United States Department of Agriculture

Weed Risk Assessment for *Calendula arvensis* L. (Asteraceae) – Field marigold

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Version 1

Top left: *Calendula arvensis* flowers and seeds (floraofqatar, n.d.); bottom left: *C. arvensis* growing thickly (anentangledbank, 2012); right: *C. arvensis* (Plants for a Future, n.d.)

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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.

	***Calendula arvensis* L. – Field marigold**
Species Information	Family: Asteraceae
	Synonyms: *Calendula aegyptiaca* Pers., *C. gracilis* DC., *C. micrantha* Tineo & Guss., and *C. persica* C.A. Mey. (NGRP, 2015).
	Common names: Field marigold, wild marigold (NGRP, 2015).
	Botanical description: *Calendula arvensis* is an upright, single or multi-stemmed herbaceous annual that grows from 15 to 30 cm in height (de Clavijo, 2005; Stace, 2010). It exhibits achene polymorphism, with three distinct types of achenes. Rostrate achenes are curved with a narrow beak and numerous dorsal spines, cymbiform achenes are broad-winged, and annual achenes exhibit a tuberculate or rough back (de Clavijo, 2005).
	Initiation: A commodity risk assessment for Italy wheat seeds for planting identified this species as being potentially actionable and needing further evaluation. The PPQ Cross Functional Working Group recommended that a full weed risk assessment be conducted. This species is also included in the weed list for Ukraine wheat for consumption/feed in the United States.
	Foreign distribution and status: *Calendula arvensis* is native to Europe and northern Africa (Auld and Medd, 1987; NGRP, 2015). It has spread in its native range and onto new continents and is now naturalized in Asia (temperate and tropical), Australia, New Zealand, South America (Argentina, Chile, and Uruguay) (NGRP, 2015) and the Canary Islands (Stierstorfer and Gaisbergm, 2006).
	U.S. distribution and status: It is naturalized in California (EDDMapS, 2016; NGRP, 2015) and was placed on the California Invasive Plant Council's (Cal-IPC) watch list in 2011 (Cal-IPC, 2015). The California Invasive Plant Council has received a few comments from people concerned about *C. arvensis* at the edge of vineyards or in restoration projects, but Cal-IPC has not taken any action on it (Brusati, 2016). An ecology restoration program manager in California describes it as well established in Sonoma County with records going back to the 1950s. It is doing well there in vineyards, other cultivated areas, and in riparian areas with poor canopy cover; he refers to it as a strong competitor and controls it through hand pulling and bagging the plants to avoid spread (Newhouser, 2016). It may be cultivated to a small extent in other areas of the United States; seeds are available from two nurseries, one in Oregon and the other in Colorado (Plant Information Online, 2015), and an online crafts website (Etsy, 2015). An online gardeners' database mentions it as growing in Missouri and recommends deadheading to avoid volunteer seedlings (Dave's Garden, 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. *Calendula arvensis* analysis

Establishment/Spread Potential

This herbaceous annual has spread outside its native range in Europe and naturalized elsewhere on multiple continents (NGRP, 2015; Stierstorfer and Gaisbergm, 2006). It reproduces via seed and is both self-compatible and pollinated by insects (de Clavijo, 2005). It is a prolific seed producer that exhibits achene polymorphism (as described above), resulting in multiple natural dispersal vectors (wind, bird, and animal). Additionally, *C. arvensis* can form a persistent seed bank (de Clavijo, 2005). We had an average amount of uncertainty for this risk element.

Risk score = 17 Uncertainty index = 0.14

Impact Potential

Calendula arvensis is considered a weed in natural systems (Aksoy, 2011; Newhouser, 2016; Randall, 2007), along roadsides, in disturbed sites (de Clavijo, 2005), in rangelands (Auld and Medd, 1987), vineyards (Newhouser, 2016), and in cultivated fields (de Clavijo, 2005; Randall, 2007; Turland et al., 2004). It is reported to be allelopathic (Sher et al., 2011), but this is based on laboratory studies. Although there are few direct impacts reported, it is considered a weed throughout its established range in production, anthropogenic, and natural systems. It is considered a "strong competitor" in agricultural and natural settings in California and is controlled through hand pulling and bagging of plants (Newhouser, 2016). We had an average amount of uncertainty for this element.

