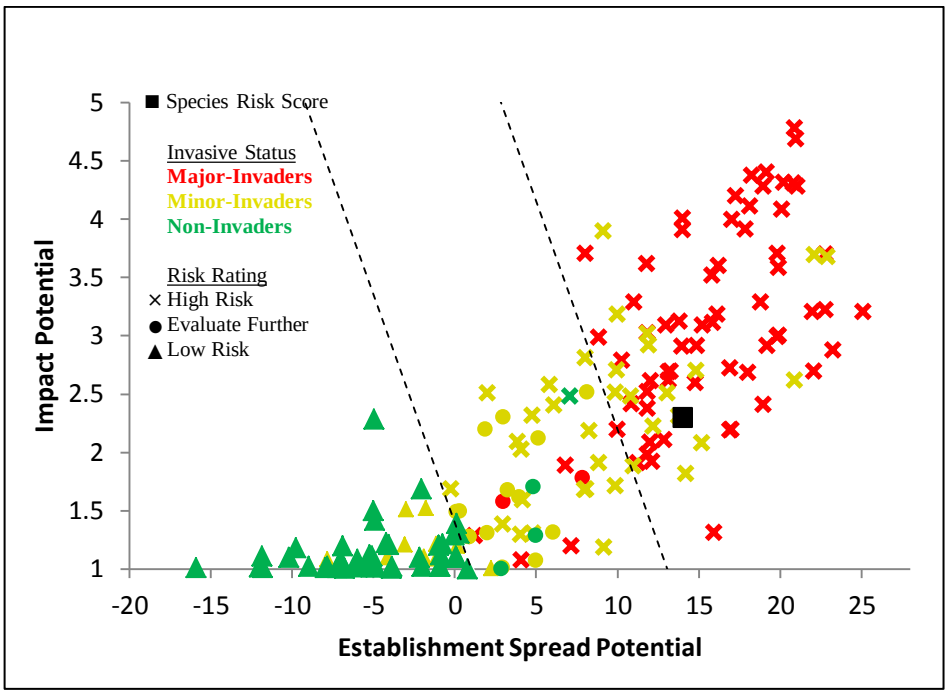

Figure 2. *Euonymus fortunei* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

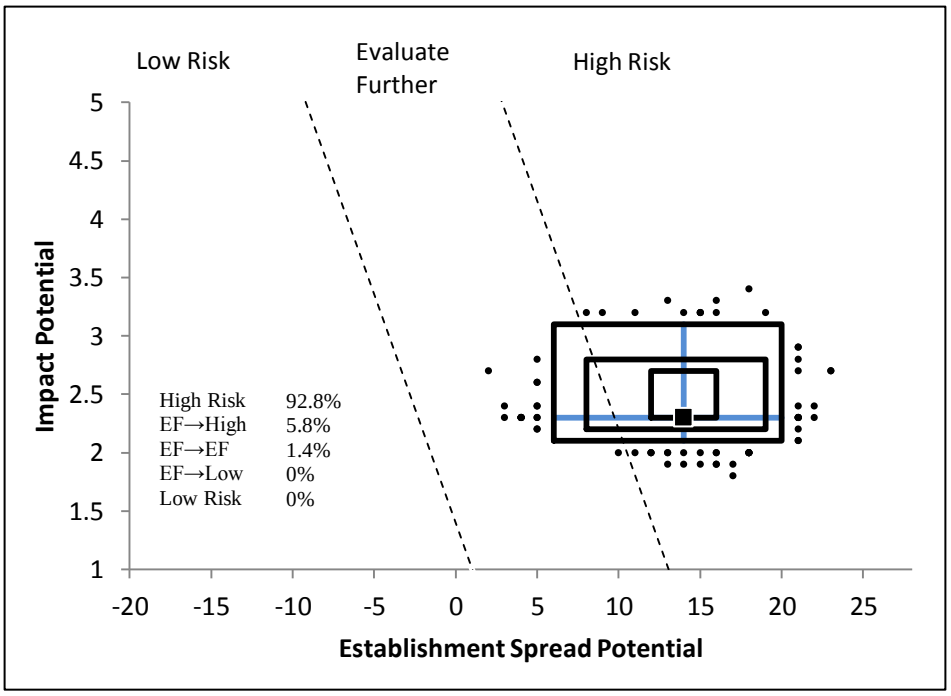

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Euonymus fortunei*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Euonymus fortunei* is High Risk. The species shares traits in common with other major invaders (Fig.2) used to develop and validate the PPQ WRA model. Ninety-three percent of the simulated risk scores received a rating of High Risk (Fig.3), indicating that our assessment is very robust. *Euonymus fortunei* tolerates heavy shade (Zouhar 2009) and grows in a wide range of environments (GBIF 2015). It can form dense mats on the ground and grow into trees, resulting in changes to habitat structure and species diversity (Smith and Reynolds 2012; Miller et al. 2010; Swedo et al. 2008; Hutchison 2006; Schwegman 1996). We found no impacts on anthropogenic or agricultural systems.

