Weed Risk Assessment for *Rhamnus cathartica* L. (Rhamnaceae) – Common buckthorn

Michigan Department of Agriculture and Rural Development

May 15, 2025

Version 1

Top left: *Rhamnus cathartica* subopposite, oval leaves with toothed margins (source: Paul Wray, Iowa State University, Bugwood.org). Top right: female *Rhamnus cathartica* tree with black, round fleshy fruits ¼ inch in size (source: Jan Samanek, Phytosanitary Administration, Bugwood.org). Bottom left: dense shrub growth pattern *of Rhamnus cathartica* (source: Chris Evans, University of Illinois, Bugwood.org). Bottom right: Winter twig and fruit of *Rhamnus cathartica* showing spines at the ends of the branchlets (source: Rob Routledge, Sault College, Bugwood.org).

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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 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: *Rhamnus cathartica* L. (Rhamnaceae) (CABI, 2019; Kartesz, 1994).

SYNONYMS: *Cervispina cathartica* (L.) Moench, *Rhamnus cadevallii* Pau, *Rhamnus cathartica* subsp. *caucasica* Kusn., *Rhamnus cathartica* var. *caucasica* Kusn., *Rhamnus cathartica* var. *microphylla* Beck, *Rhamnus cathartica* var. *pubescens* Lange, *Rhamnus elbursensis* Gauba & Rech.fil., *Rhamnus hydriensis* Hacq., *Rhamnus solutina* Erndt, *Rhamnus spinosa* Gilib., *Rhamnus sylvatica* J.Serres, *Rhamnus wichellii* K.Koch, *Rhamnus wichellii* hort., *Rhamnus wichellii* hort. ex C.Koch, *Rhamnus wicklia* K.Koch, *Rhamnus wicklia* hort., *Rhamnus wicklia* hort. ex C.Koch, *Rhamnus wihhor* Lucé, *Rhamnus willdenowiana* Schult., *Rhamnus xanthocarpa K*.Koch, *Rhamnus xanthocarpa* hort., *Rhamnus xanthocarpa* hort. ex C.Koch (GBIF, 2021).

COMMON NAMES: Common buckthorn, buckthorn, European buckthorn, purging buckthorn (EPPO, 2022), Carolina buckthorn (Wisconsin DNR, 2022).

BOTANICAL DESCRIPTION: *Rhamnus cathartica* is a deciduous tree or shrub that can grow up to 25 feet tall and establishes in deadfall openings in forests as well as native shrub communities, fence rows and roadsides (CABI, 2019). It is diecious and females produce black drupes 0.25 inches in diameter that remain on plants into winter (CABI, 2019). Branches end with a sharp spine and contain orange heartwood when cut (Wisconsin DNR, 2022). 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 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: The native range of *Rhamnus cathartica* consists of Europe, western Asia, as well as northern Africa including Algeria and Morocco (CABI, 2019; Missouri Botanical Garden, 2022). It is widely present in the understories of forests, especially oak, beech, and ash woods in the UK and both mixed and pine forests in Asia (CABI, 2019). It has been introduced to India and Argentina as well, though the extent of its regulation there is unclear (GBIF, 2021). It has been cultivated for use as dye and is used in Russia for ornamental art and plywood (Zouhar, 2011).

U.S. DISTRIBUTION AND STATUS: *Rhamnus cathartica* is naturalized throughout most of the northern U.S. but can be found in at least 34 states from Maine to California and north of Tennessee

[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).

