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Weed Risk Assessment for *Fumaria schleicheri* Soy.-Will (Papaveraceae) – Fumitory

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Version 1

Left: Habit of *Fumaria schleicheri* growing in Ukraine (Photographer: Malibog, 2016a). Right: Herbarium image of *F. schleicheri* [Obtained from http://arctos.database.museum/SpecimenSearch.cfm and used with kind permission from Ickert-Bond (2016).

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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.

	***Fumaria schleicheri* Soy.-Will. – Fumitory**
Species	Family: Papaveraceae (ITIS, 2016; NGRP, 2016), but in an alternate botanical scheme it is also placed in the Fumariaceae (Bojňanský and Fargašová, 2007).
Information	Synonyms: *Fumaria acrocarpa* Peterm. (The Plant List, 2016), *F. carinata* Schur (Anonymous, 2016a), *F. laggeri* Jord. (The Plant List, 2016), *F. mucronulata* Schur (Anonymous, 2016a), *F. parviflora* subsp. *schleicheri* (Soy.-Will.) Bonnier (Anonymous, 2016a), *F. vaillantii* subsp. *schleicheri* (Soy.-Will.) Rouy & Foucaud (Euro+Med, 2006+). For additional synonyms see The Plant List (2016).

Common names: We found no species-specific common name for *F. schleicheri*; however, "fumitory" is often used to refer to species in this genus (MCMA, 2008; Pugsley, 1919).

Botanical description: *Fumaria schleicheri* is a slender, annual species growing in open sites. Branches are straight or reflexed, growing 10-50 cm in height from the base. The leaves, which are more or less glaucous and bi- or tri-pinnatisect, contrast with the deep pink-violet flowers, which darken towards the apex. The deeply colored flowers are characteristic of this species, along with its fruits, which are borne on long and slender pedicels (Bojňanský and Fargašová, 2007; Komarov, 1970; Pugsley, 1919).

Initiation: PPQ received a market access request for corn kernels for human and animal consumption from the government of Ukraine (Government of Ukraine, 2013). An import risk analysis determined that seeds of *F. schleicheri* are likely to be associated with this commodity from Ukraine. In this WRA, we evaluated the weed 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: *Fumaria schleicheri* is distributed throughout southern and central Europe, east to western Siberia, and south into northeastern Iran and the Caucasus region (Bojňanský and Fargašová, 2007; Euro+Med, 2006+; Hanf, 1983; Lepsi and Lepsi, 2010). It also extends to the Altai district in central Asia (ARCTOS, 2016; Pugsley, 1919). *Fumaria schleicheri* is present in the following countries: Armenia, Austria, Azerbaijan, Bulgaria, the Czech Republic, Croatia, France, Germany, Georgia, Greece, Switzerland, Hungary, Iran, Italy, Moldova, Mongolia, Poland, Romania, Sardinia, Slovakia, Serbia, Turkey, Ukraine, and the former Yugoslavia (ARCTOS, 2016; Bojňanský and Fargašová, 2007; Buttler and Hand, 2008; Euro+Med, 2006+; Habibi Tirtash et al., 2011; Lepsi and Lepsi, 2010; Păltinean et al., 2013). Its exact native range is not very clear, and the preceding distribution includes human-mediated spread throughout the region (Euro+Med, 2006+; Lepsi and Lepsi, 2010). It is considered a naturalized alien in Germany (DAISIE, 2016), the Czech Republic (Pyšek et al., 2012), and

Poland (Zając and Zając, 2014), and in Bulgaria and Ukraine it is listed as an alien (DAISIE, 2016). In Poland, it is considered an archaeophyte that has become endangered (Tyc, 2007; Zając and Zając, 2014).

U.S. distribution and status: We found no evidence that this species is present in the United States as either a naturalized species (e.g., EDDMapS, 2016; Kartesz, 2016; NRCS, 2016) or a cultivated species (e.g., Bailey and Bailey, 1976; Dave's Garden, 2016; Page and Olds, 2001; Univ. of Minn., 2016).

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

1. *Fumaria schleicheri* analysis

Establishment/Spread Potential *Fumaria schleicheri* is an herbaceous annual that can form dense patches (Corregia, 2009) in open habitats. Like other members of its genus, it is self-compatible (Anonymous, 2016a) and does not need to rely on pollinators to set seed (Pugsley, 1919). It produces small, rounded achenes, which are a type of indehiscent fruit (Bojňanský and Fargašová, 2007; Păltinean et al., 2013). As with other *Fumaria* species, its fruit are likely dispersed by ants that are attracted to food bodies (i.e., elaiosomes) present on the achenes (MCMA, 2008; Pemberton and Irving, 1990; Pfeiffer et al., 2010; van der Pijl, 1982) and very likely to be unintentionally dispersed by people on clothing, boots, tillage, vehicles, and harvest machinery (MCMA, 2008), as well as by agricultural trade (see App. A, question ES-16). Although this species has not been introduced outside of Eurasia, it has spread beyond its original native range in this region as it is considered an archaeophyte[2] by several countries [e.g., Poland (Tyc, 2007; Zając and Zając, 2014) and the Czech Republic (Pyšek et al., 2012)]. We had high uncertainty for this risk element.

