United States Department of Agriculture

United States Department of Agriculture

Animal and Plant Health Inspection Service

January 31, 2017

Version 1

Weed Risk Assessment for *Aegilops geniculata* Roth, *Aegilops neglecta* Req. ex Bertol., and *Aegilops triuncialis* L. (Poaceae) – Goatgrass

Aegilops triuncialis infestation (left) and flowering spike with long awns (right) (source: Joseph M. DiTomaso, University of California - Davis, Bugwood.org; Bugwood, 2017).

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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.

Aegilops geniculata Roth – Ovate goatgrass
Aegilops neglecta Req. ex Bertol. – Three-awn goatgrass
Aegilops triuncialis L. – Barb goatgrass

Species Information

Family: Poaceae

Synonyms: Selected synonymy for each species is listed below. For a complete list see van Slageren (1994).

Aegilops geniculata Roth: *Aegilops ovata* auct., *Ae. ovata* subsp. *gibberosa* Zhuk., *Triticum ovatum* auct. (NGRP, 2016).

Aegilops neglecta Req. ex Bertol: *Aegilops ovata* L., *Ae. recta* (Zhuk.) Chennav., *Ae. triaristata* Willd., *Triticum neglecta* (Req. ex Bertol.) Greuter, *T. rectum* (Zhuk.) Bowden, *T. triaristatum* (Willd.) Godr. & Gren (NGRP, 2016).

Aegilops triuncialis L.: *Triticum triunciale* (L.) Raspail (van Slageren, 1994).

Common names:

Aegilops geniculata Roth: Ovate goat grass (NGRP, 2016).

Aegilops neglecta Req. ex Bertol: Three-awn goat grass (NGRP, 2016). Small goatgrass (Weakley, 2015). Ovate goatgrass (Zaharieva and Monneveux, 2006).

Aegilops triuncialis L.: Barb goat grass, jointed goat grass (NGRP, 2016); barbed goatgrass (Weakley, 2015).

Botanical description: All three species are tillering, tufted annual grasses (Zaharieva and Monneveux, 2006) with stems that range from about 10 to 40 cm (*Ae. geniculata*), 20 to 50 cm (*Ae. neglecta*), and 10 to 60 cm high (*Ae. triuncialis*) (van Slageren, 1994). Depending on the species, leaf blades range from 1.5 to 8 cm long. Plants are self-fertile and produce short inflorescences called spikes (1 to 6 cm long, excluding the awns). The caryopses (seeds) are 4-8 mm long by 2.6 to 3 mm wide (Bojňanský and Fargašová, 2007; Saufferer, 2007). Grains of *Ae. triuncialis* resemble those of wheat (ODA, 2016). For more detailed descriptions of these species, morphological comparisons, and taxonomic keys see van Slageren (1994) and Zaharieva and Monneveux (2006).

The genus *Aegilops* contains 22 species that are considered wild, close relatives of wheat (*Triticum* spp.) (van Slageren, 1994). Some of these species were very important in the evolution and domestication of wheat (Kilian et al., 2011), and today are considered potentially important sources of traits in wheat breeding programs (Kilian et al., 2011). Ten of the *Aegilops* species are diploids and the rest are polyploid combinations of the diploids (van Slageren, 1994). The genus evolved and is centered in the Transcaucasian and Irano-Turanian region of western Asia (Kilian et al., 2011). In general, the diploids have relatively narrow distributions, but the polyploids, because of their greater adaptive capacity, have much broader distributions that include the Mediterranean region of southern Europe and northern Africa, as well as Central Asia (Kilian et al., 2011). *Aegilops triuncialis* and *Ae. geniculata* are the most widespread species in the genus (van Slageren, 1994). As a rule, the polyploids of these *Aegilops* species are quite variable and have been described as "inherently weedy" (Giraldo et al., 2016; Zohary, 1965).

The three species being evaluated in this assessment are all closely related allopolyploids [tetraploids (2n=28) and hexaploids (2n=42)] in the section Aegilops of the genus (van Slageren, 1994) and share a common genome in *Ae. umbellulata* (Kilian et al., 2011; van Slageren, 1994). The hybrid origin of the three species and their infraspecific taxa are listed below, along with their designated genomic codes that correspond to their parents. In the crosses, the female parent is shown first. Note that *Ae. geniculata* and *Ae. neglecta* have the same parents, but represent reciprocal crosses. The species *Ae. triuncialis* includes two varieties representing the two reciprocal crosses. Finally, *Ae. neglecta* includes a subspecies that is a hexaploid (2n=42; Giraldo et al., 2016).

- *Ae. geniculata* (MMUU) = *Ae. comosa* (MM) x *Ae. umbellulata* (UU)
- *Ae. neglecta* subsp. *neglecta* (UUMM) = *Ae. umbellulata* (UU) x *Ae. comosa* (MM)
- *Ae. neglecta* subsp. *recta* (UUMMNN) = [*Ae. umbellulata* (UU) x *Ae. comosa* (MM)] x [*Ae. uniaristata* (NN)]
- *Ae. triuncialis* var. *triuncialis* (UUCC) = *Ae. umbellulata* (UU) x *Ae. caudata* (CC)
- *Ae. triuncialis* var. *persica* (CCUU) = *Ae. caudata* (CC) x *Ae. umbellulata* (UU)

In this weed risk assessment, we analyzed all three species together for several reasons. First, as noted above, all three taxa are closely related polyploids that share a common genome in *Ae. umbellulata*. Researchers have noted that it is not uncommon for the polyploids in the U group to hybridize and introgress with each other (Zohary, 1965), as well as with wheat (Arrigo et al., 2011). Second, not only do *Ae. geniculata* and *Ae. neglecta* have the same parents, but their names have been confounded for 200 years (Wiersema, 2017). Specifically, *Ae. ovata* L. has generally been used to refer to *Ae. geniculata* Roth, but the type specimen for *Ae. ovata* is identifiable as *Ae. neglecta* Req. ex Bertol (Wiersema, 2017). Finally, as a group, the *Aegilops* polyploids are ecologically similar in that they have similar geographic ranges (Giraldo et al., 2016; Zohary, 1965).

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

Foreign distribution and status: All three species have similar native ranges (Zohary, 1965) that correspond to northern Africa (e.g., Algeria, Morocco, Tunisia, Egypt), southern Europe (e.g., Albania, Greece, Italy, France, Portugal, Serbia, Slovenia, Spain), eastern Europe (e.g., Hungary, Ukraine), western Asia (e.g., Cyprus, Iran, Iraq, Israel, Jordan, Lebanon, Syria, and Turkey), and the Caucasus (e.g., Armenia, Azerbaijan, Georgia) (NGRP, 2016; van Slageren, 1994). *Aegilops triuncialis* also extends to Central Asia (Kazakhstan, Tajikistan, Turkmenistan), Kuwait, and Pakistan (NGRP, 2016). All three species have also been reported as adventives (representing casual and naturalized species) in central and northern Europe. For example, *Ae. geniculata* is also present in Belgium, the Czech Republic, Germany, and the United Kingdom (GBIF, 2017; Pyšek et al., 2002; Ryves et al., 1996; Verloove, 2006). In the United Kingdom it is a casual alien associated with wool, esparto (a grass fiber), and docks (Ryves et al., 1996). It is also casual in the Czech Republic (Pyšek et al., 2012). *Aegilops neglecta* is a casual alien in the United Kingdom (Ryves et al., 1996) and Switzerland (Wittenberg et al., 2005), and present in Belgium and Germany (Zaharieva and Monneveux, 2006). *Aegilops triuncialis* is also present in the United Kingdom, Belgium, and Germany (GBIF, 2017; Ryves et al., 1996; Verloove, 2006). It is classified as an invasive alien species in Japan (Mito and Uesugi, 2004); however, we found no evidence that it is present in the flora (Ohwi, 1984). *Aegilops neglecta* and *Ae. triuncialis* are grown at Kew Botanical Garden in the United Kingdom (Ryves et al., 1996). Given the importance of these species to wheat breeding programs, it is likely they have been introduced to many other countries for research (e.g., Australia; ALA, 2017).