(USDA NRCS, 2022). This species is prohibited in both New York and Connecticut, where it is considered invasive (USDA NRCS, 2022). It is restricted in Wisconsin and on the state noxious weed lists in Connecticut, Iowa, Massachusetts, Minnesota, New Hampshire, and Vermont (Zouhar, 2011). A number of organizations include *R. cathartica* on their advisory lists including: City of Ann Arbor Michigan Parks and Recreation, Commonwealth of Pennsylvania Department of Conservation and Natural Resources, Connecticut Invasive Plant Working Group, Wisconsin Department of Natural Resources, The Nature Conservancy, Kentucky Exotic Pest Plant Council, New Hampshire Invasive Species Committee, Non-Native Invasive Plants of Arlington County Virginia, Rhode Island Natural History Survey, Tennessee Exotic Pest Plant Council, and the West Virginia Native Plant Society (Invasive Plant Atlas, 2018). It was introduced in North America prior to the 19th century primarily for medicinal purposes, then was touted as a hedge species in the mid-1800s before falling off in popularity (Kurylo and Endress, 2012). It seems to be commercially available online and at nurseries today, however somewhat difficult to find (hobbyseeds.com).

Analysis

ESTABLISHMENT/SPREAD POTENTIAL: *Rhamnus cathartica* is already naturalized throughout the northern U.S. and Canada and is particularly problematic in the Great Lakes Region (Converse et al., 2014; Kurylo and Endress, 2012). It thrives in a variety of environmental conditions but grows best in well-drained soils and is commonly found in deciduous woodlands (CABI, 2019) since it can survive in very low light levels (Knight et al., 2007). *R. cathartica* tends to adopt a tree-like architecture in the understory, but a shrub-like shape under full sun conditions; it can modulate this to be competitive in different environments (Charles-Dominique et al., 2012). Additionally, it resprouts vigorously through lateral crown growth following cutting or burning. This enables it to form dense thickets rapidly, maturing in as little as two years (Converse et al., 2014). Thickets tend to be even-aged. This dioecious species is also a prolific seed producer, where a female tree can produce between 15,000 and 54,000 seeds per year (NH Department of Agriculture, Markets and Food). Most of the seeds fall below the mother tree, contributing to dense populations. The seeds are also dispersed by birds along fencerows and below perch trees (Knight et al., 2007). Other mammals aid in dispersal including field mice and voles, while water dispersal is minimal (CABI, 2019). *R. cathartica* seeds persist in the soil between 2-6 years (NH Department of Agriculture, Markets and Food). We had low uncertainty for this risk element.

Risk score = 10.0 Uncertainty index = 0.08

IMPACT POTENTIAL: *R. cathartica* is a threat to natural systems due to its ability to outcompete native species and drastically alter soil conditions in the areas it invades (Heneghan et al., 2004). It is highly allelopathic, fast-growing, and leafs out earlier in the spring than other species, allowing it to photosynthesize longer (Knight et al., 2007; NH Department of Agriculture, Markets and Food; Warren et al., 2017). Leaf exudates reduced germination of alfalfa seeds by 42%, but this allelopathic effect is highly dependent on species (Archibold et al., 1997; Knight et al., 2007). Its leaf litter decomposes rapidly, releasing nitrogen and further promoting its own rapid growth. This alteration of nitrogen cycling allows *R. cathartica* to prevent establishment of other native species and reduce overall plant diversity (Heneghan et al., 2004). It also changes soil fauna diversity and promotes invasive earthworm proliferation (CABI, 2019; Madritch and Lindroth, 2009). The compound emodin is a secondary metabolite produced by this species that has been shown to cause deformities in fish, invertebrates, and amphibian larvae that can be fatal (Brenes et al., 2022). Therefore *R. cathartica* invasions may be contributing to declining populations of these species (Brenes et al., 2022). The fruits can cause unsightly staining on sidewalks and driveways (Minnesota DNR, 2013). Efforts to control this species have included removing saplings by hand or treatment with fire, or the use of herbicides (NH Department of Agriculture, Markets and Food; Sheehan, 2007). This can be costly, as The Nature Conservancy reported costs up to $700 per acre in forests in southern Wisconsin (Sheehan, 2007). We did not find evidence that this species is likely to impact production systems greatly. However, it is an alternate host for the alfalfa mosaic virus, crown rust disease of oat, and soybean aphids, which could indirectly impact production of certain food crops (CABI, 2019). We had average uncertainty for this risk element.

