Weed Risk Assessment for *Euonymus alatus* (Thunb.) Siebold (Celastraceae) – winged burning bush

Maryland Department
of Agriculture

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Version 1

Burning bush leaves and fruits in fall. 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, ecological, 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 the 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 alatus* (Thunb) Siebold. – winged burning bush**
Species Information	Family: Celastraceae
	Synonyms: *Celastrus alatus* Thunb. (ARS, 2014).
	Common names: burning bush, winged euonymus, winged spindle tree (ARS, 2014)
	Botanical description: Burning bush is a deciduous woody shrub that grows in a wide range of habitats from prairies to wooded wetlands in temperate latitudes. Shrubs grow to 12 ft. in height with a broad canopy. Opposite simple leaves turn bright red in the fall. Inconspicuous flowers bloom in spring and fruit capsules mature in fall releasing orange fleshy-coated seeds. For additional information see Plants of Pennsylvania (Rhoads and Block 2007) and Miller et al. (2010).
	Initiation: This plant is listed on the MD Department of Natural Resources 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: This species is native to northeast temperate Asia (ARS 2014).
	U.S. distribution and status: *Euonymus alatus* is naturalized extensively in the northeastern and midwestern United States. It is also naturalized as far south as Georgia and is listed as a noxious weed in Massachusetts and Connecticut.
	WRA area[1]: Entire United States, including territories.

Summary Statement

Euonymus alatus received a rating of high risk under the PPQ WRA model because this plant can spread easily in shady or sunny conditions to form dense thickets, producing thousands of seeds per plant, which can be spread by birds. The plant also spreads through root sprouts. The species received a Tier 2 ranking in the Maryland Filter analysis because it is already widely distributed in the state and there is no documented evidence of its threatening endangered species or ecosystems in the state.

[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 alatus* analysis

Establishment/Spread Potential

Burning bush is a prolific seed producer, with the ability to produce thousands of seeds/plant (Brand et al. 2012). It grows in full shade and can form dense thickets (Swearingen et al. 2010). Seeds are bird-dispersed (Swearingen et al. 2010).
Risk score =10 Uncertainty index = 0.19

Impact Potential

Because burning bush forms dense thickets, it can change community structure and composition (Fryer 2009). It invades a wide range of habitats from prairies to forests (Smith et al. 2010). Burning bush does not impact infrastructure, but it is considered weedy by some gardeners (GardenWeb 2014). We found no evidence that it impacts production systems.
Risk score = 2.7 Uncertainty index = 0.08

Geographic Potential

Based on three climatic variables, we estimate that about 84 percent of the United States is suitable for the establishment of *Euonymus alatus* (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 alatus* represents the joint distribution of Plant Hardiness Zones 4-11, areas with 0-100 inches of annual precipitation, and the following Köppen-Geiger climate classes: Steppe, Mediterranean, Humid subtropical, Marine west coast, Humid continental warm summer, Humid continental cool summer, and Subarctic.

The area of the United States shown to be climatically suitable is likely overestimated as our analysis considered 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 alatus* grows at woods edges, within woodlands, in forested floodplains, in prairies and along road edges (NPGS 2015; Smith 2010).

Entry Potential

We did not assess the entry potential of *Euonymus alatus* because it is already present in the United States (ARS 2014, Swearingen et al. 2010).

