Weed Risk Assessment for *Berberis thunbergii* DC. (Berberidaceae) – Japanese barberry

Michigan Department of Agriculture and Rural Development

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Version 1

Top left: Japanese barberry spiny branches and red fruits (source: Getty Images). Bottom left: perfect yellow flowers of Japanese barberry (source: Leslie J. Mehrhoff, University of Connecticut, Bugwood.org). Right: ornamental varieties of *B. thunbergii* in varying colors from deep purple to bright yellow planted in a landscaping bed (source: pahls.com).

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Introduction

The Michigan Department of Agriculture and Rural Development (MDARD) regulates terrestrial species through a Prohibited and Restricted species list, under the authority of Michigan's Natural Resources and Environmental Protection Act (NREPA), Act 451 of 1994, Part 413 (MCL 324.41301-41305). Prohibited species are defined as species which "(i) are not native or are genetically engineered, (ii) are not naturalized in this state or, if naturalized, are not widely distributed, and further, fulfill at least one of two requirements: (A) The organism has the potential to harm human health or to severely harm natural, agricultural, or silvicultural resources and (B) Effective management or control techniques for the organism are not available." Restricted species are defined as species which "(i) are not native, and (ii) are naturalized in this state, and one or more of the following apply: (A) The organism has the potential to harm human health or to harm natural, agricultural, or silvicultural resources. (B) Effective management or control techniques for the organism are available." Per a recently signed amendment to NREPA (MCL 324.41302), MDARD will be conducting reviews of all species on the lists to ensure that the lists are as accurate as possible.

We use the United States Department of Agriculture's, Plant Protection and Quarantine (PPQ) Weed Risk Assessment (WRA) process (PPQ, 2015) to evaluate the risk potential of plants. The PPQ WRA process includes three analytical components that together describe the risk profile of a plant species (risk potential, uncertainty, and geographic potential; PPQ, 2015). At the core of the process is the predictive risk model that evaluates the baseline invasive/weed potential of a plant species using information related to its ability to establish, spread, and cause harm in natural, anthropogenic, and production systems (Koop et al., 2012). Because the predictive model is geographically and climatically neutral, it can be used to evaluate the risk of any plant species for the entire United States or for any area within it. We then use a stochastic simulation to evaluate how much the uncertainty associated with the risk analysis affects the outcomes from the predictive model. The simulation essentially evaluates what other risk scores might result if any answers in the predictive model might change. Finally, we use Geographic Information System (GIS) overlays to evaluate those areas of the United States that may be suitable for the establishment of the species. For a detailed description of the PPQ WRA process, please refer to the PPQ Weed Risk Assessment Guidelines (PPQ, 2015), which is available upon request.

We emphasize that our WRA process is designed to estimate the baseline—or unmitigated—risk associated with a plant species. We use evidence from anywhere in the world and in any type of system (production, anthropogenic, or natural) for the assessment, which makes our process a very broad evaluation. This is appropriate for the types of actions considered by our agency (e.g., State regulation). Furthermore, risk assessment and risk management are distinctly different phases of pest risk analysis (e.g., IPPC, 2015). Although we may use evidence about existing or proposed control programs in the assessment, the ease or difficulty of control has no bearing on the risk potential for a species. That information could be considered during the risk management (decision making) process, which is not addressed in this document.

Plant Information and Background

PLANT SPECIES: *Berberis thunbergii* DC. (Berberidaceae) (GBIF, 2021).

SYNONYMS: *Berberis thunbergii* f. *erecta* Rehder, *Berberis thunbergii* f. *grandiflora* E.L.Wolf ex V.V.Byalt, L.V.Orlova & Potokin, *Berberis thunbergii* f. *microcarpa* E.L.Wolf ex V.V.Byalt, L.V.Orlova & Potokin, *Berberis thunbergii* f. *obovata* E.L.Wolf, *Berberis thunbergii* f. *trispinosa* E.L.Wolf ex V.V.Byalt, L.V.Orlova & Potokin, *Berberis thunbergii* subsp. *atropurpurea* Chenault, *Berberis thunbergii* var. *argenteomarginata* C.K.Schneid., *Berberis thunbergii* var. *atropurpurea* Chenault, *Berberis thunbergii* var. *erecta* (Rehder) Ahrendt, *Berberis thunbergii* var. *maximowiczii* (Regel) Regel, *Berberis thunbergii* var. *minor* Rehder, *Berberis thunbergii* var. *pluriflora* Koehne, *Berberis thunbergii* var. *rubrifolia* Ahrendt, *Berberis thunbergii* var. *uniflora* Koehne (GBIF, 2021).