Euonymus fortunei ranks as a Tier 1 plant (Appendix B). It is naturalized in at least four counties in Maryland in the Coastal Plain and Piedmont (EDDMapS 2015) and could easily grow in other regions of Maryland (see the geographic analysis for this WRA). It occurs in at least two locations within floodplain forests in the immediate vicinity of state endangered plant species (Kyde 2015).

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Appendix A. Weed risk assessment for *Euonymus fortunei* (Turcz.) Hand.-Mazz. (Celastraceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - mod	5	Wintercreeper is native to China, Japan, Taiwan, Korea, India, Indonesia, Laos, Phillipines, and Vietnam (Flora of China Editorial Committee 2014). Naturalized in Chile (Teillier et al. 2003) and escaped/casual in New Zealand (Howell and Sawyer 2006) . It has naturalized from Ontario south to Georgia and west to Texas (ARS 2014). It occurs in many forest types in the United States and is described as competitive and hard to control (Zouhar 2009). Spreads to new places by seed and then further spread is by vigorous vegetative reproduction (Swearingen et al. 2010). In Indiana it, "quickly spread to forests in every county of the state" (TNC 2015). We answered "f" with moderate uncertainty since most reports do not specify spread even though it is widely naturalized and controlled. Alternative answers for the Monte Carlo simulation are "d" and "e."
ES-2 (Is the species highly domesticated)	n - mod	0	We found no evidence that wintercreeper is highly domesticated. Wintercreeper is extremely variable in leaf shape, size and color (Dirr 1998). Variegated forms may produce few to no fruits (Jacquart et al. 2005).
ES-3 (Weedy congeners)	y - negl	1	There are 142 species of *Euonymus* (The Plant List 2013). *Euonymus alatus*, *E. latifolius*, and *E. japonicus* are listed as invasive by Randall (2007) and several other species are listed as weeds (Randall 2007). *Euonymus japonicus* has been introduced into Australia where it has been ranked as an environmental weed, a garden escape, an agricultural weed, and is a declared weed (regulated) with the potential to have serious impact (Randall 2007). *Euonymus alatus* is considered an invasive plant in the United States because of its spread in forests (Swearingen et al. 2010; Miller et al. 2010). *Euonymus europaeus* is invasive in New Zealand and New York, U.S. (Popay et al. 2010; Glenn and Moore 2009). *Euonymus japonicus* and *E. europaeus* are considered environmental weeds in New Zealand (Howell 2008). All of these species are woody shrubs that tend to form dense stands in forests or shrublands and disturbed areas (Swearingen et al. 2010; Miller et al. 2010; NPPA 2008; Glenn and Moore 2009).
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	Several reviews suggest wintercreeper is tolerant of heavy shade (Zouhar 2009; Remaley 2009; Dirr 1998) Wintercreeper shows relatively efficient use of low light (Wang and Ma 2004).
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	y - negl	1	Wintercreeper grows as an evergreen, woody, clinging vine climbing to 12 - 22 m (40 – 70 feet) with the support of aerial roots, or it can form a dense ground cover or low shrub to 1m tall (Hutchison 2006; Miller et al. 2010).
ES-6 (Forms dense thickets, patches, or populations)	y - low	2	Forms a dense groundcover (Andre and Wait 2006; Remaley 2009). "Under ideal conditions it only needs one year to cover 75 percent of the ground with a dense mat" (Texas Invasive Species Institute 2014).
ES-7 (Aquatic)	n - negl	0	Wintercreeper is not an aquatic plant, it is a terrestrial vine that either grows on the ground or grows up trees (Hutchison 2006; Miller et al. 2010). "Plants avoid wet areas" (Miller et al. 2010).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-8 (Grass)	n - negl	0	Wintercreeper is in the family Celastraceae (ARS 2014), and therefore not a grass.
