United States Department of Agriculture

Weed Risk Assessment for *Myagrum perfoliatum* L. (Brassicaceae) – Bird's-eye cress

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Top left: *Myagrum perfoliatum* seed pods on the stem (source: Andrea Moro; Moro et al., 2003+). Top center: Rosette (source: Richard Murphy; iNaturalist.org, 2016). Top right: Flowers (source: Andrea Moro; Moro et al., 2003+). Bottom left (source: user kimberlietx; iNaturalist.org, 2016) and center (source: Jim Varnum; iNaturalist.org, 2016): Branched growth of *M. perfoliatum.* Bottom right: Leaves, stem, and flowers (source: Andrea Moro; Moro et al., 2003+). Moro photographs licensed under CC-BY-SA 3.0; iNaturalist.org photographs licensed under CC-BY-NC 4.0.

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Introduction Plant Protection and Quarantine (PPQ) regulates noxious weeds under the authority of the Plant Protection Act (7 U.S.C. § 7701-7786, 2000) and the Federal Seed Act (7 U.S.C. § 1581-1610, 1939). A noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (7 U.S.C. § 7701-7786, 2000). We use the PPQ weed risk assessment (WRA) process (PPQ, 2015) to evaluate the risk potential of plants, including those newly detected in the United States, those proposed for import, and those emerging as weeds elsewhere in the world.

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., Federal 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.

***Myagrum perfoliatum* L. – Bird's-eye cress**

Species Information

Family: Brassicaceae (NGRP, 2016a)

Synonyms: *Crucifera myagrum, Rapistrum perfoliatum* (The Plant List, 2016).

Common names: Bird's-eye cress (NRCS, 2016), muskweed, mite cress, mitre cress, dog mustard (NGRP, 2016a).

Botanical description: *Myagrum perfoliatum* is an annual herb with erect, branching stems that grows from 20 to 80 cm (Bojňanský and Fargašová, 2007) or up to a meter high (Parsons and Cuthbertson, 2001). Its basal leaves form a rosette (Auld and Medd, 1987; Lonchamp, 2000) that grows up to 45 cm wide and is flat to the ground (Storrie, 2014). It grows in disturbed areas, waste lands, and roadsides (eFloras, no date). The flowers, which appear in the summer, are yellow with oblong petals, and the pedicels are tightly pressed to the stem (Rollins, 1993). The fruit is a wedge- or pear-shaped pod that is about 5 to 7 mm long and 4 to 5 mm wide (Hanf, 1983; Parsons and Cuthbertson, 2001), although the pod may be longer (e.g., 8 to 10 mm, Bojňanský and Fargašová, 2007). The pod is hard, has a "prominent persistent style" (Parsons and Cuthbertson, 2001) and two empty cavities, is reddish-brown (Hanf, 1983) or straw-brown in color, and is indehiscent (Bojňanský and Fargašová, 2007). The pods are similar in size and shape to grains (Parsons and Cuthbertson, 2001; Storrie, 2014). The pod contains a single seed, rarely two (Rollins, 1993), that is reddish-brown and about 3 x 2 mm (Hanf, 1983). For a full botanical description, see Hanf (1983), Bojňanský and Fargašová (2007), or Rollins (1993).

Initiation: PPQ received a market access request for wheat seed for human and animal consumption from the government of Ukraine (Government of Ukraine, 2013). A commodity import risk analysis revealed that *M. perfoliatum* could be associated with this commodity as a seed contaminant. In this assessment, PERAL evaluated the risk potential of this species to the United States to help policy makers determine whether it should be regulated as a Federal Noxious Weed.

Foreign distribution and status: *Myagrum perfoliatum* is described as native to parts of western Asia and Europe (including Ukraine) (NGRP, 2016a). However, some authors report a more limited native range (e.g., Bojňanský and Fargašová, 2007; Hanf, 1983; Rollins, 1993), and others describe it as naturalized rather than native in some countries (Medvecká et al., 2012; Portale Della Flora di Roma, no date; Pyšek, 2003; Terpó et al., 1999). In some parts of its native or naturalized range, it is rare or declining (e.g., Bergmeier and Strid, 2014; Eliáš et al., 2007; Hulina, 2005; Májeková and Zaliberová, 2007; Pollak, 2015; Portale Della Flora di Roma, no date), while in others it is increasing (e.g., Lonchamp, 2000). It has been reported in the British Isles (Clement and Foster, 2000), Belgium (Verloove, 2006, 2012), and the Czech Republic (Pyšek, 2003)

as a casual alien, as well as from Norway, where it is not expected to be able to reproduce in the wild (Gederaas et al., 2012). It is considered naturalized in Algeria, Japan, Australia, and Germany (NGRP, 2016a). In Germany, it is rare (Meyer, no date). In Australia, it occurs in South Australia (Virtue, 1996), Victoria (Parsons and Cuthbertson, 2001), Queensland (Auld and Medd, 1987), and New South Wales (Cheam et al., 2008). In South Australia and Victoria, it was "initially very troublesome...but declined in later years"; however, it has begun to increase again in South Australia (Parsons and Cuthbertson, 2001), where it is a declared plant (i.e., a noxious weed) (Government of South Australia, 2014). In Canada, the only two reports of this species are from Quebec in 1895 and the 1940s, and "there is no evidence that it can persist in nature" (Mulligan, 2002). We found no evidence that *Myagrum perfoliatum* is currently being cultivated, other than a single vendor in France who is selling seeds (B & T World Seeds, 2016).

U.S. distribution and status: *Myagrum perfoliatum* is naturalized in the United States (NGRP, 2016a) and has been present since at least 1953 (University of Texas Herbarium, 2017). However, the extent of its distribution is unclear. It is naturalized in Texas and has been reported from Oklahoma, Ohio (NRCS, 2016), Virginia (NGRP, 2016a), Kansas (Barnard, 2006), and Oregon (Parsons and Cuthbertson, 2001). However, we found no evidence that it is currently present outside of northeastern and north central Texas and Bryan County, OK, which borders two of the Texas countries from which *M. perfoliatum* has been reported (Diggs et al., 1999). In Texas, it has been described as "abundant and spreading" (Diggs et al., 1999), although a more recent publication describes it as no longer spreading and occurring infrequently (Nesom, 2009). A 1965 publication stated that earlier reports of *M. perfoliatum* in Ohio had been misidentifications and that the species does not occur in Ohio (Easterley, 1965); we found no reports of its presence there after 1965. Some sources list *M. perfoliatum* as introduced or naturalized in Virginia (e.g., eFloras; NGRP, 2016a); however, Weakley (2015) stated that "the basis of this report is unknown" and did not include it in the flora of the southeastern United States. The species was reported in Kansas in 2002 in a cattle pen at Tallgrass Prairie National Reserve, but control measures were applied, and no populations were found in 2004 and 2005 (Barnard, 2006). We found statements that *M. perfoliatum* is a weed in Oregon (Parsons and Cuthbertson, 2001) and that it was possibly introduced to Texas in vetch from Oregon (Diggs et al., 1999), but we found no records of its presence in Oregon. We found no evidence that this species is cultivated (e.g., Dave's Garden, 2016; GardenWeb, 2016; Greenleaf Nursery, 2016; Monrovia, 2016) or being managed or regulated in the United States.