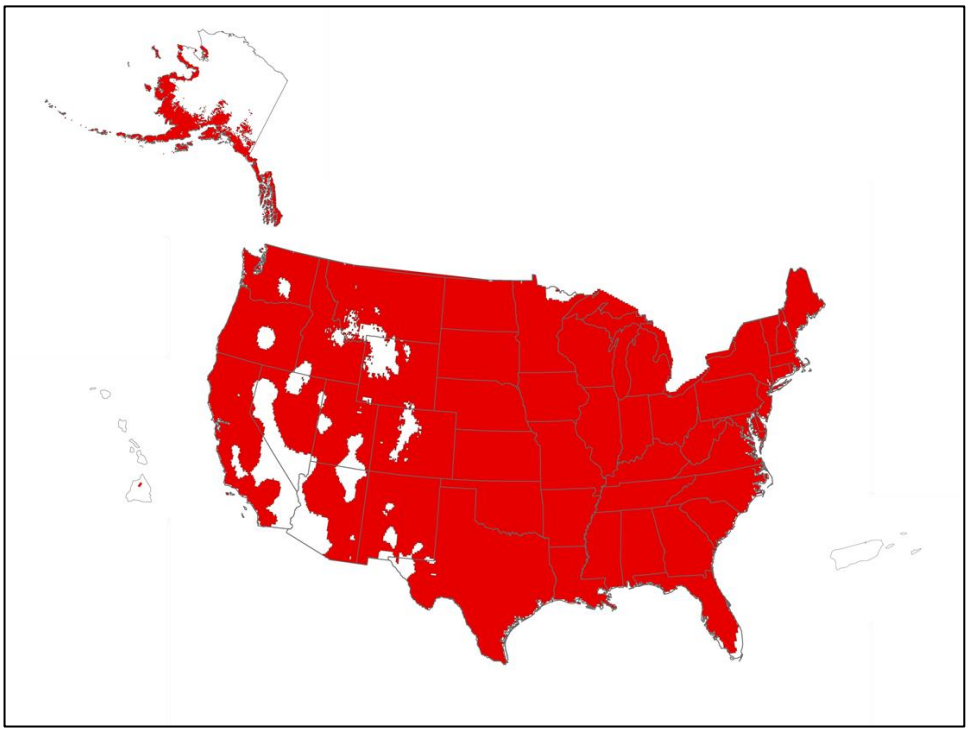

Figure 1. Predicted distribution of *Euonymus alatus* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 46.2%
P(Minor Invader) = 50.4%
P(Non-Invader) = 3.4%

