United States Department of Agriculture

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Animal and Plant Health Inspection Service

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Version 1

Weed Risk Assessment for *Adonis aestivalis* L. (Ranunculaceae) – Summer pheasant's-eye

Left: foliage has feathery appearance, flowers are simple, terminal, scarlet with a black center and purple stamens [GBIF, 2018; Photo credit: Marco Bonifacino (iNaturalist); License: https://creativecommons.org/licenses/by-nc/4.0/]. Top right: flowers are cup shaped [GBIF, 2018; Photo credit: Cristina Florentina Plecaru (iNaturalist); License: https://creativecommons.org/licenses/by-nc/4.0/]. Bottom right: *Adonis aestivalis* forms plant patches and thickets (ODA, 2018b).

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1. 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 or 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 a plant species for the entire United States or for any area within it. We 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 information in the predictive model were to change. We use Geographic Information System (GIS) overlays to identify 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 *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, such as Federal regulation. Risk assessment and risk management are distinctly different phases of pest risk analysis (IPPC, 2016). 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.

2. Plant Information and Background

SPECIES: *Adonis aestivalis* L. (NGRP, 2018).

FAMILY: Ranunculaceae

SYNONYM: *Adonis ambigua* Gaudin, *A. autumnalis* M. Bieb., *A. bienertii* Butkov ex Riedl., *A. citrina* Hoffm., *A. crinita* Hoffm., *A. cristata* Stapf, *A. flava* Vill., *A. inermis* Stapf, *A. inglisii* Royle, *A. linnaei* Senne, *A. maculata* Wallr., *A. micrantha* DC., *A. miniata* Jacq., *A. polymorpha* Zumagl., *A. squarrosa* Steven, *Cosmarium aestivale* Dulac (The Plant List, 2010). *Adonis aestivalis var. citrina* Hoffm. (GBIF, 2018).

COMMON NAME: Summer pheasant's-eye (NGRP, 2018; GBIF, 2018), summer pheasants-eye (GBIF, 2018, Belgian Species List, 2018), summer pheasant's eye (GBIF, 2018), summer adonis (Woods et al., 2004a), poison hemlock (ODA, 2018a).

BOTANICAL DESCRIPTION: *Adonis aestivalis* is an herbaceous annual plant with erect stems that are 20-60 cm tall with linear ridges (Heyn and Pazy, 1989). Leaves are simple with blades two to three times pinnately dissected into linear segments, giving the foliage a feathery appearance (Woods et al., 2004a, ODA, 2018b). It blooms in mid-summer (ODA, 2018b). Flowers are simple and terminal, with colors ranging from scarlet to orange to yellow (Tri-County CWMA, 2015). It has waxy petals and purplish black anthers (Woods et al., 2004a; Heyn and Pazy, 1989). Carpels of the genus *Adonis* develop achenes that are oblique to ovoid in shape, range from 4.0 x 3.4 mm to 4.4 × 3.8 mm, are wrinkly and pitted with a transverse ridge, are usually crested and dentate around the middle, have obtuse or acute margins, and have apices with terminal recurved or slightly curved beaks (Bojňanský and Fargašová, 2007). The surfaces are dull grayish green or yellow (Bojňanský and Fargašová, 2007). *Adonis aestivalis* achenes have some distance between the dorsal hump and the beak (Heyn and Pazy, 1989); this differs from the achenes of other *Adonis* species where the hump adjoins the beak. A single plant can produce 114 seeds (Hussain et al., 1993). For field identification please refer to the Field Guide to Northeast Oregon's Noxious Weeds (Tri-County CWMA, 2015).

INITIATION: The Animal and Plant Health Inspection Service (APHIS) received several market access requests for wheat grain and seed from Europe. *Adonis aestivalis* is a weed of cereals and may be able to follow the pathway in these commodities. In this document, we evaluate the weed risk potential of this species.

WRA AREA[1]: United States and Territories.

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

FOREIGN DISTRIBUTION: *Adonis aestivalis* originated from the Mediterranean Basin and western Asia (Meyer et al., 2015) and is currently distributed from eastern Asia to northwestern Africa (African Plants - A Photo Guide, 2018) and the Mediterranean Basin (Heyn and Pazy, 1989, Meyer et al., 2015, GBIF, 2018). The exact native and introduced ranges of the species in Europe are not very clear. According to GRISS (2018), *A. aestivalis* is native throughout Europe except in the Czech Republic, Poland, Slovakia, and Ukraine, where it is listed as introduced. The Euro+Med Database (Euro+Med, 2018), however, lists the species as native to these countries. *Adonis aestivalis* is a rare weed of arable lands (Meyer et al., 2015; Royo-Esnal et al., 2011) in parts of Europe, and it has been declared regionally extinct in the Belgian regions of Flanders and Wallonia (Belgian Species List, 2018). In contrast, this species is characterized as invasive in northeastern Bulgaria (Šarić et al., 2011), where it is native, and also in Croatia (GBIF, 2018), where it is listed as introduced. In Turkey and Morocco, where the species is native (Yilmaz and Yilmaz, 2009; Chambouleyron et al., 2015), *A. aestivalis* is listed as a weed of unknown economic importance (Holm et al., 1979; Erman et al., 2004). The species is introduced in Australia (Randall, 2007; 2017). In Canada, the species was introduced as an ornamental; however, it is unknown to what extent it is cultivated (CFIA, 2018).

U.S. DISTRIBUTION AND STATUS: *Adonis aestivalis* was introduced into North America as a horticultural plant, but it escaped cultivation and is now abundant in disturbed sites and open forests in 23 counties of the western United States (Woods et al., 2004a; Fig. 1). According to Kartesz (2018), *A. aestivalis* is found in California, Colorado, Idaho, Montana, Oregon, Utah, and Washington. Kartesz (2018) also indicates that *A. aestivalis* is present in New York; however, because this occurrence is based on cultivated specimens at the New York Botanical Garden in Bronx County, NY (New York Botanical Garden, 2018), we excluded it from the map in Figure 1. *Adonis aestivalis* is considered invasive and is regulated in Klamath, Lake, Harney, Wallowa and Grant counties in Oregon (ODA, 2018b; 2018a). *Adonis aestivalis* is increasing in abundance in Oregon (ODA, 2018b), and the state lists it as a Class B noxious weed (ODA, 2018a). Class B weeds are economically important and regionally abundant but may have limited distribution in some counties. The goals of Class B weed management are control and prevention of new infestations (ODA, 2018a).