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

[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. *Myagrum perfoliatum* analysis

Establishment/Spread Potential

Myagrum perfoliatum is an annual herb (Auld and Medd, 1987; Parsons and Cuthbertson, 2001) that produces viable seed (Royal Botanic Gardens Kew, 2016; Saatkamp et al., 2009) and generates a large, persistent seed bank (Saatkamp et al., 2009; Stuchbery, 2004). It may be able to form dense populations in crops (Parsons, 1973; Stuchbery, 2004). The seed pods or seeds are dispersed on harvesting equipment (Cheam et al., 2008; Storrie, 2014) and as a contaminant of grain (Clement and Foster, 2000; Storrie, 2014; Verloove, 2012), hay (Storrie, 2014), birdseed (Clement and Foster, 2000; Hanson and Mason, 1985), and wool (Stuchbery, 2004; Verloove, 2012 36). When the whole plant is cut down, it can tumble across paddocks, dispersing seed pods (Stuchbery, 2004). *Myagrum perfoliatum* tolerates many of the herbicides used in crops (Government of South Australia, 2014; Texas Invasives, 2013). It has been introduced to a number of countries outside of its native range (e.g., NGRP, 2016a). In some of these countries, such as Canada (Mulligan, 2002) and Norway (Gederaas et al., 2012), it appears to be unable to survive in the wild, and in others, such as Belgium, it is a casual alien (Verloove, 2012). However, in Australia, where it was first introduced to Victoria and South Australia in the early 1900s, it was "initially very troublesome," then "declined," and is now increasing again in South Australia, possibly due to reduced competition from other crop weeds that have been controlled (Parsons and Cuthbertson, 2001), and it has not yet reached its full potential distribution in Australia (Cheam et al., 2008). We had a low level of uncertainty for this risk element.

Risk score = 20 Uncertainty index = 0.12

Impact Potential

Myagrum perfoliatum is an agricultural weed of pastures and crops (Cheam et al., 2008), including wheat, sugar beet, sunflowers (Portale Della Flora di Roma, no date), lentils (Yenish et al., 2009), cereals (Auld and Medd, 1987), and cornfields (Dunn, 1905). In Australia, it "is a major weed of chickpeas, lentils, lupins, field peas, faba bean and canola in western Victoria and South Australia" and "a weed of winter cereals and lucerne" (Storrie, 2014). In chickpeas and lentils, *Myagrum perfoliatum* can cause up to 50 percent yield losses; it can smother cereal and canola (Storrie, 2014) and outcompete crops late in the season (Stuchbery, 2004). It reduces commodity values by contaminating seed and hay (Government of South Australia, 2014), resulting in additional cleaning (Storrie, 2014), and by slowing harvests when the bulky, branched plants clog equipment (Auld and Medd, 1987; Parsons and Cuthbertson, 2001). Several methods of control are available, including herbicides (Storrie et al., 2006; Storrie, 2014), fallow phases, weed-free seed, cleaning farm machinery (Cheam et al., 2008; Storrie, 2014), weed wiping (Storrie, 2014), heavy grazing (Parsons, 1973), and soil solarization (Cohen and Rubin, 2007). However, control of *M. perfoliatum* can be difficult and costly once it has established, due in part to the species' tolerance to some herbicides and the lack of herbicides available for control

in some crops (Government of South Australia, 2014). We found no evidence that *Myagrum perfoliatum* has any impacts outside of agricultural systems. We had an average level of uncertainty for this risk element due to lack of specific information about *Myagrum perfoliatum*'s impacts.
Risk score = 2.5 Uncertainty index = 0.13

Geographic Potential Based on three climatic variables, we estimate that about 69 percent of the United States is suitable for the establishment of *Myagrum perfoliatum* (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 *Myagrum perfoliatum* represents the joint distribution of Plant Hardiness Zones 5-11, areas with 10-90 inches of mean annual precipitation, and the following Köppen-Geiger climate classes: steppe, Mediterranean, humid subtropical, marine west coast, humid continental warm summers, humid continental cool summers, and subarctic. It was not clear if *Myagrum perfoliatum* can survive in Zones 3, 4, or 12; because we had only one data point for each of those zones, we did not include them in the predicted distribution.

The area of the United States shown to be climatically suitable (Fig. 1) is likely overestimated since 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. *Myagrum perfoliatum* is found in disturbed areas, such as fields, roadsides (Rollins, 1993), refuse areas (Dunn, 1905; Fraser, 1904), waste lands, railway banks, port areas, and areas where grain is harvested or milled (Verloove, 2012). It grows on warm, calcareous loams and sandy soils (Hanf, 1983) and in temperate regions particularly on dry exposed sites. It grows well on both light and heavy soils (Parsons and Cuthbertson, 2001).

Entry Potential *Myagrum perfoliatum* is already present in the United States (NGRP, 2016a; NRCS, 2016). However, we assessed its entry potential because we found no evidence that it is present in the United States outside of northeastern and north central Texas and one county in Oklahoma (Diggs et al., 1999), and because assessment of its entry potential can provide additional information to risk managers and policy makers. This WRA was initiated due to *M. perfoliatum*'s association with wheat proposed for import into the United States from Ukraine (Government of Ukraine, 2013). This species is a contaminant of seeds, hay (Government of South Australia, 2014), wool, and grains (Verloove, 2006), including wheat (Parsons and Cuthbertson, 2001; Storrie, 2014), barley, canola, and pulses (Storrie, 2014). Crop seeds and harvesting machinery are likely pathways for its introduction to new areas (Cheam et al., 2008). On a scale of 0 to 1, where 1 represents a maximum likelihood for entry, we ranked this species with a score of 0.16.
Risk score = 0.16 Uncertainty index = 0.07

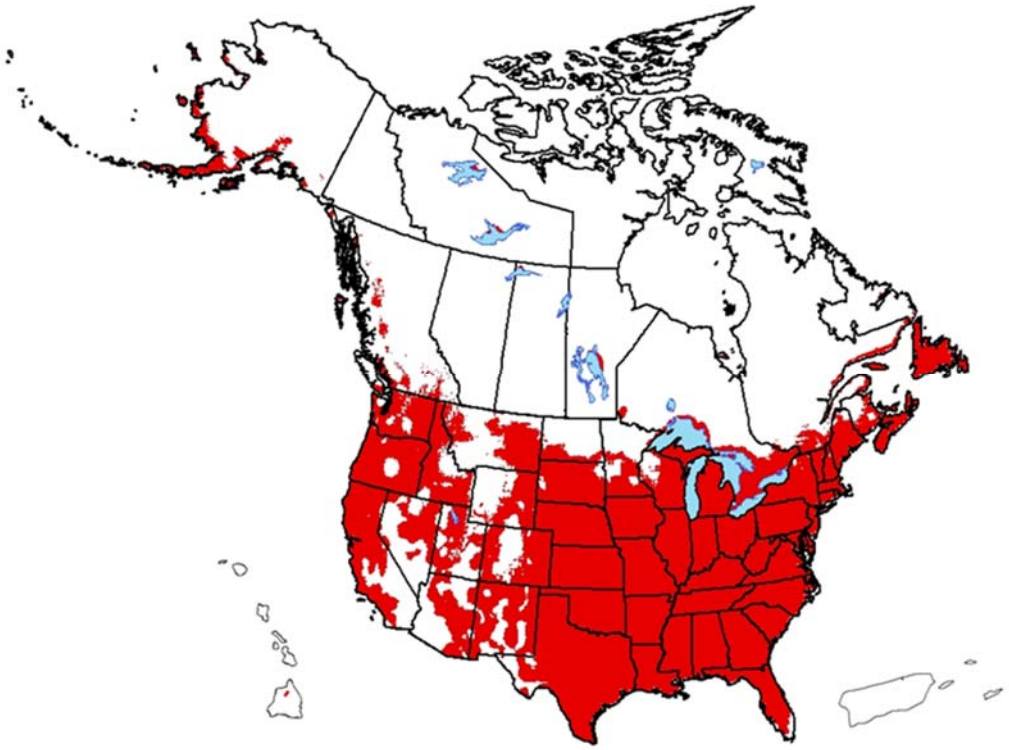

Figure 1. Potential geographic distribution of *Myagrum perfoliatum* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 88.9%
P(Minor Invader) = 10.7%
P(Non-Invader) = 0.4%