U.S. distribution and status: *Aegilops triuncialis* is well naturalized and spreading in California, and is reported to be present in one to two counties each of Maryland, Nevada, New York, Oregon, and Pennsylvania (Kartesz, 2016; NRCS, 2016). In California, *Aegilops triuncialis* is a significant weed of rangeland and forage areas (Marty et al., 2015), occupying several million acres in the Central Valley region (Kelch, 2017). It is regulated as a noxious weed seed contaminant in Hawaii and Nevada (USDA-AMS, 2016), and as a noxious weed in California and Oregon (Kartesz, 2016; NRCS, 2016). All *Aegilops* species are regulated as weed seed contaminants in Oregon, Alaska, New Mexico, and Texas (USDA-AMS, 2016). *Aegilops triuncialis* is categorized for Early Detection and Rapid Response by Oregon (ODA, 2007, 2016).

The distribution and status of *Ae. geniculata* and *Ae. neglecta* are more difficult to determine and are confounded given the taxonomic issues described above. For example, a draft treatment of the grass flora of the United States reports that *Ae. geniculata* is naturalized in one county in California (Saufferer, 2007). However, the Jepson Flora Project of California reports it is as a waif (non-persistent plant) in that county (Jepson Flora Project, 2017), while the California Flora reports it for three counties (Calflora, 2017). Kartesz (2016) also reports it for one county in New York, but on closer examination this record corresponds to a waif in a newly seeded lawn (Weldy et al., 2017). For *Ae. neglecta*, the U.S. grass flora (Saufferer, 2007) states that it is not established in the United States, yet the Jepson Flora Project (2017) reports that it is naturalized in California. James Smith Jr., who published the treatments for *Aegilops* in the Jepson Flora, notes that many specimens of *Ae. neglecta* were misidentified as *Ae. triuncialis* (Jepson Flora Project, 2017). *Aegilops neglecta* was collected once from Arlington, VA (Saufferer, 2007), but it is probably not established there as we found no additional information from Virginia. In summary, there is a lot of uncertainty concerning the exact distribution and status of these species in the United States. However, it appears that *Ae. geniculata* and *Ae. neglecta* are more restricted than *Ae. triuncialis*, and that all three appear to occur primarily in California (Calflora, 2017; Jepson Flora Project, 2017; Kartesz, 2016; NRCS, 2016).

Like *Ae. triuncialis, Ae. geniculata* and *Ae. neglecta* are regulated as state noxious weeds in California and Oregon, but under the name of *Ae. ovata* (Anonymous, 2015; ODA, 2016). The entire genus of *Aegilops* is regulated and prohibited entry into the United States by APHIS because, as a close relative of wheat, it may serve as a pathway for wheat diseases (7 CFR § 319-59, 2017). Under these regulations, seeds, plants, straw, chaff, and most products of the milling process are prohibited entry from certain countries, including Ukraine. *Aegilops triuncialis* is very invasive in California, where it has dominated millions of acres in the Central Valley (Kelch, 2017). Various control measures have been tested for it, but the grass has proven difficult to control (summarized in Davy et al., 2008). We found no evidence that any these three species are cultivated as ornamental plants in the United States (e.g., Bailey and Bailey, 1976; Dave's Garden, 2017; Page and Olds, 2001; Univ. of Minn., 2016).

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

[1] "WRA area" is the area in relation to which the weed risk assessment is conducted (definition modified from that for "PRA area") (IPPC, 2012).

1. *Aegilops geniculata*, *Ae. neglecta*, and *Ae. triuncialis* analysis

Establishment/Spread Potential

The three species of *Aegilops* evaluated here have very similar biological traits. They are primarily self-fertilizing annuals that propagate through seed (Loureiro et al., 2007; Zohary, 1965). They colonize disturbed sites, grasslands, rangelands, and some agricultural areas, sometimes forming dense stands (DiTomaso et al., 2001; Marañón, 1987; van Slageren, 1994). Plant propagules are readily dispersed by people when they stick to clothing or equipment (Harrison et al., 2002; Peters et al., 1996). They also disperse in trade as seed and grain contaminants (AOSA, 2014; Verloove, 2006), and as contaminants of other pathways such as wool (Ryves et al., 1996). The spikes of these *Aegilops* species are reported to be dispersed by wind on open ground (Peters et al., 1996; Thomson, 2007). They are also dispersed by animals when the long awns on the spikelets get tangled in animal fur (Kennedy, 1928). All three species possess seed dormancy (DiTomaso et al., 2001; Loureiro et al., 2007), which makes weed management more challenging (Aigner and Woerly, 2011). Finally, because of their potential to hybridize with wheat, it is possible that these species may acquire herbicide resistance through hybridization and introgression with herbicide-resistant wheat (Loureiro et al., 2007; Schoenenberger, 2005; Zaharieva and Monneveux, 2006), as has already happened in *Ae. cylindrica* in the United States (Martins et al., 2015). We had an average level of uncertainty in this risk element.

Risk score = 31 Uncertainty index = 0.13

Impact Potential

All three species of *Aegilops* evaluated here have been reported as weeds in anthropogenic (Arrigo et al., 2010; Ryves et al., 1996; Wittenberg et al., 2005), agricultural (e.g., Holm et al., 1979; Pujadas Salva and Hernandez Bermejo, 1988; Taleb et al., 1998; Turland et al., 2004; Williams, 1982), and natural areas (Cal-IPC, 2006; Winston et al., 2014). However, we only found evidence of specific impacts for *Ae. triuncialis*. In natural systems in California, *Ae. triuncialis* invades grasslands, woodlands, and rangelands (DiTomaso et al., 2001; Kaufman and Kaufman, 2007; ODA, 2016), altering soil nutrient levels (Drenovsky and Batten, 2007), changing soil microbial communities (Batten et al., 2008), forming monocultures (Davy et al., 2008), and excluding other species (Aigner and Woerly, 2011). In agricultural areas such as rangelands and pastures, it reduces forage quantity and quality, crowds out more desirable species (Davy et al., 2008), and reduces livestock range capacity by 50 to 75 percent (DiTomaso et al., 2001) by outcompeting more desirable species (Peters et al., 1996). These grasses are avoided by livestock because they produce barbed awns on the flowering spikes that injure the noses, mouths, and eyes of cattle (DiTomaso et al., 2001; Kennedy, 1928). An Oregon Department of Agriculture factsheet reports that *Ae. triuncialis* and *Ae. ovata* (i.e., *Ae. geniculata* and *Ae. neglecta*) readily cross with wheat, producing sterile seed and an unmarketable product (ODA, 2016). These and other species of *Aegilops* are regulated as state noxious weeds and noxious weed seed contaminants in

various western states (see notes above under U.S. distribution and status), and are controlled in natural and agriculture areas. We had an average amount of uncertainty for this risk element.
Risk score = 4.1 Uncertainty index = 0.15

Geographic Potential Based on three climatic variables, we estimate that about 76 percent of the United States is suitable for the establishment of *Ae. geniculata*, *Ae. neglecta*, and *Ae. triuncialis* (Fig. 1). This predicted distribution is based on georeferenced localities of these species' known distributions from elsewhere in the world (GBIF, 2017). The map for these taxa represents the joint distribution of Plant Hardiness Zones 5-11, areas with 0-80 inches of mean annual precipitation, and the following Köppen-Geiger climate classes: Mediterranean, steppe, desert, humid subtropical, marine west coast, humid continental warm summers, humid continental cool summers, and subarctic.

For this analysis, we combined all georeferenced localities for all three species to generate the map shown in Figure 1. This was necessary for *Ae. neglecta* and *Ae. geniculata* given how highly confounded these species are. However, we think it was also justified for *Ae. triuncialis* since all three species have very similar distributions (van Slageren, 1994). While conducting this analysis we confirmed that, with one exception, all three species have the same climatic tolerances. The one exception is that *Ae. triuncialis* appears to be hardy to one more plant hardiness zone (Zone 5) than the other two species.