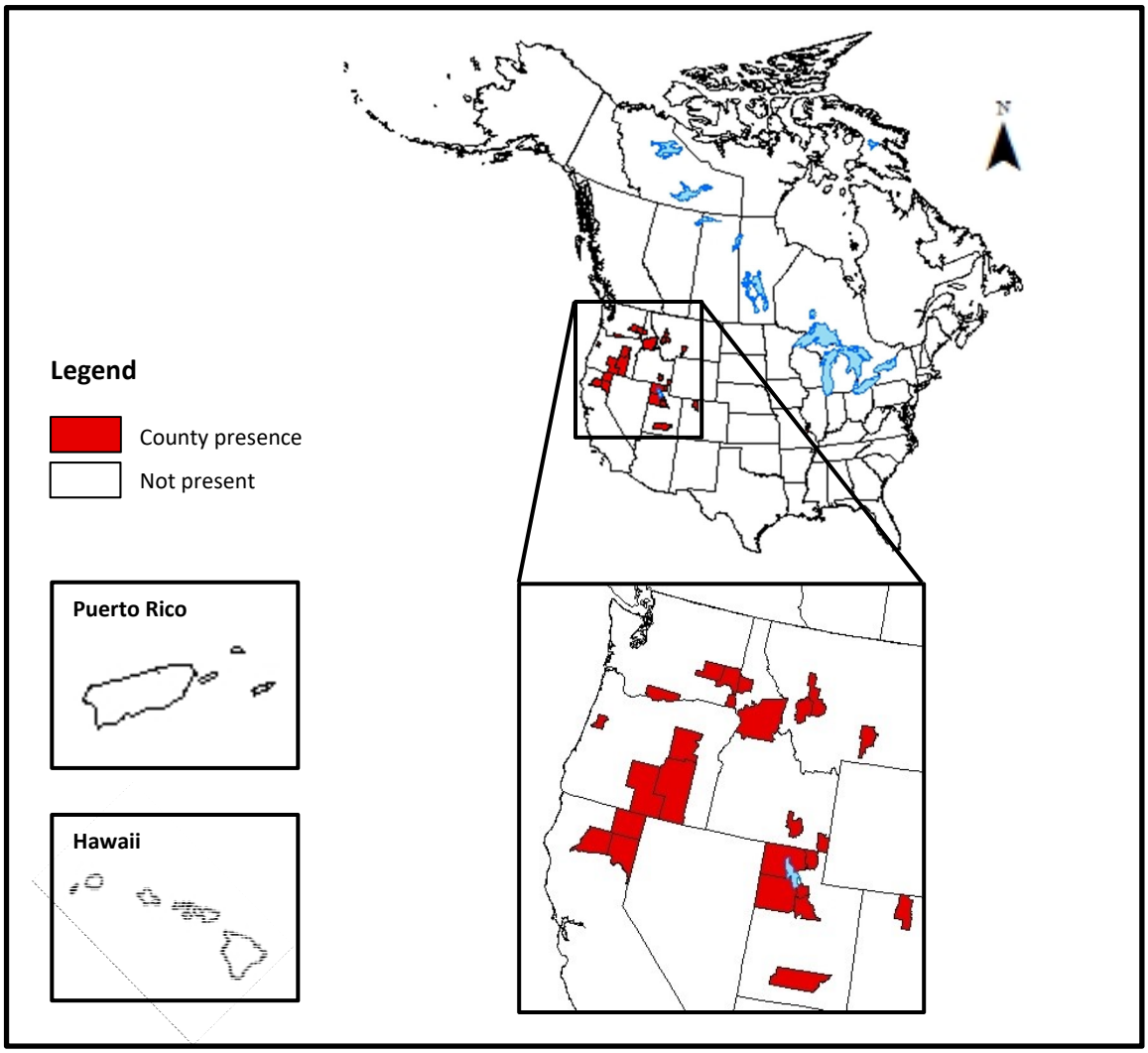

Figure 1. Known distribution of *A. aestivalis* in the United States and Canada. The records shown here were obtained primarily from other species distribution databases (Kartesz, 2018; NGRP, 2018; NRCS, 2018) and were not independently verified by PERAL. Scales differ for Hawaii, Puerto Rico, and the continental United States and Canada.

3. Analysis

ESTABLISHMENT/SPREAD POTENTIAL

Adonis aestivalis has established and naturalized beyond its native range in Australia (Randall, 2007, 2017) and North America. This species was introduced to the United States as a horticultural plant but has escaped from cultivation and is becoming invasive in disturbed sites in the western United States (Burrows and Tyrl, 2013; Woods et al., 2004a; ODA, 2018b) across 23 counties in seven states. *Adonis aestivalis* is a weed of pasture ecosystems, irrigated alfalfa fields, and roadsides. It can form thick

stands, but the populations are highly variable year to year (ODA, 2018b). The species forms a persistent seed bank (Royo-Esnal et al., 2011). Wäldchen et al. (2005) determined that seeds of *A. aestivalis* remained viable in the seedbank for 54 years. Only a small fraction of seeds germinate immediately after seed shedding in summer (Heyn and Pazy, 1989) because primary dormancy mostly delays germination until the following spring (Poschlod and Bonn, 1998). Animals are important for the dispersal of this species. *Adonis aestivalis* was introduced to the British Isles (including the Channel Islands and Ireland) in wool (Clement and Foster, 2000). The species produces achenes with terminal recurved or slightly curved beaks, probably adapted to dispersal by ants (Bojňanský and Fargašová, 2007). *Adonis aestivalis* is a weed of pastures (ODA, 2010; Woods et al., 2004) however, we found no evidence that it can be dispersed in the manure of grazing animals. We had average uncertainty for this risk element.