Risk Result = High Risk

Secondary Screening = Not Applicable

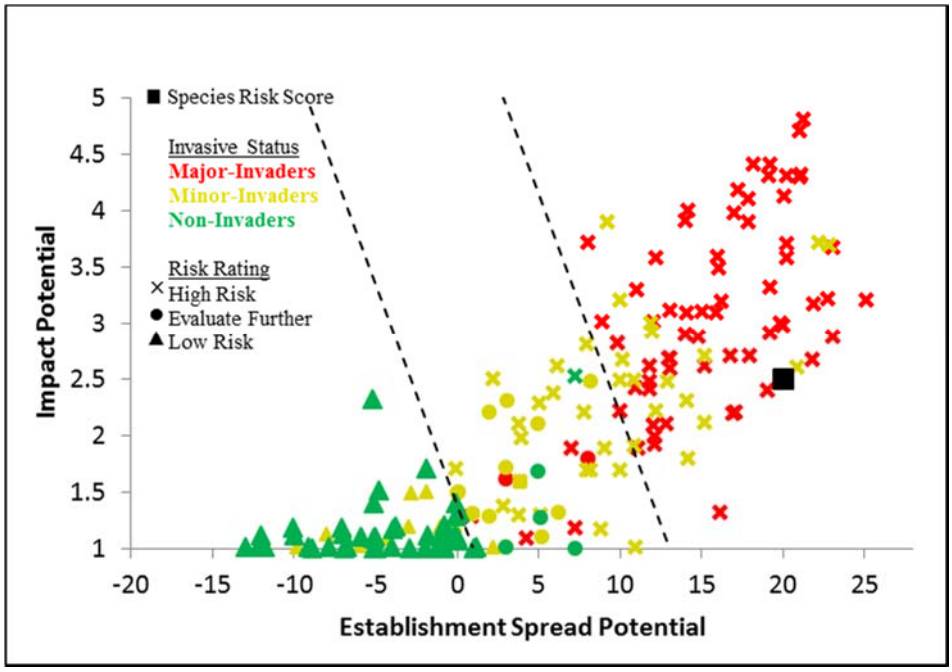

Figure 2. *Myagrum perfoliatum* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

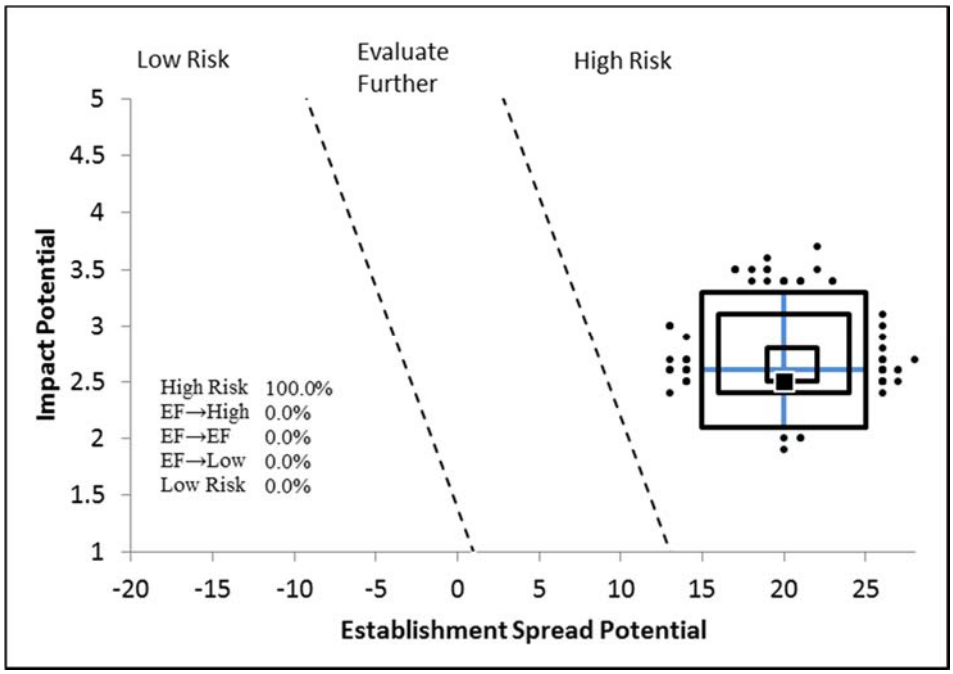

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Myagrum perfoliatum*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Myagrum perfoliatum* is High Risk (Fig. 2). There was some uncertainty in the assessment due to a lack of specific information about *M. perfoliatum*'s biology, behavior, and impacts, especially in natural and anthropogenic systems. However, all 5,000 iterations of the uncertainty simulation were located within the High Risk range (Fig. 3), which suggests that additional information would not change our result of High Risk.

Myagrum perfoliatum is a weed of grain (Clement and Foster, 2000; Storrie, 2014; Verloove, 2012), hay (Storrie, 2014), and birdseed (Clement and Foster, 2000; Hanson and Mason, 1985). Contamination of seed is a likely pathway for its introduction to new areas (Cheam et al., 2008). In South Australia and western Victoria, where *M. perfoliatum* has been introduced, it has become a major weed of several crops, including chickpeas, lentils, and canola (Storrie, 2014). Farmers in Victoria ranked it as one of the most serious weeds they deal with on their farms and expected it to become a bigger problem over time (Niknam et al., 2002). In South Australia, where its distribution is still limited, *M. perfoliatum* is a declared plant (i.e., a noxious weed) due to its significance as a seed contaminant (Government of South Australia, 2014). Herbicide options are limited in some of the crops that *M. perfoliatum* infests, and it is tolerant to many of the herbicides that would typically be used in cereals or fallow fields (Government of South Australia, 2014).

In the United States, *M. perfoliatum* appears to be naturalized in counties in north central and northeastern Texas and one county in Oklahoma (Diggs et al., 1999) that borders two of those Texas counties. We found little evidence about how the species is behaving in Texas or its impacts there, and the evidence we did find was conflicting. For example, one author observed that *M. perfoliatum* was "abundant and spreading" (Diggs et al., 1999), but a decade later another author categorized it as a non-native plant that occurs infrequently and is no longer spreading (Nesom, 2009). Other U.S. reports appear either to have been quickly eradicated (Kansas: Barnard, 2006) or to have been misidentifications (Ohio: Easterley, 1965) or unconfirmed reports (Virginia: Weakley, 2015; Oregon).

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Appendix A. Weed risk assessment for *Myagrum perfoliatum* L. (Brassicaceae). Below is all of 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. The Excel file, where this assessment was conducted, is available upon request.