COMMON NAMES: Japanese barberry (CABI, 2019), barberry, Thunberg's barberry, Japanese berberis (MISIN, Wisconsin DNR).

BOTANICAL DESCRIPTION: *Berberis thunbergii* is a deciduous perennial shrub usually 2-3 feet in height, but can grow up to 6 feet (CABI, 2019; Michigan Department of Natural Resources, 2012). It forms arching stems with a single spine at each node, and small, spoon-shaped leaves that turn red in the fall. Umbels of yellow flowers droop from the underside of branches in the spring, growing into red, ovoid berries 8-13 mm long (CABI, 2019). For a full botanical description see (World Flora Online, 2022).

INITIATION: In accordance with the Natural Resources and Environmental Protection Act Part 413, the Michigan Department of Agriculture and Rural Development was tasked with evaluating the species currently on Michigan's Prohibited and Restricted Species List (MCL 324.41302). USDA Plant Epidemiology and Risk Analysis Laboratory's (PERAL) Weed Team worked with MDARD to evaluate and review this species.

WRA AREA[1]: United States and Territories.

FOREIGN DISTRIBUTION: *Berberis thunbergii* is native to Japan and is also present in China, Turkey, and South Korea (CABI, 2019). It has been repeatedly introduced throughout Europe and is now naturalized. It is considered invasive in Germany (CABI, 2019). *B. thunbergii* occurrences have also been recorded in New Zealand and Australia (CABI, 2019; GBIF, 2021). It is invasive in Canada, though according to the Woody Invasives of the Great Lakes Collaborative, *Berberis thunbergii* is not regulated in Ontario (CABI, 2019; WIGL, 2022). It is not a common problem in Africa, except for in South Africa where it is a proposed Category 3 Invader Plant (CABI, 2019).

[1] The "WRA area" is the area in relation to which the weed risk assessment is conducted (definition modified from that for "PRA area") (IPPC, 2017).

U.S. DISTRIBUTION AND STATUS: *Berberis thunbergii* was first introduced to the U.S. in 1875 (Degasperis & Motzkin, 2007). Soon after, it was marketed by nurseries as a landscaping shrub, and many hybrid cultivars have been developed since. Now, nurseries and online vendors sell dozens of cultivars that are widely available (Amazon.Com; The Tree Center Plant Supply Co.; Woodies Garden Goods). *B. thunbergii* is present throughout the northeastern United States, the Great Lakes Region, extending south to Georgia, and west to parts of the Great Plains between North Dakota and Kansas. *B. thunbergii* is on state invasive species lists in Indiana, Pennsylvania, Kentucky, Virginia, West Virginia, Delaware, New Jersey, Connecticut, Alabama, Georgia and South Carolina. It is regulated through both state law and invasive species lists in Wisconsin, Maryland, and New Hampshire, and only by state law in New York, Minnesota, Vermont, Massachusetts and Maine (EDDMapS, 2022). In Michigan, *Berberis spp*. bushes that are prone to black stem rust are prohibited (Michigan Department of Natural Resources, 2012). Control efforts can also be costly. According to the Indiana DNR, the cost of controlling *B. thunbergii* invasions may be up to $2,000 per acre each year (Matson, 2011).

Analysis

ESTABLISHMENT/SPREAD POTENTIAL: *Berberis thunbergii* is a widely distributed invasive species that forms dense, impenetrable thickets in both disturbed and undisturbed landscapes, from fields to wetlands and woodlands (CABI, 2019; Michigan Department of Natural Resources, 2012). It reproduces vegetatively through layering and sprouting from the root crown; mowing, cutting or burning only causes the plant to proliferate (Ehrenfeld, 1999; Michigan Department of Natural Resources, 2012; Zouhar, 2008). *B. thunbergii* can also produce up to 1,000 seeds per plant (Brand et al., 2012). It is extremely shade tolerant and reproduces at just two years of age (CABI, 2019; Cameron and Wheeler, 2020). This plant can also adapt to a range of climates, withstanding severe drought and wetlands (Butzler, 2021). Birds and other small animals readily eat the fruits and distribute seeds long distances (Butzler, 2021; Ehrenfeld, 1999; Juzwik et al., 2021). In addition, seeds can be dispersed by human travel on roadways (Kurtz and Hansen, 2018). A congener species is Berberis vulgaris L. which is also an introduced invasive species, prohibited in Connecticut (USDA NRCS, 2022). We had low uncertainty for this risk element.