Risk score = 16 Uncertainty index = 0.15

IMPACT POTENTIAL

The major impact of this species is reduction of the nutritional quality and commercial value of contaminated hay (ODA, 2018b). In the United States, this species invades disturbed sites and pasture systems (ODA, 2018b; Puschner and Woods, 2003). According to the Oregon Department of Agriculture (ODA, 2010) "irrigated alfalfa fields are at risk from pheasant eye invasion" and "with millions of acres of suitable habitat in the western U.S., pheasant's eye can be expected to increase significantly in the future". *Adonis aestivalis* is also toxic to horses, sheep, and rabbits (Woods et al., 2004a; Woods et al., 2011; Hobbenaghi et al., 2012) because it contains cardiac glycosides. These compounds are present in other members of the genus (Al-Snafi, 2016), and *Adonis* poisoning with the congener *A. microcarpa* has been reported in pigs (Davies and Whyte, 1989). In Oregon, the species is listed as a Class B weed, which means that "it shall be managed on a priority basis as resources allow." We only have direct evidence for control of *A. aestivalis* in Modoc County, CA (ODA, 2013). Evidence for impacts elsewhere in its introduced range is scarce. In Croatia and Bulgaria, the species is considered invasive, and in Turkey it reduced yield on lentils (Erman et al., 2004). We had very high uncertainty for this risk element.

Risk score = 2.9 Uncertainty index = 0.26

GEOGRAPHIC POTENTIAL

Based on three climatic variables, we estimated that about 84 percent of the United States and 13.6 percent of Canada is suitable for the establishment of *A. aestivalis* (Fig. 2). This predicted distribution is based on the known distribution of the species elsewhere and uses data from point-referenced localities and general areas of occurrence. The map for *A. aestivalis* represents the joint distribution of Plant Hardiness Zones 4-11, areas with 0-90 inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, desert, Mediterranean, humid subtropical, marine west coast, humid continental with warm summers, humid continental with cool summers, subarctic, and tundra. It was not clear if *A. aestivalis* occurs in desert and tundra because we found few records of the species in those areas. For this prediction, we assumed those environments to be suitable.

The area of the United States and Canada shown to be climatically suitable (Fig. 2) for species establishment considered only three climatic variables. Other variables, such as soil and habitat type, novel climatic conditions, or plant genotypes, may alter the areas in which this species is likely to establish. The species occurs in winter crop fields, lentil fields, and pasture ecosystems, as well as in field edges, roadsides, and prairies (Herbich, 1996; Heyn and Pazy, 1989; Royo-Esnal et al., 2011; ODA, 2013; Erman et al., 2004). In natural areas it occurs mainly in stony, shallow soils rich in calcium carbonate and in regions that are warm and dry during the summer (Herbich, 1996).

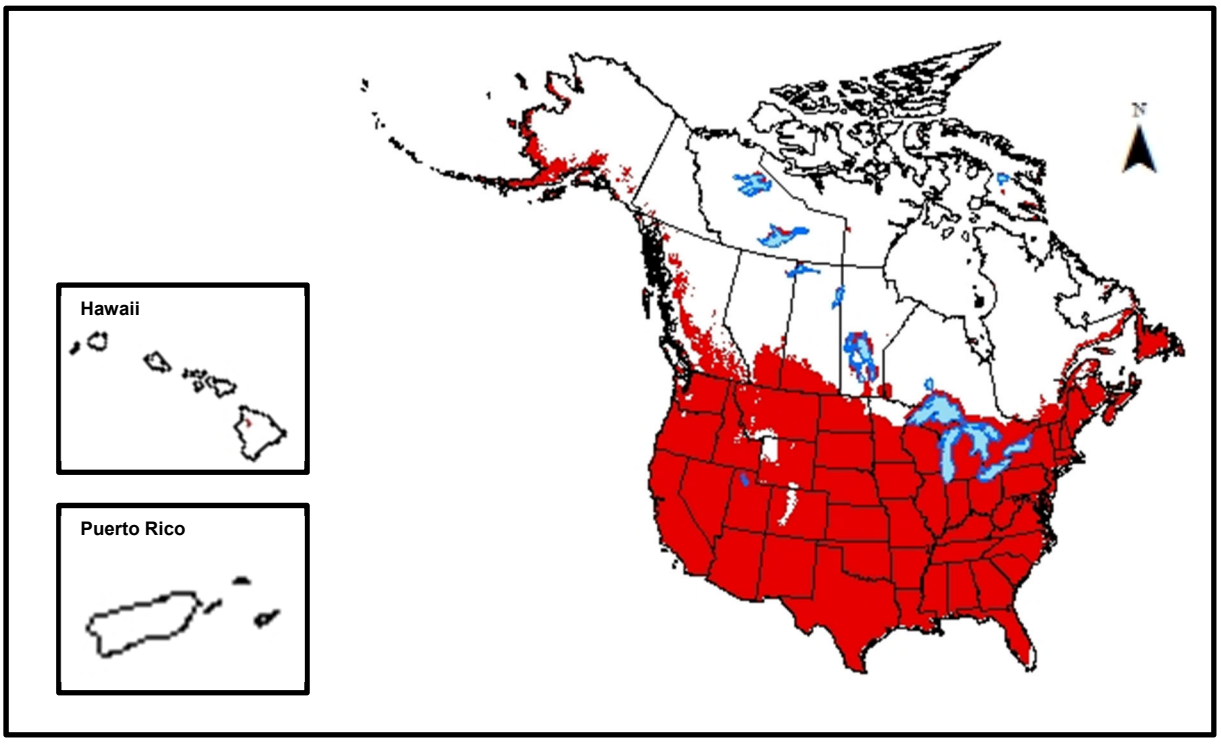

Figure 2. Potential geographic distribution of *Adonis aestivalis* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

ENTRY POTENTIAL

Adonis aestivalis is already present in 23 counties across seven states (Kartesz, 2018; NRCS, 2018). Our analysis indicates that additional plant propagules of *A. aestivalis* have a high likelihood of entering North America. On a scale of 0 to 1, where 1 represents the maximum likelihood of entry, *A. aestivalis* scored 0.72. This result is based on the cultivation of the species as a garden plant. *Adonis aestivalis* follows the grain pathway (AQAS, 2019) and is commonly associated with winter cereals (Bonn, 2005; Meyer et al., 2015; Poschlod and Bonn, 1998; Šarić et al., 2011) and lentils (Holm et al., 1979; Erman et al., 2004). In the United States, the species has been intercepted as a contaminant of grass seed from France and other seeds for propagation from Denmark (AQAS, 2019). The Canadian Food Inspection Agency (CFIA) Seed Laboratory identified this species in a sample of flower seed mixture

from the Netherlands (CFIA, 2008). The species may be a concern in forage seed, since it occurs as a contaminant of hay (Woods et al., 2004) in pasture ecosystems (ODA, 2018). We had average uncertainty for this risk element.