Risk score = 13 Uncertainty index = 0.27

Impact Potential *Fumaria schleicheri* is a weed of natural areas (Gorbunov et al., 2008; Lyubinska, 2009; Török et al., 2012), roadways and gardens (Bojňanský and Fargašová, 2007), and agriculture (Hilbeck et al., 2008; Holm et al., 1979; Ipatov et al., 1989). In agricultural areas it is considered weedy in fields, vineyards, and fallows (Bojňanský and Fargašová, 2007; Pyšek et al., 2002), corn (Jensen et al., 2011; Saavedra et al., 2011), beets (Molnar and Precsenyi, 1991), poppy (Pinke et al., 2011), and wheat (Zubkov and Grichanov, 2015). However, despite these numerous reports of weediness, we did not find any evidence of specific impacts in any of these systems. Other *Fumaria* species reduce crop yield (MCMA, 2008), are difficult to control (Holm et al., 1997), have developed herbicide resistance (Heap,

[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).
[2] The term archaeophyte is used in Europe to refer to an exotic species when it was introduced to an area before 1500 A.D. This contrasts with the term neophyte which refers to species introduced after 1500 A.D.

2016), and have prompted research for biocontrol agents (Jourdan et al., 2008). Due to limited information available on this species we had very high uncertainty for this risk element.
Risk score = 1.5 Uncertainty index = 0.45

Geographic Potential Based on three climatic variables, we estimate that about 78 percent of the United States is suitable for the establishment of *F. schleicheri* (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 *F. schleicheri* represents the joint distribution of Plant Hardiness Zones 2-8, areas with 10-100 inches of 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.

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. *Fumaria schleicheri* occurs in open habitats such as fields, gardens, vineyards, fallows, roadsides, grasslands, cereal crops, and weedy places (Anonymous, 2016b; Bojňanský and Fargašová, 2007; Komarov, 1970; Purger et al., 2008). This species prefers nutrient rich dry sites and dry thickets (Hanf, 1983).

Entry Potential Because we did not find any evidence that *F. schleicheri* is present in the United States, we evaluated its entry potential. The most likely pathways for entry would be either as a plant for planting or as a contaminant of grain and seed. *Fumaria schleicheri* is used in traditional folk medicine (Habibi Tirtash et al., 2011), and its chemical properties have been studied by several authors to evaluate whether it has any potential beneficial uses (Habibi Tirtash et al., 2011; Kiryakov et al., 1980; Naboka et al., 2014). Thus, it may be introduced at some point for research or by ethnic groups. Also, *F. schleicheri* could be mistaken for its congener *F. officinalis*, which is widely used by herbalists (Păltinean et al., 2015; Păltinean et al., 2013). We did not find any direct evidence that *F. schleicheri* is a contaminant of grain or seed, but indirect evidence from its status in Eurasia strongly suggests that it has expanded its original native range in Eurasia through agriculture. Furthermore, other *Fumaria* species are dispersed as contaminants of grain and seed (MCMA, 2008). U.S. inspectors have intercepted *Fumaria* species (mostly *Fumaria* sp.) hundreds of times on cumin, soybeans, and other commodities (AQAS, 2016). We had very high uncertainty associated with this risk element.
Risk score = 0.1 Uncertainty index = 0.38