Risk score = 12 Uncertainty index = 0.11

IMPACT POTENTIAL: *Berberis thunbergii* can drastically alter ecosystem parameters by increasing nitrogen cycling and altering soil pH, increasing the alkalinity (Dawkins et al., 2022; WIGL, 2022). It outcompetes other species by leafing out earlier in the spring and keeping its leaves later in the fall (Xu et al., 2007). The presence of *B. thunbergii* reduces the number of saplings and seedlings in the forest therefore suppressing native species (Kurtz and Hansen, 2018; Link et al., 2018). A study in New York demonstrated a reduction in predatory insects in habitats where *B. thunbergii* has invaded as well (Clark and Seewagen, 2019). Its spines and toxicity deter browsing by white-tailed deer making it a better competitor (Cameron and Wheeler, 2020; Wisconsin DNR). The dense shrub populations create a microclimate of increased humidity favorable for ticks; studies have shown increased densities of deer ticks and blacklegged ticks (Linske et al., 2018; Michigan Department of Natural Resources, 2012). This is a threat to human health, pets and livestock due to increased infection rates and spread of Lyme disease (Butzler, 2021). In production systems, lowbush blueberry yields decrease due to preferential pollination of *Berberis thunbergii* by bees (Dibble et al., 2018). It threatens cultivated plants by harboring aphids, mildews and other diseases, and hampering tillage on field margins (CABI, 2019). We had average uncertainty for this risk element.

Risk score = 3.7 Uncertainty index = 0.16

GEOGRAPHIC POTENTIAL: Using the PPQ climate-matching model for weeds (Magarey et al., 2017), we estimate that about 49.3% percent of the United States is suitable for the establishment of *B. thunbergii* (Fig. 1). This area represents the joint distribution of Plant Hardiness Zones 4a-9b, areas with 20-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: humid subtropical, temperate oceanic climate, warm and hot-summer Mediterranean climate, warm-summer humid continental climate, hot-summer humid continental climate, subarctic climate, and monsoon-influenced hot-summer humid continental climate (app. A). The area of the United States shown to be climatically suitable was determined using only these three climatic variables. Other factors, such as soil, hydrology, disturbance regime, and species interactions may alter the areas in which this species is likely to establish. *B. thunbergii* is known to invade a variety of both disturbed and undisturbed landscapes, from fields to wetlands and woodlands (CABI, 2019).