Risk score = 2.9 Uncertainty index = 0.12

GEOGRAPHIC POTENTIAL: Using the PPQ climate-matching model for weeds (Magarey et al., 2017), we estimate that about 88.7% percent of the United States is suitable for the establishment of *R. cathartica* (Fig. 1). This area represents the joint distribution of Plant Hardiness Zones 2a-10a, areas with 10-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: cold arid desert, cold arid steppe, temperate dry-summer hot and warm-summers, temperate no dry season hot and warm-summers, cold dry-summer warm-summer, cold dry-winter hot, warm, and cold-summers, cold no dry season hot, warm, and cold-summers, and polar tundra (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. *R. cathartica* is commonly found in forest gaps, roadsides, pastures, and old fields.

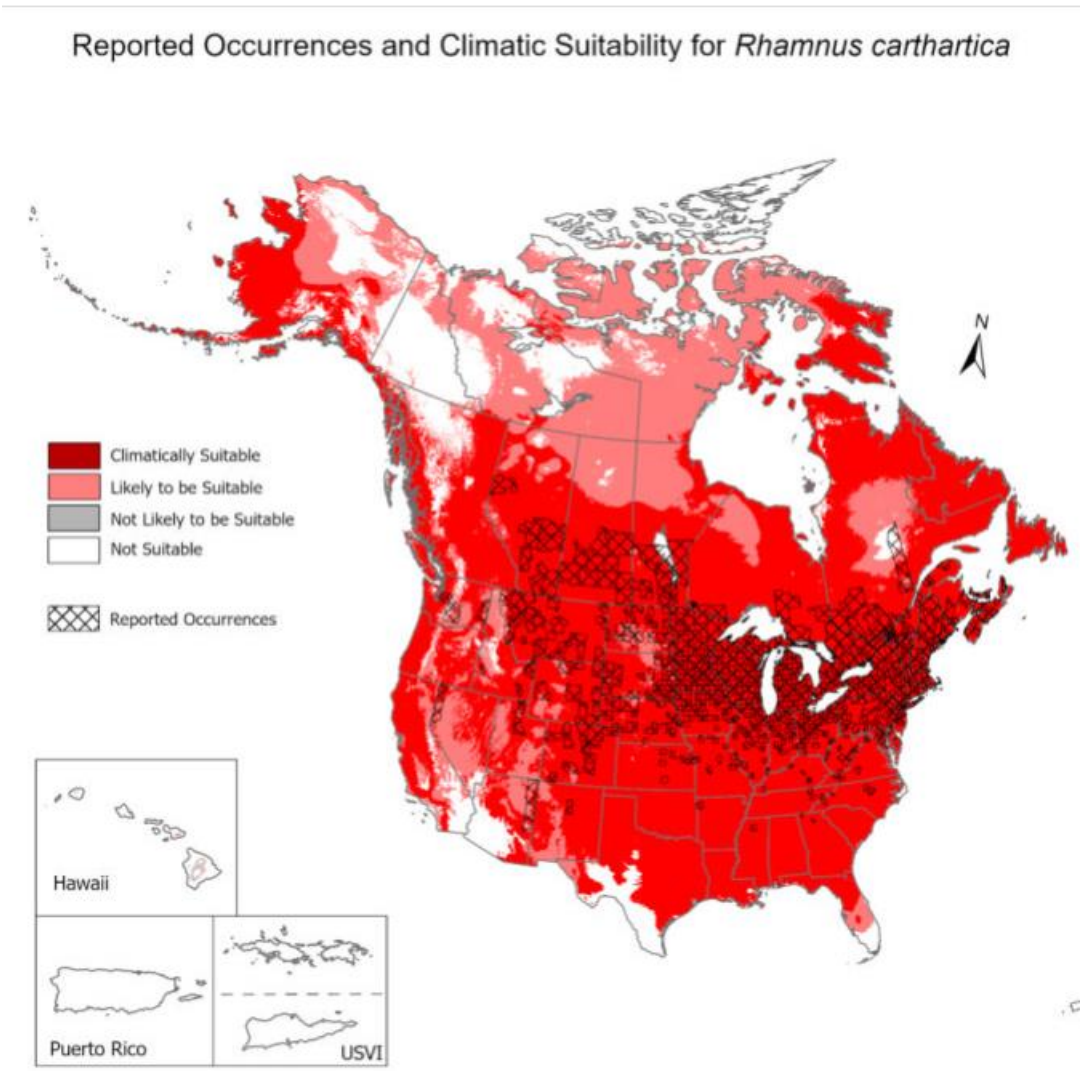

Figure 1. Current and potential distribution of *Rhamnus cathartica* in the United States. Climatic suitability was determined using the APHIS-PPQ climate matching tool for invasive plants (Magarey et al., 2017). The known distribution of *R. cathartica* was based on county distribution records from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

ENTRY POTENTIAL: We did not assess the entry potential of *Rhamnus cathartica* because it is already present in the United States (Kurylo and Endress, 2012) (Fig. 1).

Risk Model Results

Model Probabilities: P(Major Invader) = 49.2%
P(Minor Invader) = 47.8%
P(Non-Invader) = 3.0%
Risk Result = High Risk
Risk Result after Secondary Screening = N/A