Risk score = 2.3 Uncertainty index = 0.18

Geographic Potential

Based on three climatic variables, we estimate that about 62 percent of the United States is suitable for the establishment of *Calendula arvensis* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes georeferenced localities and other reported areas of occurrence. The map for *C. arvensis* represents the joint distribution of Plant Hardiness Zones 6–11, 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 warm summers, humid continental cool summers, and subarctic. We have high uncertainty for it occurring in the subarctic climate class, but because it was based on georeferenced locations, we included this class in the prediction.

The area of the United States shown to be climatically suitable (Fig. 1) is likely overestimated since our analysis considered only three climatic variables. Other environmental variables, such as soil and habitat type, may further limit the areas in which this species is likely to establish. *Calendula arvensis* prefers warm, loose, mainly sandy loams, and grows on open or disturbed soils, dry pastures, wastelands, and vineyards, and in cereal and vegetable croplands (Hanf, 1983.

Entry Potential We did not assess the entry potential of *Calendula arvensis* because it is already present in the United States (NGRP, 2015).

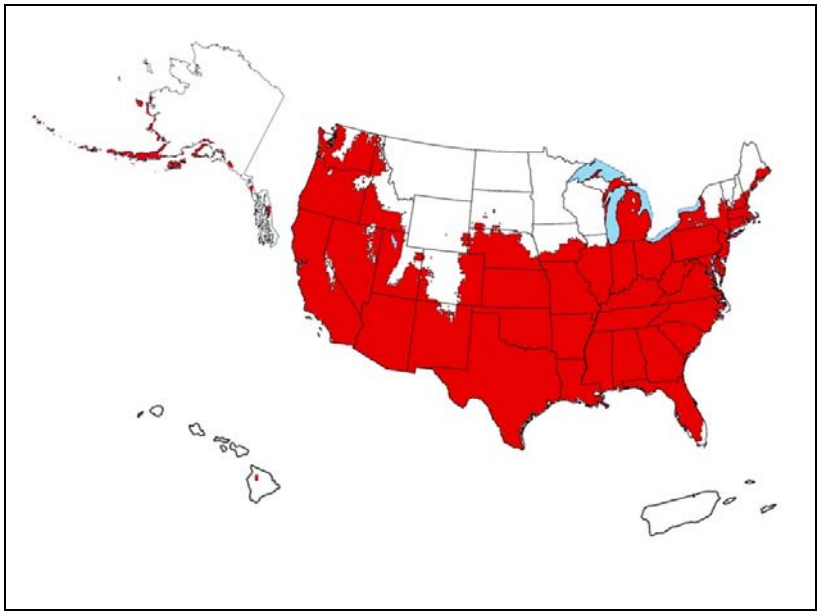

Figure 1. Predicted distribution of *Calendula arvensis* in the United States. Map insets for Alaska, Hawaii, and Puerto Rico are not to scale.

2. Results

Model Probabilities: P(Major Invader) = 77.8%
P(Minor Invader) = 21.3%
P(Non-Invader) = 0.9%