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 - low	5	*Myagrum perfoliatum* is described as native to parts of western Asia (Armenia, Azerbaijan, Georgia, India, Iran, Iraq, Israel, Jordan, Lebanon, Russia, Syria, Turkey) and Europe (Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, France, Greece, Hungary, Italy, Macedonia, Montenegro, Romania, Serbia, Slovakia, Slovenia, Switzerland, Ukraine) (NGRP, 2016a). However, some authors report a more limited native range (e.g., Bojňanský and Fargašová, 2007; Hanf, 1983; Rollins, 1993) or naturalized rather than native status (e.g., Medvecká et al., 2012; Portale Della Flora di Roma, no date; Pyšek, 2003; Terpó et al., 1999). It is considered naturalized in Algeria, Japan, Australia, and Germany (NGRP, 2016a). In some parts of its native or naturalized range, it is rare or declining [e.g., Italy (Portale Della Flora di Roma, no date), Israel (Pollak, 2015), Slovakia (Eliáš et al., 2007; Májeková and Zaliberová, 2007), Croatia (Hulina, 2005), Greece (Bergmeier and Strid, 2014), Germany (Meyer, no date)], while in others it is rare but increasing [e.g., France (Lonchamp, 2000)]. It was first recorded in South Australia in 1925 (Virtue, 1996) and in Victoria around 1900 (Parsons and Cuthbertson, 2001); it also occurs in Queensland (Auld and Medd, 1987) and is "very limited" in New South Wales (Cheam et al., 2008). In South Australia and Victoria, it was "initially very troublesome...but declined in later years for unknown reasons," but has begun to increase again in South Australia, possibly due to the decline of other weeds that are being selectively removed by herbicide (Parsons and Cuthbertson, 2001) or due to changes in crop practices (Storrie, 2014). In 1998, it was infesting about 60,000 hectares in Wimmera, Victoria, and spreading (Stuchbery, 2004). It is described as a new (Virtue, 1996) or emerging weed whose range is expanding in Australia (Cheam et al., 2008). *Myagrum perfoliatum* has been reported in the British Isles (Clement and Foster, 2000), Belgium (Verloove, 2006, 2012), and the Czech Republic (Pyšek, 2003) as a casual alien. It has also been reported from Norway (Gederaas et al., 2012) and twice from Quebec, Canada (Mulligan, 2002), but is not thought to be able to establish in those areas. In the United States, *M. perfoliatum* is naturalized in Texas and has been reported from Oklahoma, Ohio (NRCS, 2016), Virginia (NGRP, 2016a), and Kansas (Barnard, 2006). However, we found no evidence that it is present outside of northeastern and north central Texas and Bryan County, OK (Diggs et al., 1999). Refer to the U.S. distribution and status section of the assessment for additional information. The alternate answers for the uncertainty simulation are both "e."
ES-2 (Is the species highly domesticated)	n - negl	0	We found no evidence that *Myagrum perfoliatum* has been domesticated or bred for reduced weed potential. While this species is occasionally cultivated (e.g., Wilkes, 1819; Mulligan, 2002), and its seeds are available for purchase from a seed vendor

Question ID	Answer – Uncertainty	Score	Notes (and references)
			in France (B & T World Seeds, 2016), it is not discussed, sold, or traded on popular gardening websites (e.g., Dave's Garden, 2016; GardenWeb, 2016; Greenleaf Nursery, 2016; Monrovia, 2016). This suggests it is not widely cultivated, and very unlikely to have been domesticated.
ES-3 (Weedy congeners)	y - high	1	*Myagrum perfoliatum* is currently the only species in the genus *Myagrum*; all other species previously classified in this genus were redistributed across other genera sometime prior to the mid-19th century (Wilson, 1852). Several of these former *Myagrum* species are listed at the species level in the Global Compendium of Weeds (Randall, 2007) as both agricultural and environmental weeds [*Rapistrum rugosum, Calepina irregularis, Camelina sativa* subsp. *sativa, Neslia paniculata* (NRCS, 2016)], as agricultural weeds [*Camelina alyssum* (NGRP, 2016b)], or as weeds [*Rapistrum perenne* (NGRP, 2016b)]. Of these, only *Rapistrum rugosum* is listed as a serious or principal weed in several countries by Holm et al. (1979). It is present in 16 U.S. states and is a terrestrial noxious weed seed in Texas. *Rapistrum rugosum* outcompetes native species, forms monocultures (Texas Invasives, 2012), and "taints dairy products and meat and can reduce crop yield significantly" (Parsons and Cuthbertson, 2001). We answered yes, but with high uncertainty because *Rapistrum rugosum* is not a true congener of *Myagrum perfoliatum*.
ES-4 (Shade tolerant at some stage of its life cycle)	? - max		We found no evidence that *Myagrum perfoliatum* is shade tolerant and no information on its light requirements. Its habitat is described as "temperate regions[,] particularly on dry exposed sites" (Parsons and Cuthbertson, 2001). Based on the species' traits, a post-fire recovery manual includes *Myagrum perfoliatum* in a broad grouping called "herbs in disturbed ground"; species included in the group are thought to be somewhat shade tolerant (Zimmer et al., 2012). Because this evidence is conflicting, we answered this question as unknown.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	y - low	1	*Myagrum perfoliatum* is an erect annual herb with branching stems that grows up to a meter high (Parsons and Cuthbertson, 2001). Its basal leaves form a rosette (Auld and Medd, 1987; Lonchamp, 2000) that grows up to 40 cm in diameter; "it can compete strongly with crops because of the rosette base" (Texas Invasives, 2013). "Rosettes grow to 450 mm in diameter and are very flat to the ground…It can also completely smother patches of cereal and canola" (Storrie, 2014).
ES-6 (Forms dense thickets, patches, or populations)	y - mod	2	In a study on *M. perfoliatum* populations in chickpeas at two study locations before and after treatment with several post-sowing, pre-emergent herbicides, densities ranged from 8 to 70 plants/m^2 before spraying and from 4 to 103 plants/m^2 after spraying. While the size of the plants is not reported, at least some were larger rosettes at the time of spraying (Stuchbery, 2004). Some photographs show many of the plants in a small area (e.g., Meyer, no date), including a photo of *M. perfoliatum* in a lentil crop (Cheam et al., 2008, p. 12, Fig. 1.28). "When densely established, musk weed competes with cereal crops" (Parsons, 1973).
ES-7 (Aquatic)	n - negl	0	*Myagrum perfoliatum* is not an aquatic plant; it is a terrestrial herb (NGRP, 2016a).