Risk Result = High Risk

Secondary Screening = Not Applicable

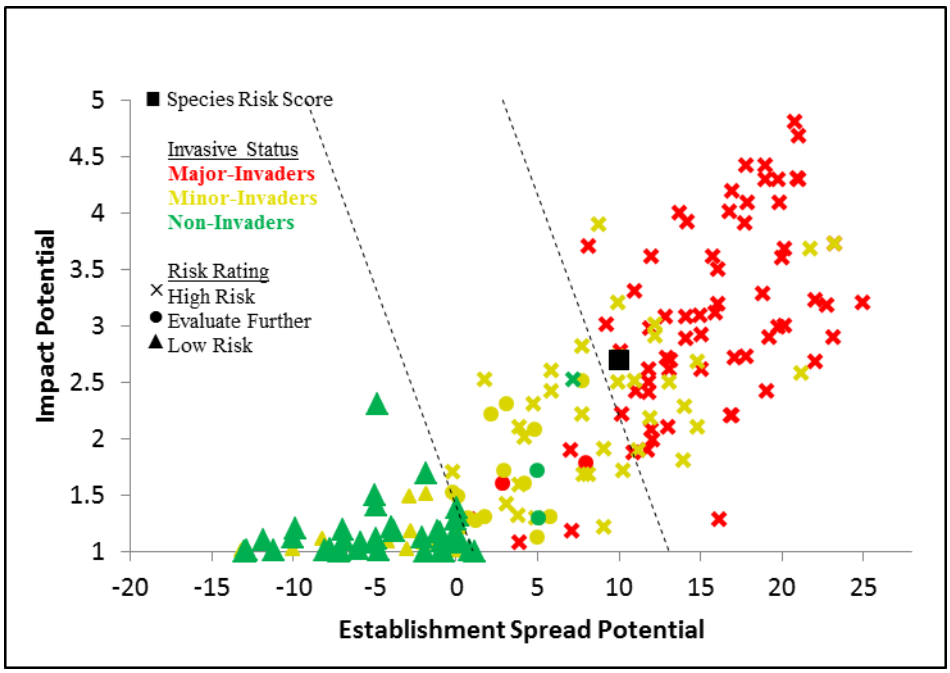

Figure 2. *Euonymus alatus* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

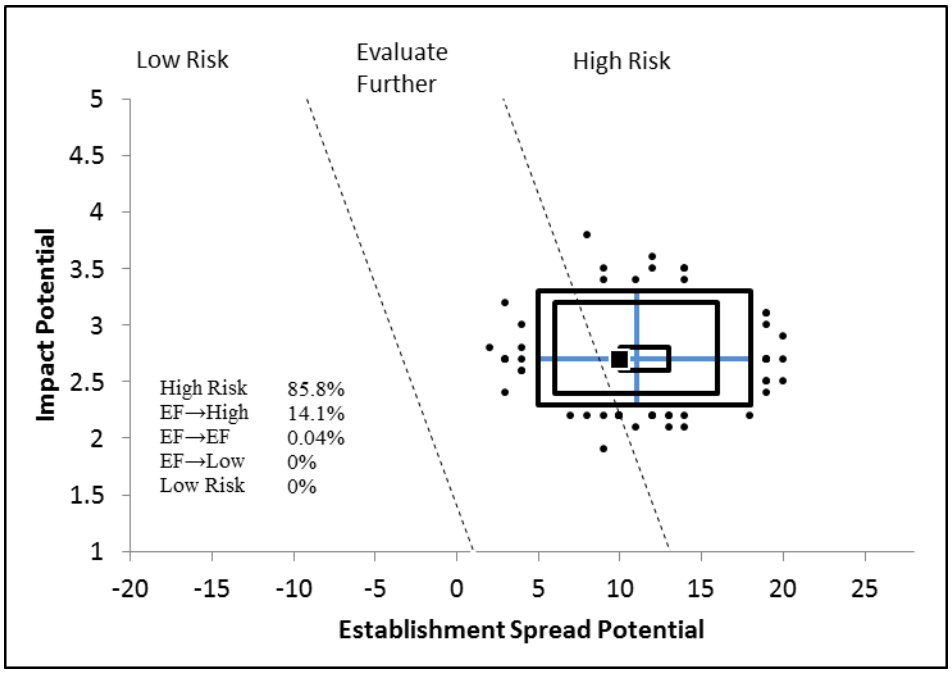

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Euonymus alatus*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.[a]

3. Discussion

The result of the weed risk assessment for *Euonymus alatus* is High Risk. *Euonymus alatus* shares traits in common with other major invaders (Fig.2) used to develop and validate the PPQ WRA model. 86% of the simulated risk scores received a rating of High Risk (Fig.3), indicating that our assessment is very robust. The capacity of this plant to grow and reproduce in full sun or dense shade (Dirr 1998), its ability to form dense thickets that can change natural community structure and composition (Robertson et al. 1995; Swearingen et al. 2010), its high fecundity (Brand et al. 2012), dispersal by birds (Dirr 1998), and its ability to spread vegetatively (USFS 2005) all support its rating as High Risk. The plant is reported by gardeners to spread invasively and produce hundreds of seedlings, although it is not reported to have a persistent seed bank. The species is an ornamental: the horticulture industry is developing a sterile cultivar which is not yet available commercially (Thammina et al. 2011).

Euonymus alatus ranks as a Tier 2 plant (Appendix B). *Euonymus alatus* has a wide distribution in Maryland and has been sold and naturalized in the state for at least twenty years (EDDMapS 2015; Norton Brown Herbarium 2015). We found no documentation of its effect on threatened and endangered species or ecosystems in the state, but it does seem likely that it could affect species and ecosystems based on its wide distribution and community level impacts. Because the species is already widely distributed and has been in Maryland for a long time period (an herbarium specimen of a cultivated plant from Baltimore dates to 1933 (Norton Brown Herbarium 2015) additional sales are unlikely to increase burning bush's potential to persist and spread.