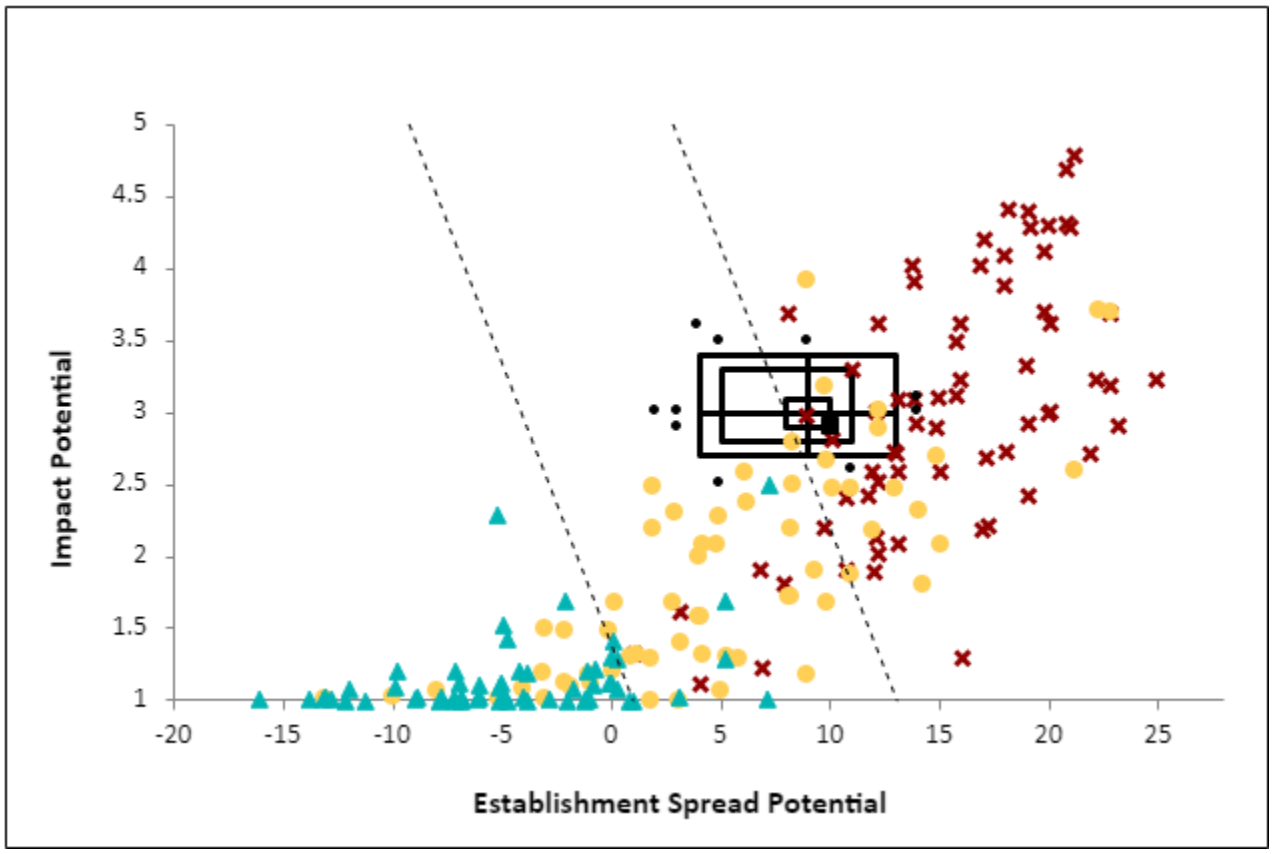

Figure 2. Risk and uncertainty results for *Rhamnus cathartica*. The risk score for this species (solid black symbol) is plotted relative to the risk scores of the species used to develop and validate the PPQ WRA model (Koop et al., 2012). The results from the uncertainty analysis are plotted around the risk score for *Rhamnus cathartica*. 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 *Rhamnus cathartica* is high risk, which is well supported by the uncertainty analysis (Fig. 2). *R. cathartica* is fast-growing and establishes dense populations by producing thousands of seeds, which are readily dispersed by birds and persist in the soil for up to six years (Knight et al., 2007; NH Department of Agriculture, Markets and Food). This species thrives in well-drained soil and can tolerate low light levels, making it a competitive forest invasive (CABI, 2019; Knight et al., 2007). It can modulate its branch architecture to be competitive in various environments (Charles-Dominique et al., 2012), and creates dense thickets through lateral crown spread (Converse et al., 2014). *R. cathartica* is a threat to natural systems due to its allelopathic properties, leafing out earlier in the spring than native plants, and ability to alter nitrogen cycling (Heneghan et al., 2004). It is

also an alternate host for the alfalfa mosaic virus, crown rust disease of oat, and soybean aphids, which could indirectly impact certain crop production in the state (CABI, 2019).

Rhamnus cathartica is regulated as a noxious weed in Connecticut, Iowa, Massachusetts, Minnesota, New Hampshire, and Vermont (Zouhar, 2011). It is already present in at least 33 counties in Michigan where it has naturalized and is “sometimes cultivated” (Michigan Flora Online, 2011). Control methods include removing saplings by hand or treatment with fire, or the use of herbicides (Sheehan, 2007), often at great cost (Sheehan, 2007). Action to prevent new infestations, control the species in high-value areas, and inform the public of its harmful effects will reduce further impact.

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Appendix A. Weed risk assessment for *Rhamnus cathartica* L. (Rhamnaceae)