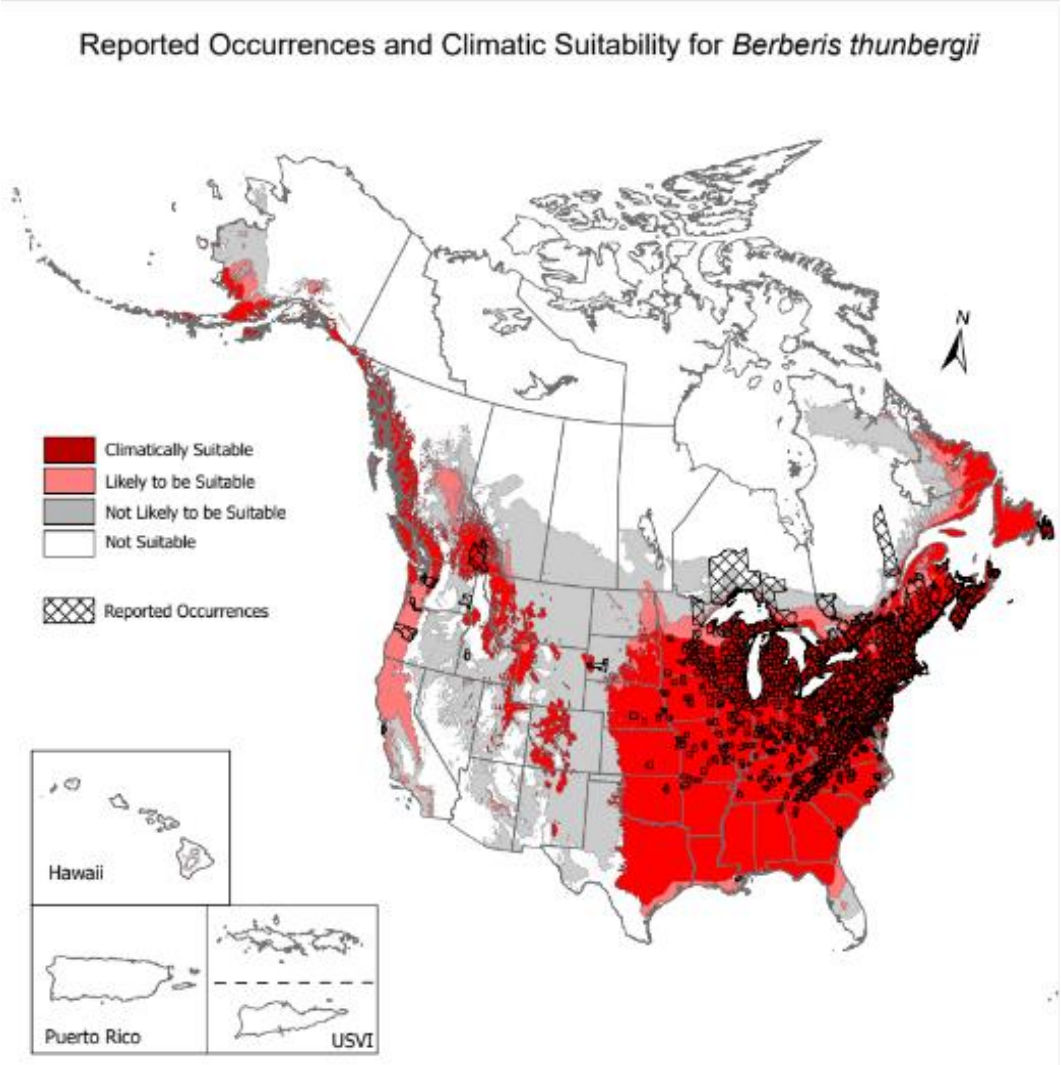

Figure 1. Current and potential distribution of *Berberis thunbergii* in the United States. Climatic suitability was determined using the APHIS-PPQ climate matching tool for invasive plants (Magarey et al., 2017). The known distribution of *B. thunbergii* was based on county distribution records from online databases and other sources (see text). Map components are shown at different scales.

ENTRY POTENTIAL: We did not assess the entry potential of *Berberis thunbergii* because it is already present in the United States (Fig. 1).

Risk Model Results

Model Probabilities: P(Major Invader) = 71.5%
P(Minor Invader) = 27.3%
P(Non-Invader) = 1.2%

