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# Weed Risk Assessment for *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn. (Poaceae) – Pampas grass

*Cortaderia selloana* (source for left image: The Nature Conservancy Archive, The Nature Conservancy, Bugwood.org; source for right image: Joseph M. DiTomaso, University of California - Davis, Bugwood.org).

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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 weed risk assessment (WRA)—specifically, the PPQ WRA model (Koop et al., 2012)—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.

Because the PPQ WRA model is geographically and climatically neutral, it can be used to evaluate the baseline invasive/weed potential of any plant species for the entire United States or for any area within it. As part of this analysis, we use a stochastic simulation to evaluate how much the uncertainty associated with the analysis affects the model outcomes. We also use GIS overlays to evaluate those areas of the United States that may be suitable for the establishment of the plant. For more information on the PPQ WRA process, please refer to the document, *Background information on the PPQ Weed Risk Assessment*, which is available upon request.

***Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn. – Pampas grass**

**Species Information**

Family: Poaceae

Synonyms: *Arundo selloana* Schult. & Schult. f. (basionym; NGRP, 2013); *Cortaderia argentea* (Nees) Stapf (NGRP, 2013); *Gynerium argenteum* (The Plant List, 2013).

Common Names: Pampas (MPI, 2012), pampas grass (Anonymous, 2013b), and pampasgrass (Motooka et al., 2003).

Initiation: In September 2013, APHIS Public Affairs relayed a media inquiry to PPQ about PPQ's policy on *Cortaderia selloana* and *C. jubata*, which are cultivated and invasive in the United States (Curlett, 2013). Given the media request for information on this species and its invasive status in the United States, the PPQ Weed Team prioritized both species for assessment.

Foreign distribution: *Cortaderia selloana* is native to four countries in South America: Argentina, Brazil, Chile, and Uruguay (NGRP, 2013; Parsons and Cuthbertson, 2001). It has been introduced to and become naturalized in Australia, Azerbaijan, the Azores, France, Georgia, Italy, Libya, New Zealand, Portugal, Reunion, Slovenia, Spain, South Africa, Tunisia, and the United Kingdom (NGRP, 2013; Parsons and Cuthbertson, 2001). It has also been introduced to China, Costa Rica, and Taiwan (NGRP, 2013). *Cortaderia selloana* is regulated in Australia, New Zealand, and

South Africa (Henderson, 2001; MPI, 2012; Parsons and Cuthbertson, 2001).

U.S. distribution and status: *Cortaderia selloana* was first introduced to California, and possibly other U.S. states, around 1848, and entered into commercial production in 1874 (Bossard et al., 2000; Lambrinos, 2001). It was initially cultivated as an ornamental, but in 1946 was planted by the Civilian Conservation Service for fodder in rangelands and soil conservation (Bossard et al., 2000). It appears to have first naturalized in 1929, but it did not begin spreading rapidly until the 1950s (Lambrinos, 2001). This species is widely cultivated in Europe, South Africa, and the United States (Bossard et al., 2000; DiTomaso, 2005; Neal and Senesac, 1991; Parsons and Cuthbertson, 2001; Robacker and Corley, 1992). *Cortaderia selloana* is sporadically naturalized in the United States, primarily in the southern and western states (Kartesz, 2013). Although it is not listed as a state noxious weed by any U.S. state, it is considered a weed by invasive plant organizations (e.g., NRCS, 2013). *Cortaderia selloana* is targeted for control in Hawaii (Anonymous, 2013b; Starr et al., 2003), and is being managed in California (Lambrinos, 2001). The California Native Plant Society has established volunteer work parties to remove it from public lands in the Santa Cruz area (Blair, 2004).