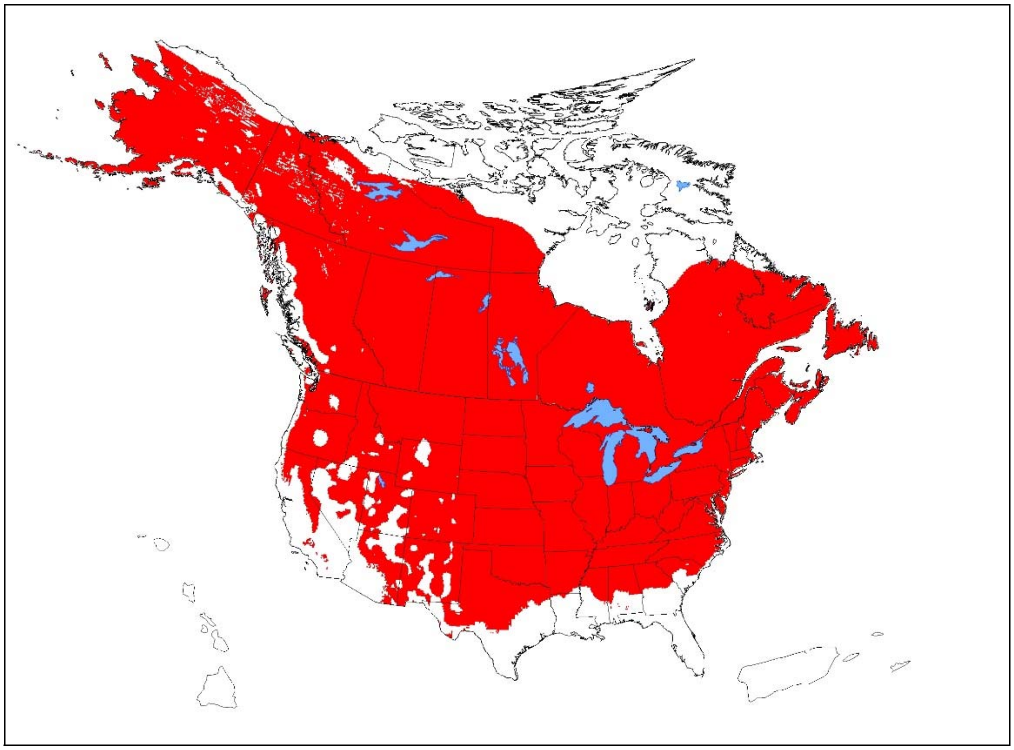

Figure 1. Potential geographic distribution of *Fumaria schleicheri* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 45.8%
P(Minor Invader) = 50.8%
P(Non-Invader) = 3.4%
Risk Result = High Risk
Secondary Screening = Not Applicable

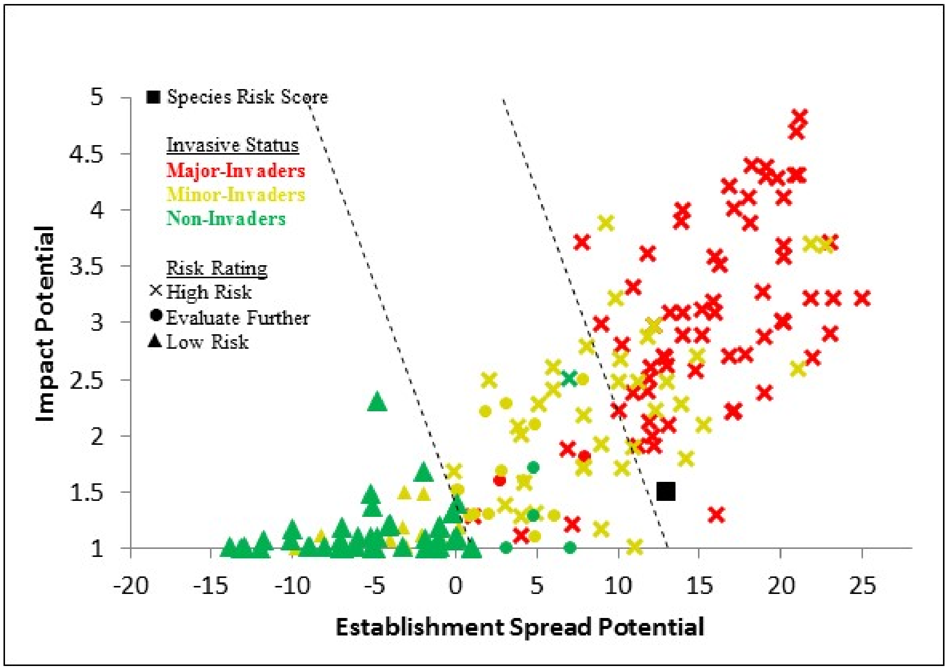

Figure 2. *Fumaria schleicheri* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