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 these species are likely to establish. *Aegilops* species generally grow in dry and disturbed places such as field edges, roadsides, and in grasslands (van Slageren, 1994; Zaharieva and Monneveux, 2006), and often grow together (Marañón, 1987; Zohary, 1965). *Aegilops geniculata* grows on dry and uncultivated ground in Europe, and also occurs on roadsides (Bojňanský and Fargašová, 2007). In California, it grows in silty clay and along roadsides (Saufferer, 2007). *Aegilops neglecta* grows in dry, somewhat disturbed habitats and vegetation types such as fallow, grasslands, roadsides, stony fields, and hill slopes, and in various types of crops (van Slageren, 1994). *Aegilops triuncialis* occurs in pastures and rangelands (Marty et al., 2015), grassy communities (Aigner and Woerly, 2011), wheat fields (USDA-FS, 1953), and oak woodlands (Cal-IPC, 2006), and along roadsides (Harrison et al., 2002), as well as in various crops such as maize, barley, wheat, vineyards, and fruit tree plantations (van Slageren, 1994).

Entry Potential Although all three species of *Aegilops* are already present in the United States (Calflora, 2017; Davy et al., 2008; DiTomaso et al., 2001; Harrison et al., 2002; Kartesz, 2016; Peters et al., 1996), we evaluated their entry potential to help inform policy makers. The most likely pathway for their introduction is to be brought in intentionally for research and use in wheat breeding programs (Kilian et al., 2011). Because these species grow in crops (Togay et al., 2009), rangelands and pastures (DiTomaso et al., 2001; Marañón, 1987), and disturbed areas such as field borders (van Slageren, 1994), they may potentially enter as contaminants of a variety of pathways. For example, some sources state they were introduced to central and northern European countries as contaminants of wool (Ryves et al., 1996), seed, and grain (Verloove, 2006). Here in the United States, port inspectors have intercepted all three species, including *Aegilops* spp., 15 times in cargo and baggage over the last 20 years (AQAS, 2017). Other species of *Aegilops* have also been documented to be associated with trade, including *Ae. speltoides* in grain (Reynolds, 2002) and *Ae. cylindrica* in wheat (Martins et al., 2015; Schrader et al., 1950). On a scale of 0 to 1, where a 1 indicates a species is highly likely to enter the United States, these species obtained a combined score of 0.57 in this risk element.

Risk score = 0.57 Uncertainty index = 0.17

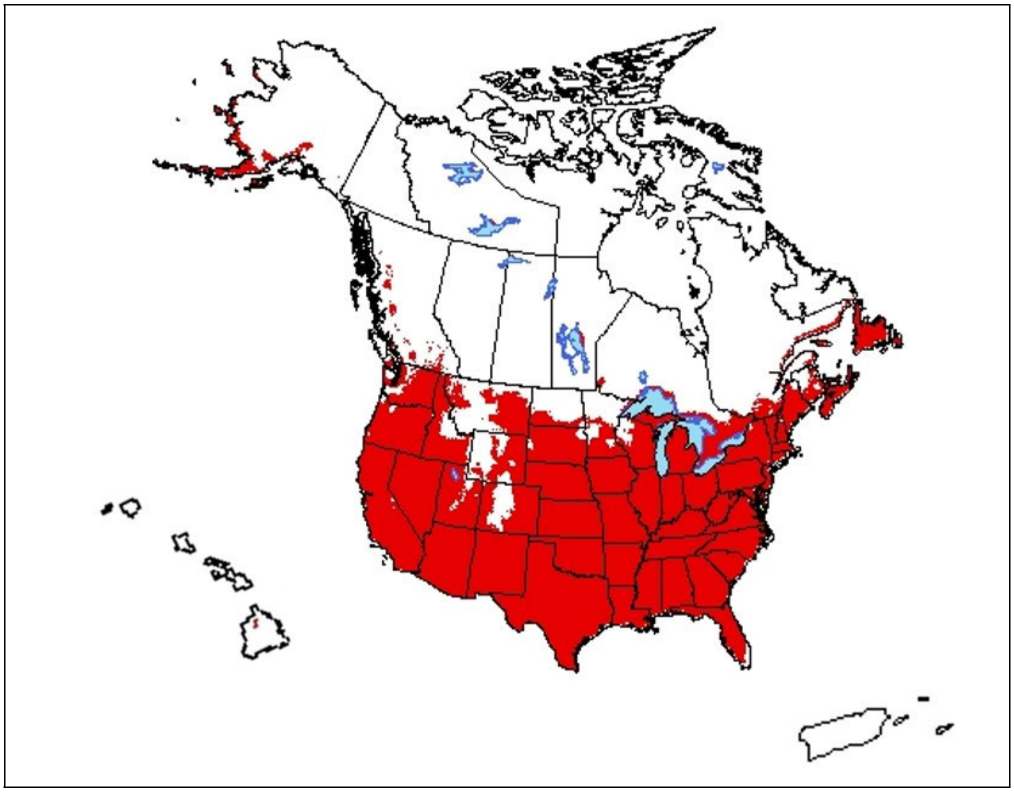

Figure 1. Potential geographic distribution of *Aegilops geniculata*, *Ae. neglecta,* and *Ae. triuncialis* in the United States and Canada. Map insets for Hawaii and Puerto Rico are not to scale.

<u>2. Results</u>

Model Probabilities: P(Major Invader) = 96.4%
P(Minor Invader) = 3.5%
P(Non-Invader) = 0.1%
Risk Result = High Risk
Secondary Screening = Not Applicable

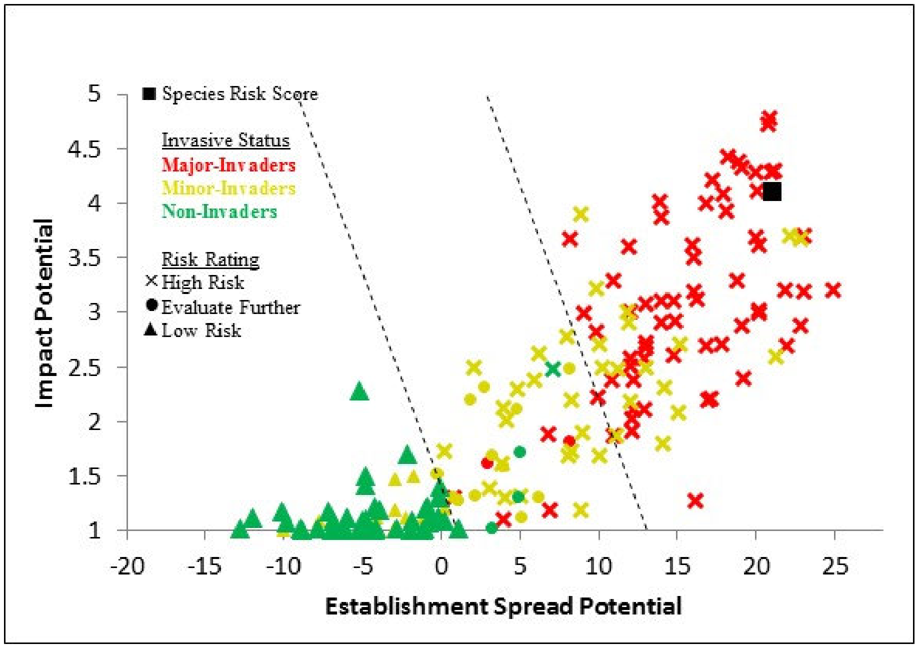

Figure 2. The combined risk score of *Ae. geniculata*, *Ae. neglecta*, and *Ae. triuncialis* (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

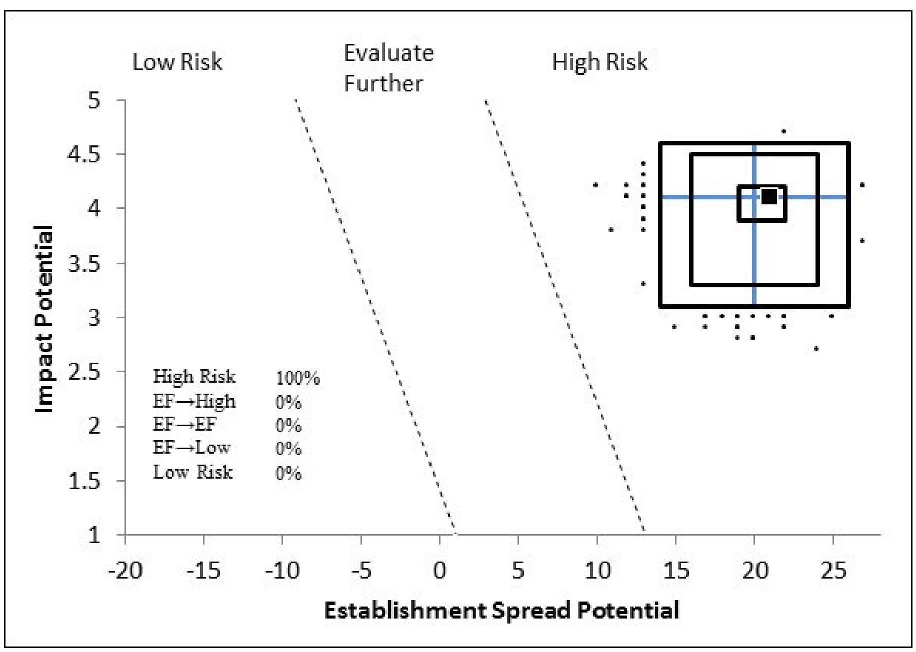

Figure 3. Model simulation results (N=5,000) for uncertainty around the combined risk score for *Ae. geniculata*, *Ae. neglecta*, and *Ae. triuncialis*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and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