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that it fixes nitrogen. Furthermore, plants in the Celastraceae are not known to fix nitrogen (Martin and Dowd 1990; Santi et al. 2013)
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Fruiting occurs on upright, climbing stems (Miller et al. 2010). Groundcover plants seldom fruit or flower because the vine diameter must reach approximately 1 cm to trigger flowering (Zouhar 2009). Fruits often persist on plants into winter (Zouhar 2009). Each dry capsule holds up to four seeds covered in a bright orange aril (Miller et al. 2010). Seeds germinate after a period of cold stratification (Dirr 1998).
ES-11 (Self-compatible or apomictic)	? - max	0	Plants in the genus *Euonymus* are sometimes apomictic (Naumova 2008), but *Euonymus fortunei* is not reported as demonstrating apomixis (Brizicky 1964).
ES-12 (Requires specialist pollinators)	n - mod	0	We found no specific information on pollinators, although there is a record of numerous wasps and flies visiting the flowers in Michigan, USA, along with two cerambycid beetle species feeding on pollen, *Brachyleptura champlaini* and *B. rubrica* (Gosling 1984). Given that this exotic species is producing fruit in the United States (Zouhar 2009), we assumed that these flower visitors are effective pollinators and that the species does not need specialist pollinators.
ES-13 [What is the taxon's minimum generation time? (a) less than a year with multiple generations per year; (b) 1 year, usually annuals; (c) 2 or 3 years; (d) more than 3 years; or (?) unknown]	? - max		We found no information available on time to maturity when plants are grown from seed. Plants do reproduce vegetatively by rooting at nodes (Miller et al. 2010) and are propagated vegetatively (Dirr 2009). Plants probably take more than three years to reproduce by seed, but we think it is likely that vegetative reproduction could occur within 2 to 3 years. Alternate answers for the Monte Carlo simulation are "c" and "d."
ES-14 (Prolific reproduction)	n - mod	-1	Plants reproduce only when vines are climbing and reach a certain diameter (Zouhar 2009). Only four fruits/capsule are produced (Miller et al. 2010; Zouhar 2009) and there are no reports of abundant capsules being produced on climbing vines.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	We found no direct evidence for accidental introduction, although gardeners could easily dispose of plant parts that could reproduce. "Roots and stems form viable propagules" (Jacquart et al. 2005).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - low	-1	Seeds are bird-dispersed (Miller et al. 2010) and unlikely to be moved in trade, or to come in contact with most trade commodities. Plant parts are likely to be moved deliberately only in seed and live plant trade.
ES-17 (Number of natural dispersal vectors)	2	0	Fruit and seed traits for questions ES-17a through ES-17e. Plants produce dry capsules containing up to four seeds covered in a bright orange aril (Miller et al. 2010).
ES-17a (Wind dispersal)	n - negl		We found no evidence for wind dispersal and seeds have no adaptations for wind dispersal. Seed capsules are 0.2- 0.4 inches in diameter, each containing four seeds (Miller et al. 2010).
ES-17b (Water dispersal)	n - high		We found no direct evidence of water dispersal or evidence indicating seeds are buoyant. Some reviews say that seeds are water-dispersed, but an original source was not provided (Miller et al. 2010; Remaley 2009). Plants generally grow on upland sites (Miller et al. 2010).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17c (Bird dispersal)	y - negl		Seeds are bird-dispersed (Zouhar, 2009). No information is available on specific species of birds that consume wintercreeper. Seeds are coated with a bright orange aril and the similar fruits of *E. alatus* are bird dispersed (ISSG 2014).
ES-17d (Animal external dispersal)	n - negl		We found no evidence for external dispersal by animals and fruits have no adaptations for external dispersal.
ES-17e (Animal internal dispersal)	y - mod		Some reviews report dispersal by animals other than birds (Swearingen et al. 2010; Miller et al. 2010).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	? - max	0	No information was available on seed banks, but seeds of several species of *Euonymus* can be stored for more than two years (Wyman 1953).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - mod	1	Stem fragments root easily (Zouhar 2009). "When cut, wintercreeper sprouts from roots, root crowns, and/or cut stems" (Zouhar 2009). "Cutting alone may lead to sprouting from roots, root crowns, and cut stems" (Zouhar 2009).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence of herbicide resistance. It is not listed by Heap (2014).