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]	e - negl	2	Native to most of Europe and Asia, Rhamnus cathartica was introduced to the U.S. as an ornamental plant in the mid-19th century and is now naturalized throughout the northen U.S and Canada (Converse et al., 2014; Kurylo and Endress, 2012). There is also some evidence it was used as a medicinal plant, since the fruits had cathartic benefits (Kurylo and Endress, 2012). It was also introduced to Argentina and India (CABI, 2019), although the extent of regulation is unclear.
ES-2 (Is the species highly domesticated)	n - negl	0	This species is not highly domesticated.
ES-3 (Significant weedy congeners)	y - negl	1	Glossy buckthorn - Frangula alnus Mill. is in the same plant family and is regulated to some degree in New York, Illinois, Wisconsin, Minnesota, and Connecticut (Sturtevant et al., 2022; USDA NRCS, 2022).
ES-4 (Shade tolerant at some stage of its life cycle)	y - mod	1	Although this species prefers full to partial shade, it can tolerate full shade (NH Department of Agriculture, Markets and Food). It is commonly found in the low light of decidious woodlands (CABI, 2019). Seedlings can survive in very low light levels (1-2%) (Knight et al., 2007).
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	See next question.
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	Its growth habit is a shrub/tree that send up multiple stems from the same individual rapidly forming dense thickets (Charles-Dominique et al., 2012). It exhibits phenotypic plasticity whereby it takes more of a tree form in the understory of forests, and is more shrub-like in higher light conditions. Additionally, most seedling recruitment occurs just under the mother tree, since seeds just fall to the ground there, further contributing to dense populations.
ES-7 (Aquatic)	n - negl	0	This is a deciduous tree or shrub.
ES-8 (Grass)	n - negl	0	This is a deciduous tree or shrub.
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	This species does not associate with N-fixing actinomycetes (Knight et al., 2007).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	This is a dioecious species, so only females produce fruits and there can be four seeds per fruit (Converse et al., 2014). Germination rates are also high.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-11 (Self-compatible or apomictic)	n - negl	-1	R. cathartica is dioecious meaning there are separate male and female individuals (Converse et al., 2014).
ES-12 (Requires specialist pollinators)	n - negl	0	This species is pollinated by generalist insects (Knight et al., 2007; NH Department of Agriculture, Markets and Food).
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	Trees will reach reproductive age after just two years (NH Department of Agriculture, Markets and Food). However, this varies greatly with growing conditions and have been reported as long as 9-20 years in North America, or 4-11 in Europe (Knight et al., 2007).
ES-14 (Prolific seed producer)	y - mod	1	A single tree can produce between 15,000 and 54,000 seeds per year (NH Department of Agriculture, Markets and Food). There can be 4 seeds per fruit, and seed mass can range from 62 - 398mg (Converse et al., 2014; Knight et al., 2007)
ES-15 (Propagules likely to be dispersed unintentionally by people)	n - low	-1	Was originally introduced intentionally by humans, however, there is no evidence of a dispersal mechanism which would facilitate unintentional spread by humans.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	n - low	-1	There is not a known route for dispersal through these methods (CABI, 2019).
ES-17 (Number of natural dispersal vectors)	3	2	0
ES-17a (Wind dispersal)	n - negl		Most seeds fall with gravity underneath the mother plants (90% in one study), so wind does not impact dispersal (Archibold et al., 1997; CABI, 2019).