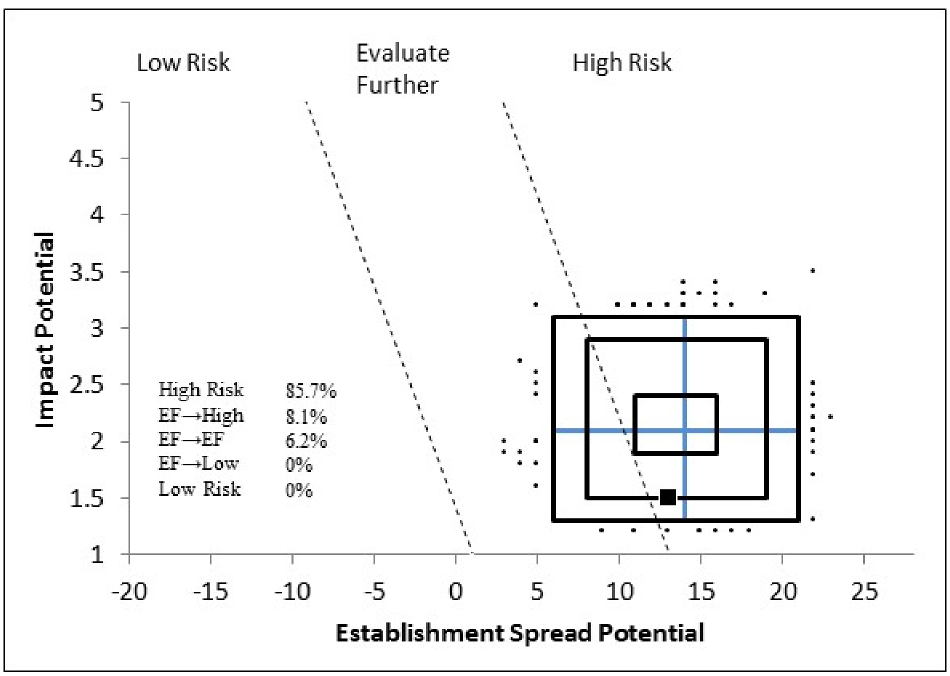

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *F. schleicheri*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Fumaria schleicheri* is High Risk (Fig. 2). The results of our uncertainty analysis support this conclusion since almost all of the simulated risk scores also obtained results of High Risk. Relative to other species with the same or similar establishment/spread risk score, *F. schleicheri* obtained a very low impact risk score (Fig. 2). While it is theoretically possible to have highly invasive species with limited impacts, and high impact species with limited invasiveness, during validation of our WRA model we showed that in general these two properties of species (establishment/spread potential and impact potential) are broadly correlated [(Fig. 2; Koop et al., 2012)]. We therefore may have overestimated this species' establishment/spread potential, or underestimated its impact potential. Based on the biology and associated impacts of other *Fumaria* species (e.g., Heap, 2016; Holm et al., 1997; Jourdan et al., 2008; MCMA, 2008), we believe that it is more likely that we underestimated this species' impact potential. The results of our uncertainty analysis support this idea since the median risk score of the simulated risk scores is directly above the observed risk score. Overall, there was a high to very high level of uncertainty associated with this analysis, primarily because there is very little detailed biological information available for *F. schleicheri*.

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Appendix A. Weed risk assessment for *Fumaria schleicheri* Soy.-Will (Papaveraceae). 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]	e - high	2	*Fumaria schleicheri* is distributed throughout southern and central Europe, east to western Siberia, and south from there into northeastern Iran and the Caucasus region (Bojňanský and Fargašová, 2007; Euro+Med, 2006+; Hanf, 1983; Lepsi and Lepsi, 2010). One old reference states that it extends to the Altai district in central Asia (Pugsley, 1919). Its exact native range is not very clear, and the preceding distribution includes human-mediated spread throughout the region (Euro+Med, 2006+; Lepsi and Lepsi, 2010). It is considered a naturalized alien in Germany (DAISIE, 2016), the Czech Republic (Pyšek et al., 2012), and Poland (Zając and Zając, 2014). In Bulgaria and Ukraine, it is listed as an alien (DAISIE, 2016). Numerous European researchers have classified this species as an archaeophyte (Lyubinska, 2009; Pyšek et al., 2012; Tokarska-Guzik et al., 2010; Zając and Zając, 2014), which is an agricultural and ruderal plant species associated with people and that moved outside of its original range prior to 1500 A.D. Although there is some evidence of spread, because this appears to be mostly historical, we chose "e" as our answer with high uncertainty. The alternate answers for the uncertainty simulation were both "f."
ES-2 (Is the species highly domesticated)	n - negl	0	We found no evidence that *Fumaria schleicheri* is cultivated, so it is very unlikely that it would be highly domesticated. Its close relative *F. officinalis* is used as a medicinal plant, as a yellow dye, and as a curdling agent in milk (PFAF, 2016).
ES-3 (Weedy congeners)	y - negl	1	There are about 50 species in the genus *Fumaria* (Mabberley, 2008). Approximately 24 of these have been reported as weeds or naturalized species according to the Global Compendium of Weeds; however, only the following four species emerge as potentially significant weeds with 40 or more individual reports: *Fumaria capreolata*, *F. muralis*, *F. officinalis*, and *F. parviflora* (Randall, 2012). *Fumaria officinalis* is a significant agricultural weed across many countries and in a variety of crops including cereals and vegetables (Holm et al., 1997). It is particularly problematic because it begins to grow when temperatures are generally too cold for effective weed management (Holm et al., 1997). *Fumaria densiflora* is ranked in the top 10 of 50 weeds in cereals in one region of Australia and has developed herbicide resistance, requiring researchers to search for potential biological control agents (Jourdan et al., 2008). It has emerged as a significant weed over the last four decades in Australia