Risk Result = High Risk

Secondary Screening = Not Applicable

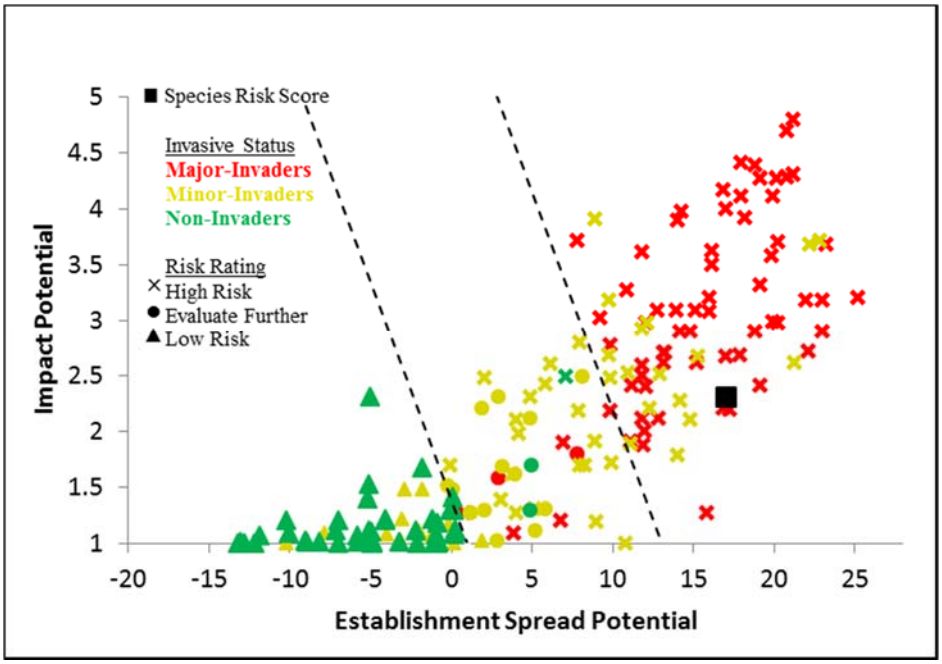

Figure 2. *Calendula arvensis* risk score (black box) relative to the risk scores of species used to develop and validate the PPQ WRA model (other symbols). See Appendix A for the complete assessment.

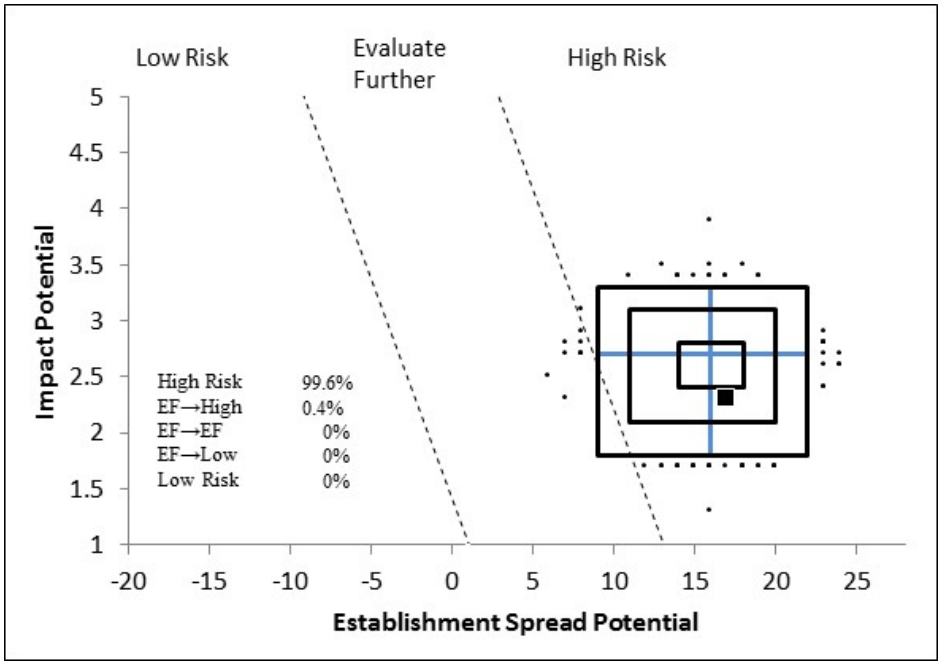

Figure 3. Model simulation results (N=5,000) for uncertainty around the risk score for *Calendula arvensis*. The blue "+" symbol represents the medians of the simulated outcomes. The smallest box contains 50 percent of the outcomes, the second 95 percent, and the largest 99 percent.