Risk score = 0.72 Uncertainty index = 0.12

4. Predictive Risk Model Results

Model Probabilities: P(Major Invader) = 79.9 %
P(Minor Invader) = 19.3 %
P(Non-Invader) = 0.008 %
Risk Result = High Risk
Secondary Screening = Not Applicable

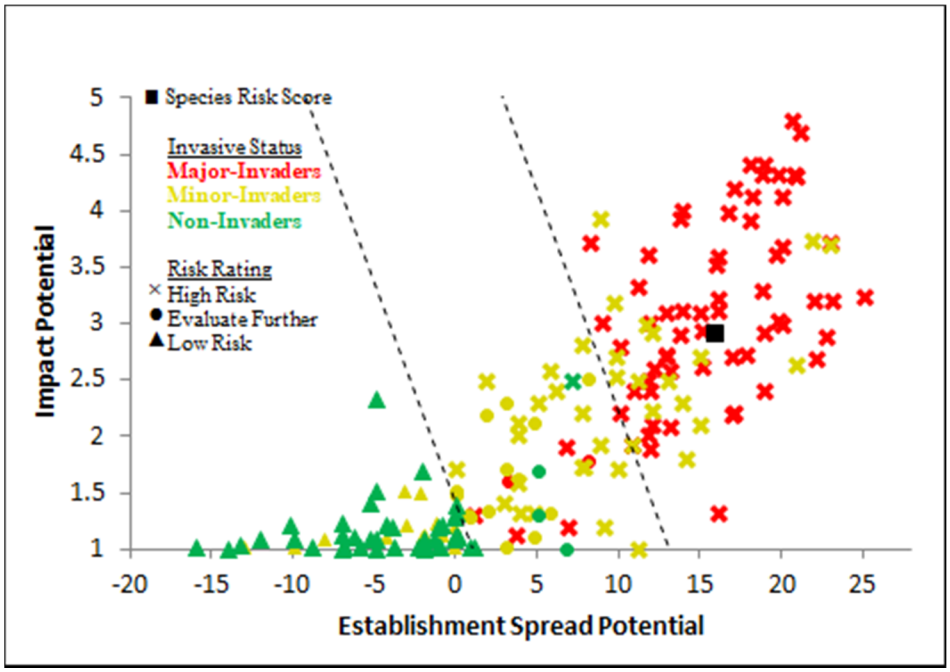

Figure 3. *Adonis aestivalis* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

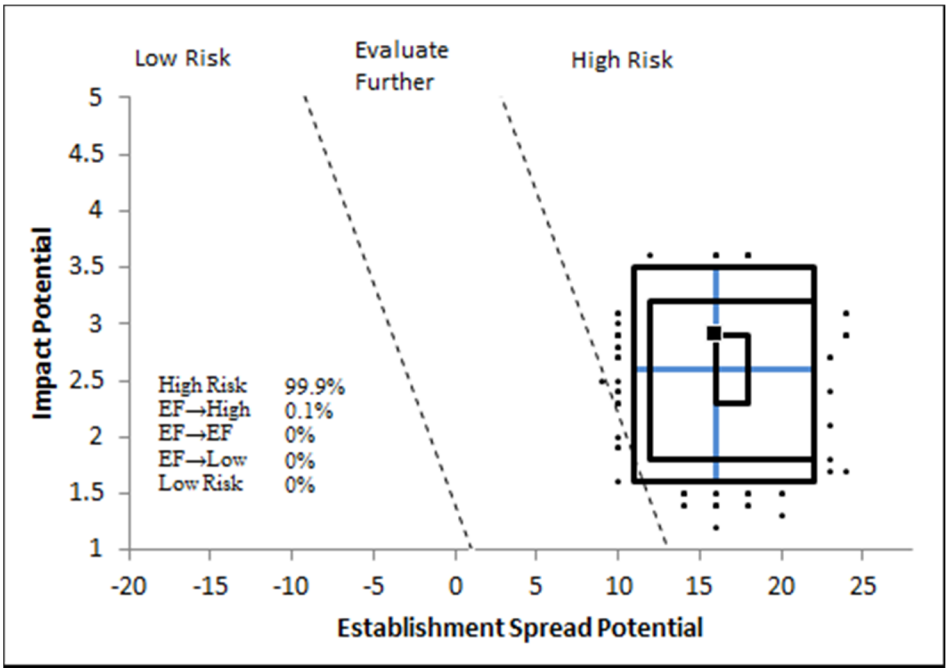

Figure 4. Model simulation results (N=5,000) for uncertainty around the risk score for *A. aestivalis*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

5. Discussion

The result of the weed risk assessment for *Adonis aestivalis* is High Risk, and despite the uncertainty surrounding some of the answers in our assessment, the result is statistically robust. The species is associated with winter cereals and lentils. The most important impact of *A. aestivalis* may be in pasture ecosystems due to its acute toxicity to horses and sheep, which very often leads to death. This species may also be a concern as a contaminant of hay. While the species is regulated Oregon, this may not be enough to prevent its spread. We estimated that about 84 percent of the United States and 13.6 percent of Canada are suitable for the establishment of *A. aestivalis*. We had average uncertainty for the establishment and spread potential, as well as for the entry potential of the species because some fundamental aspects of the ecology of the species are poorly characterized in the literature, such as seed production and species dispersal mechanisms, as well as information on how mutilation, cultivation, and fire may affect it. Similarly, we lacked direct evidence for several potential pathways by which the species may continue to be introduced. We also had very high uncertainty on the status of this species in natural ecosystems and on its impacts to production systems due to the scarcity of information.