Question ID	Answer - Uncertainty	Score	Notes (and references)
			(Norton et al., 2004). "Fumitory [i.e, *Fumaria* spp.] infestations can cause yield losses of up to 40% in wheat and 36% in canola, depending on the time of emergence in relation to the crop and the density of infestation" (MCMA, 2008). Fumitory is also a significant problem in pulse crops (MCMA, 2008).
ES-4 (Shade tolerant at some stage of its life cycle)	n - mod	0	We found no direct evidence about this species' shade tolerance. However, it is reported to grow in fields, gardens, vineyards, fallows, roadsides, and grasslands (Bojňanský and Fargašová, 2007; Hanf, 1983; Purger et al., 2008), all of which are fairly open habitats. It seems unlikely this species would be adapted to shade.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - high	0	This species is a slender herbaceous annual with basal branches that are either erect or ascending (Komarov, 1970; Pugsley, 1919). Naturalized *Fumaria* species in Australia have similar life forms and are described as weakly climbing (MCMA, 2008; Walsh and Norton, 2007). While there is a tendency in the genus for some weak climbing (Pugsley, 1919), it has not been described for *F. schleicheri*. Thus, we answered no, but with high uncertainty.
ES-6 (Forms dense thickets, patches, or populations)	y - mod	2	It forms dense and extensive colonies along forest edges and in poplar groves in Italy (Corregia, 2009). Researchers in one Russian study found that *F. schleicheri* is one of the most important weeds in winter wheat and, along with seven other weed species, occurred at densities of 100 individuals per square meter (Zubkov and Grichanov, 2015).
ES-7 (Aquatic)	n - negl	0	*Fumaria schleicheri* is a terrestrial plant found growing in fields, fallows, gardens, vineyards, roadsides, weedy places, and subalpine slopes (Bojňanský and Fargašová, 2007; Komarov, 1970; Pugsley, 1919); it is not an aquatic plant.
ES-8 (Grass)	n - negl	0	*Fumaria schleicheri* is not a grass; it is in the Papaveraceae family (NGRP, 2016).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that this species fixes nitrogen. Furthermore, it is neither a woody plant (Walsh and Norton, 2007) nor in a plant family known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - low	1	It propagates by seeds (Anonymous, 2016b). Since we found no evidence of vegetative reproduction, and since it is a fruit-producing annual (Bojňanský and Fargašová, 2007; Komarov, 1970), its seed must be viable.
ES-11 (Self-compatible or apomictic)	y - low	1	Pollination is autogamous, meaning that plants are self-pollinated (Anonymous, 2016a). Most members of the genus are autogamous (Mabberley, 2008).
ES-12 (Requires specialist pollinators)	n - low	0	We found no evidence that this species or genus requires specialist pollinators. In fact, "[f]rom the regularity with which the more or less cleistogamous flowers in this genus develop fruit, it may be concluded that self-fertilization regularly takes place and that Fumitories are not dependent on insect visitors for their pollination" (Pugsley, 1919).

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
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 - low	1	*Fumaria schleicheri* is an annual (Bojňanský and Fargašová, 2007). The species is a therophyte (Anonymous, 2016a), which are plants that survive unfavorable conditions as a seed. Most members of the genus are annuals (Mabberley, 2008; Walsh and Norton, 2007). We found no evidence indicating that it produces multiple generations per year, but because we cannot rule that out, we chose "a" for both of our alternate answers in the uncertainty simulation.
ES-14 (Prolific seed producer)	? - max	0	Unknown. There about 35 flowers in an inflorescence (Pugsley, 1932). From an online image, it seems that there could be from 25 to 75 inflorescences per square meter (Malibog, 2016b), which would represent 875-2625 flowers per square meter. One plant produces 400 seed (Anonymous, 2016b). One report states that individual plants do not produce more than 5000 propagules (Kurdyukova and Konoplya, 2013); unfortunately, this reference did not describe how many plants may occur per square meter. We found no other information on the number of flowers that produce seed, the number of seeds per fruit, or seed viability. Consequently, we could not answer this question.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - high	1	We found no specific or direct evidence for this kind of dispersal for *F. schleicheri*. For naturalized *Fumaria* species in Australia, which have seeds similar in size and shape to that of *F. schleicheri* [see seed drawings in Bojňanský and Fargašová (2007)], seeds can be dispersed via clothing, boots, tillage, vehicles, and harvest machinery (MCMA, 2008). Based on this congeneric information, we answered yes, but with high uncertainty.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - low	2	Although we found no direct evidence indicating that *F. schleicheri* is a contaminant of agricultural trade, a lot of other evidence indicates this type of dispersal is very likely. First, numerous European researchers have classified this species an archaeophyte (Lyubinska, 2009; Pyšek et al., 2012; Tokarska-Guzik et al., 2010; Zając and Zając, 2014), which is an agricultural and ruderal plant species associated with people and that was moved outside of its original range prior to 1500 A.D. Because *F. schleicheri* has been well documented to be associated with numerous crops, including corn (Jensen et al., 2011), beets (Molnar and Precsenyi, 1991), poppy (Pinke et al., 2011), cereal crops (Anonymous, 2016b), and wheat (Zubkov and Grichanov, 2015), it seems likely that it may have been spread to these European countries as a contaminant of agricultural goods. Second, in Australia, other *Fumaria* species "can be spread via ... crop and pasture seed and forage. In practice, insufficiently cleaned crop seed, especially canola and sub-clover seed, is the most common method of long distance dispersal" (MCMA, 2008). The seeds of some of these *Fumaria* species are generally very similar in size and shape to the seeds of *F. schleicheri* (e.g., *F. densiflora,* Bojňanský and Fargašová, 2007). Thus, it seems reasonable to conclude