ES-21 (Number of cold hardiness zones suitable for its survival)	8	0	
ES-22 (Number of climate types suitable for its survival)	5	2	
ES-23 (Number of precipitation bands suitable for its survival)	10	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	We found no evidence of allelopathy.
Imp-G2 (Parasitic)	n - negl	0	There is no evidence that wintercreeper is parasitic from botanical descriptions (Bailey 1976; Walker 2003)
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - high	0	We found no evidence that wintercreeper changes ecosystem processes.
Imp-N2 (Changes habitat structure)	y - low	0.2	Forms a dense groundcover in forests (Swearingen et al. 2010). Smothers trees (Schwegman 1996), potentially causing canopy gaps and therefore a change in habitat structure.
Imp-N3 (Changes species diversity)	y - negl	0.2	Wintercreeper appears to alter soil communities in a woodland affecting the growth of a native plant species (Swedo et al. 2008; Smith and Reynolds 2012). Forms a dense groundcover (Swearingen et al. 2010). Wintercreeper can smother and kill trees (Schwegman 1996).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - low	0.1	This species forms a dense groundcover impacting habitat for the state-listed imperiled plant, *Trillium pusillum* (Andre and Wait 2006). It threatens four state-listed species in Indiana (Jaquart et al. 2005).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - mod	0.1	Wintercreeper has naturalized in several globally outstanding ecoregions (Appalachian Blue Ridge, Appalachian mixed-mesophytic, and Southeastern Mixed forests (NatureServe Explorer 2014). It can alter community structure and composition in these regions (Schwegman 1996; Swedo et al. 2008; Smith and Reynolds 2012; Swearingen et al. 2010).
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - negl	0.6	Wintercreeper is recognized as an environmental weed and controlled in natural areas (Texas Invasive Species Institute 2014; Zouhar 2009; Swearingen et al. 2010). Kentucky and Tennesee list this species as a severe threat (Zouhar 2009). Alternative answers for the Monte Carlo simulation are both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - low	0	We found no evidence for this impact.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence. Although one gardener described it as, "If it lays 'flat' on the ground, it can be like having a bunch of trip wires" and she cut it back because of this (Dave's Garden 2014).
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	y - mod	0.1	Usually grown as a groundcover by gardeners but "rampant growing and will grow into lots of other plants and will become a vine when hitting a tree or wall" (Dave's Garden 2014).
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	a - low	0	In general wintercreeper is deliberately grown in anthropogenic areas as a groundover and reports of control are due to the plant's fast growth and pruning to prevent climbing. Alternative answers for the Monte Carlo simulation are "b" and "c."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - low	0	We found no evidence for this impact.
Imp-P2 (Lowers commodity value)	n - low	0	We found no evidence for this impact.
Imp-P3 (Is it likely to impact trade?)	n - low	0	We found no evidence for this impact.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - low	0	We found no evidence for this impact.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no evidence for this impact.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	a - low	0	This plant is not a weed in production systems. Alternate answers for Monte Carlo simulation both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically-referenced points obtained from the Global Biodiversity Information Facility (GBIF). Non-georeferenced locations from GBIF and other sources are noted as occurrences (occ.)
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-Z5 (Zone 5)	y - mod	N/A	One point is recorded in this zone in Michigan (GBIF 2015) The species is recognized by horticultural experts as occurring in this PHZ (Page and Olds 2001).
Geo-Z6 (Zone 6)	y - negl	N/A	Multiple points exist in Midwestern US, NY, WV and MA. Points in Norway and New Zealand.
Geo-Z7 (Zone 7)	y - negl	N/A	Canada - Ontario; New Zealand; US: KS, MA, PA, VA, WV
Geo-Z8 (Zone 8)	y - negl	N/A	Italy; New Zealand; Sweden; US: AL, GA, MS, UT
Geo-Z9 (Zone 9)	y - negl	N/A	US: GA
Geo-Z10 (Zone 10)	y - negl	N/A	Multiple points in China.
Geo-Z11 (Zone 11)	y - negl	N/A	Multiple points in China.
Geo-Z12 (Zone 12)	y - mod	N/A	Points in Taiwan (GBIF 2015); one reported occurrence in Chiriqui region of Panama that could be cultivated, but it is impossible to tell from the record (GBIF 2015 occ).