6. Acknowledgements

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SUGGESTED CITATION

PPQ. 2019. Weed risk assessment for *Adonis aestivalis* (Ranunculaceae) – Pheasant's eye. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ), Raleigh, NC. 22 pp.

DOCUMENT HISTORY

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Appendix A. Weed risk assessment for *Adonis aestivalis* L. (Ranunculaceae)

In this table are 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, in which 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 - negl	5	*Adonis aestivalis* is native to central Europe (Wodehouse, 1936) and Asia (Woods et al., 2004). The species has been introduced in Australia (Randall, 2007, 2017). *Adonis aestivalis* was introduced into North America as a horticultural plant, but it escaped cultivation and is now present in 23 counties in seven states. According to some sources, the species is "now abundant in disturbed sites and open forests in the western United States" (Burrows and Tyrl, 2013; Woods et al., 2004). It is increasing in abundance in Oregon (ODA, 2018b). Alternate answers for the uncertainty simulation were both "e".
ES-2 (Is the species highly domesticated)	n - negl	0	*Adonis aestivalis* is commonly cultivated in Europe (Wodehouse, 1936) and occasionally in North America (Dave's Garden, 2018). A cultivar of *A. aestivalis* [National Collection of Industrial and Marine Bacteria Limited, Aberdeen, Accession No. NCIMB 40309 (NCIMB, 2019)] having an average of 18-22 petals per flower head and containing an average of 200-350 mg of astaxanthin pigment per flower head was patented by Mawson (1995) as a source of astaxanthin, which is added to salmonid fish diets to promote the expected flesh pigmentation of the fish. The patent does not specify the number of achenes produced by the strain, so we could not determine if the weed potential of the cultivar would be less than that of the wild type. We did not found evidence that this species has been domesticated or bred for traits conferring reduced weed potential.
ES-3 (Significant weedy congeners)	y - negl	1	The genus *Adonis* consists of 35 species (Duretto, 2009). Randall (2017) lists three of these as significant weeds. *Adonis microcarpa* is a serious weed in South Australia, affecting barley, wheat, and sown pastures (Parsons and Cuthbertson, 2001; Simmonds et al., 2000). It is toxic to horses, sheep, pigs, and potentially all grazing animals (Parsons & Cuthbertson, 2001; Simmonds et al. 2000) and has been classified as a high risk species in a Weed Risk Assessment (WRA) conducted by PPQ (2016). In North America, *A. flammea* and *A. annua* are weedy and toxic (Burrows & Tyrl 2013; Nelson et al., 2007). *Adonis annua* is on the monitor list of Washington (Washington State. Noxious Weed Control Board, 2018); the goal of the list is to gather more information on suspect weeds, as well as to monitor for occurrence or spread.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-4 (Shade tolerant at some stage of its life cycle)	n - negl	0	*Adonis aestivalis* prefers full sun, and it can also grow in lightly wooded areas (Outsidepride, 2018; PFAF, 2018). It has also been characterized as a half-shade to semi-light plant (Botanischer Informationsknoten Bayern, 2018). Because we found no evidence that this species can survive in full shade (10 percent or less of full sunlight), we answered no with negligible uncertainty.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	*Adonis aestivalis* is an herbaceous annual plant with erect, branching, leafy stems that are 20-60 cm tall (Heyn and Pazy, 1989; Duretto, 2009). The species is not a vine, nor does it form a basal rosette of leaves.
ES-6 (Forms dense thickets, patches, or populations)	y - mod	2	*Adonis aestivalis* can form thick stands in roadsides and irrigated alfalfa fields; however, populations are highly variable year to year (ODA, 2018b).
ES-7 (Aquatic)	n - negl	0	This species is part of the genus *Adonis,* which includes only terrestrial plants (NGRP, 2018; Duretto, 2009).
ES-8 (Grass)	n - negl	0	This species is part of the Ranunculaceae family (NGRP, 2018; Duretto, 2009) and is not a grass.
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	This species is an herbaceous plant (Heyn and Pazy, 1989). We found no evidence that *A. aestivalis* is a nitrogen-fixing plant. The species is part of the Ranunculaceae family which is not known to contain nitrogen-fixing species (Martin and Dowd, 1990; Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Adonis aestivalis* reproduces through seed production (Wäldchen et al., 2005).
ES-11 (Self-compatible or apomictic)	y - negl	1	The male flower parts mature before the female, and the species has a mixed breeding system with both selfing and outcrossing (Meyer et al., 2015; Sutherland and Delph, 1984).
ES-12 (Requires specialist pollinators)	n - negl	0	We found no evidence that *A. aestivalis* requires specialist pollinators. It is mostly pollinated by pollen-collecting bees and other pollen-eating insects (Bonn, 2005). Flowers are nectarless (Ren et al., 2009).
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	*Adonis aestivalis* is an annual (Heyn and Pazy, 1989; ODA, 2018b). We found no evidence that this species reproduces vegetatively. Its life cycle begins in March or April and finishes in late June in the south Caucasus region in Eurasia (Gasimzade and Ibadullayeva, 2017). In Oregon, the species blooms in mid-summer (ODA, 2018b). Only a small fraction of seeds germinate immediately after seed shedding in summer (Heyn and Pazy, 1989). Primary dormancy mostly delays germination until the following spring Poschlod and Bonn, 1998); these newly germinated plants do not reach reproductive maturity. Alternate answers for the uncertainty simulation were both "a".