ES-17b (Water dispersal)	y - high		The dry fruits can float for up to 6 days, while seeds may float for up to 3 days. If near a water source, this could facilitate long-distance seed dispersal although it would be minimal (CABI, 2019). However, submersion in water for greater than 2 weeks reduces germination rates (Archibold et al., 1997).
ES-17c (Bird dispersal)	y - negl		Dispersal by birds is likely the main mechanism for seed dispersal in R. cathartica. A 2 year study in New York showed that up to 100% of fruits produced were eaten by birds. This is further supported by the fact that seeds are spread along fencerows, and below perch trees (Knight et al., 2007).
ES-17d (Animal external dispersal)	y - low		Seed predation is common by small mammals including voles and mice (CABI, 2019). Field mice will store R. cathartica seeds, which will then be able to germinate (Knight et al., 2007).
ES-17e (Animal internal dispersal)	n - low		In a study assessing goat browsing for control of this species, only 2% of seeds passed through their digestive system intact, and 11% of them were viable (Marchetto et al, 2020). Therefore, there is very low likelihood that this would be a significant dispersal mechanism.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - mod	1	Seeds may persist in the soil between 2-6 years, with an 88% germination rate (NH Department of Agriculture, Markets and Food).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	y - mod	1	It has been shown that a single treatment with fire allows plants to reemerge and develop more vigorously than untreated stumps (Archibold et al., 1997), however multiple treatments may be effective. This plant may also be able to regenerate following cutting (Invasive Plant Atlas, 2018).
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - negl	0	Not listed on weedscience.org. Herbicides are a common control method (CABI, 2019, Wisconsin DNR).
ES-21 (Number of cold hardiness zones suitable for its survival)	7	0	
ES-22 (Number of climate types suitable for its survival)	5	2	
ES-23 (Number of precipitation bands suitable for its survival)	4	-1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	y - mod	0.1	Leaf exudates from R. cathartica can inhibit seed germination of alfalfa by 42% (Knight et al., 2007). In contrast, there was no allelopathic effects to tomato, radish or lettuce seeds (Archibold et al., 1997).
Imp-G2 (Parasitic)	n - negl	0	This plant is not known to be parasitic.
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	y - negl	0.4	Leaf litter decomposes rapidly, releasing high nitrogen and further promoting the rapid growth of R. cathartica. This alteration of nitrogen cycling can have effects on plant diversity. R. cathartica infestations have also been shown to increase soil pH and gravimetric water content (Heneghan et al., 2004).
Imp-N2 (Changes habitat structure)	y - negl	0.2	This plant leafs out earlier in the spring than other species and keeps its leaves later, allowing it to photosynthesize longer (Knight et al., 2007). It prevents establishment of other native species (NH Department of Agriculture, Markets and Food).
Imp-N3 (Changes species diversity)	y - negl	0.2	By outcompeting native species, Rhamnus cathartica invasions reduce plant diversity. In addition, bird populations are impacted since their nests are more prone to predation when built in R. cathartica shrubs compared to native ones. This includes American robins and wood thrush (CABI, 2019). Increased soil fertility from leaf litter decomposition also changes soil fauna diversity (CABI, 2019). Finally, invasive earthworms are associated with R. cathartica invasions, where removing the shrubs decreases the earthworm biomass by 50% (Madritch and Lindroth, 2009).