3. Discussion

The result of the weed risk assessment for *Calendula arvensis* is High Risk (Fig. 2), and this result is well supported by our uncertainty analysis (Fig. 3). A result of High Risk is supported by its ability to establish and spread in new locations. Although there are few direct impacts reported, it is considered a weed throughout its established range in production, anthropogenic, and natural systems, and it is being controlled in California through hand-pulling and bagging of plants (Newhouser, 2016). A laboratory experiment from Pakistan shows allelopathy toward wheat and millet (Chughtai et al., 1987), and the authors suggest that rain washing off the plants could inhibit germination and growth. It is being locally controlled in California and the California Invasive Plant Council has added it to its watch list.

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Appendix A. Weed risk assessment for *Calendula arvensis* L. (Asteraceae). Below is all of the evidence and associated references used to evaluate the risk potential of this taxon. We also include the answer, uncertainty rating, and score for each question. The Excel file, where this assessment was conducted, is available upon request.

Question ID	Answer - Uncertainty	Score	Notes (and references)
ESTABLISHMENT/SPREAD POTENTIAL			
ES-1 [What is the taxon's establishment and spread status outside its native range? (a) Introduced elsewhere =>75 years ago but not escaped; (b) Introduced <75 years ago but not escaped; (c) Never moved beyond its native range; (d) Escaped/Casual; (e) Naturalized; (f) Invasive; (?) Unknown]	f - low	2	This taxon is native to northern Africa (e.g., Algeria, Egypt, Tunisia) and southern and middle Europe (e.g., Portugal, Italy, Germany, Greece, Ukraine), as well as in western Asia (e.g., Turkey, Israel) through Turkmenistan (NGRP, 2015; Auld and Medd, 1987). It has naturalized in other countries in Europe and other continents. It is now naturalized in Africa, Asia (temperate and tropical), Australia, New Zealand, Europe, North America (California), and South America (Argentina, Chile, and Uruguay) (NGRP, 2015). It has also been reported (as *C. aegyptiaca*) as introduced into the Canary Islands (Stierstorfer and Gaisbergm, 2006). Our alternate answers for the Monte Carlo simulation were both "e".
ES-2 (Is the species highly domesticated)	n - low	0	We found no evidence of domestication; this taxon is used for medicinal purposes (Lavagna et al., 2001) and has been cultivated for centuries, but does not appear to have been bred for any specific characteristics related to weediness.
ES-3 (Weedy congeners)	y - high	0	There are 11 species within the genus *Calendula* on The Plant List (2013): *Calendula arvensis*, *C. denticulata*, *C. eckerleinii*, *C. lanzae*, *C. maroccana*, *C. meuselii*, *C. officinalis*, *C. palaestina*, *C. stellata*, *C. suffruticosa*, and *C. tripterocarpa*. None are listed in Holm et al. (1997); however, Randall (2012) lists 79 references that have indicated that *C. officinalis* is a weed. *Calendula officinalis* is listed as a sleeper weed in Australia, with a species rating of three (naturalized and known to be a minor problem warranting control at 4 or more locations within a state or territory) (WWF Australia, 2006). Because this species appears to be warranting control in Australia, we answered yes. Note that *Calendula officinalis* is cultivated in the United States; it self-seeds readily and is not known to be invasive (Cornell Univ., 2006; Gilman and Howe, 2014), but comments from a gardening website (Dave's Garden, 2016) suggest that it can become weedy.
ES-4 (Shade tolerant at some stage of its life cycle)	n - mod	0	We found no evidence for shade tolerance in *C. arvensis*.
ES-5 (Plant a vine or scrambling plant, or forms tightly appressed basal rosettes)	n - negl	0	*Calendula arvensis* is a single or multi-stemmed herbaceous annual; it is not a vine (Hanf, 1983).