Question ID	Answer - Uncertainty	Score	Notes (and references)
			that *F. schleicheri* may also be dispersed in this manner. Finally, U.S. inspectors have intercepted *Fumaria* species (mostly *Fumaria* sp.) hundreds of times on cumin, soybeans, and other commodities (AQAS, 2016).
ES-17 (Number of natural dispersal vectors)	1	-2	Propagule traits for questions ES-17a through ES-17e: Fruits are round to elliptical achenes with a small beak at the apex, measure 1.8-2.0 mm by 2.0-2.4 mm (Bojňanský and Fargašová, 2007), and are indehiscent (Păltinean et al., 2013). Another source states that fruit are capsules and that they are dispersed by gravity (barochory) (Anonymous, 2016a).
ES-17a (Wind dispersal)	n - negl		We found no evidence indicating this species is wind dispersed. Furthermore, this species does not have any obvious adaptions for wind dispersal, such as plumed or winged fruit/seeds (Bojňanský and Fargašová, 2007).
ES-17b (Water dispersal)	n - high		We found no specific or direct evidence indicating that *F. schleicheri* is dispersed by water. Seeds of *Fumaria* species naturalized in Australia are dispersed by water along creeks and rivers (MCMA, 2008). Holm et al. (1997) note that water dispersal is not an important dispersal mechanism for *F. officinalis*. Because *F. schleicheri* is not restricted to riparian habitats, we answered no, but with high uncertainty.
ES-17c (Bird dispersal)	n - mod		We found no evidence supporting this dispersal vector.
ES-17d (Animal external dispersal)	y - high		We found no specific or direct evidence for *F. schleicheri*. Several references describe species in the genus *Fumaria* as possessing elaiosomes, which are specialized structures on seeds designed to attract ants for seed dispersal (Pemberton and Irving, 1990; Pfeiffer et al., 2010; van der Pijl, 1982). For example, naturalized *Fumaria* species in Australia are dispersed by ants (MCMA, 2008). "Ants have a mutually beneficial relationship with fumitory: the seed coating is a food source for the ants and the ants collecting habits benefit the seed by depositing it in 'safe sites'" (MCMA, 2008). *Fumaria capreolata* is dispersed by ants (Weiss, 1908), and *F. officinalis* and *F. parviflora* have elaiosomes (Pemberton and Irving, 1990). However, the three *Fumaria* species present in the Flora of North America are described as "elaiosome absent" and these include *F. officinalis* and *F. capreolata* (Boufford, No Date), which contradicts Weiss (1908) and Pemberton and Irving (1990). It is not clear whether *F. schleicheri* is dispersed by ants or not, but based on the weight of the evidence, and because some of the species described as being dispersed by ants have seeds similar to those of *F. schleicheri* [see images in Bojňanský and Fargašová (2007)], we answered yes with high uncertainty.
ES-17e (Animal internal dispersal)	n - mod		We found no evidence supporting this dispersal vector.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - low	1	*Fumaria schleicheri* seeds can remain viable in the soil for 4-5 years (Anonymous, 2016b). Seeds of *F. officinalis* can remain viable for hundreds of years (Holm et al., 1997). Seeds of *Fumaria densiflora* remain viable for at least 10

Question ID	Answer - Uncertainty	Score	Notes (and references)
			years at soil depths of 15 cm (Norton et al., 2004). For the *Fumaria* species naturalized in Australia "[a]nts can assist with longevity by carrying seed to 'safe sites' well below the soil surface" (MCMA, 2008).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Unknown.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - mod	0	We found no evidence that *F. schleicheri* is resistant to herbicides, nor is it listed by Heap (2016). In fact, it is categorized as sensitive to non-selective herbicides (Hilbeck et al., 2008), but a waxy coating on the plant may make it somewhat tolerant to herbicides (Anonymous, 2016b). *Fumaria densiflora* has developed resistance to K1/3 herbicides in Australia (Heap, 2016). We do not know whether *F. schleicheri* could hybridize with *F. densiflora* to acquire resistance, but this seems unlikely given that *F. schleicheri* is autogamous (Anonymous, 2016a; Mabberley, 2008), as are other *Fumaria* species (MCMA, 2008). Because *F. schleicheri* is an agricultural weed (see Imp-P6) it may be able to evolve resistance on its own under heavy or prolonged herbicide use.
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)	9	1	
IMPACT POTENTIAL			Because so little is known about the biology of this species, and because we do not have any evidence of how it might behave if moved beyond Eurasia where the genus is centered and is likely under biotic pressure from coevolved herbivores and pathogens, we generally used high uncertainty for all of the questions in this risk element.
General Impacts			
Imp-G1 (Allelopathic)	? - max		We found no specific evidence for *F. schleicheri*. Because the seven species that are naturalized in Australia are reported to be allelopathic (MCMA, 2008), we answered unknown.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence for this species. Furthermore, this species is not a member of a plant family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - high	0	We found no evidence that this species changes ecosystem properties.
Imp-N2 (Changes habitat structure)	n - high	0	We found no evidence that it changes habitat structure.
Imp-N3 (Changes species diversity)	n - high	0	We found no evidence that it changes species diversity.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	n - mod	0	We found no evidence to suggest that this impact is likely.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - mod	0	We found no evidence to suggest that this impact is likely.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	b - mod	0.2	*Fumaria schleicheri* is naturalized in the Podilski Tovtry National Nature Park in Ukraine, where invasive and weedy plants are considered a threat to natural biodiversity (Lyubinska, 2009). It is also a weed in grassland restoration areas where conservationists are trying to restore native plant communities after farming (Gorbunov et al., 2008; Török et al., 2012). In these cases, all exotic plants are being managed by sowing native species or periodically mowing grasslands. Because no specific weed species are being specifically targeted, we answered this question as "b" rather than "c." Alternate answers for the uncertainty analysis were "c" and "a."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - low	0	We found no evidence, and because it seems unlikely that a terrestrial herb would have this impact, we used low uncertainty.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence, and because it seems unlikely that a terrestrial herb would have this impact, we used low uncertainty.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - high	0	We found no evidence that it affects desirable or ornamental plants.
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]	b - high	0.1	It is a weed in gardens and roadsides (Bojňanský and Fargašová, 2007). It occurs in disturbed areas in the Czech Republic (Pyšek et al., 2002), and is a ruderal archaeophyte in Poland and now considered endangered (Zając and Zając, 2014). Alternate answers for the uncertainty analysis were both "a."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	? - max		We found no evidence that *F. schleicheri* reduces crop yield. The only study reporting yield loss involved an analysis of multiple weed species (Zubkov and Grichanov, 2015). In Australia, the semi-climbing habit of other *Fumaria* species allows them to smother smaller plant species (MCMA, 2008). "The competitive impact of fumitory depends on crop species and cultivar, time of fumitory emergence and density of the infestation. Fumitory can reduce wheat yields by up to 40% and canola yields by up to 36%" (cited in MCMA, 2008). Based on this congeneric information, we answered unknown for *F. schleicheri*, as it may have this impact where it currently occurs.
Imp-P2 (Lowers commodity value)	n - high	0	We found no evidence of this impact for this species.
Imp-P3 (Is it likely to impact trade?)	n - high	0	Although it seems likely that *F. schleicheri* could be dispersed as a contaminant of agricultural trade, we found no evidence that this species is regulated (e.g., APHIS, 2016; USDA-AMS, 2016).
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - low	0	We found no evidence of this impact for this species and consider this impact unlikely, as this species is not an aquatic.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	We found no evidence that *F. schleicheri* is toxic (e.g., Burrows and Tyrl, 2013). Sheep will graze on fumitory, but only when it is in the vegetative state (MCMA, 2008). *Fumaria officinalis* is used as a medicinal plant. Although