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - mod	0.1	According to the U.S. Fish and Wildlife service, Rhamnus cathartica is monopolizing reseources and will affect the Threatened species Asplenium scolopendrium var. americanum (American hart's-tongue fern) through competition (CABI, 2019).
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - mod	0.1	Based on this species ability to alter nutrient cycling and gravimatric water content of soils where it has invaded, and its ability to outcompete native species, it is likely that R. cathartica would affect U.S. globally outstanding ecoregions. It would also alter species diversity of both plants and vertebrates.
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	Rhamnus cathartica is an invasive weed in natural systems that threatens native plants and vertebrates by competing for resources. The primary concern listed by the New Hampshire Department of Agriculture was that it is "fast growing, aggressive, and outcompetes native species". There have been a number of efforts to control this species through removing saplings by hand or fire, and through herbicides (NH Department of Agriculture, Markets and Food; Sheehan, 2007). The Nature Conservancy reported costs up to $700 per acre in forests in southern Wisconsin (Sheehan, 2007). It is regulated as a noxious weed in Connecticut, Iowa, Massachusetts, Minnesota, New Hampshire, and Vermont (Zouhar, 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	Fruits stain sidewalks and driveways (Minnesota DNR, 2013).
Imp-A2 (Changes or limits recreational use of an area)	n - high	0	No direct evidence of this.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - high	0	No direct evidence of this.
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 - high	0	No direct evidence of this. Answering alternate "b" since there may be cases where R. cathartica is a weed in anthropogenic systems, but control efforts are primarily focused on natural systems instead.
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	n - low	0	Rhamnus cathartica does not directly impact crop or commodity yield, however it is an alternate host for the alfalfa mosaic virus, crown rust disease of oat, and soybean aphids, which could indirectly impact production (CABI, 2019). Direct evidence of this is not apparent.
Imp-P2 (Lowers commodity value)	n - low	0	Rhamnus cathartica does not directly impact crop or commodity yield, however it is an alternate host for the alfalfa mosaic virus, crown rust disease of