3. Discussion

The result of the weed risk assessment for *Ae. geniculata, Ae. neglecta,* and *Ae. triuncialis* is High Risk (Fig. 2). Our uncertainty analysis indicates that our conclusion is statistically robust since minor, random changes to the answers would still result in High Risk (Fig. 3). These species obtained a relatively high risk score for establishment and spread potential because they possess a variety of traits associated with weedy and invasive species, including self-compatibility, a variety of dispersal vectors, seed dormancy, broad environmental tolerance, and, most importantly, evidence of naturalization elsewhere. The three species also obtained a high impact risk score because they (primarily *Ae. triuncialis*) have a broad range of impacts in natural and agricultural systems.

In this assessment, we combined our evaluation of the invasive and weed potential of these three tetraploid species into one analysis. This was necessary for *Ae. geniculata* and *Ae. neglecta* given the extent to which these species are confounded in the literature, and practical with respect to *Ae. triuncialis,* given that all three species have similar ranges, genomes, and have "a distinctly weedy nature" (Zohary, 1965). Although we performed one risk assessment for all three species, during our analysis, we ascribed every piece of evidence to the species identified in the literature so that we could differentiate the risk potential between *Ae. triuncialis* and *Ae. geniculata/Ae. neglecta*. Careful examination of the evidence in Appendix A shows that if *Ae. triuncialis* were to be evaluated separately, its risk score would not change; the risk score for *Ae. ovata* (i.e., *Ae. geniculata* and *Ae. neglecta*) would decrease due to limited evidence of specific impacts, but it would still result in a conclusion of High Risk.

Molecular evidence indicates that *Ae. triuncialis* underwent a strong genetic bottleneck when it was introduced into the United States (Meimberg et al., 2006). Although these species are already present and spreading in the United States, it may be beneficial to prevent the introduction of additional genotypes. Researchers have found evidence indicating that the number of independent origins of the allotetraploids in *Aegilops* is correlated with the geographic range and ecological success of the associated species (Meimberg et al., 2009). Therefore, introducing additional biotypes of these species to the United States may contribute to their overall invasive potential.

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Appendix A. Weed risk assessment for *Aegilops geniculata* Roth, *Aegilops neglecta* Req. ex Bertol., and *Aegilops triuncialis* L. (Poaceae). Below is all of the evidence and associated references used to evaluate the risk potential of these taxa. We also include the answer, uncertainty rating, and score for each question. The Excel file, where this assessment was conducted, is available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - mod	5	*Aegilops triuncialis*, *Ae. geniculata*, and *Ae. neglecta* have very similar native ranges that encompass the countries bordering the Mediterranean Sea and extend eastward through the Caucasus region (van Slageren, 1994), and into central Asia in the case of *Ae. triuncialis* (van Slageren, 1994). All three species have also been reported as adventives (representing casual and naturalized species) in central and northern Europe. For example, *Ae. geniculata* is also present in Belgium, the Czech Republic, Germany, and the United Kingdom (GBIF, 2017; Pyšek et al., 2002; Ryves et al., 1996; Verloove, 2006). *Aegilops neglecta* is a casual alien in the United Kingdom (Ryves et al., 1996) and Switzerland (Wittenberg et al., 2005), and present in Belgium and Germany (Zaharieva and Monneveux, 2006). *Aegilops triuncialis* is also present in the United Kingdom, Belgium, and Germany (GBIF, 2017; Ryves et al., 1996; Verloove, 2006). It is classified as an invasive alien species in Japan (Mito and Uesugi, 2004); however, we found no evidence that it is present in the flora (Ohwi, 1984). Based on our review, the European literature is not very clear on how many of these occurrences represent naturalized populations versus transient (i.e., casual) ones. Thus, we focused more on how these species are behaving in the United States to answer this question. *Aegilops triuncialis* has been present in the United States since about 1915. It spread slowly at first, but has spread more quickly over the last few decades (Davy et al., 2008; DiTomaso et al., 2001; Harrison et al., 2002; Peters et al., 1996). Within twenty years, *Ae. triuncialis* "can expand from a single infestation to dominance of a ranch" (Peters et al., 1996). Demographic data from California populations of *Ae. triuncialis* indicate that populations are growing (Thomson, 2007). "At our sites, *A. triuncialis* continued to expand its range by 20–40% into areas previously dominated by native plants from 2000–2003" (Drenovsky and Batten, 2007). We found no detailed accounts about the behavior of the other two *Aegilops* species in the United States, other than that they are naturalized and expected to spread (Anonymous, 2015; DiTomaso and Healy, 2007). Based on this evidence we answered "f" with moderate uncertainty because of the limited information about the other two species. Alternate answers for the uncertainty simulation were both "e."
ES-2 (Is the species highly domesticated)	n - low	0	While the genus *Aegilops* is very important as a potential source of genes for wheat improvement programs, "cultivated or otherwise improved forms of *Aegilops* species do not exist" (Kilian et al., 2011). We found no evidence that these species have been bred for reduced weed potential.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-3 (Weedy congeners)	y - negl	1	There are 23 species in the genus *Aegilops* (Mabberley, 2008). Thirteen other species of *Aegilops* have been reported as weedy or naturalized beyond their native range (Randall, 2012). Of these, *Ae. cylindrica* Host is a significant weed (Randall, 2012), including in the United States, where USDA scientists organized a special science symposium in 1988 to compile what was known about this species. This species is an agricultural weed that occurs in wheat, pastures, and rangelands (USDA-FS, 1953), and its awns are injurious to grazing animals (USDA-FS, 1953). It is regulated as a state noxious weed in seven western U.S. states (NRCS, 2016) and is considered a troublesome weed in U.S. cereals (Bridges, 1992) because it is difficult to control (Buchholtz et al., 1960). It competes with wheat, reducing its yield, and also lowers the value of seed for planting as it hybridizes with wheat to produce sterile seed (William and Ogg, 1991). *Aegilops cylindrica* is also considered a potentially serious weed of crops, rangelands, and pastures in Australia (Richardson et al., 2006).
ES-4 (Shade tolerant at some stage of its life cycle)	n - mod	0	Although seeds of *Ae. neglecta* can germinate in the dark (Marañón, 1987), we found no evidence that plants are shade tolerant. These three species are grasses that grow in open and disturbed environments (van Slageren, 1994), where light availability is generally high. Thus it seems unlikely they are shade tolerant.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	All three species are grasses with stems that range from about 10 to 60 cm high (van Slageren, 1994). These species are neither vines nor plants that form a basal rosette of leaves.
ES-6 (Forms dense thickets, patches, or populations)	y - negl	2	In heavily infested California pastures, *Ae. triuncialis* has coverage values of 40 to 100 percent, with seedling densities of 236 to 645 plants per square meter (DiTomaso et al., 2001). It forms dense stands in serpentine habitats in California (Lyons et al., 2010). It forms dense stands, and a deep and rapidly establishing root system that makes it very competitive on annual rangelands (Davy et al., 2008). As a typical colonizer, *Ae. geniculata* and *Ae. triuncialis* can be found in massive stands, especially in regularly disturbed places such as roadsides (van Slageren, 1994). In its native range in the Mediterranean, *Ae. neglecta* forms dense stands (Marañón, 1987).
ES-7 (Aquatic)	n - negl	0	*Aegilops* species are not aquatic plants. They generally grow in dry habitats such as field edges, roadsides, and grasslands (Zaharieva and Monneveux, 2006).
ES-8 (Grass)	y - negl	1	*Aegilops* is a genus in the grass family (Poaceae; NGRP, 2016).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	We found no evidence that these species fix nitrogen. Furthermore they are neither woody plants nor members of plant families known to contain nitrogen-fixing species (e.g., Martin and Dowd, 1990; Santi et al., 2013).
ES-10 (Does it produce viable seeds or spores)	y - negl	1	*Aegilops* species are primarily autogamous species propagated by seed (Loureiro et al., 2007). All three species produce viable seed [*Ae. triuncialis* (Marty et al., 2015), *Ae. geniculata* (Onnis et al., 1995), and *Ae. neglecta* (Marañón, 1987)].