4. Literature

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Appendix A. Weed risk assessment for *Euonymus alatus* (Thub.) Siebold (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 (Status/invasiveness outside its native range)	f - negl	5	Winged burning bush is native to northeastern Asia (Miller et al. 2010). In North America, it has naturalized from southern Ontario to Georgia and throughout much of the midwest (Kartesz 2014; Kaufman and Kaufman 2013). It grows in a wide range of habitats from prairies to woodlands and second growth forests (Fryer 2009). In Pennsylvania, "found with increasing frequency in moist forests throughout eastern counties" (Rhoads and Block 2007). In Australia, introduced but not reported as having escaped cultivation (Randall 2007). Answering "f" based on its widespread naturalization and reports of spread in the United States. Alternate answers both "e" for Monte Carlo simulation.
ES-2 (Is the species highly domesticated)	n - low	0	There are numerous cultivars of burning bush, but until recently plants were selected for hardiness, size and color (UConn 2014; Brand et al. 2010). Researchers have produced a triploid sterile cultivar *of Euonymus alatus* 'Compacta', but it is not marketed yet (Thammina et al. 2011).
ES-3 (Weedy congeners)	y - low	1	*Euonymus fortunei* is considered invasive in parts of the US (CABI 2013). *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 fortunei* and *E. latifolius* are also labeled as weeds with the potential for serious impact by Randall (2007). *Euonymus japonicus* has also been listed as a casual escape in Italy (Celesti et al. 2009)
ES-4 (Shade tolerant at some stage of its life cycle)	y - low	1	Burning bush is described as tolerant of full shade (ISSG 2014) and as growing well in heavy shade as well as full sun (Dirr 1998).
ES-5 (Climbing or smothering growth form)	n - negl	0	It is neither a vine nor an herb with a basal rosette. Botanical description describes it as a flat-topped shrub (Dirr 1998).
ES-6 (Forms dense thickets)	y - negl	2	Described as forming dense thickets, where "hundreds of seedlings are often found below the parent plant in what is termed a "seed shadow." (Swearingen et al. 2010). "This species can form dense patches in woodlands and grasslands" in New England (Bronson et al. 2006).
ES-7 (Aquatic)	n - negl	0	Burning bush is not described as an aquatic plant (Bailey 1976). Occurs in forests, grasslands, shrublands and urban areas (ISSG 2014).
ES-8 (Grass)	n - negl	0	Burning bush is in the family Celastraceae (ARS 2014), and therefore not a grass.
ES-9 (Nitrogen-fixing woody	n - negl	0	Plants in the Celastraceae are not known to fix nitrogen