Risk Result = High Risk
Risk Result after Secondary Screening = Not applicable

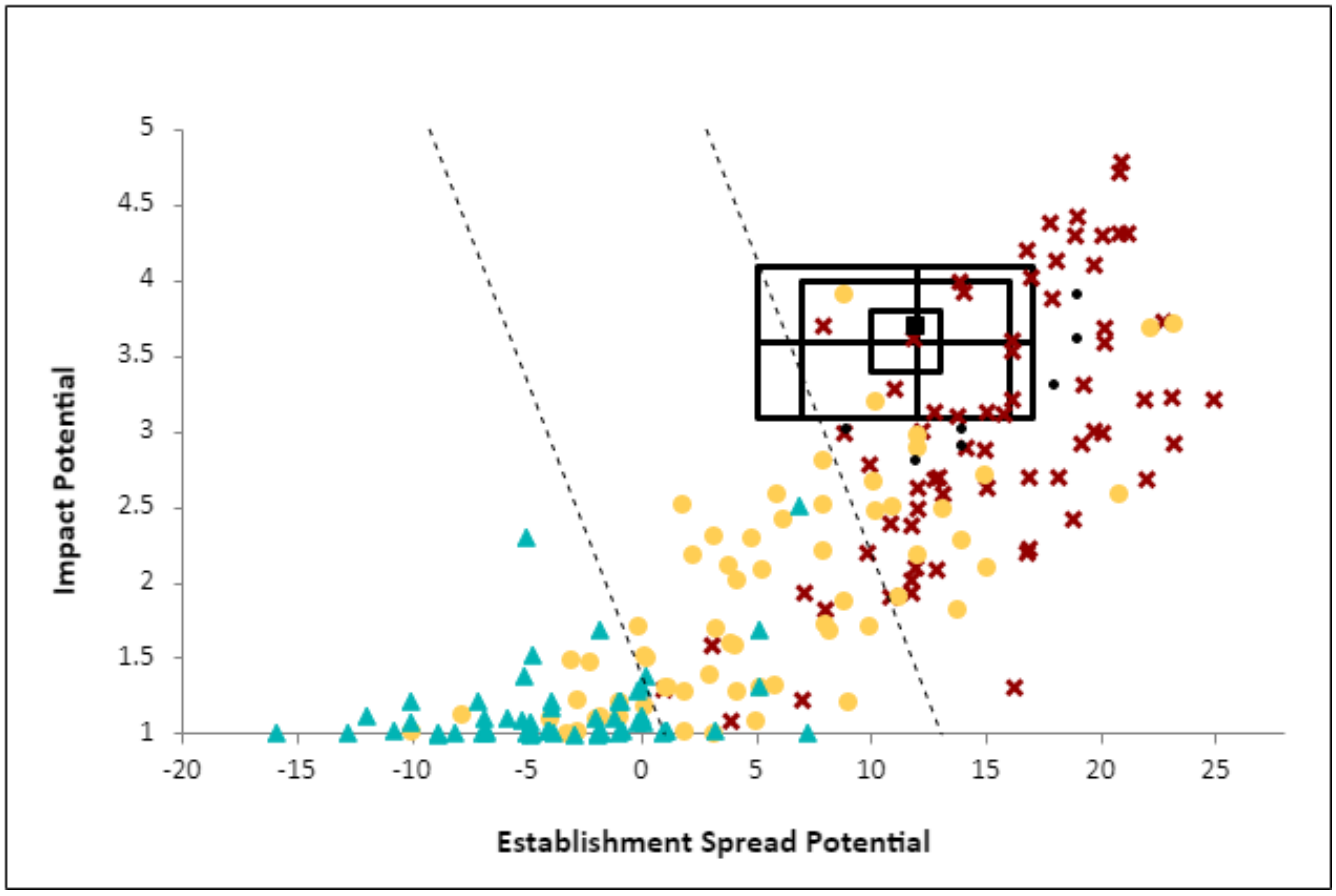

Figure 2. Risk and uncertainty results for *Berberis thunbergii.* The risk score for this species (solid black symbol) is plotted relative to the risk scores of the species used to develop and validate the PPQ WRA model (Koop et al., 2012). The results from the uncertainty analysis are plotted around the risk score for *Berberis thunbergii.* The smallest, black box contains 50 percent of the simulated risk scores, the second 95 percent, and the largest 99 percent. The black vertical and horizontal lines in the middle of the boxes represent the medians of the simulated risk scores (N=5000). For additional information on the uncertainty analysis used, see Caton et al. (2018).

Discussion

The result of the weed risk assessment for *Berberis thunbergii* is high risk of becoming weedy or invasive in the United States and is well supported by the uncertainty analysis (Fig. 2). Historically, it has been a preferred landscaping shrub for both aesthetics and for providing a barrier (Butzler, 2021). Numerous hybrid cultivars have been bred for their vibrant array of colors and flowers. However, *Berberis thunbergii* displays many invasive traits that make it a threat to both natural and anthropogenic systems. Its prolific seed production combined with its ability to form dense thickets enables its rapid spread beyond cultivation (Brand et al., 2012; Zouhar, 2008). Birds feed on the small red fruits aiding in long-distance seed dispersal to both disturbed and undisturbed landscapes (Cameron and Wheeler, 2020). *B. thunbergii* is a well-adapted competitor that drastically alters the environments it invades, outcompeting native species (Clark and Seewagen, 2019; Dawkins et al., 2022; Link et al., 2018). It tolerates a wide range of environmental conditions, from shade to full sun, and soil conditions from drought to wetlands (Butzler, 2021). The spines on the branches deter browsing by animals and it is toxic to deer, making native species more prone to herbivory (Cameron and Wheeler, 2020; Wisconsin DNR).

In addition, dense stands of *B. thunbergii* provide habitat for ticks, resulting in the increased spread and infection of Lyme disease (Linske et al., 2018; Michigan Department of Natural Resources, 2012). This is a threat to public health and is cited as a main cause for restriction, prohibition, and adding it to state invasive species lists (Butzler, 2021; Matson, 2011; Minnesota Department of Agriculture; 2022). It is listed as invasive in Indiana, Pennsylvania, Kentucky, Virginia, West Virginia, Delaware, New Jersey, Connecticut, Alabama, Georgia and South Carolina. *B. thunbergii* is also regulated through both state law in multiple places (EDDMapS, 2022). Already, there are over 900 positive reports of *B. thunbergii* in Michigan, and climate change models predict that invasions will spread both north and south due to increased growth and germination (EDDMapS, 2022; Merow et al., 2017). Prompt action to remove or control existing plantings, prevent continued trade, and inform the public of the harmful effects of *B. thunbergii* will prevent further impact.