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-14 (Prolific seed producer)	n - high	-1	In a study on weed control in winter lentils, the species was found at a density of three plants/m^2 the first year and 30 plants/m^2 the second year (Erman et al., 2004). A single plant can produce 114 seeds (Hussain et al., 1993). In a study on emergence of rare arable plants in relation to seed disturbance, *A. aestivalis* had a 3.5 and 2.1 percent emergence when the soil was not tilled and 14.1 and 5.4 percent emergence when the soil was tilled over two consecutive years. In this experiment only "high-quality" seed was used (Royo-Esnal et al., 2011). The authors did not report the ratio of low-quality to high-quality seed, which limits our ability to calculate the germination rate for the species. Assuming 100 percent seed viability and the maximum density (30 plants m-2) and fertility reported (114 seeds/plant), then 30 plants would produce 3420 seeds per square meter. To reach the threshold of 5000 seeds for this question, the density would need to be 43 plants/m^2, or plants would have to produce a minimum of 167 viable seeds each. Based upon the available evidence, it seems unlikely that *A. aestivalis* is a prolific reproducer. We answered no with high uncertainty because we found very little direct evidence to support this answer.
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	0	The species occurs in roadsides and disturbed areas (Oregon Department of Agriculture, 2010; Bhutyal and Bhatia, 2014; Meyer et al., 2015). Because the seeds are small and have beaks, they may be able to disperse through attachment to vehicle tires or shoes. We did not, however, find direct evidence for this dispersal mechanism. Therefore, we answered unknown with maximum uncertainty.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	The species can follow the grain pathway (APHIS, 2018). It was also intercepted as a contaminant of grass seed from France and other seeds for propagation from Denmark (AQAS, 2019). Additionally, the species was recently identified by the CFIA Seed Laboratory (CFIA, 2008) in a sample of a flower seed mixture from the Netherlands. In the United States, *A. aestivalis* may be a concern as a contaminant of forage seed, since the species occurs in production systems (ODA, 2018b). We found no direct evidence, however, of this species being a contaminant of forage seed. The species is associated with winter cereals (Bonn, 2005; Meyer et al., 2015; Poschlod and Bonn, 1998; Šarić et al., 2011) and lentils (Erman et al., 2004; Holm et al., 1979).
ES-17 (Number of natural dispersal vectors)	2	0	Propagule traits for questions ES-17a through ES-17e: *Adonis aestivalis* produces achenes that are oblique to ovoid in shape, are 4.0 x 3.4 to 4.4 x 3.8 mm in size, and have apices with terminal recurved or slightly curved beaks (Bojňanský and Fargašová, 2007).
ES-17a (Wind dispersal)	n - low		We found no evidence that *A. aestivalis* is wind dispersed. Because it does not possess any specific adaptations for wind dispersal, such as wings or plumes, we answered no with low uncertainty.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-17b (Water dispersal)	n - low		We found no evidence that *A. aestivalis* is water dispersed. Because it does not possess any specific adaptation for water dispersal, such as buoyancy, or for life in aquatic or riparian habitats, we answered no with low uncertainty.
ES-17c (Bird dispersal)	? - max		Over a 60-year study in Hungary, *A. aestivalis* was found to be an important component of the diet of the common quail (*Coturnix coturnix*) (Pinke et al., 2008). It is unknown, however, if these birds disperse the seed or if it is destroyed during digestion. We did not find sufficient information to answer this question, so we answered unknown with maximum uncertainty.
ES-17d (Animal external dispersal)	y - negl		It was introduced into the British Isles (including the Channel Islands) in wool (Clement and Foster, 2000). *Adonis aestivalis* propagates by achenes with terminal recurved or slightly curved beaks, probably adapted to dispersal by ants (Bojňanský and Fargašová, 2007).
ES-17e (Animal internal dispersal)	y - high		*Adonis aestivalis* is a weed of pastures (Oregon Department of Agriculture, 2010; Woods et al., 2004) and has a hard achene that may be dispersed through the manure of grazing animals such as sheep (Woods et al., 2004). Since we found no direct evidence of this dispersal mechanism for *A. aestivalis*, we rated the uncertainty as high.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - negl	1	This species forms a persistent seedbank (Royo-Esnal et al., 2011). Wäldchen et al. (2005) determined that seeds of *A. aestivalis* remained viable in the seedbank for 54 years. Only a small fraction of seeds germinate immediately after seed shedding in summer (Heyn and Pazy, 1989) because primary dormancy mostly delays germination until the following spring (Bonn, 2005).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	-1	We found no direct evidence that the species would or would not benefit from these processes. We found no information on the species response to grazing or mowing in pasture systems.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence that *A. aestivalis* is resistant to herbicides (e.g.,Heap, 2018).
ES-21 (Number of cold hardiness zones suitable for its survival)	8	0	
ES-22 (Number of climate types suitable for its survival)	9	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	

Question ID	Answer - Uncertainty	Score	Notes (and references)
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	n - low	0	Reviews conducted on families and species that are allelopathic do not include *A. aestivalis* or its congeners (Qasem and Foy, 2001). We found one source, however, that characterized the species as a "greedy" plant, inhibiting the growth of other plants around it, especially legumes (PFAF, 2018). After an extensive search of the current literature we were not able to find support for the negative effect of *A. aestivalis* on legumes. We did, however, find that the congener *A. vernalis* has allelopathic compounds in its aerial tissue that are growth inhibitory, cytotoxic, and genotoxic (Dragoeva et al., 2015). In addition, Willis and Rosinska (2016) found that *A. wolgensis* Stev. contained inhibitory compounds in the whole fruit, purified seed, and pericarp. Since these studies were conducted in-vitro and are not based on field experiments, the evidence on allelopathy of the congeners is not sufficiently robust to claim that *A. aestivalis* is allelopathic in natural settings. It seems unlikely that *A. aestivalis* could be allelopathic in a field setting, so we answered "no" and rated the uncertainty low.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that *A. aestivalis* or its congeners are parasitic. The family Ranunculaceae is not known to contain parasitic plants (Nickrent, 2009; Nickrent and Musselman, 2004).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - low	0	We found no evidence that this species changes ecosystem processes. Because this species is not a weed of natural areas, we used low uncertainty for this question and the others in this risk element.
Imp-N2 (Changes habitat structure)	n - low	0	We found no evidence that this species changes habitat structure.
Imp-N3 (Changes species diversity)	n - low	0	We found no evidence that this species affects species diversity.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	n - mod	0	We found no direct evidence that this species poses a threat to Threatened and Endangered species. *Adonis aestivalis* grows in arable land, pastures, roadsides, and wastelands. Because some Federally Threatened and Endangered species may occur in these habitats, we used moderate uncertainty.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - low	0	We found no evidence that the species could affect these ecoregions.
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 - high	0	The species has been controlled in Modoc County, OR (ODA, 2013), but we have no evidence of these controls being applied in natural systems, nor do we have evidence that this species is a weed of natural systems. Alternate answers for the uncertainty simulation were "b" and "c".