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
ES-11 (Self-compatible or apomictic)	y - negl	1	With one exception, all species in *Aegilops* and *Triticum* are predominantly self-pollinated, facultative outcrossers (Zohary, 1965). *Aegilops triuncialis* is primarily selfing, although it can also cross, including with wheat (Pajkovic et al., 2014). *Aegilops geniculata* is also autogamous (cited in Arrigo et al., 2010). *Aegilops ovata* is a selfing species (David et al., 2004).
ES-12 (Requires specialist pollinators)	n - negl	0	Because *Aegilops* species are primarily selfing (see evidence in ES-11), they do not require specialist pollinators. Furthermore, grasses in general are wind-pollinated (Faegri and Van der Pijl, 1979).
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	*Aegilops* species are annuals (ODA, 2016; Saufferer, 2007; Zaharieva and Monneveux, 2006), including the three species evaluated here (van Slageren, 1994). Because we found no evidence of multiple generations per year, we used negligible uncertainty and set the alternate answers to "c."
ES-14 (Prolific seed producer)	y - high	1	We did not find enough information to answer this question for any of the three species being evaluated; in particular, we needed estimates of the number of spikes per plant and/or the number of reproductive plants per square meter. Consequently, we answered this question as unknown. *Aegilops* species are annuals that grow in tufts and produce numerous non-ramified tillers (Zaharieva and Monneveux, 2006). Although there is some variation in reported germination rates, primarily due to the type of seed and its inherent dormancy, numerous studies have shown that all species can reach high to very high germination rates [e.g., 76-100 percent in *Ae. triuncialis* (Dyer, 2004; Marty et al., 2015; Peters et al., 1996), 50-100 percent in *Ae. geniculata* (Loureiro et al., 2007; Onnis et al., 1995), and 100 percent in *Ae. neglecta* (Marañón, 1987)]. There is also good data on the number of seeds produced per spike (inflorescence), with plants generally producing means of about 3-4 seeds per spike in *Ae. neglecta* (Marañón, 1987; Spetsov et al., 2006), 6-8 in *Ae. geniculata* (Onnis et al., 1995; Spetsov et al., 2006), and 6-8 in *Ae. triuncialis* (Dyer, 2004; Spetsov et al., 2006). With respect to whole plant fertility, we found that *Ae. geniculata* produces on average 800 to 1400 seeds (Loureiro et al., 2007; Zaharieva and Monneveux, 2006), and it can grow at densities of 19 to 82 plants per square meter in wheat fields (Togay et al., 2009). If we assume that 19 plants each produce 800 seeds and only half of those are viable, then plants are producing 7600 viable seeds per square meter, which exceeds our threshold for this question. However, because the evidence is limited and because we don't have complete evidence for the other species, we answered yes with high uncertainty. Additional evidence: A few researchers from California report that *Ae. triuncialis* produces 3 to 5 spikes per plant (Peters et al., 1996), but this is somewhat inconsistent with the description of this species as a tufted, many-tillered annual (van Slageren, 1994). DiTomaso et al. estimated mean densities of 1474 to 5950 seeds per square meter for *Ae. triuncialis* in California soils (DiTomaso

Question ID	Answer - Uncertainty	Score	Notes (and references)
			et al., 2001), but these estimates may reflect the combined input for multiple years.
ES-15 (Propagules likely to be dispersed unintentionally by people)	y - negl	1	All three species produce long-barbs called awns (van Slageren, 1994) that catch on wool, clothes, and shoes, helping to transport seeds to new areas (Kaufman and Kaufman, 2007). Movement of equipment can facilitate the movement of *Ae. ovata* (ODA, 2016). *Aegilops triuncialis* disperses on clothing and vehicles (Harrison et al., 2002; Peters et al., 1996). Analysis of the pattern of population genetic diversity of *Ae. geniculata* from around the Mediterranean basin indicates that the species spread primarily on its own during prehistoric times, but that human activity likely contributed to the spread and establishment of some genotypes (Arrigo et al., 2010). The congener *Ae. cylindrica* is spread by combines and grain trucks (Martins et al., 2015).
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - negl	2	*Aegilops geniculata* and *Ae. triuncialis* are classified as weed seed contaminants (AOSA, 2014) and were introduced into Belgium in contaminated seed and grain (Verloove, 2006). It is also associated with wool and docks (Ryves et al., 1996). In the United Kingdom, *Ae. geniculata* is associated with wool, esparto (a grass used in weaving), and docks (Ryves et al., 1996). In Belgium, it has been reported near a wool-processing facility (Verloove, 2016). *Aegilops neglecta* is a casual of grain, tips, docks, and possibly birdseed (Ryves et al., 1996). Movement of cattle can move *Ae. ovata* (ODA, 2016); its introduction to California was associated with the introduction of Mexican cattle (Davy et al., 2008), although we found no evidence that it is present in Mexico. The seeds of *Aegilops cylindrica* are similar in size to those of wheat, and consequently are hard to separate from wheat; it was spread in the United States by planting contaminated wheat seed (Stubbendieck et al., 2003). Other species of *Aegilops* have been documented to be associated with trade including *Ae. speltoides* in grain (Reynolds, 2002) and *Ae. cylindrica* in wheat (Martins et al., 2015; Schrader et al., 1950). Also, *Ae. caudata* was reported near a flour mill (Reynolds, 2002).
ES-17 (Number of natural dispersal vectors)	2	0	Propagule traits for questions ES-17a through ES-17e: All three *Aegilops* species have an awned umbrella-like dispersal unit that is characteristic of their common diploid genome found in *Ae. umbellulata* (Zohary, 1965), so they have similar dispersal mechanisms. At maturity, the entire spike breaks off at the base, and later disarticulates into individual segments as in *Ae. triuncialis* (Davy et al., 2008). *Aegilops neglecta* has been reported to move on its own through hygroscopic movements; however, this has not been confirmed (see discussion in van der Pijl, 1982).
ES-17a (Wind dispersal)	y - mod		*Aegilops* species are dispersed passively by wind, but are also classified as wedge fruits because the hygroscopic awns help to wedge the seeds in cracks in soil and rock (van der Pijl, 1982). Spikes of *Ae. triuncialis* are dispersed by wind on bare ground (Peters et al., 1996; Thomson, 2007).
ES-17b (Water dispersal)	n - mod		Peters et al. (1996) report that *Ae. triuncialis* is dispersed by water, but we found no other information indicating or suggesting that water dispersal is an important dispersal