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

1. *Cortaderia selloana* analysis

**Establishment/Spread Potential**

Ample evidence documents the establishment and spread of *C. selloana* abroad (Brundu et al., 2005; Charpentier, 2005; Domènech et al., 2005; Gosling et al., 2000; Marchante et al., 2005; Parsons and Cuthbertson, 2001) and in the United States (Bossard et al., 2000; Cal-IPC, 2006; Lambrinos, 2001). This grass species can establish from either seeds or rhizome fragments (Domènech et al., 2006). It grows quickly and may begin reproducing in its first year (Parsons and Cuthbertson, 2001). It forms dense clumps (Bossard et al., 2000). Depending on its size, an individual clump may produce up to one million seeds (Domènech and Vilà, 2008b; Lambrinos, 2002). Seeds are dispersed by wind (MPI, 2012; Saura-Mas and Lloret, 2005) and people, either in garden waste (Connor, 1965; Timmins et al., 2010) or in trade (Anonymous, 2013a; Lambrinos, 2001). Because this species has been well studied, our uncertainty was low.

Risk score = 15 Uncertainty index = 0.07

**Impact Potential**

*Cortaderia selloana* obtained a relatively high impact potential risk score because it impacts natural, anthropogenic, and production systems. In natural systems, it displaces native plants (Motooka et al., 2003; MPI, 2012), changes the relative frequencies of plant growth forms, reduces total plant

[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).

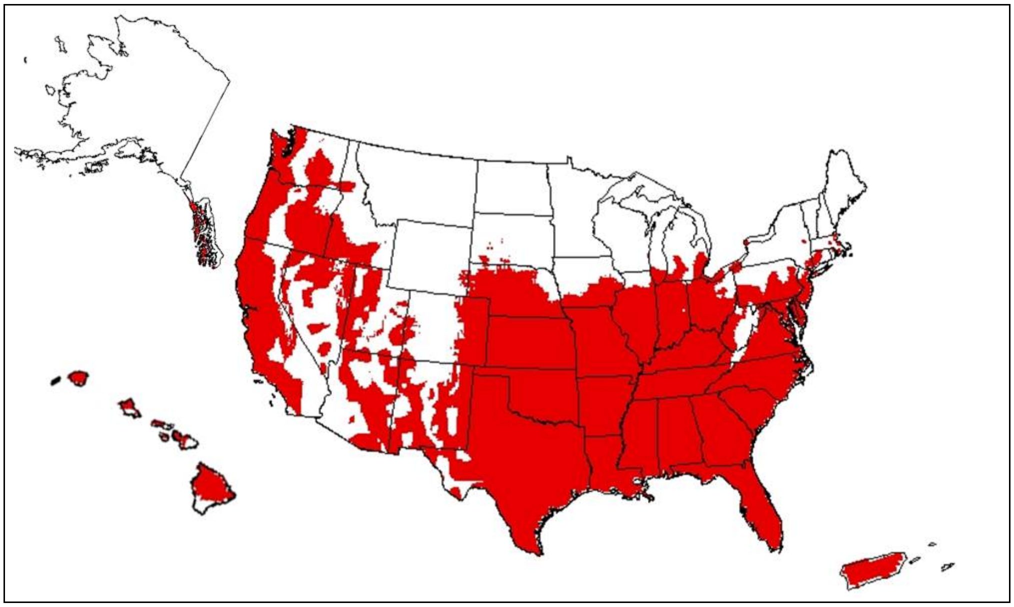
cover, and alters soil nutrient properties (Domènech et al., 2006). In cities and suburban regions, it establishes in disturbed areas (Parsons and Cuthbertson, 2001), reduces aesthetic and recreational value of conservation areas (Bossard et al., 2000), and contributes to human allergies (Dave's Garden, 2013). In production systems, it competes with forest plantation trees, reducing their growth and increasing control costs (Gadgil et al., 1992; Knowles, 1991; Parsons and Cuthbertson, 2001; Richardson et al., 1996). *Cortaderia selloana* is controlled in natural (Andreu et al., 2009; Popay et al., 2003; Wotherspoon and Wotherspoon, 2002) and production systems (Knowles, 1991; Rolando et al., 2011; West and Dean, 1990). Although some homeowners value the ornamental value provided by *C. selloana*, others consider it a weed and have removed it from their yards (Dave's Garden, 2013). The California Invasive Plant Council has categorized this species as having severe impacts in the state (Cal-IPC, 2006). We had low uncertainty for this risk element.
Risk score = 4.3 Uncertainty index = 0.08