Question ID	Answer - Uncertainty	Score	Notes (and references)
			oat, and soybean aphids, which could indirectly impact production (CABI, 2019). Crown rust can impact quality of oat production. Direct evidence of this relationship is not apparent.
Imp-P3 (Is it likely to impact trade?)	n - negl	0	None of the plant parts are known to be transported in trade (CABI, 2019).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - negl	0	This species grows best in well-drained soils and less so in flooded soils (Zouhar, 2011), so competition for water would not be an issue.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - negl	0.1	The compound anthroquinone is present in all plant parts, which is metabolized into emodin when ingested by wildlife which can cause moderate to severe diarrhea, or oppositely retention of stomach/gut contents when consumed at low doses (NH Department of Agriculture, Markets and Food). Additionally, high concentrations of emodin produces deformities in invertebrates, fish, and amphibian larvae, which can be fatal (Brenes et al., 2022). This contributes to declininng populations. Emodin causes embryo mortality and deformation of both the Western Chorus Frog and the African Clawed Frog (Sacerdote and King, 2014). However, Rhamnus cathartica has not been shown to impact livestock production (CABI, 2019).
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	There is no direct evidence that this species directly impacts productions systems, though there may be indirect effects since it is an alternate host for various pests. Therefore, we are answering "a" with alternate answers 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 points in this region.
Geo-Z2 (Zone 2)	n - mod	N/A	No points in this region.
Geo-Z3 (Zone 3)	y - negl	N/A	Canada (NC State Extension, 2022).
Geo-Z4 (Zone 4)	y - negl	N/A	Canada, Wisconsin, Minnesota and Norh Dakota in the U.S. (NC State Extension, 2022).
Geo-Z5 (Zone 5)	y - negl	N/A	New York, New Hampshire, Vermont, Wisconsin, Minnesota, Iowa in the U.S., Russia (NC State Extension, 2022).
Geo-Z6 (Zone 6)	y - negl	N/A	Michigan, Ohio, Indiana, Illinois, Pennsylvania in the U.S., Russia (NC State Extension, 2022).
Geo-Z7 (Zone 7)	y - negl	N/A	Parts of Europe, southeastern U.S. (NC State Extension, 2022).
Geo-Z8 (Zone 8)	y - low	N/A	Most of Europe.
Geo-Z9 (Zone 9)	y - low	N/A	Most of Europe.
Geo-Z10 (Zone 10)	n - negl	N/A	No points in this region.
Geo-Z11 (Zone 11)	n - negl	N/A	No points in this region.
Geo-Z12 (Zone 12)	n - negl	N/A	No points in this region.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z13 (Zone 13)	n - negl	N/A	No points in this region.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	No points in this region.
Geo-C2 (Tropical savanna)	n - negl	N/A	No points in this region.
Geo-C3 (Steppe)	n - negl	N/A	No points in this region.
Geo-C4 (Desert)	n - negl	N/A	No points in this region.
Geo-C5 (Mediterranean)	y - high	N/A	Possibly parts of Spain.
Geo-C6 (Humid subtropical)	y - mod	N/A	Few parts of the southeastern U.S.
Geo-C7 (Marine west coast)	y - negl	N/A	Most of Europe.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Midwestern U.S., Russia, Ukraine.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Far northern U.S. and Canada.
Geo-C10 (Subarctic)	n - negl	N/A	No points in this region.
Geo-C11 (Tundra)	n - negl	N/A	No points in this region.
Geo-C12 (Icecap)	n - negl	N/A	No points in this region.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - negl	N/A	No points in this region.
Geo-R2 (10-20 inches; 25-51 cm)	n - mod	N/A	No points in this region.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Northern U.S. and Canada (CABI, 2019).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Great LakesRegion/Midwestern U.S., parts of Europe (CABI, 2019).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Parts of Europe (CABI, 2019).
Geo-R6 (50-60 inches; 127-152 cm)	y - low	N/A	Parts of southeastern U.S. and Europe.
Geo-R7 (60-70 inches; 152-178 cm)	n - high	N/A	Few points if any in these regions.
Geo-R8 (70-80 inches; 178-203 cm)	n - mod	N/A	No points in this region.
Geo-R9 (80-90 inches; 203-229 cm)	n - mod	N/A	No points in this region.
Geo-R10 (90-100 inches; 229-254 cm)	n - negl	N/A	No points in this region.
Geo-R11 (100+ inches; 254+ cm)	n - negl	N/A	No points in this region.
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	

Question ID	Answer - Uncertainty	Score	Notes (and references)
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	