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
			mechanism for the three species. Because we found no evidence of specific adaptations for water dispersal, and because these three species are generally distributed in dry environments (Zaharieva and Monneveux, 2006), we answered no with moderate uncertainty.
ES-17c (Bird dispersal)	n - mod		We found no evidence that these grasses are dispersed by birds.
ES-17d (Animal external dispersal)	y - negl		All three species possess long-barbs called awns on the spikelets of the fruiting heads (van Slageren, 1994). These awns help the propagules become entangled in the wool of sheep who then easily disperse it (Kennedy, 1928). In as little as three years, an entire pasture or ranch can become infested with *Ae. triuncialis* due to animal spread (Davy et al., 2008). *Aegilops geniculata* has been reported near a wool processing facility in Belgium (Verloove, 2016). "The morphological features of spikes (e.g. awns and hairs) [of *Ae. geniculata*] ensure an efficient zoochorous dispersal of seeds" (Arrigo et al., 2010). *Aegilops triuncialis* awns get caught in the wool of sheep and the hair of livestock, horses, and deer (Harrison et al., 2002; Peters et al., 1996).
ES-17e (Animal internal dispersal)	n - mod		We did not find any evidence whether animal consumption of the seeds is an important pathway for the dispersal of the three species we evaluated. In an experiment where cattle were fed seed of the congener *Ae. cylindrica*, about 75 percent of the seed recovered from the feces were viable, indicating the potential for animal dispersal (Lyon et al., 1992). However, because these species tend to be avoided by livestock (Kaufman and Kaufman, 2007; ODA, 2016; USDA-FS, 1953), presumably because of the sharp awns that can physically injure livestock (see evidence under Imp-A5), it seems unlikely that livestock would consume propagules of these species. Consequently, we answered no with moderate uncertainty.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - negl	1	Typical of many grasses of dry regions (reviewed in Marañón, 1987), all three species evaluated here produce dimorphic seeds that disperse together [*Ae. neglecta* (Marañón, 1987), *Ae. triuncialis* (Dyer, 2004), and *Ae. geniculata* (Onnis et al., 1995)]. In *Ae. triuncialis*, the smaller seed is inhibited due to maternal effects enforcing dormancy and direct inhibition from the larger seed in each pair (Dyer, 2004). Marañón (1987) came to a similar conclusion for *Ae. neglecta*. Spikes of *Ae. geniculata* can remain intact in the soil for years, ensuring a persistent seed bank (Arrigo et al., 2010). Seed dormancy has been reported for all three species [*Ae. geniculata* and *Ae. neglecta* (Loureiro et al., 2007), and *Ae. triuncialis* (DiTomaso et al., 2001)]. Weed managers in the United States have reported that hand-pulling for 5-6 years is needed to completely eradicate *Ae. triuncialis* from a site (Aigner and Woerly, 2011). A seed burial experiment involving the congener *Ae. cylindrica* showed that some to many seeds could survive in the soil for two to five years, depending on the type of soil (Burnside et al., 1996).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	? - max	0	Unknown.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	y - negl	1	We found no evidence that wild populations of any of these species are resistant to herbicides (e.g., Heap, 2017); however, there is a potential for them to acquire resistance from wheat relatives (Schoenenberger, 2005), leading some researchers to argue that the risk of gene transfer should be evaluated more carefully (e.g., Hegde and Waines, 2004). It is well known that wheat forms a species complex with *Aegilops* species and that the two taxa hybridize (Loureiro et al., 2007) and produce hybrids under natural field conditions (reviewed in Zaharieva and Monneveux, 2006). Herbicide-resistant wheat cultivars are currently available and used in agriculture (e.g., Loureiro et al., 2007; Miroshnichenko et al., 2016). Field and greenhouse studies have shown that herbicide resistance genes can be transferred to wheat-*Aegilops* hybrids. For example, in a field experiment in which pots of *Ae. geniculata* and *Ae. biuncialis* were placed in small plots of herbicide-resistant wheat, herbicide-resistant hybrids (from wheat to *Aegilops* spp.) formed at about a 0.5 percent rate, and some of these were able to backcross with wheat and exhibit a low level of self-fertility (Loureiro et al., 2007). These authors concluded that gene flow is possible and that *Aegilops* species should be controlled around field borders of wheat (Loureiro et al., 2007). "Since wild populations of *Aegilops* already possess potential weediness traits, the consequence of adding one or a few adaptive traits [to wheat], such as resistance to disease, pests, cold, or drought, would need to be assessed" because of potential gene flow to wild relatives (Zaharieva and Monneveux, 2006). The formation of neopolyploid hybrids (i.e., through fusion of unreduced gametes of both parents) presents another mechanism for potential gene flow between these taxa (David et al., 2004). In Oregon, herbicide resistance has been detected in natural hybrids of *Ae. cylindrica* and wheat, and their backcrosses (Martins et al., 2015).
ES-21 (Number of cold hardiness zones suitable for its survival)	7	0	
ES-22 (Number of climate types suitable for its survival)	8	2	
ES-23 (Number of precipitation bands suitable for its survival)	8	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max		*Aegilops ovata* and *Ae. triuncialis* have germination inhibitors in dispersal units (Cooper et al., 1977; Dyer, 2004; Gutterman, 1994; Lavie et al., 1974) that are used by maternal plants to regulate the germination of dimorphic seeds). *Aegilops taushii* and *Ae. speltoides* have been shown to be weakly to moderately allelopathic to germinating lettuce seedlings under laboratory conditions (Zuo et al., 2005), but we found no evidence of allelopathy under field conditions. Because seeds may serve as allelopathic agents (Friedman and Waller, 1983), we answered this question as unknown until additional

Question ID	Answer - Uncertainty	Score	Notes (and references)
			research evaluates whether *Aegilops* seeds may have an allelopathic effect on other species under field conditions.
Imp-G2 (Parasitic)	n - negl	0	We found no evidence that these species are parasitic. Furthermore, they are not members 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)	y - mod	0.4	Relative to non-invaded areas in a serpentine community (a type of plant community) in California, areas invaded by *Ae. triuncialis* had lower levels of some soil nutrients and lower litter decomposition rates, leading to increased standing dead biomass; this was probably due to the lower quality of biomass produced by this species (Drenovsky and Batten, 2007). Consequently, this species is changing nutrient cycling in invaded habitats and exacerbating the impact of low soil nutrients already associated with serpentine soils (Drenovsky and Batten, 2007). Because this species increases the level of aboveground dead biomass, it may also be able to alter fire regime (Davy et al., 2008; Kaufman and Kaufman, 2007). A greenhouse experiment showed that after two months, *Ae. triuncialis* plants changed the microbial community in native soil, relative to two native plant species; and that one of the native plant species exhibited less fitness in the *Ae. triuncialis*-primed soil (Batten et al., 2008). We found no evidence of this impact for the other two species. Consequently, we used moderate uncertainty.
Imp-N2 (Changes habitat structure)	y - mod	0.2	In a serpentine community in California, an area invaded by *Ae. triuncialis* had significantly greater aboveground biomass than areas not invaded by it (Drenovsky and Batten, 2007). "Barb goatgrass [*Ae. triuncialis*] populations quickly create a devastating monoculture ... that diminishes species diversity ... and wildlife habitat of infested areas" (Davy et al., 2008). Because this species is changing the density of a vegetative layer, we answered yes, but used moderate uncertainty since we found no evidence for the other two species.
Imp-N3 (Changes species diversity)	y - mod	0.2	In California serpentine grasslands, *Ae. triuncialis* invades pristine areas dominated by native species and replaces them (Aigner and Woerly, 2011). In Europe, *Ae. triuncialis* can form massive stands and dominate vegetation (van Slageren, 1994. We answered yes, but with moderate uncertainty since we did not find this kind of evidence for the other two species.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	y - mod	0.1	"In addition, the ability of *Ae. triuncialis* to invade edaphically stressful serpentine habitats in California (Meimberg et al. 2006; Lyons et al. 2010) makes it a significant threat to biodiversity because of the pronounced native species endemism found within serpentine sites" (Rice et al., 2013). *Aegilops triuncialis* poses a direct threat to some of the rarest species in California (Lyons et al., 2010). Because we didn’t find similar evidence for other two species, we used moderate uncertainty.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	y - low	0.1	Serpentine grasslands are unique plant communities that are adapted to poor edaphic conditions and are generally resistant to invasion by exotic plant species (Aigner and Woerly, 2011).