ES-6 (Forms dense thickets, patches, or populations)	n - mod	0	It is not described in the literature as forming dense thickets or patches; although photographs show many plants growing close together, the plants themselves are fairly open.
ES-7 (Aquatic)	n - negl	0	*Calendula arvensis* is not an aquatic; it is gregarious on open soils, in vineyards, and in cereal, vegetable and other crops; common also in well-drained dry pastures, wasteland, etc. Prefers warm, loose, mainly sandy loams (Hanf, 1983).
ES-8 (Grass)	n - negl	0	This plant is in the family Asteraceae (Lavagna et al., 2001).
ES-9 (Nitrogen-fixing woody plant)	n - negl	0	*Calendula arvensis* is an herbaceous plant in the Asteraceae family; it is not woody (Auld and Medd, 1987). Additionally, we found no evidence that it fixes nitrogen.
ES-10 (Does it produce viable seeds or spores)	y - negl	1	Under natural conditions in southwest Spain, the achene germination period begins after the first rains of autumn (September-October) and can extend into April (de Clavijo, 2005).
ES-11 (Self-compatible or apomictic)	y - negl	1	*Calendula arvensis* is a self-compatible annual (de Clavijo, 2005; Heyn and Joel, 1983). A study from southwest Spain demonstrated that 74.7 percent of bagged ligulate flowers produced fruits, indicating automatic pollen transfer from tubular to ligulate flowers (geitonogamous self-pollination) (de Clavijo, 2005).
ES-12 (Requires specialist pollinators)	n - negl	0	From a study in Spain, insects most frequently visiting *C. arvensis* capitula were generalists insects that also visited other types of flowers regularly (de Clavijo, 2005). Of the ligulate flowers in capitula exposed to natural pollination (in a natural population), 96.5 percent produced fruits (de Clavijo, 2005).
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	*Calendula arvensis* is an annual (Hanf, 1983; Heyn and Joel, 1983). Our alternate answers for the Monte Carlo simulation were both "c".
ES-14 (Prolific seed producer)	y - high	1	The average number of achenes (seeds) per capitulum is 20.5 (de Clavijo, 2005) and the estimated number of capitula per plant (from a photograph, floraofqatar, n.d.) is 17; thus, there are an estimated 348.5, rounded up to 350 achenes per plant. It is not clear how many plants may be present per square meter, but it would require only 14 plants per square meter to reach the 5,000 seeds per square meter criterion for an herbaceous plant. Based on photographs from established patches of *C. arvensis* (e.g., luirig.altervista.org), this seems quite possible.
ES-15 (Propagules likely to be dispersed unintentionally by people)	? - max	0	The seeds are strongly curved, the outer ones beaked and spiny on the back (Auld and Medd, 1987). We found no evidence of human assisted movement, e.g., clothes, backpacks), but because

			of the morphology of the rostrate achenes, this is very possible.
ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers)	y - low	2	*Calendula arvensis* is a weed in Pakistan wheat fields (Sher et al., 2011); it is thought to have been introduced into England and Belgium as a contaminant of grain (Dunn, 1905; Verloove, 2006).
ES-17 (Number of natural dispersal vectors)	3	2	Fruit and seed traits for questions ES-17a through ES17e: *Calendula arvensis* exhibits achene polymorphism, meaning it produces three distinct types of achenes: rostrate achenes are incurved with a narrow beak and numerous dorsal spines; cymbiform achenes are broad-winged; and vermiculate or annual achenes exhibit a tuberculate or rough back. Rostrate and cymbiform achenes may be adapted to long-range dispersal (rostrate by exozoochory [dispersal by animals] and cymbiform by anemochory [wind]; annual achenes lack a specialized dispersal mechanism and are adapted to short-range dispersal (de Clavijo, 2005).
ES-17a (Wind dispersal)	y - negl		The cymbiform achenes are adapted to wind dispersal (de Clavijo, 2005).
ES-17b (Water dispersal)	n - low		We found no evidence for water dispersal.
ES-17c (Bird dispersal)	y - high		The rostrate achenes are adapted to dispersal by animals (de Clavijo, 2005). We found no evidence that dispersal is through bird consumption of seeds, or specific evidence that birds disperse seeds at all, but the rostrate achenes may stick to bird feathers as easily as animal fur. This is a strategy used by other plants with sharp achenes that can catch in fur or feathers (e.g., Elliot, 1891).
ES-17d (Animal external dispersal)	y - negl		The rostrate achenes are adapted to dispersal by animals; all three dispersal achenes can be dispersed by ants (*Messor* spp.) (de Clavijo, 2005). *Calendula arvensis* possesses elaiosomes (fleshy appendages or protuberances on seeds) that promote seed dispersal by ants (myrmecochory) (Pemberton and Irving, 1990).
ES-17e (Animal internal dispersal)	n - mod		We found no evidence for internal dispersal.
ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed)	y - high	1	In *C. arvensis*, the germination period is extended and a fraction of achenes with well-formed embryos that fail to germinate ensure the presence of a soil seed bank (de Clavijo, 2005). Additionally, the rostrate and cymbiform achenes (those with the heavier embryos) show a high capacity to emerge from greater burial depths than the annual achenes (de Clavijo, 2005).
ES-19 (Tolerates/benefits from mutilation, cultivation or fire)	n - high	-1	We found no evidence of tolerance or benefit from mutilation, cultivation, or fire.
ES-20 (Is resistant to some herbicides or has the potential to become resistant)	n - low	0	We found no evidence for resistance to herbicides. Additionally, it is not listed by Heap (Heap, 2016).