Question ID	Answer - Uncertainty	Score	Notes (and references)
Impacts 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 of these type of impacts.
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	We found no evidence of these type of impacts on recreational areas.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - low	0	We found no evidence of these type of impacts on 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 weed and evidence of control efforts]	c - mod	0.4	The species is a weed of roadways (ODA, 2018b). In Oregon, *A. aestivalis* is listed as a Class B weed, which means that "it shall be managed on a priority basis as resources allow" (ODA, 2018a). The species has been controlled in Modoc County, OR (ODA, 2013), but we lack information on how widespread and frequently these controls were applied, so we rated the uncertainty moderate. County extension publications list control methods for the species (Tri-County CWMA, 2015). Alternate answers for the uncertainty simulation were both "b".
Impacts to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - high	0.4	We did not find quantitative information on crop yield reduction effects from *A. aestivalis*. In a study of weed control in lentil cultivation, however, treatments that effectively controlled *A. aestivalis* promoted yields similar to those obtained on weed-free plots, suggesting that this weed can significantly impact yield (Erman et al., 2004).
Imp-P2 (Lowers commodity value)	y - mod	0.2	*Adonis aestivalis* contamination can reduce the value of alfalfa and hay as a commodities due to its toxicity to horses and sheep (ODA, 2018b).
Imp-P3 (Is it likely to impact trade?)	y - high	0.2	Oregon regulates the species as a Class B Noxious Weed (ODA, 2018b). We also found Federal regulatory measures (7 CFR § 360, 2016; 7 CFR § 361, 2015; USDA-AMS, 2018; USDA-APHIS, 2018). The species can follow the grain pathway (APHIS, 2018). *Adonis microcarpa*, a congener of *A. aestivalis*, is regulated in New Zealand (PCIT, 2019). In Australia, *A. microcarpa* is monitored by states affected by the species, but no regulations are in place (Government of South Australia, 2014). This species is not regulated in Canada (CFIA, 2018).
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 species having negative impact on irrigation water, due to the high toxicity of the species (see evidence in Imp-P5) we rated the uncertainty low.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	y - negl	0.1	*Adonis aestivalis* produces cardiac glycosides that can be acutely toxic to some terrestrial animals (Woods et al., 2004; Woods et al., 2011) and fish (Kamata et al., 1990). Recently, eight previously undescribed adonilide glycosides, named aestivalosides AeH (1e8), and four previously undescribed glycosides of the adonilide derivatives, named aestivalosides, were characterized in seeds of this species (Kuroda et al., 2018). Reports of poisoning from *A. aestivalis* are rare because the plant is unpalatable (Woods et al., 2004). In the United States, three horses experienced gastrointestinal distress and later died due to the consumption of hay contaminated with dried *A. aestivalis* (Woods et al., 2004). In an experimental setting, cattle were fed various amounts of dried *A. aestivalis* and displayed mild cardiac abnormalities. This led the researchers to conclude that cattle are not as susceptible to *A. aestivalis* as other livestock such as horses and pigs (Woods et al., 2011; Woods et al., 2004b). Experiments attempting to improve pigmentation in rainbow trout (*Salmo gairdneri*) found that when the fish were fed *A. aestivalis* flower petals, they died (Kamata et al., 1990).
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]	c - high	0.6	In Oregon, this species has been listed as a Class B noxious weed, meaning that it is economically important and regionally abundant but may have limited distribution in some counties (Oregon Department of Agriculture, 2010). According to the ODA (2010), "irrigated alfalfa fields are at risk from pheasant eye invasion" and "with millions of acres of suitable habitat in the western U.S., pheasant's eye can be expected to increase significantly in the future". *Adonis aestivalis* is an agricultural weed with unknown economic importance in Turkey and Morocco (Holm et al., 1979). In Bulgaria, it infests winter wheat fields and was found to be increasing in 2006 and 2007 (Šarić et al., 2011). The most effective means for controlling *A. aestivalis* in Turkey are hand hoeing and applying the pre-emergent herbicide trifluralin (Erman et al., 2004). It can also be effectively controlled by solarization (Upadhyaya and Blackshaw, 2007). Management practices in production systems in Turkey and Morocco are different from those commonly implemented in the United States, so more information on the impacts of this species in pasture systems and the availability of control alternatives is needed in order to predict the potential U.S. impacts. In its native range, the abundance of *A. aestivalis* has decreased drastically in recent decades (Meyer et al., 2013) and is now extinct in parts of Belgium (Belgian Species List, 2018). Due to the conflicting information on the species status throughout the world, we answered the question unknown with high uncertainty. Alternate answers for the uncertainty simulation were both "b."