Question ID	Answer - Uncertainty	Score	Notes (and references)
			These communities occur in California and are part of California's globally outstanding ecoregions (Ricketts et al., 1999). *Aegilops triuncialis* is phenotypically plastic and is able to invade a wide range of dry ecosystems, including serpentine grasslands (Aigner and Woerly, 2011). Although we found no evidence that it is currently invading habitats in California, *Ae. geniculata* is also adapted to serpentine habitats and poses a risk to this community (Lyons et al., 2010).
Imp-N6 [What is the taxon's weed status in natural systems? (a) Taxon not a weed; (b) taxon a weed but no evidence of control; (c) taxon a weed and evidence of control efforts]	c - low	0.6	*Aegilops triuncialis* and *Ae. geniculata* are invasive in California undisturbed grasslands (DiTomaso et al., 2001) and are considered invasive by the USDA Forest Service (Winston et al., 2014). *Aegilops triuncialis* colonizes grasslands and oak woodlands (Kaufman and Kaufman, 2007; ODA, 2016). It rated highly under California's inventory of invasive plants that threaten wildlands (Cal-IPC, 2006). A recent study examined the long-term efficacy of prescribed fire for controlling *Ae. triuncialis* in California grasslands (Marty et al., 2015). Due to lower fuel levels in serpentine grasslands, researchers have investigated the efficacy of hand pulling, mowing, and herbicide applications as alternative or complimentary strategies to prescribed burning (Aigner and Woerly, 2011). Alternate answers for the uncertainty simulation were both "b."
Impact to Anthropogenic Systems (e.g., cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - mod	0	We found no evidence of this impact.
Imp-A2 (Changes or limits recreational use of an area)	n - mod	0	We found no evidence of this impact.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - mod	0	We found no evidence of this impact (e.g., Dave's Garden, 2017).
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 - mod	0.1	All three species grow in disturbed areas such as docks, refuge sites, and wastelands (Ryves et al., 1996). *Aegilops geniculata* can form "massive stands" in disturbed areas and at the edges of cultivated fields (Loureiro et al., 2007). *Aegilops neglecta* is a considered a disturbance weed in Switzerland (Wittenberg et al., 2005). *Aegilops triuncialis* and *Ae. geniculata* are invasive in California disturbed grasslands (DiTomaso et al., 2001). *Aegilops geniculata* is common in disturbed areas in Europe (Arrigo et al., 2010). However, we found no specific evidence that it is specifically controlled in these areas. We answered "b" with moderate uncertainty. Alternate answers for the uncertainty simulation were "c" and "a."
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	y - negl	0.4	*Aegilops triuncialis* is primarily a rangeland weed and reduces forage for cattle, sheep, and wildlife (Kaufman and Kaufman, 2007). It reduces forage quantity and quality, crowds out more desirable species (Davy et al., 2008), and reduces livestock range capacity by 50 to 75 percent (cited in DiTomaso et al., 2001) by outcompeting more desirable species (Peters et al., 1996). In a survey of the ruderal and agrestal weeds of one

Question ID	**Answer - Uncertainty**	**Score**	**Notes (and references)**
			county in southern Spain, *Ae. neglecta* was categorized as a harmful species, which are species that were frequently encountered in the survey, occurred in crops, but were not as harmful or persistent as the "very harmful" species (Pujadas Salva and Hernandez Bermejo, 1988). Although this study did not quantify or describe the extent of harm for the 941 species surveyed, because there were three less impactful categories (rare or casual, slightly harmful, and locally harmful) and because it was described as one of the most important of the "harmful" species (Pujadas Salva and Hernandez Bermejo, 1988), we think that it is probably having some significant impact on crop yield. All three species display noxious characteristics by vigorously competing with wheat or rangeland/native vegetation (Anonymous, 2015).
Imp-P2 (Lowers commodity value)	y - mod	0.2	On rangelands, *Ae. triuncialis* is avoided by cattle and other grazers allowing it to survive and thrive relative to other, more desirable species (Kaufman and Kaufman, 2007; ODA, 2016; USDA-FS, 1953). Thus, if it is avoided, *Ae. triuncialis* is likely lowering the value of grazing land for ranchers. "*A. triuncialis* and *A. ovata* dominate dryland pastures in California, readily cross with wheat, producing sterile seed and an unmarketable product" (ODA, 2016).
Imp-P3 (Is it likely to impact trade?)	y - low	0.2	All *Aegilops* species are regulated in Australia and Nauru (APHIS, 2016). *Aegilops triuncialis* is regulated as a noxious weed seed contaminant in Hawaii and Nevada (USDA-AMS, 2016). All *Aegilops* species are regulated as weed seed contaminants in Oregon, Alaska, New Mexico, and Texas (USDA-AMS, 2016). These three species, as well as *Ae. cylindrica*, have been previously intercepted at U.S. ports as contaminants in wheat and spice seed imports (AQAS, 2017). Additional evidence that this species is a contaminant of trade is available in ES-16. Thus, these three species could impact trade if they were discovered as contaminants in commodities.
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.
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - low	0	We found no evidence that these species are toxic to animals or livestock (e.g., Burrows and Tyrl, 2013; Cooper and Johnson, 1984; Nelson et al., 2007); consequently, we answered no. However, the awns of *Ae. neglecta* and *Ae. triuncialis* are physically harmful to cattle (ODA, 2016; USDA-FS, 1953). Barbed awns injure cattle, getting stuck in their noses, mouths, and eyes (DiTomaso et al., 2001). A California County Commissioner wrote that the very pointed fruit of *Ae. triuncialis* puncture the eyes of hogs, penetrating the brain and causing death (Kennedy, 1928). This last bit of evidence is somewhat questionable as we found no other evidence indicating that these species can kill livestock.
Imp-P6 [What is the taxon's weed status in production systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a	c - mod	0.6	*Aegilops triuncialis*, *Ae. geniculata*, and *Ae. neglecta* are considered agricultural weeds elsewhere (e.g., Arrigo et al., 2010; Holm et al., 1979; Pujadas Salva and Hernandez Bermejo, 1988; Taleb et al., 1998; Turland et al., 2004; Williams, 1982; Williams and Hunyadi, 1987) and in the