Question ID	Answer - Uncertainty	Score	Notes (and references)
			this species is considered safe to use, there are possible adverse effects to the liver (Burrows and Tyrl, 2013).
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]	b - high	0.2	*Fumaria schleicheri* is an agricultural weed in Europe (Hilbeck et al., 2008) and in the former Soviet Union (Holm et al., 1979; Ipatov et al., 1989). It is considered weedy in fields, vineyards, fallows (Bojňanský and Fargašová, 2007; Pyšek et al., 2002), corn (Jensen et al., 2011; Saavedra et al., 2011), beets (Molnar and Precsenyi, 1991), poppy (Pinke et al., 2011), and wheat (Zubkov and Grichanov, 2015). Some control strategies are described for Russia (Anonymous, 2016b). In contrast, Hanf (1983) reports that it is rarely on arable lands and vineyards in Europe, and Zając and Zając (2014) state that it has become endangered in Poland. Other *Fumaria* species are managed in Australia and specific control strategies are available (MCMA, 2008). Some Australian researchers are exploring Europe for potential biocontrol options (Jourdan et al., 2008). Because the weight of the evidence indicates that *F. schleicheri* is an agricultural weed, we answered "b" with high uncertainty. Alternate answers for the uncertainty analysis were "c" and "a." We did not chose "c" as our main answer because we felt there was not enough evidence of specific control for this species.
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 - high	N/A	This and another species of *Fumaria* are reported to occur in the western region of Mongolia that includes this zone (Flora GREIF, 2016), but because this zone makes up only a small portion of this area, we answered no.
Geo-Z2 (Zone 2)	y - high	N/A	This and another species of *Fumaria* are reported to occur in the western region of Mongolia that includes this zone (Flora GREIF, 2016). Because this zone makes up a large portion of this area, we answered yes.
Geo-Z3 (Zone 3)	y - low	N/A	This species occurs in a region south of and near Ust-Kan, Russia, that is primarily represented by this zone (ARCTOS, 2016).
Geo-Z4 (Zone 4)	y - low	N/A	One point in France, one in Georgia, and three in Armenia.
Geo-Z5 (Zone 5)	y - low	N/A	One point in Austria (GBIF, 2016).
Geo-Z6 (Zone 6)	y - negl	N/A	Some points in Germany and Austria, and one point each in Georgia and Armenia.
Geo-Z7 (Zone 7)	y - negl	N/A	Germany. One point in Armenia.
Geo-Z8 (Zone 8)	y - low	N/A	One point in France, and general occurrence in France, where this zone makes up most of the area.
Geo-Z9 (Zone 9)	n - high	N/A	One point in Spain, but because it is near the edge of Zone 8, we answered no.
Geo-Z10 (Zone 10)	n - mod	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z11 (Zone 11)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z12 (Zone 12)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence that it occurs in this hardiness zone.
Köppen -Geiger climate classes			