Question ID	Answer – Uncertainty	Score	Notes (and references)
ES-8 (Grass)	n - negl	0	This species is not a grass; it is an herb in the Brassicaceae family (NGRP, 2016a).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	*Myagrum perfoliatum* is in the Brassicaceae family (NGRP, 2016a), which is not one of the families known to contain nitrogen-fixing species (e.g., Martin and Dowd, 1990; Santi et al., 2013). Furthermore, this species is herbaceous and not woody (NGRP, 2016a).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	This species reproduces only by seed (Parsons and Cuthbertson, 2001). One study found that 40 percent of the seeds recovered from the soil were viable (cited in Stuchbery, 2004). *Myagrum perfoliatum* seeds consistently germinate under a variety of experimental conditions (e.g., Royal Botanic Gardens Kew, 2016; Saatkamp et al., 2009).
ES-11 (Self-compatible or apomictic)	y - low	1	*Myagrum perfoliatum* is described as autogamous (self-compatible) (e.g., Knuth and Müller, 1906; Salisbury, 2002; Virtue, 1996).
ES-12 (Requires specialist pollinators)	n - negl	0	We found no evidence that *Myagrum perfoliatum* requires specialist pollinators. This species is described as both entomophilous (pollinated by insects) (Brundu et al., 2001) and self-pollinating (Cheam et al., 2008).
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]	b - negl	1	*Myagrum perfoliatum* is an annual (Auld and Medd, 1987; Bojňanský and Fargašová, 2007; Hanf, 1983; Rollins, 1993). In Australia, it germinates and establishes from April to October, flowers from late July to mid-October, and produces seeds from mid-August to early December (Storrie, 2014). In Europe, it is an overwintering annual that flowers from May to July (Hanf, 1983). For the uncertainty simulation, we chose "c" for both of the alternate answers since we found no evidence of multiple generations per year.
ES-14 (Prolific seed producer)	y - high	1	During research on the effect of weed wiping (application of herbicide to weeds that are taller than the host crop) on *Myagrum perfoliatum* seed production and germination, the number of seeds per weed-wiped plant ranged from 43 to 747, with most plants having seed counts in the 400s or 500s (Stuchbery, 2004). Saatkamp et al. (2009) found an average of 76.1 seeds per individual plant when sampling 10 plants, but other estimates are much higher [e.g., 1000 seeds (Storrie, 2014)]. Germination rates of 95 to 100 percent have been observed in the laboratory (Royal Botanic Gardens Kew, 2016), including rates of up to 45 percent in seeds of plants that had been weed-wiped (Stuchbery, 2004). Stuchbery (2004) reported densities ranging from 8 to 70 plants/m^2 prior to spraying during a trial on post-sowing, pre-emergent spraying in chickpeas. Using the lower end of the density range (8 plants/m^2) reported by Stuchbery (2004), this works out to 609 seeds produced/m^2 at the 76.1 seeds per plant reported by Saatkamp et al. (2009) and 4,000 seeds/m^2 at 500 seeds per plant (a seed production number more in line with what was observed in Stuchbery, 2004). At the high end of the density range (70 plants/m^2) reported by Stuchbery (2004), this works out to about 5327 seeds/m^2 at the 76.1 seeds per plant reported by Saatkamp et al. (2009) and 35,000 seeds/m^2 at 500 seeds per plant (a seed production number more in line with what was observed in Stuchbery, 2004). These densities appear to be reported for

Question ID	Answer – Uncertainty	Score	Notes (and references)
			plants up to the rosette stage rather than for pod-producing plants. However, if an individual plant produces 500 seeds, only 10 plants/m^2 are required to meet the 5,000 seed/m^2 threshold to answer "yes" to this question at a germination rate of 100 percent, and about 34 plants/m^2 are required if the germination rate is 30 percent. A per-plant seed production rate of several hundred seeds aligns with estimates (e.g., about 1000 seeds, Storrie, 2014 and cited in Stuchbery, 2004) and data (e.g., multiple studies in Stuchbery, 2004), and photographs show several mature plants growing close together (Cheam et al., 2008, p. 12, Fig. 1.28; Meyer, no date).
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	*Myagrum perfoliatum* is found in disturbed areas, such as fields, roadsides (Rollins, 1993), refuse areas (Dunn, 1905; Fraser, 1904), waste lands, railway banks, port areas, and areas where grain is harvested or milled (Verloove, 2012). The seeds are reported to be spread through mud (Hosking et al., 2003), and the species is spread by harvesting equipment (Cheam et al., 2008; Storrie, 2014). Contamination of machinery is a likely pathway for the introduction of this species to new areas (Cheam et al., 2008). "[M]ost of the pods will exit with the chaff and straw in a properly adjusted harvester" (Storrie, 2014). *Myagrum perfoliatum* was likely introduced to Kansas via the shipment of cattle from Texas; while the seeds were probably dispersed in some way by the cattle, it is possible that they were carried by the trucks unloading the animals (Barnard, 2006).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	*Myagrum perfoliatum* has been described as a weed of grain (Clement and Foster, 2000; Storrie, 2014; Verloove, 2012), hay (Storrie, 2014), and birdseed (Clement and Foster, 2000; Hanson and Mason, 1985). It is listed in an identification guide for seed impurities of grain (GTA, No Date); "the fruit is similar in size to a wheat grain and not always separated in cleaning operations" (Parsons and Cuthbertson, 2001). "The pods are the same size as wheat and barley grains. When muskweed is present in canola and pulse grain, additional seed cleaning is often required before delivery" (Storrie, 2014). It was unintentionally introduced into Belgium as a contaminant of grain and wool (Verloove, 2006). Contamination of crop seeds is a likely pathway for the introduction of this species to new areas (Cheam et al., 2008).
ES-17 (Number of natural dispersal vectors)	2	0	Fruit and seed descriptions for ES-17a through ES-17e: The fruit of *Myagrum perfoliatum* is a wedge- or pear-shaped pod that is about 5 to 7 mm long and 4 to 5 mm wide (Hanf, 1983; Parsons and Cuthbertson, 2001), although the pod may be longer (e.g., 8 to 10 mm, Bojňanský and Fargašová, 2007). The pod is hard, has a "prominent persistent style" (Parsons and Cuthbertson, 2001) and two empty cavities, is reddish-brown (Hanf, 1983) or straw-brown in color, and is indehiscent (Bojňanský and Fargašová, 2007). The pod contains a single seed, rarely two (Rollins, 1993), that is reddish-brown and about 3 x 2 mm (Hanf, 1983).
ES-17a (Wind dispersal)	y - low		Australian farmers report that mature plants have been blown up to 1 km away after being cut down during harvest, shedding seed pods as they are blown and resulting in localized spread to uninfested paddocks (Stuchbery, 2004). "Plants... tumble across paddocks, dispersing seed" (Storrie, 2014).

Question ID	Answer – Uncertainty	Score	Notes (and references)
ES-17b (Water dispersal)	n - mod		We found no evidence that this species is dispersed by water, other than one reference that states that it "spreads by seed, either in contaminated grain or by water and mud" (Hosking et al., 2003).
ES-17c (Bird dispersal)	n - mod		While the fruit does not have any adaptations that would make it particularly attractive to birds (see seed description in ES-17), *Myagrum perfoliatum* is a casual or sporadic weed of birdseed (Clement and Foster, 2000; Hanson and Mason, 1985), suggesting that birds may consume the seed. Whether or not they effectively disperse it cannot be determined from this evidence.
ES-17d (Animal external dispersal)	y - low		Farmers and agronomists have found *Myagrum perfoliatum* seed pods in sheep's wool (Stuchbery, 2004), and it was reported as a wool alien in Belgium between 1891 and 1907 (Verloove, 2012). Its introduction to Kansas likely resulted from the shipment of cattle from Texas; the seeds may have been in the cattle's hide or in mud on their hooves (Barnard, 2006).
ES-17e (Animal internal dispersal)	n - high		We found no evidence that propagules of *Myagrum perfoliatum* are dispersed internally by animals, or that they have any adaptations that would encourage such dispersal. The species is a weed of pastures (Cheam et al., 2008), and grazing has been suggested as a method of control (Parsons, 1973; Simmonds et al., 2000), but we did not find any information about whether animals actually graze on this species. The author who reported *Myagrum perfoliatum*'s introduction to Kansas states that it likely arrived via a shipment of cattle from Texas and suggested cattle manure as one of several possible means of introduction (Barnard, 2006).
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - negl	1	In a seed bank longevity experiment in which seeds of *Myagrum perfoliatum* were buried 10 cm deep in a Mediterranean climate, 100 percent of the seeds survived after six months, 81.2 percent after 18 months, and 31.2 percent after 30 months (Saatkamp et al., 2009). *Myagrum perfoliatum* seed pods are retained on the plant for a prolonged time in a dormant state (Benvenuti, 2007). Seeds have been suggested to remain viable in the soil for anywhere from two to three years (Parsons and Cuthbertson, 2001) to six years (Stuchbery, 2004) to up to 10 years (Storrie, 2014; Texas Invasives, 2013). Control over several years is required to deplete the seed bank (Parsons and Cuthbertson, 2001; Stuchbery, 2004).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - mod	-1	Based on the species' traits, a post-fire recovery manual includes *Myagrum perfoliatum* in a broad grouping called "herbs in disturbed ground"; species included in the group are thought to "rely on continuing disturbance (sometimes frequent fire or flooding) for persistence," and their post-fire response is a "short-term increase via seed germination" (Zimmer et al., 2012). Burning is suggested as a method of depleting the seed bank (Cheam et al., 2008). Australian farmers have noticed higher rates of seed germination in cultivated areas (Stuchbery, 2004). Because we found no direct evidence that that this species tolerates or benefits from mutilation, cultivation, or fire, and because we cannot use information about seed banks and seed disturbance to answer this question, we answered no with moderate uncertainty.