Question ID	Answer - Uncertainty	Score	Notes (and references)
weed and evidence of control efforts]			United States (WSSA, 2010). For example, *Ae. triuncialis* and *Ae. geniculata* are invasive in pastures and rangelands in the United States (DiTomaso et al., 2001; ODA, 2016). The USDA classifies *Ae. triuncialis* as a troublesome weed in wheat fields and foothill rangeland, and it classifies *Ae. neglecta* as an "obnoxious weed" (USDA-FS, 1953). *Aegilops geniculata* was a major weed of wheat in one study in Turkey, where it occurred at a density of 19 plants per square meter in one year, and then 82 plants per square meter the following year (Togay et al., 2009). In the early 20th century in the United States, *Aegilops* species raised significant concern due to their agricultural impacts and were subject to control activities (Kennedy, 1928). *Aegilops triuncialis* is difficult to manage once it establishes, but can be controlled with specific techniques (Kaufman and Kaufman, 2007). Various control measures have been tested for *Ae. triuncialis*, with varying levels of success (reviewed in Davy et al., 2008). Suggestions for control strategies are available in several studies (Peters et al., 1996). We found no evidence of specific control for *Ae. geniculata* or *Ae. neglecta*. Based on the amount of evidence for *Ae. triuncialis*, we answered ”c”, but with moderate uncertainty given the limited evidence for the other two species. Alternate answers for the uncertainty simulation were both "b."
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2017).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that these species occur in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that these species occur in this hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that these species occur in this hardiness zone.
Geo-Z4 (Zone 4)	n - mod	N/A	A few points in Turkey and Russia (near Azerbaijan). One point in France. We answered no because these species are primarily distributed in warmer areas, and may only be present as casuals or transients in Zone 4.
Geo-Z5 (Zone 5)	y - high	N/A	Several points in Armenia and Turkey. One point each in Bulgaria and Austria. These points all corresponded to *Ae. triuncialis*.
Geo-Z6 (Zone 6)	y - negl	N/A	Bulgaria, France, and Serbia and Montenegro. Several points in Turkey and a few in Afghanistan.
Geo-Z7 (Zone 7)	y - negl	N/A	Bulgaria, Greece, Iran, Tajikistan, and Uzbekistan.
Geo-Z8 (Zone 8)	y - negl	N/A	France, Portugal, Spain, and Turkey.
Geo-Z9 (Zone 9)	y - negl	N/A	Algeria, France, Portugal, Spain, and Syria.
Geo-Z10 (Zone 10)	y - negl	N/A	Israel, Morocco, Portugal, Spain, and Syria.
Geo-Z11 (Zone 11)	y - negl	N/A	Israel, Portugal, Spain, Syria.
Geo-Z12 (Zone 12)	n - high	N/A	Several points along Israel's coast where there is a very narrow strip of this hardiness zone. Because of potential mapping errors and because we found no other evidence that these species occur in this zone, we answered no.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence that these species occur in this hardiness zone.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that these species occur in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that these species occur in this climate class.
Geo-C3 (Steppe)	y - negl	N/A	Afghanistan, Algeria, Iran, Morocco, and Turkey. *Aegilops geniculata* grows in steppe environments in Algeria (Bandou et al., 2008; van Slageren, 1994).
Geo-C4 (Desert)	y - negl	N/A	Some points in Afghanistan and Turkmenistan. A few points in Iran, Morocco, and Spain.
Geo-C5 (Mediterranean)	y - negl	N/A	Greece, Israel, Lebanon, Morocco, Portugal, and Spain.
Geo-C6 (Humid subtropical)	y - low	N/A	A few points in Azerbaijan, Bulgaria, Croatia, Italy, and Serbia and Montenegro.
Geo-C7 (Marine west coast)	y - negl	N/A	France, Spain, and Turkey. A few points in Bulgaria and Germany.
Geo-C8 (Humid cont. warm sum.)	y - negl	N/A	Armenia, Georgia, and Turkey.
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	Some points in Greece, France, Spain, and Turkey. A few points in Bulgaria, Germany, and Tunisia.
Geo-C10 (Subarctic)	y - mod	N/A	A few points in France, Macedonia, and Spain.
Geo-C11 (Tundra)	n - high	N/A	A few points in France and Spain. Some in Bulgaria. In general, these species are distributed in warmer regions. Because they are annuals, they may only be in these areas due to continual reintroduction from other areas.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that these species occur in this climate class.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - negl	N/A	A few points in Afghanistan, Iraq, Iran, Jordan, Pakistan, and Syria. *Aegilops geniculata* and *Ae. triuncialis* occur in areas receiving from 100 to 1400 mm annual precipitation, however most data are from the range of 350-700 mm (Bandou et al., 2008; van Slageren, 1994). *Aegilops neglecta* generally grows in areas receiving 450 to 750 mm, and up to 1400 mm (van Slageren, 1994).
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	Israel, Spain, Syria, and Turkey. A few points in France and the United States (California).
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	France, Spain, and Turkey. A few points in the United States (California).
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	France, Spain, and Turkey. A few points in Portugal.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	France, Greece, and Turkey. A few points in Spain.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	France and Greece. *Aegilops geniculata* and *Ae. triuncialis* occur in areas receiving from 100 to 1400 mm of annual precipitation, however most data are from the range of 350 to 700 mm (Bandou et al., 2008; van Slageren, 1994). *Aegilops neglecta* generally grows in areas receiving 450 to 750 mm, and up to 1400 mm (van Slageren, 1994).
Geo-R7 (60-70 inches; 152-178 cm)	y - mod	N/A	Four points in Tajikistan. A few points in Georgia and Russia.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Geo-R8 (70-80 inches; 178-203 cm)	y - high	N/A	A few points in the United States (Oregon) near the edge of the 60-70 inch band.
Geo-R9 (80-90 inches; 203-229 cm)	n - high	N/A	One point on the edge with the 70-80 inch band in Russia. We answered no because this record may be an anomaly or an error that is not reflective of the species.
Geo-R10 (90-100 inches; 229-254 cm)	n - negl	N/A	We found no evidence that these species occur in this precipitation band.
Geo-R11 (100+ inches; 254+ cm)	n - negl	N/A	We found no evidence that these species occur in this precipitation band.
ENTRY POTENTIAL			
Ent-1 (Plant already here)	n - negl	0	All three species are already present in the United States (Calflora, 2017; Davy et al., 2008; DiTomaso et al., 2001; Harrison et al., 2002; Kartesz, 2016; Peters et al., 1996). However, to evaluate their entry potential, we set this answer to no and evaluated the rest of the questions in the risk element.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - mod	0	We found no evidence that their 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]	c - low	0.25	Although we found no evidence that these species are cultivated as ornamental plants, all *Aegilops* species are inherently valuable as potential sources for adaptive traits in wheat breeding programs (Kilian et al., 2011). For example, these taxa are important for breeding diseases and stress tolerance into wheat (e.g., Ghazvini et al., 2012; Mguis et al., 2013; Wang et al., 2015). Many biotypes of *Aegilops* taxa are conserved as accessions in germplasm banks (Giraldo et al., 2016). *Aegilops neglecta* and *Ae. triuncialis* are grown at Kew Botanical Garden in the United Kingdom (Ryves et al., 1996). We answered "c" because these species would need to be cultivated to maintain their germplasm in specialized collections, and because they are grown for research purposes. We did not answer "d" because they are not widely grown (e.g., for ornamental purposes).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	y - high		*Aegilops triuncialis* (Anonymous, 2015) and *Ae. ovata* (Davy et al., 2008) are reported to be in Mexico; however, we found no other evidence indicating they are present (e.g., NGRP, 2016; Villaseñor Ríos and Espinosa García, 1998). Consequently, we answered yes but with high uncertainty.
Ent-4b (Contaminant of plant propagative material (except seeds))	n - mod	0	We found no evidence.
Ent-4c (Contaminant of seeds for planting)	y - negl	0.08	*Aegilops geniculata* and *Ae. triuncialis* are classified as weed seed contaminants (AOSA, 2014) and were introduced into Belgium in contaminated seed and grain (Verloove, 2006). The seeds of *Aegilops cylindrica* are similar in size to those of wheat, and consequently are hard to separate from wheat; it was spread in the United States by planting contaminated wheat seed (Stubbendieck et al., 2003).
Ent-4d (Contaminant of ballast water)	n - low	0	We found no evidence. Because these species are adapted to dry habitats and are not riparian species, this pathway seems unlikely.

Question ID	Answer - Uncertainty	Score	Notes (and references)
Ent-4e (Contaminant of aquarium plants or other aquarium products)	n - low	0	We found no evidence. Because these species are adapted to dry habitats and are not riparian species, this pathway seems unlikely.
Ent-4f (Contaminant of landscape products)	y - mod	0.04	*Aegilops triuncialis* seeds disperse in hay from dryland pastures, thus spreading to more distant feeding areas and roadsides (Davy et al., 2008). Although hay is technically used for animal consumption, it is sometimes confused with straw, or used as straw in landscapes. Furthermore, as hay is fed to animals, inevitably, spikes containing viable seed may not be consumed and get discarded on the ground, or be disposed of in outdoor refuse sites where seeds may later germinate. Although we only have evidence for one species, we think this pathway is equally likely for other species since their overall biology is similar. Consequently, we used moderate uncertainty.
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	y - mod	0.04	*Aegilops ovata* can be moved on contaminated equipment (ODA, 2016).
Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	y - low	0.02	*Aegilops geniculata* and *Ae. triuncialis* are classified as weed seed contaminants (AOSA, 2014) and were introduced into Belgium in contaminated seed and grain (Verloove, 2006). In the United Kingdom, *Ae. geniculata* is associated with docks (Ryves et al., 1996). *Aegilops neglecta* is a casual of grain (Ryves et al., 1996). The seeds of *Aegilops cylindrica* are similar in size to those of wheat, and consequently are hard to separate from wheat (Stubbendieck et al., 2003). Other species of *Aegilops* have been documented to be associated with trade including, *Ae. speltoides* in grain (Reynolds, 2002), and *Ae. cylindrica* in wheat (Martins et al., 2015; Schrader et al., 1950). *Aegilops caudata* was detected near a flour mill (Reynolds, 2002).
Ent-4i (Contaminant of some other pathway)	e - low	0.08	*Aegilops ovata* can be moved with livestock (ODA, 2016); its introduction to California was associated with the introduction of Mexican cattle (Davy et al., 2008), although we did not find any evidence it is present in Mexico. In the United Kingdom, *Ae. geniculata* is associated with wool and esparto (a grass used in weaving) (Ryves et al., 1996). In Belgium, it has been reported near a wool-processing facility (Verloove, 2016). *Aegilops triuncialis* is associated with wool and docks (Ryves et al., 1996). *Aegilops neglecta* is possibly a casual of birdseed (Ryves et al., 1996). Based on these potential pathways, we answered "e."
Ent-5 (Likely to enter through natural dispersal)	y - high	0.06	Based on the ability of the propagules for getting caught in animal fur (see evidence under ES-17d), it is likely to spread on its own through animal movement. Davy et. al. (2008) report it was introduced to California with human movement of Mexican cattle; however, we were unable to verify that it is present in Mexico. Consequently, we answered yes, but with high uncertainty.