ES-21 (Number of cold hardiness zones suitable for its survival)	6	0	
ES-22 (Number of climate types suitable for its survival)	8	2	
ES-23 (Number of precipitation bands suitable for its survival)	9	1	
IMPACT POTENTIAL			
General Impacts			
Imp-G1 (Allelopathic)	? - max	0.1	Under experimental (laboratory) conditions, extracts of *C. arvensis* inhibited the germination and growth of wheat and millet (Chughtai et al., 1987), but we did not find additional evidence from the field.
Imp-G2 (Parasitic)	n - negl	0	*Calendula arvensis* is a stand-alone, herbaceous, terrestrial plant that grows in the soil. It is not described as parasitic, nor does it appear to have any characteristics that would suggest it is or could be parasitic. It is not a member of any plant family known to contain parasitic plants (Heide-Jorgensen, 2008; Nickrent, 2009).
Impacts to Natural Systems			
Imp-N1 (Changes ecosystem processes and parameters that affect other species)	n - low	0	We found no evidence of significant ecosystem changes. We note that this species uptakes heavy metals (lead and zinc) from soils, but it does not do so in amounts that would make it ideal for use in remediation of contaminated soils (Del Rio-Celestino et al., 2006).
Imp-N2 (Changes habitat structure)	n - mod	0	We found no evidence of *C. arvensis* changing habitat structure.
Imp-N3 (Changes species diversity)	n - mod	0	We found no evidence of *C. arvensis* outcompeting other species or changing species diversity.
Imp-N4 (Is it likely to affect federal Threatened and Endangered species?)	n - mod	0	Other than its allelopathy reported in cropping systems, we found no evidence of harmful effects on other plants.
Imp-N5 (Is it likely to affect any globally outstanding ecoregions?)	n - low	0	We found no evidence that this species may affect any U.S. globally outstanding 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]	c - low	0.6	*Calendula arvensis* is a weed that grows in disturbed sites on a variety of soil types (de Clavijo, 2005). It is naturalized in California and was placed on the California Invasive Plant Council's watch list in 2011 (Cal-IPC, 2015). An ecology restoration program manager describes it as a strong competitor in riparian areas with poor canopy cover and says it is controlled through hand pulling and bagging the plants (Newhouser, 2016). It is a weed of natural environments in Australia (Randall, 2007); it is a widespread weed of wasteland and rangelands in all states except Western Australia (Auld and Medd, 1987). It is a weed in Australian rangelands, but not considered a threat to biodiversity (Martin et al., 2006). It is considered a threat to natural forest ecosystems of Turkey (Aksoy, 2011), but the authors provided no explanation as to why