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that it occurs in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that it occurs in this climate class.
Geo-C3 (Steppe)	y - high	N/A	This and another species of *Fumaria* are reported to occur in the western region of Mongolia that includes this climate class (Flora GREIF, 2016).
Geo-C4 (Desert)	n - high	N/A	This and another species of *Fumaria* are reported to occur in the western region of Mongolia that includes this climate class (Flora GREIF, 2016), but deserts represent a smaller portion of the total area than steppe habitats. Because this species does not seem to have any particular adaptations to living in very dry environments, we answered no.
Geo-C5 (Mediterranean)	y - high	N/A	One point in northeast Spain. This species is also reported to occur in Italy (GBIF, 2016), half of which is represented by this climate class. We answered yes, but used high uncertainty.
Geo-C6 (Humid subtropical)	y - mod	N/A	Four points in Germany. Occurs regionally around Turin, Italy (Corregia, 2009).
Geo-C7 (Marine west coast)	y - negl	N/A	Many points in Germany, and one in France.
Geo-C8 (Humid cont. warm sum.)	y - low	N/A	Several points in Armenia, and one in Georgia.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Lots of points in Germany, some in Austria, and one point in Georgia.
Geo-C10 (Subarctic)	y - high	N/A	One point in the French Alps (GBIF, 2016), also known from the Swiss Alps (Pugsley, 1919).
Geo-C11 (Tundra)	n - high	N/A	We found no specific evidence but it is reported to occur in regions where there are some subalpine areas (Bojňanský and Fargašová, 2007; Pugsley, 1919).
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that it occurs in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	n - high	N/A	Two points in Armenia (GBIF, 2016), and reported to occur in western Mongolia (Flora GREIF, 2016), which includes this precipitation band. However, because we found no evidence of particular adaptations to dry conditions, we questioned whether this species generally grows in this band. Perhaps it does occur in these areas, but only in highly protected or artificial sites.
Geo-R2 (10-20 inches; 25-51 cm)	y - mod	N/A	This species occurs in a region south of and near Ust-Kan, Russia, that is primarily represented by this precipitation band (ARCTOS, 2016). This and another species of *Fumaria* are reported to occur in the western region of Mongolia that includes this band (Flora GREIF, 2016).
Geo-R3 (20-30 inches; 51-76 cm)	y - low	N/A	Some points in Germany, and one in Armenia.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	Germany. Two points in Armenia and one in Georgia.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Lots of points in Germany.
Geo-R6 (50-60 inches; 127-152 cm)	y - low	N/A	A few points in Germany.
Geo-R7 (60-70 inches; 152-178 cm)	y - mod	N/A	Two points in Germany.
Geo-R8 (70-80 inches; 178-203 cm)	y - high	N/A	We found no direct evidence that this species occurs in this band. However, because the species' overall distribution in Europe includes many areas in this precipitation band, we answered yes with high uncertainty.
Geo-R9 (80-90 inches; 203-229 cm)	y - high	N/A	One point in Georgia.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R10 (90-100 inches; 229-254 cm)	y - high	N/A	One point in Austria.
Geo-R11 (100+ inches; 254+ cm)	n - mod	N/A	We found no evidence that it occurs in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - low	0	We found no evidence that this species is present in the United States either as a naturalized species (e.g., EDDMapS, 2016; Kartesz, 2016; NRCS, 2016) or as a cultivated species (e.g., Bailey and Bailey, 1976; Dave's Garden, 2016; Page and Olds, 2001; Univ. of Minn., 2016).
Ent-2 (Plant proposed for entry, or entry is imminent)	n - low	0	We found no evidence.
Ent-3 (Human value & cultivation/trade status)	b - mod	0.05	*Fumaria schleicheri* is used in traditional folk medicine (Habibi Tirtash et al., 2011). Its chemical properties have been studied by several authors to examine whether it has any potential beneficial uses (Habibi Tirtash et al., 2011; Kiryakov et al., 1980; Naboka et al., 2014). Its congener, *Fumaria officinalis* is used more widely by herbalists, and thus it is possible that *F. schleicheri* may be mistaken for its congener (Păltinean et al., 2015; Păltinean et al., 2013) and imported, but we found no specific evidence of this. Based on this evidence, we answered “b” (i.e., not cultivated, but positively valued or potentially beneficial).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	? - max		*Fumaria schleicheri* is reported as growing in China (MBG, 2016); however, it is not listed in the electronic Flora of China (Zhang and Liden, 2016). Because we found no other evidence stating it is in China, we answered unknown.
Ent-4b (Contaminant of plant propagative material (except seeds))	n - mod	0	We found no evidence.
Ent-4c (Contaminant of seeds for planting)	y - high	0.04	Although we found no direct evidence that this species spreads in seeds for planting, other evidence strongly suggests that this is likely. See evidence under ES-16.
Ent-4d (Contaminant of ballast water)	n - mod	0	We found no evidence.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - low	0	We found no evidence. Furthermore, contamination of such products seems unlikely since *F. schleicheri* is not an aquatic or wetland species, or otherwise associated with such species.
Ent-4f (Contaminant of landscape products)	n - mod	0	We found no evidence.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	n - mod	0	We found no evidence.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - high	0.01	Although we found no direct evidence that this species spreads in grain, other evidence strongly suggests that this is likely. See evidence under ES-16.
Ent-4i (Contaminant of some other pathway)	a - mod	0	We found no evidence.
Ent-5 (Likely to enter through natural dispersal)	n - negl	0	Because this species is not naturalized in a nearby geographic region, we answered no.