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Appendix A. Weed risk assessment for *Berberis thunbergii* DC. (Berberidaceae)

The following table includes the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question.

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 - negl	5	Native to Japan, Japanese barberry was first introduced to the U.S. in 1875. It is now widely naturalized throughout the Northeastern United States, extending to the south in Georgia, throughout the Great Lakes Region, and west to parts of the Great Plains. It is invasive in Canada as well. It was introduced and is now naturalized throughout most of Europe (CABI, 2019). Alternate answers are "e" or "d" since it is also described as escaping cultivation.
ES-2 (Is the species highly domesticated)	y - low	-3	Numerous hybrid cultivars have been bred for different ornamental purposes including color and lower growth type. Decades of plant selection has made this a preferred landscaping plant for both aesthetics (vibrant array of colors and flowers), and the spines provide a barrier resistant to deer-browsing (Butzler, 2021). There are less vigorous cultivars that produce less seed (0-10 seeds per plant), are less dense, and are overall smaller (Matson, 2011).
ES-3 (Significant weedy congeners)	y - low	1	Berberis vulgaris L. is also an introduced invasive species, prohibited in Connecticut (USDA NRCS, 2022).
ES-4 (Shade tolerant at some stage of its life cycle)	y - negl	1	Can tolerate full shade (CABI, 2019).
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	Does not exhibit this growth type. See next question.
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	Reproduces vegetatively both above-ground and below-ground through layering as well as forming sprouts from the root crown (Zouhar, 2008). The tips of branches may root when they reach the ground (Michigan Department of Natural Resources, 2012). There is also a low level of density-dependent mortality, allowing the population to spread rapidly (Ehrenfeld, 1999).
ES-7 (Aquatic)	n - negl	0	Japanese barberry is a perennial shrub (CABI, 2019).
ES-8 (Grass)	n - negl	0	From the Berberidaceae family (GBIF, 2021).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	Not from a genus known to fix nitrogen.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Yes, reported to spread by seed and vegetatively (Ehrenfeld, 1999).

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-11 (Self-compatible or apomictic)	n - mod	-1	Japanese barberry is monoecious with perfect flowers (Wenning, 2012).
ES-12 (Requires specialist pollinators)	n - low	0	Pollinators include bees, flies, wasps, ants and beetles (Butzler, 2021; CABI, 2019).
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]	c - high	0	Shrubs reproduce at two years of age, producing fruits for dispersal (Cameron and Wheeler, 2020). May take up to 5 years (Matson, 2011). Choosing alternate answers "c" or "d".
ES-14 (Prolific seed producer)	y - mod	1	Some cultivars may produce over 1,000 seeds per plant, though some have been reported to produce less than 10 (Brand et al., 2012). Seeds are a key contributor to population growth even with mortality rates reaching 90% (Ehrenfeld, 1999). Hybrids between Korean and Japanese cultivars do not produce viable seed (Matson, 2011). Seed production is higher in areas with more light (Zouhar, 2008).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - low	1	Studies found that sites with Japanese barberry present are closer to roads than those without the invasive, indicating it is likely spread by vehicles on roadways (Kurtz and Hansen, 2018).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	? - high	0	Though Japanese barberry seeds could be a potential contaminant in wood containers and packages, direct evidence of this is unknown (CABI, 2019).
ES-17 (Number of natural dispersal vectors)	3	2	0
ES-17a (Wind dispersal)	n - low		Most seeds are dropped near the branches due to gravity or dispersed by birds, as shown by the correlation of stem density and seedling density (Ehrenfeld, 1999). Listed as wind dispersed by NH Department of Agriculture, n.d.
ES-17b (Water dispersal)	n - low		Most seeds are dropped near the branches due to gravity or dispersed by birds, as shown by the correlation of stem density and seedling density (Ehrenfeld, 1999). However, listed as water dispersed by NH Department of Agriculture, n.d.
ES-17c (Bird dispersal)	y - negl		Birds will feed on the fruits in late winter, including mockingbirds, cedar waxwings, and blackbirds (Butzler, 2021). Ground dwelling birds may aid in dispersal more than songbirds, and fruits are especially attractive to turkey and grouse (Cameron and Wheeler, 2020; Michigan Department of Natural Resources, 2012).
ES-17d (Animal external dispersal)	y - high		Fauna travel near roadways, potentially aiding in the spread of propagules (Kurtz and Hansen, 2018).
ES-17e (Animal internal dispersal)	y - high		Eaten by birds and other animals (Juzwik et al., 2021). Fruits might also be consumed by chipmunks and deer (Ehrenfeld, 1999).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	n - low	-1	Germination rates fall dramatically within one year and therefore seeds do not persist in the seedbank