Question ID	Answer - Uncertainty	Score	Notes (and references)
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2018).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	One occurrence point in Russia, probably a misidentification.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that the species occurs in this Zone.
.Geo-Z3 (Zone 3)	n - high	N/A	One point in Switzerland.
Geo-Z4 (Zone 4)	y - high	N/A	Three points in France, one in Switzerland, three in Armenia, one in Kazakhstan, and one in India (mountainous region).
Geo-Z5 (Zone 5)	y - low	N/A	Four points in France, two in Germany, two in Austria, two in Switzerland, and three in Finland (near the edge of Zone 6).
Geo-Z6 (Zone 6)	y - negl	N/A	Some points in France and Germany and many in Austria.
Geo-Z7 (Zone 7)	y - negl	N/A	Some points in in France, Germany, and Spain.
Geo-Z8 (Zone 8)	y - negl	N/A	France and Spain, some points in Belgium and Germany.
Geo-Z9 (Zone 9)	y - negl	N/A	Spain, some points in France.
Geo-Z10 (Zone 10)	y - negl	N/A	Some points in Israel, a few in France and Spain, two in Italy, one in Algeria, two in Tunisia, one in Morocco, and two in Syria.
Geo-Z11 (Zone 11)	y - low	N/A	Few points in Israel and Spain, one in Portugal, and one in Italy (Sardinia).
Geo-Z12 (Zone 12)	n - low	N/A	One point in Israel (near the edge of Zone 11).
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence that the species occurs in this Zone.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that the species occurs in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that the species occurs in this climate class.
Geo-C3 (Steppe)	y - negl	N/A	Spain, two points in Armenia, one in Turkey, one in Azerbaijan, one in Israel, and one in Tajikistan.
Geo-C4 (Desert)	y - high	N/A	Few points in Morocco and Tunisia and two points in Jordan (near steppe).
Geo-C5 (Mediterranean)	y - negl	N/A	Spain, many points in Israel, a few in Morocco, three in Turkey and Syria, two in Iran, and one each in Algeria, France, Jordan, and Portugal.
Geo-C6 (Humid subtropical)	y - high	N/A	Few points in Italy and Morocco, two in China and India, and one each in Algeria, France, and Pakistan.
Geo-C7 (Marine west coast)	y - negl	N/A	France, Germany, and Spain.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Some points in Armenia, few in Russia, and three in Georgia and the United States (Colorado).
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	France and Germany.
Geo-C10 (Subarctic)	y - negl	N/A	Many points in Germany, some in France, and one in Spain.
Geo-C11 (Tundra)	y - high	N/A	Few points in France and Germany, four in Switzerland, one in Romania, and one in Bulgaria.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that the species occurs in this climate class

Question ID	Answer - Uncertainty	Score	Notes (and references)
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - mod	N/A	Few points in Armenia and Spain; some in Israel; three in Pakistan; two each in Afghanistan, Morocco, and Tunisia; and one in Uzbekistan.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Spain, some points in Armenia and a few in France and Israel.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	Belgium, France, Germany, and Spain.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	France, Germany, some Spain.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	France and Germany.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Germany, few points in France, and one in Switzerland.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Germany, few points in France, and one in Switzerland.
Geo-R8 (70-80 inches; 178-203 cm)	y - negl	N/A	Few points in France and Germany.
Geo-R9 (80-90 inches; 203-229 cm)	y - low	N/A	Germany, one point in Switzerland.
Geo-R10 (90-100 inches; 229-254 cm)	n - high	N/A	Two points in Switzerland.
Geo-R11 (100+ inches; 254+ cm)	n - low	N/A	We found no evidence that the species occurs in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	Even though this species is present in the United States, we set the answer to "no" to evaluate the potential for additional introductions of this species.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - low	0	We found no evidence that the species has been proposed for introduction or that its entry is imminent.
Ent-3 [Human value & cultivation/trade status: (a) Neither cultivated or positively valued; (b) Not cultivated, but positively valued or potentially beneficial; (c) Cultivated, but no evidence of trade or resale; (d) Commercially cultivated or other evidence of trade or resale]	d- mod	0.5	The species is cultivated as an ornamental (Dave's Garden, 2018). It is recommended for its ability "to naturalize" in the garden (Outsidepride, 2018) and is available for trade on gardening websites (Dave's Garden, 2018). It is also available for purchase from Amazon (Amazon.com, 2018), eBay (2018), and Etsy (Etsy.com, 2018) and from sellers in China, Hungary, Indonesia, Moldova, Poland, Ukraine, and the United Kingdom.
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - negl		The species is present in China (GBIF, 2018). Although we found no reports of *A. aestivalis* for Canada, the species is known to be sold for cultivation in the country. It is unclear, however, to what extent the plant may be cultivated in Canada (CFIA, 2008).
Ent-4b (Contaminant of plant propagative material (except seeds))	n - low	0	We found no evidence of *A. aestivalis* as a contaminant of propagative plant material.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4c (Contaminant of seeds for planting)	y - negl	0.08	The species can follow the grain pathway (APHIS, 2018). It was also intercepted as a contaminant of grass seed from France and other seeds for propagation from Denmark (AQAS, 2019). Additionally, the species was recently identified by the CFIA (2008) Seed Laboratory in a sample of a flower seed mixture from the Netherlands. In the United States, *A. aestivalis* may be a concern as a contaminant of forage seed, since the species occurs in production systems (ODA, 2018b). We found no direct evidence, however, of this species as a contaminant of forage seed. The species is associated with winter cereals (Šarić et al., 2011; Meyer et al., 2015; Bonn, 2005; Poschlod and Bonn, 1998) and lentils (Holm et al., 1979; Erman et al., 2004).
Ent-4d (Contaminant of ballast water)	n - low	0	We found no evidence that the species is a contaminant of ballast.
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - negl	0	We found no evidence that the species is a contaminant of aquarium plants. The species is not an aquatic plant, so this is highly unlikely, and we rated the uncertainty as "negl".
Ent-4f (Contaminant of landscape products)	y - mod	0.04	*Adonis aestivalis* is a weed of pasture systems. Straw mulch (produced in pasture systems) is used as landscape material The seed morphology, growth habit, and distribution make the species likely to be spread in landscape products, so we answered yes with moderate uncertainty.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	n - high	0	We found no evidence of this type of contamination. Because the seeds are small and have beaks, however, they could be dispersed through attachment to vehicle tires or shoes. Thus, we rated the uncertainty as high.
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - mod	0.2	We found no evidence that the species is a contaminant of highly processed commodities. Since the weed is a contaminant of grain, it may be introduced into the food processing chain, so we rated the uncertainty as moderate.
Ent-4i (Contaminant of some other pathway)	e - low	0.08	In the United States, the species may be a concern as a contaminant of hay (Woods et al., 2004) in pasture ecosystems (ODA, 2018b). Weeds reduce the quality of hay Ball et al., 2001), and quality analyses are not mandatory. Weed-free certification (NAISMA, 2018) is available in the United States but only considers currently listed Noxious Weeds.
Ent-5 (Likely to enter through natural dispersal)	n - low	0	*Adonis aestivalis* is not present in Canada or Mexico.