plant)			(Martin and Dowd 1990; Santi et al. 2013)
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Seedlings are often found below parent plants (Swearingen et al. 2010; Assessor, personal observation). Brand et al. (2012) found seed germination rates in experiments in natural areas as high as 37.8%. Unpublished research by Renz and Gull (2012) demonstrates seed viability and seed germination of different cultivars under both laboratory and natural conditions.
ES-11 (Self-compatible or apomictic)	y - mod	1	Plants in the genus *Euonymus* are sometimes apomictic (Naumova 2008), and *Euonymus alatus* is reported as demonstrating apomixis (Brizicky 1964). Answering "yes" with moderate uncertainty since the reference specific to *E. alatus* is not an original source reference and does not cite a source for apomixis that we could verify.
ES-12 (Requires special pollinators)	n - high	0	European species of *Eunoymus* are reportedly pollinated by bees and flies (Brizicky 1964). Answering "no" with high uncertainty since no information specific to *E. alatus* could be found.
ES-13 (Minimum generation time)	d - high	-1	A fact sheet from New Hampshire lists reproductive maturity at 5 years (NH Dept. of Ag. 2014). Burning bush in horticulture is generally grown from cuttings, and no other information was found on age of reproduction following either growth from seeds or cuttings. Because this is a woody plant, it is likely to take at least two years before seed production. Alternate answers for the Monte Carlo simulation are both "c.".
ES-14 (Prolific reproduction)	y - high	1	Brand et al. (2012) estimated seedling contribution of cultivars to range from 588 to 3763 /plant/year (combined data from seed germination and establishment). In a seedbank study of *Euonymus alatus*, seed rain averaged 168 seeds m^2 (IPANE 2003). "Shrubs with diameters less than 15 mm produced little to no seeds, and trunks greater than 30 mm had 100 seeds or more, with the largest seed count of 701 occurring on a 43.89 mm diameter plant" (Bronson et al. 2006).
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	0	We found no direct evidence of unintentional dispersal by people, but discarded cuttings or branches with seeds could lead to dispersal.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - low	-1	Burning bush is grown as an ornamental, and there are no reports of its propagules being a contaminant in trade.
ES-17 (Number of natural dispersal vectors)	1	-2	Fruits are a 1 - 4 part capsule 1 - 1.3 cm in diameter that contains up to four seeds. Each seed is surrounded by a bright orange-red fleshy aril (Flora of China 2014).
ES-17a (Wind dispersal)	n - low		There is no evidence of wind dispersal. The fruit do not have any obvious adaptation for wind dispersal; fruit is a dry capsule having seeds with a fleshy aril surrounding them (Rhoads and Block 2007).
ES-17b (Water dispersal)	n - mod		There is no evidence of water dispersal. Fruit is a dry capsule having seeds with a fleshy aril surrounding them; fruit is eaten by birds (Rhoads and Block 2007).
ES-17c (Bird dispersal)	y - negl		Seeds are bird-dispersed into shady woods (Dirr 1998).

			Birds relish the fruit of *E. alatus*, and seeds passing through their digestive tract are viable (ISSG 2014). Seeds dispersed this way germinate easily and spread the infestation to other areas (ISSG 2014).
ES-17d (Animal external dispersal)	n - low		There are no apparent morphological features evident to suggest external animal dispersal (Bailey 1976).
ES-17e (Animal internal dispersal)	? - max		Fruits are consumed by small rodents, but unclear if seeds are dispersed successfully (Bronson et al. 2006).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - high	-1	Two seedbank studies where burning bush was found in the overstory did not find burning bush seeds in the seed bank (Leck and Leck 2005; Kostel-Hughes et al. 1998). We answered "no" but with high uncertainty since studies were looking for multiple species.
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	1	Resprouts after cutting (Fryer 2009) but no evidence that plants are more vigorous after cutting. Colonizes by root sprouts (USFS 2005). Likely to resprout after from the root crown after fire (Fryer 2009). Because there is no direct evidence of vigorous resprouting we are answering "?".
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)	9	0	
ES-22 (Number of climate types suitable for its survival)	7	2	
ES-23 (Number of precipitation bands suitable for its survival)	11	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 burning bush is parasitic from botanical descriptions (Bailey 1976; Walker 2003).
Impacts to Natural Systems			
Imp-N1 (Change ecosystem processes and parameters that affect other species)	n - mod	0	We found no evidence of changes to ecosystem processes.
Imp-N2 (Change community structure)	y - low	0.2	Burning bush forms a dense shrub layer (Fryer 2009; Swearingen et al. 2009). Changes prairie vegetation to shrubland (Fryer 2009).
Imp-N3 (Change community composition)	y - low	0.2	Displaces native plant species (Swearingen et al. 2010). "*Euonymus alatus* (burning bush) could be a major woody invader of hill prairies when a seed source occurs in the immediate area." (Robertson et al. 1995). "Invading forest understories, pastures, and coastal shrub lands" (Miller et al. 2010).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species)	y - mod	0.1	Burning bush invades a wide range of natural habitats including deciduous forests, hill prairies and coastal shrub lands (Robertson et al. 1995; Miller et al. 2010). These community types are likely to harbor threatened and endangered species, and because burning bush alters community structure and composition (Fryer 2009), it is likely to affect these species.