			this is the case, particularly since the species is native to Turkey (NGRP, 2015). Alternate answers for the Monte Carlo simulation are "b" and "b".
Impact to Anthropogenic Systems (cities, suburbs, roadways)			
Imp-A1 (Negatively impacts personal property, human safety, or public infrastructure)	n - negl	0	We found no evidence that *C. arvensis* negatively affects human safety; in fact, it is an effective herbal remedy for skin problems and repairing surgical wounds (Lavagna et al., 2001).
Imp-A2 (Changes or limits recreational use of an area)	n - low	0	*Calendula arvensis* is a well-studied species. We found no evidence of *C. arvensis* changing or limiting recreational use of an area.
Imp-A3 (Affects desirable and ornamental plants, and vegetation)	n - mod	0	We found no evidence of *C. arvensis* affecting urban plants.
Imp-A4 [What is the taxon's weed status in anthropogenic systems? (a) Taxon not a weed; (b) Taxon a weed but no evidence of control; (c) Taxon a weed and evidence of control efforts]	b - low	0.1	*Calendula arvensis* is a weed that grows along roadsides and in disturbed sites on a variety of soil types (de Clavijo, 2005). A popular garden website warns that it "self-sows freely; deadhead if you do not want volunteer seedlings next season" (Dave's Garden, 2016). However, we found no evidence of anyone controlling *C. arvensis* in urban areas or along roadways. Our alternate answers for the Monte Carlo simulation were both "a".
Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)			
Imp-P1 (Reduces crop/product yield)	? - max		*Calendula arvensis* is a common weed of wheat and millet in Pakistan; a laboratory study of potential allelopathic effects of *C. arvensis* concluded that this species contains water soluble substances which inhibit the germination and growth of wheat and millet and suggests that rainwash from growing *C. arvensis* carries toxins to the soil to produce detrimental effects on crop plants (Chughtai et al., 1987). It is very likely that this plant does reduce crop or commodity yields, but because this evidence is based on laboratory studies and speculation, and because we could find no additional evidence that it directly reduces crops or commodity yields, we are answering unknown.
Imp-P2 (Lowers commodity value)	n - mod	0	We found no evidence of species taxon lowering commodity value.
Imp-P3 (Is it likely to impact trade?)	n - low	0	We found no evidence of this species impacting trade, nor any evidence that makes it likely to impact trade.
Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water)	n - negl	0	Tolerates or prefers dry soils (Hanf, 1983).
Imp-P5 (Toxic to animals, including livestock/range animals and poultry)	n - mod	0	We found no evidence of toxicity to animals. This species is not listed as poisonous or injurious (Nelson et al., 2007). It does, however, seem to deter browsing or grazing in California and has a very strong odor (Newhouser, 2016).

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 - low	0.6	An ecology restoration program manager from California describes it as a strong competitor in vineyards and cultivated areas and says it is controlled through hand pulling and bagging the plants (Newhouser, 2016). *Calendula arvensis* is a weed that grows in cultivated fields (de Clavijo, 2005). It is a weed of agriculture in Australia (Randall, 2007), Crete (Turland et al., 2004), and Pakistan (Chughtai et al., 1987), and considered a weed of cultivation from southeast Europe and Western Asia though the Mediterranean and into Central Europe (Dunn, 1905). Our alternate answers for the Monte Carlo simulation were both "b".
GEOGRAPHIC POTENTIAL			Unless otherwise indicated, the following evidence represents geographically referenced points obtained from the Global Biodiversity Information Facility (GBIF, 2016).
Plant hardiness zones			
Geo-Z1 (Zone 1)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z2 (Zone 2)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z3 (Zone 3)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z4 (Zone 4)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z5 (Zone 5)	n - low	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z6 (Zone 6)	y - negl	N/A	Germany and France.
Geo-Z7 (Zone 7)	y - negl	N/A	France, Germany, and Greece.
Geo-Z8 (Zone 8)	y - negl	N/A	The United Kingdom (England), Portugal, Spain, and France.
Geo-Z9 (Zone 9)	y - negl	N/A	The United States (CA), the United Kingdom (England), Portugal, Spain, and Australia.
Geo-Z10 (Zone 10)	y - negl	N/A	The United States (CA), Portugal, and Australia.
Geo-Z11 (Zone 11)	y - negl	N/A	The United States (CA), Chile, Portugal, and Australia.
Geo-Z12 (Zone 12)	n - low	N/A	We found no evidence that this species occurs in this hardiness zone.
Geo-Z13 (Zone 13)	n - negl	N/A	We found no evidence that this species occurs in this hardiness zone.
Köppen -Geiger climate classes			
Geo-C1 (Tropical rainforest)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C2 (Tropical savanna)	n - negl	N/A	We found no evidence that this species occurs in this climate class.
Geo-C3 (Steppe)	y - negl	N/A	Spain, Israel, and Australia.
Geo-C4 (Desert)	y - negl	N/A	Israel and Australia.
Geo-C5 (Mediterranean)	y - negl	N/A	The United States (CA), Chile, Portugal, Spain, Israel, and Australia.
Geo-C6 (Humid subtropical)	y - negl	N/A	Greece and Australia.
Geo-C7 (Marine west coast)	y - negl	N/A	The United Kingdom (England), Portugal, Spain, France, Germany, and Australia.