Question ID	Answer - Uncertainty	Score	Notes (and references)
			long-term (D'Appollonio, 2006; Michigan Department of Natural Resources, 2012).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - low	1	Cutting, mowing or treatment with fire will result in resprouting from the roots (Michigan Department of Natural Resources, 2012).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	Genus not listed on International Herbicide-Resistant Weed Database (Heap, 2022).
ES-21 (Number of cold hardiness zones suitable for its survival)	7	0	
ES-22 (Number of climate types suitable for its survival)	7	2	
ES-23 (Number of precipitation bands suitable for its survival)	7	0	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	Not listed as allelopathic on the USDA PLANTS Database (USDA-NRCS, 2022). Not listed as allelopathic in a study of 37 different invasive plants (Dawkins et al., 2022).
Imp-G2 (Parasitic)	n - negl	0	Not a known parasitic species.
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	y - negl	0.4	Increases nitrogen cycling (Dawkins et al., 2022). Alters soil pH increasing alkalinity (WIGL, 2022). It leafs out earlier than other species (Xu et al., 2007). Reduces the number of saplings and seedlings in the forest (Kurtz and Hansen, 2018).
Imp-N2 (Changes habitat structure)	y - negl	0.2	Japanese barberry infestations result in the suppression of native species and decreases seedling recruitment of native trees (Link et al., 2018). The dense shrub populations alter soil conditions and the microclimate of forest understories. Barberry stands create areas of increased humidity (Butzler, 2021).
Imp-N3 (Changes species diversity)	y - negl	0.2	A study in New York demonstrated a reduction in predatory insects in habitats where Japanese barberry has invaded (Clark and Seewagen, 2019). The spines deter browsing by white-tailed deer making it a better competitor (Wisconsin DNR).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - mod	0.1	Based on the wide array of landscapes B. thunbergii can invade, combined with its current distribution in the U.S., and the effects it can have on natural landscapes, it is likely to affect these species.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - mod	0.1	Generally, Japanese barberry has the potential to alter ecosystem processes including nutrient cycling and change habitat structure by increasing foliage density of lands where it is invaded. It can be found in a variety of landscapes including old fields, on the edges of wetlands, early successional forests, and highly disturbed lands (CABI, 2019).