Question ID	Answer – Uncertainty	Score	Notes (and references)
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	y - high	1	We found no evidence that *Myagrum perfoliatum* is resistant to herbicides, and it is not listed in the International Survey of Herbicide Resistant Weeds (Heap, 2014). However, we did find some evidence that it is tolerant to some types of herbicides. For example, *Myagrum perfoliatum* is "not as susceptible to phenoxy acid herbicides as most other cruciferous weeds" (Parsons and Cuthbertson, 2001). Higher rates of glyphosate are recommended for *Myagrum perfoliatum*, as it can be hard to control (Cheam et al., 2008). “There are few herbicides registered for cereals or fallows and it is tolerant to many herbicides commonly-used in these situations” (Government of South Australia, 2014). "Since Bird's eye cress is tolerant to many commonly-used herbicides, control in agricultural crops is difficult" (Texas Invasives, 2013). Fluroxypyr, a broadleaf herbicide, had no effect on *Myagrum perfoliatum* (Radivojevic et al., 2001). Although this question focuses on evidence of resistance, because there was ample evidence for herbicide tolerance, and because two of *M. perforliatum*’s former congeners *Rapistrum rugosum* and *Neslia paniculata* are listed as resistant to some herbicides (Heap, 2014), we answered yes with high uncertainty.
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)	8	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - high		We found no evidence that this species is allelopathic. Two of its former congeners, *Camelina sativa* and *Camelina alyssum*, have "alleged allelopathic potential" (Radosevich et al., 2007).
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that this species is parasitic, and it does not belong to a plant family known to contain parasitic plants (Nickrent, 2016; Walker, 2012).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - mod	0	We found no evidence that this species changes ecosystem processes and parameters.
Imp-N2 (Changes habitat structure)	n - mod	0	We found no evidence that this species changes habitat structure. *Myagrum perfoliatum* may be able to form dense populations (see ES-6) that would change habitat structure, but without more specific evidence, and because this species is not considered a weed of natural areas, we answered no with moderate uncertainty.
Imp-N3 (Changes species diversity)	n - mod	0	We found no evidence that *Myagrum perfoliatum* changes species diversity. In a report on the management and impact of weeds on the biodiversity of Australian rangeland, *Myagrum perfoliatum* was included in a list of non-native species on Australian rangeland, but was not designated as a species known to impact biodiversity (Grice and Martin, 2005).
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	n - mod	0	Outside of production systems, *Myagrum perfoliatum* mainly grows in disturbed or anthropogenic areas (see ES-15, Imp-A1), so it seems unlikely that it would affect threatened and

Question ID	Answer – Uncertainty	Score	Notes (and references)
			endangered species, which we expect would occur primarily in natural areas.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - mod	0	We found no evidence that this species is likely to affect any U.S. globally outstanding ecoregion. Outside of production systems, *Myagrum perfoliatum* mainly grows in disturbed or anthropogenic areas (see ES-15, Imp-A1), so it seems unlikely that it would affect globally outstanding ecoregions in the United States.
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]	a - mod	0	*Myagrum perfoliatum* is listed by the Global Compendium of Weeds as an environmental weed (Randall, 2007), but the source of the original information is not clear. We did not find any evidence that it is a weed of natural systems, and we found no evidence that it is being controlled in natural areas. It is listed as occurring at the Hagerman Wildlife Refuge in Texas and Oklahoma, and the refuge's conservation plan includes the removal of invasive plants (USFWS, 2006), but no other information is provided, such as whether *Myagrum perfoliatum* is considered a weed, any impacts it is having, or whether the area it was found in was a natural area or a disturbed area. The alternate answers for the uncertainty simulation were both "b."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - low	0	Bojňanský and Fargašová (2007) describe this species as occurring "on syna[n]thropical stands"; a synanthrope is a "species linked to the voluntary or involuntary action of man which generally modify their natural distribution by extension" (di Castri et al., 2012). *Myagrum perfoliatum* is found in disturbed areas, such as fields, roadsides (Rollins, 1993), refuse areas (Dunn, 1905; Fraser, 1904), waste lands, railway banks, port areas, and around areas where grain is harvested or milled (Verloove, 2012). However, we found no evidence that it is causing any impacts in anthropogenic areas.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence that this species limits or changes the recreational use of an area. In 2000, *Myagrum perfoliatum* was found in and around cattle pens in Tallgrass Prairie National Preserve in Kansas, "mostly along fences and along building perimeters"; it persisted for a time, but did not spread outside of the five locations where it was originally found, and it was controlled and then eradicated by 2004 (Barnard, 2006). The report does not mention any negative impacts resulting from the plant's introduction. It is listed as occurring at the Hagerman Wildlife Refuge in Texas, and the refuge's conservation plan includes the removal of invasive plants (USFWS, 2006), but no other information is provided, such as whether *Myagrum perfoliatum* is considered a weed, any impacts it may be having, whether the area it was found in was a natural area or a disturbed area, or whether it was specifically targeted for removal.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - mod		We found no evidence that this species affects ornamental plants or vegetation.
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	b - mod	0	*Myagrum perfoliatum* is found in anthropogenic areas both inside and outside of its native range (e.g., Bojňanský and Fargašová, 2007; Rollins, 1993). At one time, it was valued as an ornamental (e.g., Mulligan, 2002; Wilkes, 1819; Wilson, 1852), but it has also been referred to as a garden weed (Britton, 1918; Gilliat-Smith