Geo-C8 (Humid cont. warm sum.)	y - mod	N/A	Greece (1 point), Japan (1 point), and Armenia (1 point).
Geo-C9 (Humid cont. cool sum.)	y - negl	N/A	France and Germany.
Geo-C10 (Subarctic)	y - high	N/A	France.
Geo-C11 (Tundra)	n - mod	N/A	A couple of points in Europe; seems too cold.
Geo-C12 (Icecap)	n - negl	N/A	We found no evidence that this species may survive on ice caps. Additionally, there are very few plants that survive on icecaps.
10-inch precipitation bands			
Geo-R1 (0-10 inches; 0-25 cm)	y - negl	N/A	Chile, Spain, Israel, and Australia.
Geo-R2 (10-20 inches; 25-51 cm)	y - negl	N/A	The United States (CA), Chile (1 point), Spain, France, Israel, and Australia.
Geo-R3 (20-30 inches; 51-76 cm)	y - negl	N/A	The United States (CA), Chile (1 point), Spain, France, Germany, and Australia.
Geo-R4 (30-40 inches; 76-102 cm)	y - negl	N/A	UK (England), Spain, France, and Germany.
Geo-R5 (40-50 inches; 102-127 cm)	y - negl	N/A	Portugal, Spain, France, and Germany.
Geo-R6 (50-60 inches; 127-152 cm)	y - negl	N/A	Portugal, Spain, France, and Japan.
Geo-R7 (60-70 inches; 152-178 cm)	y - negl	N/A	Spain and Germany.
Geo-R8 (70-80 inches; 178-203 cm)	y - low	N/A	Germany and Japan.
Geo-R9 (80-90 inches; 203-229 cm)	y - mod	N/A	Germany.
Geo-R10 (90-100 inches; 229-254 cm)	n - negl	N/A	We found no evidence that this species occurs in this precipitation band. It likes dry environments (Hanf, 1983).
Geo-R11 (100+ inches; 254+ cm)	n - negl	N/A	We found no evidence that this species occurs in this precipitation band. It likes dry environments (Hanf, 1983).
ENTRY POTENTIAL			
Ent-1 (Plant already here)	y - negl	1	Because this species is already naturalized in California (NGRP, 2015), we did not evaluate the rest of this risk element.
Ent-2 (Plant proposed for entry, or entry is imminent)	n - low	N/A	
Ent-3 (Human value & cultivation/trade status)	-	N/A	Plant Information Online lists seeds available from one nursery in Oregon and one wholesale nursery in Colorado (Plant Information Online, 2015). Additionally, one can find seeds on Etsy, an online crafts website (Etsy, 2015).
Ent-4 (Entry as a contaminant)			
Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China)	-	N/A	
Ent-4b (Contaminant of plant propagative material (except seeds))	-	N/A	
Ent-4c (Contaminant of seeds for planting)	-	N/A	
Ent-4d (Contaminant of ballast water)	-	N/A	
Ent-4e (Contaminant of aquarium plants or other aquarium products)	-	N/A	
Ent-4f (Contaminant of landscape products)	-	N/A	
Ent-4g (Contaminant of containers, packing materials, trade goods, equipment or conveyances)	-	N/A	

Ent-4h (Contaminants of fruit, vegetables, or other products for consumption or processing)	-	N/A
Ent-4i (Contaminant of some other pathway)	-	N/A
Ent-5 (Likely to enter through natural dispersal)	-	N/A