Imp-N5 (Is it likely to affect any globally outstanding ecoregions)	y - mod	0.1	Based on *E. alatus* being listed as an invasive weed in the Appalachians (Univ. TN 2014), which occurs in a U.S. globally outstanding ecoregion (Ricketts et al. 1999), the fact that it is known to invade forests (Miller et al. 2010), and the impacts listed in Imp-N2, we answered "yes" for this question.
Imp-N6 (Weed status in natural systems)	c - negl	0.6	Burning bush is controlled in New England natural areas (Wenning 2012); Reported as invasive in several national parks (InvasivePlantAtlas.org 2014). Alternate answers are both "b."
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Impacts human property, processes, civilization, or safety)	n - low	0	We found no evidence.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence, although plants do form dense thickets (Swearingen et al. 2010)
Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation)	y - mod	0.1	Numerous reports of having to control plants and seedlings on Dave's Garden (2014) and GardenWeb (2014), such as removing "hundreds of seedlings from my neighbor's yard … every year" (GardenWeb 2014). Reported from urban parks such as Rock Creek Park in DC (EDDMapS 2014). A report from Newton, MA reports how volunteers removed burning bush that had overrun a woodland garden (Schroeder 2013).
Imp-A4 (Weed status in anthropogenic systems)	c - mod	0.4	There is evidence of it being controlled in gardens (Dave's Garden 2014; GardenWeb 2014; Schroeder 2013) and urban and suburban parks (EDDMapS 2014). Alternate answers are both "b."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - low	0	No evidence. It has not demonstrated significant impact in production systems (Holm 1979).
Imp-P2 (Lowers commodity value)	n - low	0	We found no evidence.
Imp-P3 (Is it likely to impact trade)	n - low	0	We found no evidence.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	We found no evidence.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - mod	0	All parts of the plant are toxic, but an animal would have to consume large quantities (NC Extension 2014). Not listed as toxic to livestock, dogs, or cats (ASPCA 2014; Cornell University Department of Animal Science 2008).
Imp-P6 (Weed status in production systems)	a - low	0	Burning bush has not demonstrated significant impact in production systems (Holm 1979). Alternate answers both "b" for Monte Carlo simulation because of some reports of toxicity, but no reports of removal for that reason.
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically-referenced points (pt.) obtained from the Global Biodiversity Information