Question ID	Answer - Uncertainty	Score	Notes (and references)
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	It is known to invade a variety of both disturbed and undisturbed landscapes, from fields to wetlands and woodlands (CABI, 2019). It is on state invasive species lists in Indiana, Pennsylvania, Kentucky, Virginia, West Virginia, Delaware, New Jersey, Connecticut, Alabama, Georgia and South Carolina. Japanese barberry is also regulated through both state law and invasive species lists in multiple places (EDDMapS, 2022). Control may cost $2000 per acre per year according to the Indiana DNR (Matson, 2011).
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	y - low	0.1	Japanese barberry provides shelter for higher densities of adult deer ticks and white-footed deer mice when compared with native shrubs, resulting in increased infection rates and spread of Lyme disease (Michigan Department of Natural Resources, 2012). Similar findings were reported with blacklegged ticks (Linske et al., 2018).
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	Not known to affect recreational areas.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	y - high	0.1	Could not find much evidence of direct negative effects to ornamental plants. May be able to spread from home and commercial gardens (Wenning, 2012). Also hosts aphids and mildews which may spread to other species (CABI, 2019). Answering yes with high uncertainty due to the lack of primary literature.
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]	c - mod	0.4	Japanese barberry is a threat to public health as it provides habitat for increased spread and infection of Lyme disease. This is cited as a main cause for restriction, prohibition, and listing as state invasive species in Minnesota, Wisconsin, Pennsylvania, (Butzler, 2021; Matson, 2011; Minnesota Department of Agriculture; 2022).
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - high	0.4	Bees preferentially pollinate Japanese barberry over lowbush blueberry when they are close together, causing lower fruit set (Dibble et al., 2018). Additionally, this plant is a host for aphids and diseases that could be a threat to cultivated plants (CABI, 2019). May also hamper tillage on field margins (CABI, 2019).
Imp-P2 (Lowers commodity value)	n - mod	0	Not known to lower commodity value directly.
Imp-P3 (Is it likely to impact trade?)	n - high	0	Not known to impact trade (CABI, 2019).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - negl	0	Is not reported to impact water availability.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - mod	0.1	This species is toxic to deer and has relatively low browsing rates in general (Cameron and Wheeler, 2020).
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 - mod	0	Though it may be present near production systems, there is little evidence for direct impact. Still, Japanese barberry may be an alternate host for diseases, aphids, and be preferentially pollinated over other species. Therefore, we are answering "a" with moderate uncertainty, with an alternate answer of "b".
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	No occurrences reported.
Geo-Z2 (Zone 2)	n - negl	N/A	No occurrences reported.
Geo-Z3 (Zone 3)	y - high	N/A	Few isolated occurrences in Northern Minnesota (Zone 3b) (WIGL, 2022).
Geo-Z4 (Zone 4)	y - mod	N/A	Hardy to -28F (Kurtz and Hansen, 2018). Norway.
Geo-Z5 (Zone 5)	y - negl	N/A	Seeds require cold stratification, so this species is typically limited to Zones 4-8 (Butzler, 2021). Michigan, Minnesota, Missouri, Wisconsin, most of the Northeastern U.S.
Geo-Z6 (Zone 6)	y - negl	N/A	Michigan, Illinois, Indiana, Pennsylvania, parts of New York.
Geo-Z7 (Zone 7)	y - negl	N/A	Virginias, Kentucky, Illinois, Southern Indiana.
Geo-Z8 (Zone 8)	y - low	N/A	Spain, Portugal, Australia, New Zealand. South Carolina, Georgia, Alabama.
Geo-Z9 (Zone 9)	y - mod	N/A	Spain, Portugal, Australia, New Zealand. South Carolina, Georgia, Alabama.
Geo-Z10 (Zone 10)	n - low	N/A	No occurrences reported.
Geo-Z11 (Zone 11)	n - negl	N/A	No occurrences reported.
Geo-Z12 (Zone 12)	n - negl	N/A	No occurrences reported.
Geo-Z13 (Zone 13)	n - negl	N/A	No occurrences reported.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	No points shown in GBIF occurrences.
Geo-C2 (Tropical savanna)	n - negl	N/A	No points shown in GBIF occurrences.
Geo-C3 (Steppe)	y - high	N/A	Few occurrences in Spain and Portugal.
Geo-C4 (Desert)	n - negl	N/A	No points shown in GBIF occurrences.
Geo-C5 (Mediterranean)	n - mod	N/A	No points shown in GBIF occurrences.
Geo-C6 (Humid subtropical)	y - low	N/A	Southeastern United states, with few points in New Zealand, Australia.
Geo-C7 (Marine west coast)	y - low	N/A	Present in Europe, New Zealand and Australia.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Present in Michigan and most of northeast U.S.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Present in Michigan and most of northeast U.S., as well as in Europe.
Geo-C10 (Subarctic)	y - high	N/A	Possible points in Norway.
Geo-C11 (Tundra)	n - negl	N/A	No points shown in GBIF occurrences.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C12 (Icecap)	n - negl	N/A	No points shown in GBIF occurrences.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - low	N/A	No listed occurrences.
Geo-R2 (10-20 inches; 25-51 cm)	y - mod	N/A	Few occurrences in the Great Plains region, U.S.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Occurrences in Great Lakes Region, U.S.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Requires 30-60 inches of precipitation (Kurtz and Hansen, 2018).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Present in most of the East Coast/southeastern U.S.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Present in most of the East Coast/southeastern U.S.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Present in most of the East Coast/southeastern U.S.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Present in most of the East Coast/southeastern U.S.
Geo-R9 (80-90 inches; 203-229 cm)	n - mod	N/A	Not presently known to be in this precipitation band.
Geo-R10 (90-100 inches; 229-254 cm)	n - mod	N/A	Not presently known to be in this precipitation band.
Geo-R11 (100+ inches; 254+ cm)	n - mod	N/A	Not presently known to be in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y -	1	0
Ent-2 (Plant proposed for entry, or entry is imminent)	-	N/A	
Ent-3 [Human value & cultivation/trade status: (a) Neither cultivated or positively valued; (b) Not cultivated, but positively valued or potentially beneficial; (c) Cultivated, but no evidence of trade or resale; (d) Commercially cultivated or other evidence of trade or resale]	-	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, 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	