Geo-Z13 (Zone 13)	n - high	N/A	An occurrence in the Chiriqui region of Panama "around San Felix" is reported but it is not possible to tell if this is a cultivated or wild occurrence (GBIF 2015 occ). Given the conditions in which this species grows in its native range, we answered "no" with high uncertainty
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - high	N/A	The occurrence reported from Panama falls into this zone (GBIF 2015 occ).
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-C3 (Steppe)	y - mod	N/A	One point in Utah, US.
Geo-C4 (Desert)	n - negl	N/A	0
Geo-C5 (Mediterranean)	n - negl	N/A	0
Geo-C6 (Humid subtropical)	y - negl	N/A	Many points exist in China and Japan. Occurrence data in South Korea (GBIF 2015 occ). Multiple points in the southeastern and mid-Atlantic regions of US.
Geo-C7 (Marine west coast)	y - negl	N/A	Points in Belgium, China, France and New Zealand.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Points in South Korea and the US mid-West and WI.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Points in Austria, China, Germany, Japan, Norway, Romania, Sweden, and US: CT, MA, OH, RI (GBIF 2015).
Geo-C10 (Subarctic)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-C11 (Tundra)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that this species occurs in this zone.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Points reported from China; occurrences from South Korea and US: Points reported from China; occurrences from South Korea and US: UT (GBIF 2015 occ.)UT (GBIF 2015 occ.)
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Points reported in China, France, Germany, New Zealand, Sweden and US: KS.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Many points from Belgium, China, France (also occurrence data here), Germany, Italy, Japan, New Zealand, Romania, and the US: KS, MO, WI. Occurrence data from South Korea (GBIF 2015 occ.).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Points in Austria, Belgium, China, Japan, Norway and the US: CT, IL, MI, MO, OH, PA, RI, VA, and occurrence data from France, South Korea and the US: NY (GBIF 2015 occ.)
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Points reported from China, Japan and US: AL, CT, NC, with occurrences in South Korea and the US: GA and NY (GBIF 2015 occ.)
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Points reported from China, Japan; occurrence data from France, South Korea and the US: NY (GBIF 2015 occ).
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Points in China and Japan.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Points in China, Japan and Taiwan.
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	Points in China and Japan.
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	Points in China, Japan and Taiwan.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	It was introduced to the United States in the late 1800s or early 1900s and first reports of invasiveness did not appear until the late 1990s. It is proposed for listing as a regulated species in New York State (New York Department of Environmental Conservation 2013; Zouhar 2009).
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of aquarium plants or other aquarium products)	-	N/A	
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A	
Ent-4i (Contaminant of some other pathway)	-	N/A	
Ent-5 (Likely to enter through natural dispersal)	-	N/A	

Appendix B. Maryland Filter assessment for *Euonymus fortunei* (Turcz.) Hand.-Mazz. (Celastraceae).

Maryland Filter questions	Answer	Instructions/Result	Notes
1. Is the plant a sterile cultivar or used for root stock only? yes OR no	no	Go to question 2	Fruiting occurs on upright, climbing stems (Miller et al. 2010). Groundcover plants seldom fruit or flower because the vine diameter must reach approximately 1 cm to trigger flowering (Zouhar 2009). Fruits often persist on plants into winter (Zouhar 2009). Each dry capsule holds up to four seeds covered in a bright orange aril (Miller et al. 2010). Seeds germinate after a period of cold stratification (Dirr 1998). Variegated forms may produce few to no fruits (Jacquart et al. 2005).
2. Is the plant currently naturalized in Maryland? Yes OR no	yes	Go to Question 3	Occurs in at least four counties outside of cultivation (EDDMapS 2015; Maryland Biodiversity Project 2015).
3. What is the species' potential distribution in Maryland? wide OR narrow	wide	Go to question 4	Occurs in Coastal Plain and Piedmont (EDDMapS 2015) and could occur in other provinces based on the geographic analysis.
4. Does or could the species harm threatened or endangered Maryland species or community types or CITES listed species occurring in MD? yes OR no	yes	Tier 1	Occurs in immediate vicinity of Maryland threatened or endangered species, one in Western Branch, Prince George's County and one in the Potomac Gorge (Coastal Plain and Piedmont respectively).
5. How feasible is control of the species? easy OR difficult			Questions 5 and 6 are not answered because question 4 resulted in a ranking of Tier 1.
6. Is added propagule pressure from sales significantly increasing potential of the species to persist and spread? yes OR no			