			Facility (GBIF), accessed in January 2015. Non-georeferenced locations from GBIF and other sources are noted as occurrences (occ.) Data from earlier USDA PERAL searches are incorporated here.
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)	y - low	N/A	China: Jilin, Nei Mongol, Heilongjiang (NPGS 2015 occ.); Kyrgystan (GBIF 2009 pt.); Russia: Primorskiy Kray (NPGS 2015 occ.); Other information (Marsh 2008 pt.)
Geo-Z4 (Zone 4)	y - low	N/A	Canada: One occ. in Quebec comes from a Montreal park; China: Heilongjiang (NPGS 2014 pt.; (GBIF 2009); Heilongjiang, Jilin, Nei Mongol (NPGS 2015 occ.); Other information (Dave's Garden 2008; BayScience Foundation 2008)
Geo-Z5 (Zone 5)	y - negl	N/A	Canada: Ontario (pts. reported in Toronto and occ.); China: (NPGS 2015, pt.) Jilin, Liaoning, Nei Mongol (NPGS 2015, occ.); Korea, North (occ.); Korea, South (occ.); Kyrgystan: (GBIF 2009, pt.); US: IL, MA, NH, VT, WI. One occ. from Cache County, UT which includes PHZ 5; Other information (Dave's Garden 2008)
Geo-Z6 (Zone 6)	y - negl	N/A	China: (GBIF, NPGS 2015, pt.) Beijing, Liaoning, Nei Mongol, Shaanxi (NPGS 2015, occ.); Japan (pt.); Korea, North and South (occ.); Sweden: (GBIF 2009); US: CT, KS, MA, ME, NC, NJ, OH, PA. One occ. from Cache County, UT which includes PHZ 6; Other information (Dave's Garden 2008)
Geo-Z7 (Zone 7)	y - negl	N/A	China: (GBIF, NPGS 2015, pt.) Beijing, Liaoning, Shaanxi (GBIF, NPGS 2015 occ.); Germany; Japan; Korea, North (occ.); Korea, South: (occ., GBIF 2009); Sweden (2015 pt. and occ., Magarey 2008, GBIF 2009); US: CT, DC, IL, KS, MA, MD, MO, NJ, NY, VA; Other information (Dave's Garden 2008)
Geo-Z8 (Zone 8)	y - negl	N/A	China: (GBIF, NPGS, pt.) Jiangsu, Liaoning, Shaanxi (NPGS 2015 occ.); Germany; Japan (country level data); Korea, North (occ.); Korea, South (GBIF pt., NPGS, occ.); Spain (occ.); Sweden (pt., occ.); US: MA.Other information (Dave's Garden 2008)
Geo-Z9 (Zone 9)	y - negl	N/A	China (pt.) Jiangsu, Liaoning, Shaanxi (occ.); Japan (pt.); Korea, South (occ.); Netherlands (pt.); New Zealand: Country-level data (GBIF, 2009); Spain: Madrid (occ.). A 2015 GBIF search revealed only one point in New Zealand, at Eastwoodhill, a botanic garden; this point was therefore removed from the analysis.
Geo-Z10 (Zone 10)	y - negl	N/A	Japan: (GBIF pt.)
Geo-Z11 (Zone 11)	y - high	N/A	Taiwan (pt.) We answered “yes” with high uncertainty, as although one point in Taiwan was noted, the country was derived from coordinates and was considered invalid.
Geo-Z12 (Zone 12)	n - negl	N/A	We found no evidence that this species occurs in this

			zone.
Geo-Z13 (Zone 13)	n - high	N/A	Philippines (occ.) We found one 1910 record with no Lat-Long, but enough specific information to locate it on a particular mountain, but Mathers (2003) says the species is "particularly sensitive to high root temperatures," so this occ. is unlikely. We answered no with high uncertainty.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that this species occurs in this zone.
Geo-C2 (Tropical savanna)	n - high	N/A	We found no evidence that this species occurs in this zone.
Geo-C3 (Steppe)	y - low	N/A	China (One pt. of 1994 wild collected material in Beijing in NPGS inactive records, occ.in Nei Mongol); Kyrgyzstan; Spain: One occ. in Madrid.
Geo-C4 (Desert)	n - mod	N/A	China: NPGS occ. reported for Nei Mongol, but Mathers reports that the species is "particularly sensitive to high temperatures." We answered “no” with moderate uncertainty.
Geo-C5 (Mediterranean)	y - negl	N/A	Spain: Madrid (occ.)
Geo-C6 (Humid subtropical)	y - negl	N/A	China: We found several points in both GBIF and NPGS records, athough the NPGS points are locations of other species where *Euonymus alatus* is mentioned as an observed associate. GBIF and NPGS occ.; Japan: (pt., occ., Espenshade 1995, NPGS 2015 occ.); Taiwan: one point; US: DC, MD, IL, KS, MO, NC, VA (pt., occ.)
Geo-C7 (Marine west coast)	y - negl	N/A	China (pt, occ.) NPGS 2015 occ.; Germany (pt, occ.); Netherlands (pt, occ.).
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	China (pt, occ.) NPGS 2015 occ.; Japan (pt, occ.) NPGS 2015 occ.; North and South Korea (pt, occ.); US: CT, IL, KS, MI, MO, NJ, NY, PA (pt.) OH, UT (occ.)
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Canada: one point in Toronto, occ. in Montreal; China: both GBIF and NPGS pt. and occ.; Japan (pt and occ.) NPGS occ.; Russia: one NPGS point recorded in 2000 where *Euonymus alatus* is observed as an associated species, but there are several historic NPGS records from this part of Siberia; Sweden (pt. and occ.); US: CT, MA, ME, OH, RI, VT (pt. and occ.) MI, NY, UT (occ.)
Geo-C10 (Subarctic)	y - mod	N/A	Canada: the Quebec occ. data is from Montreal, which is in Zone C9; China (GBIF and NGPS occ.); US: NH (pt). Because of the New Hampshire point data, we answered “yes” with moderate rather than high uncertainty.
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)	y - low	N/A	It occurs within this range of rainfall in Spain, Kyrgyzstan, Sweden, Japan, South Korea (NAPPFAST 2008); China: Shaanxi (occ.) Nei Mongol (NPGS occ.)
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	China: many pts and occ.; Spain (occ.); US (occ.)

Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	China: many pts and occ.; Sweden (pt. and occ.); US (occ.).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Canada: one pt. in Toronto; China (pt. and occ.); Germany (occ.); Japan (pt. and occ.); North and South Korea (pt and occ.); Netherlands (pt. and occ.); Russia (NPGS 2015 pt.); Sweden (occ.); US (pt. and occ.)
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	China (pt. and occ.); Germany (pt.); Japan (pt. and occ., NPGS 2015 occ.); North and South Korea (occ.); Sweden (pt. and occ.); US (pt. and occ.)
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Canada (occ.) This Quebec occ. is specifically from Montreal, which is in the R6 precipitation band; other precipitation bands within Quebec are also found in other countries where *Euonymus alatus* is documented. China (pt. and occ.); Germany (occ.); Japan (pt. and occ., NPGS 2015 occ.); South Korea (occ.); US (pt. and occ.).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	China (occ.); Japan (pt. and occ., NPGS 2015 occ.); South Korea (occ.); US (one pt. in NC, occ.)
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	China (occ.); Japan (pt. and occ., NPGS 2015 occ.)
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	China (occ., NPGS 2015 pt.); Japan (pt. and occ.)
Geo-R10 (90-100 inches; 229-254 cm)	y - negl	N/A	China (occ.); Japan (pt. and occ.)
Geo-R11 (100+ inches; 254+ cm)	y - negl	N/A	China (occ.); Japan (pt. and occ.); Philippines (occ.); Taiwan (one pt.)
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Introduced in the 1860s as an ornamental plant (Kaufman and Kaufman 2013).
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	
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,	-	N/A	

vegetables, or other products for consumption or processing)		
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 alatus* (Thub.) Siebold (Celastraceae).

Maryland Filter questions	Answer	Instructions/Result	Notes
1. Is the plant a sterile cultivar or used only for root stock? yes OR no	no	Go to question 2	No, currently all cultivars produce some viable seeds (Brand et al. 2012)
2. What is the species potential distribution in Maryland? wide OR narrow	wide	Go to question 3	Species could occupy all physiographic provinces of MD (WRA geographic analysis). It is reported to occur in the Coastal plain, Piedmont, and Ridge and Valley Provinces of MD (EDDMapS 2015).
3. Does or could the species harm threatened or endangered Maryland species or community types or CITES listed species occurring in MD? yes OR no	?	Go to question 4	No information available
4. How feasible is control of the species? easy OR difficult	difficult	Go to question 5	Plants reproduce vegetatively from root sprouts (USFS 2005)
5. Is added propagule pressure from sales significantly increasing potential of the species to persist and spread? yes OR no	no	**Tier 2**	*Euonymus alatus* is widely planted and escaped in Maryland (EDDMapS 2015) and has been in the state since at least the 1930s (Norton Brown Herbarium 2015).