Question ID	Answer – Uncertainty	Score	Notes (and references)
weed and evidence of control efforts]			and Turrill, 1930). The alternate answers for the uncertainty simulation were both "a."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - low	0.4	In chickpeas and lentils, *Myagrum perfoliatum* can cause up to 50 percent yield losses; it can smother cereal and canola (Storrie, 2014). "A thick vigorous crop is required to compete with musk weed plants that germinate late in the season" (Stuchbery, 2004). When muskweed populations were monitored at paddocks on five farms in Australia, there were enough plants to cause yield loss (Stuchbery, 2004).
Imp-P2 (Lowers commodity value)	y - negl	0.2	*Myagrum perfoliatum*'s "much branched, spreading growth chokes harvesting equipment" (Parsons and Cuthbertson, 2001). It interferes with harvesting machinery (Auld and Medd, 1987); "it slows harvest due to the bulk of material and it will 'ball' in front of the comb" (Storrie, 2014). "When muskweed is present in canola and pulse grain, additional seed cleaning is often required before delivery" (Storrie, 2014). *Myagrum perfoliatum* is included in an Australian grain industry guide to identifying seed impurities of grain (GTA, No Date). In Turkey, *Myagrum perfoliatum* had one of the highest weed seed contamination rates in a lot of anise seed for foreign export; while the rate of contamination was acceptable, the anise seed had been already cleaned by a selector (Kaçan and Sokat, 2013). "It is also a contaminant reducing the value and marketability of seed and hay" (Government of South Australia, 2014). Brassicaceous weeds, particularly *Myagrum perfoliatum*, require a higher rate of glyphosate for fallow and pre-sowing control (Cheam et al., 2008). It can be "difficult and expensive to control once established in cropping land" (Government of South Australia, 2014). Because of the persistence of the seed bank, crop choice may eventually be limited in paddocks where muskweed is poorly controlled (Stuchbery, 2004).
Imp-P3 (Is it likely to impact trade?)	y - negl	0.2	*Myagrum perfoliatum* is listed as a harmful organism by Brazil, Colombia, New Zealand, and Peru (APHIS, 2015). It is a category 3 declared plant in South Australia, which means it cannot enter South Australia, and it cannot be moved, transported, or sold there on its own or as a contaminant (Government of South Australia, 2014). It is a contaminant of seed and hay (Government of South Australia, 2014).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - mod	0	We found no evidence that this species interferes with irrigation or competes with other plants for water.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	This species is highly palatable to goats (Simmonds et al., 2000), and there is no evidence that it is toxic (Parsons and Cuthbertson, 2001; Simmonds et al., 2000). Heavy grazing is suggested as a means of control (Parsons, 1973).
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	c - negl	0.6	*Myagrum perfoliatum* is listed by the Global Compendium of Weeds as an agricultural weed (Randall, 2007), and Parsons and Cuthbertson state that it is a weed in Australia, Italy, Lebanon, Turkey, and the United States (Parsons and Cuthbertson, 2001). In Italy, it is a weed of wheat, sugar beet, and sunflower fields

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weed and evidence of control efforts]			(Portale Della Flora di Roma, no date). It "is a major weed of chickpeas, lentils, lupins, field peas, faba bean and canola in western Victoria and South Australia. It is also a weed of winter cereals and lucerne" (Storrie, 2014). It is a weed of crops and pastures in Australia (Cheam et al., 2008). It is a common weed of lentil crops (Yenish et al., 2009) and cereal crops (Auld and Medd, 1987). It is a weed of barley in Bulgaria (Atanasova et al., 2010) and a cornfield weed in southern and central Europe (Dunn, 1905). Control options include applying herbicides (Storrie et al., 2006; Storrie, 2014), implementing fallow phases, sowing weed-free seed, cleaning farm machinery (Cheam et al., 2008; Storrie, 2014), weed wiping (Storrie, 2014), heavy grazing (Parsons, 1973), and implementing soil solarization (Cohen and Rubin, 2007); however, control can be difficult once it has established, as it is tolerant to some of the herbicides used in the crops it infests and there are no herbicide options available for some crops (Government of South Australia, 2014). In addition, some herbicides used to control muskweed cause unacceptable levels of yield loss or crop damage (Stuchbery, 2004). The alternate answers for the uncertainty simulation are both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2016).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - mod	N/A	We found no evidence that this species occurs in this plant hardiness zone.
Geo-Z2 (Zone 2)	n - mod	N/A	We found no evidence that this species occurs in this plant hardiness zone.
Geo-Z3 (Zone 3)	n - high	N/A	One point in Canada.
Geo-Z4 (Zone 4)	n - high	N/A	One point in Austria.
Geo-Z5 (Zone 5)	y - mod	N/A	Three points in Sweden.
Geo-Z6 (Zone 6)	y - negl	N/A	Numerous points in Germany. Several points in Austria. Three points in Norway. One point each in Georgia and Armenia. Reported in Kiev, Ukraine (Mosyakin and Yavorska, 2002); Tabriz, Azerbaijan (Gilliat-Smith and Turrill, 1930); continental Croatia (Hulina, 2005); and the United States in Chase County, Kansas (Barnard, 2006).
Geo-Z7 (Zone 7)	y - negl	N/A	Numerous points in France and Germany. Several points each in Austria, Greece, and Belgium. Two points in Sweden. One point each in Georgia and Luxembourg. Reported from Tabriz, Azerbaijan (Gilliat-Smith and Turrill, 1930), and continental Croatia (Hulina, 2005). Reported at a study location in the Great Hungarian Plain (Szigetvári, 2002) that is in this zone.
Geo-Z8 (Zone 8)	y - negl	N/A	Numerous points in Spain and France. Several points in Germany and Sweden. Three points in Greece. Two points each in the Netherlands, Italy, and Norway. One point each in Bulgaria and Turkey. Reported in Edinburgh, Scotland (Fraser, 1904).
Geo-Z9 (Zone 9)	y - negl	N/A	Numerous points in Australia, Spain, and France. Two points in Norway. Reported near villages near Lake Vrana Nature Park in Croatia (Łuczaj et al., 2013).
Geo-Z10 (Zone 10)	y - negl	N/A	Numerous points in France. A few points in Australia. Reported in Dalton-in-Furness, England (Britton, 1918).
Geo-Z11 (Zone 11)	y - low	N/A	A few points in Israel. One point in Australia.

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Geo-Z12 (Zone 12)	n - high	N/A	One point in Israel.
Geo-Z13 (Zone 13)	n - high	N/A	We found no evidence that this species occurs in this plant hardiness zone.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - mod	N/A	We found no evidence that this species occurs in this climate class.
Geo-C2 (Tropical savanna)	n - mod	N/A	We found no evidence that this species occurs in this climate class.
Geo-C3 (Steppe)	y - negl	N/A	Numerous points in Spain. Several points in Australia. Two points in Greece. One point in Armenia.
Geo-C4 (Desert)	n - mod	N/A	We found no evidence that this species occurs in this climate class.
Geo-C5 (Mediterranean)	y - negl	N/A	Numerous points in France. Several points in Spain and Israel. A few points in Australia. Two points in Italy. One point in Greece. Reported near villages near Lake Vrana Nature Park in Croatia (Łuczaj et al., 2013).
Geo-C6 (Humid subtropical)	y - negl	N/A	Several points each in Australia, Greece, France, Germany, and the United States (Texas). One point each in Bulgaria, Georgia, and Turkey.
Geo-C7 (Marine west coast)	y - negl	N/A	Numerous points in Germany and France. Several points in Spain and Belgium. Two points each in Australia, the Netherlands, and Norway. One point in Luxembourg. Reported in Dalton-in-Furness, England (Britton, 1918) and Edinburgh, Scotland (Fraser, 1904).
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Several points in the United States (Texas). One point in Georgia. Reported in Chase County, Kansas, United States (Barnard, 2006), and in Tabriz, Azerbaijan.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Numerous points in Austria, Germany, France, and Sweden. Three points in Norway. One point each in Canada, Spain, and Greece. Reported in Kiev, Ukraine (Mosyakin and Yavorska, 2002), and continental Croatia (Hulina, 2005). Reported at a study location in the Great Hungarian Plain (Szigetvári, 2002) that is in this climate class.
Geo-C10 (Subarctic)	y - negl	N/A	Numerous points in France. Three points each in Norway and Sweden.
Geo-C11 (Tundra)	n - high	N/A	We found no evidence that this species occurs in this climate class.
Geo-C12 (Icecap)	n - mod	N/A	We found no evidence that this species occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - mod	N/A	We found no evidence that this species occurs in this precipitation band.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Numerous points in Spain and France. Several points in Australia. Reported in Tabriz, Azerbaijan (Gilliat-Smith and Turrill, 1930).
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Numerous points in Spain and France. Several points in Australia, Germany, Sweden, and Israel. Two points in Austria. One point each in Georgia, Armenia, and Bulgaria. Reported in Kiev, Ukraine (Mosyakin and Yavorska, 2002). Reported at a study location in the Great Hungarian Plain (Szigetvári, 2002) that is in this zone. Reported near villages near Lake Vrana Nature Park in Croatia (Łuczaj et al., 2013).

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Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Numerous points in Greece, France, and Germany. Several points each in the United States (Texas) and Sweden. A few points each in Spain, Austria, and Belgium. Two points in the Netherlands. One point each in Luxembourg and Norway. Reported in the United States in Chase County, Kansas (Barnard, 2006). Reported in continental Croatia (Hulina, 2005) and near villages near Lake Vrana Nature Park in Croatia (Łuczaj et al., 2013).
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Numerous points in Germany and France. Two points each in Italy, Austria, and Norway. One point in Canada on the border of this band and the 50-60 inch band. One point in Greece. Reported in Dalton-in-Furness, England (Britton, 1918), and continental Croatia (Hulina, 2005).
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Numerous points in France and Germany. Two points in Norway. One point in Canada on the border of this band and the 40-50 inch band. One point each in Turkey, Georgia, and Austria. Reported in Edinburgh, Scotland (Fraser, 1904).
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Numerous points in Germany. A few points in France. Two points in Norway. One point in Austria.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Several points in Germany. A few points in France.
Geo-R9 (80-90 inches; 203-229 cm)	y - negl	N/A	Numerous points in Germany.
Geo-R10 (90-100 inches; 229-254 cm)	n - mod	N/A	We found no evidence that this species occurs in this precipitation band.
Geo-R11 (100+ inches; 254+ cm)	n - mod	N/A	We found no evidence that this species occurs in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	1	*Myagrum perfoliatum* is naturalized in Texas and reported from several other states (NGRP, 2016a; NRCS, 2016). However, we found no evidence that it is present outside of northeastern and north central Texas and one county in Oklahoma (Diggs et al., 1999). The other U.S. reports appear either to have been plants that were quickly eradicated (Kansas; Barnard, 2006), plants that were misidentified (Ohio; Easterley, 1965), or unconfirmed reports (Virginia: Weakley, 2015; Oregon). Even though it is already present in the United States, we set this answer to no and assessed *Myagrum perfoliatum*'s entry potential to provide risk managers and policy makers with additional information.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - negl	N/A	This assessment was initiated due to *M. perfoliatum*'s association with wheat proposed for import into the United States from Ukraine (Government of Ukraine, 2013).
Ent-3 (Human value & cultivation/trade status)	b - low	N/A	Survey respondents in Croatia reported boiling young *Myagrum perfoliatum* leaves or rosettes for food. The plants were collected from the wild and used infrequently as a food source, and this was the first report of the species being used for consumption (Łuczaj et al., 2013). *Myagrum perfoliatum* was valued in the past as an ornamental (e.g., Mulligan, 2002; Wilkes, 1819; Wilson, 1852), but we found no evidence that it is currently being cultivated (e.g., Dave's Garden, 2016; GardenWeb, 2016; Greenleaf Nursery, 2016; Monrovia, 2016). Herbal guides from the 1700s and 1800s mention using the tops of the plant in a tea for mouth and throat ailments (Hill, 1812) or using the oil to soften hands (Quer, 1784); however, while one reference suggests cultivating the plant to

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			harvest the oil that can be pressed from its seeds (Hill, 1812), the other states that the plant has little pharmaceutical use (Quer, 1784). Because we found no evidence that it is cultivated, we answered "b."
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	n - mod	N/A	This species has been reported twice from Canada, but not since the 1940s, and there is no evidence that it can survive in Canada's climate (Mulligan, 2002). We found no evidence that it is currently present in Mexico, Central America, the Caribbean, or China (e.g., NGRP, 2016a; NRCS, 2016).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - low	N/A	We found no interceptions of this species at U.S. ports of entry on non-seed propagative material (AQAS, 2017), and no evidence in the literature that it is a weed of nursery stock or a contaminant of non-seed plant propagative material.
Ent-4c (Contaminant of seeds for planting)	y - low	N/A	It is a contaminant of seed (Government of South Australia, 2014), and contamination of crop seeds is a likely pathway for the introduction of this species to new areas (Cheam et al., 2008). We found no interceptions of this species at U.S. ports of entry on seeds for planting (AQAS, 2017).
Ent-4d (Contaminant of ballast water)	n - mod	N/A	We found no evidence that *Myagrum perfoliatum* is a contaminant of ballast water.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - low	N/A	We found no evidence that *Myagrum perfoliatum* is a contaminant of aquarium plants or products, and this seems unlikely since the species is not an aquatic or wetland species or associated with such species.
Ent-4f (Contaminant of landscape products)	n - mod	N/A	We found no evidence that *Myagrum perfoliatum* is a contaminant of landscape products.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - negl	N/A	*Myagrum perfoliatum* seeds are spread by harvesting equipment (Cheam et al., 2008; Storrie, 2014). Contamination of machinery is a likely pathway for the introduction of this species to new areas (Cheam et al., 2008). The seeds may also be spread through mud (Hosking et al., 2003) and trucks (Barnard, 2006).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - negl	N/A	*Myagrum perfoliatum* was introduced into Belgium as a contaminant of grain and wool (Verloove, 2006). It is a contaminant of grains, including wheat (Parsons and Cuthbertson, 2001; Storrie, 2014), barley, canola, and pulses (Storrie, 2014). It has been intercepted several times at U.S. ports of entry in shipments of seed for consumption (AQAS, 2017). In Turkey, *Myagrum perfoliatum* had one of the highest weed seed contamination rates in a lot of anise seed for foreign export; while the rate of contamination was acceptable, the anise seed had been already cleaned by a selector (Kaçan and Sokat, 2013).
Ent-4i (Contaminant of some other pathway)	e - low	N/A	*Myagrum perfoliatum* is a contaminant of hay (Government of South Australia, 2014; Storrie, 2014) and birdseed (Clement and Foster, 2000; Hanson and Mason, 1985). We answered "e" (0.04 points) for this question because hay is used in agricultural environments and *M. perfoliatum* is an agricultural weed.
Ent-5 (Likely to enter through natural dispersal)	n - low	N/A	Because *Myagrum perfoliatum* is not present in Canada or Mexico, its natural dispersal mechanisms—localized dispersal of mature plants by wind (Stuchbery, 2004) and potential dispersal in the wool, hide, or hooves of animals—are unlikely pathways for its entry into the United States.