**Geographic Potential** Based on three climatic variables, we estimate that about 50 percent of the United States is suitable for the establishment of *C. selloana* (Fig. 1). This predicted distribution is based on the species' known distribution elsewhere in the world and includes point-referenced localities and areas of occurrence. The map for *C. selloana* represents the joint distribution of Plant Hardiness Zones 6-13, areas with 10-100+ inches of annual precipitation, and the following Köppen-Geiger climate classes: steppe, desert, humid subtropical, Mediterranean, marine west coast, tropical savanna, tropical rainforest, and humid continental warm summers. In this assessment we had high uncertainty for several of the hardiness zones and climate classes. The biggest reason for that is probably our limited ability to evaluate a species' climatic tolerances in regions dominated by rapid elevation changes, including those found in Hawaii. Furthermore, for plant species that are cultivated, like *C. selloana*, selection of hardier cultivars and cultivation in protected environments hinders our ability to evaluate where a species can establish beyond human intervention.

The area estimated likely represents a conservative estimate for the reasons described above and because our assessment process only uses 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. In its native range, *C. selloana* occurs in prairie habitats (Parsons and Cuthbertson, 2001). Elsewhere it occurs in sand dunes, roadways, railways, abandoned agricultural fields, coastlines, temporary riverbeds, ditches, old fields, pastures, and wetlands (Bossard et al., 2000; Brundu et al., 2005; Cal-IPC, 2006; Domènech et al., 2005; Marchante et al., 2005). Competition and herbivory are other important factors determining species distributions. For example, establishment by *C. selloana* in several Californian habitats is limited by mammalian herbivory (Lambrinos, 2002).

**Entry Potential** We did not assess the entry potential of *C. selloana* because it is already present in the United States, where it is cultivated and naturalized (Jepson Flora Project, 2013; Lambrinos, 2001; Okada et al., 2007).

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



2. Results and Conclusion

Model Probabilities: P(Major Invader) = 87.9%
P(Minor Invader) = 11.6%
P(Non-Invader) = 0.4%

Risk Result = High Risk

Secondary Screening = Not Applicable

**Figure 2**. *Cortaderia selloana* 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.

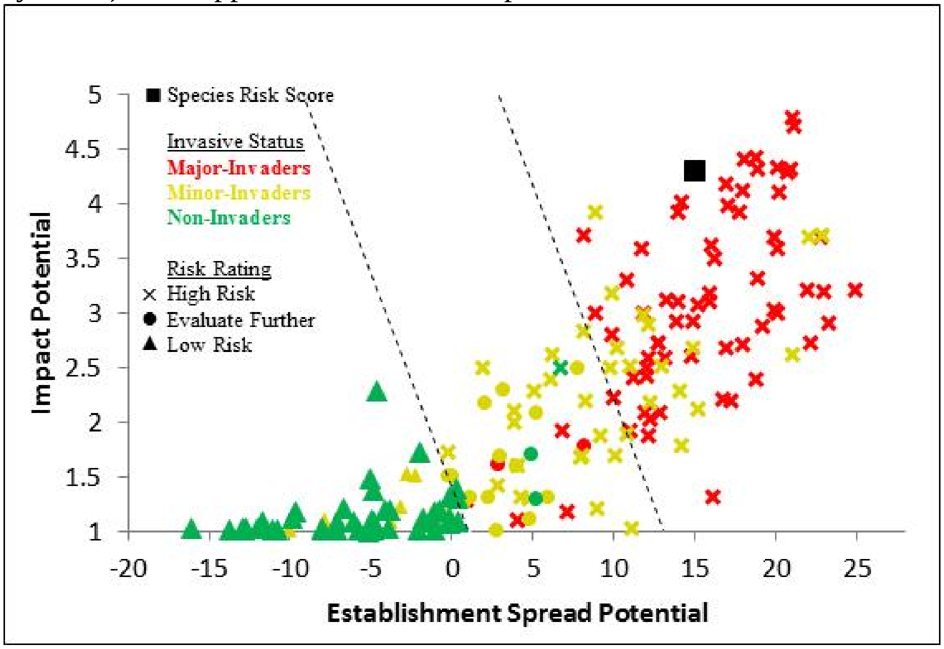
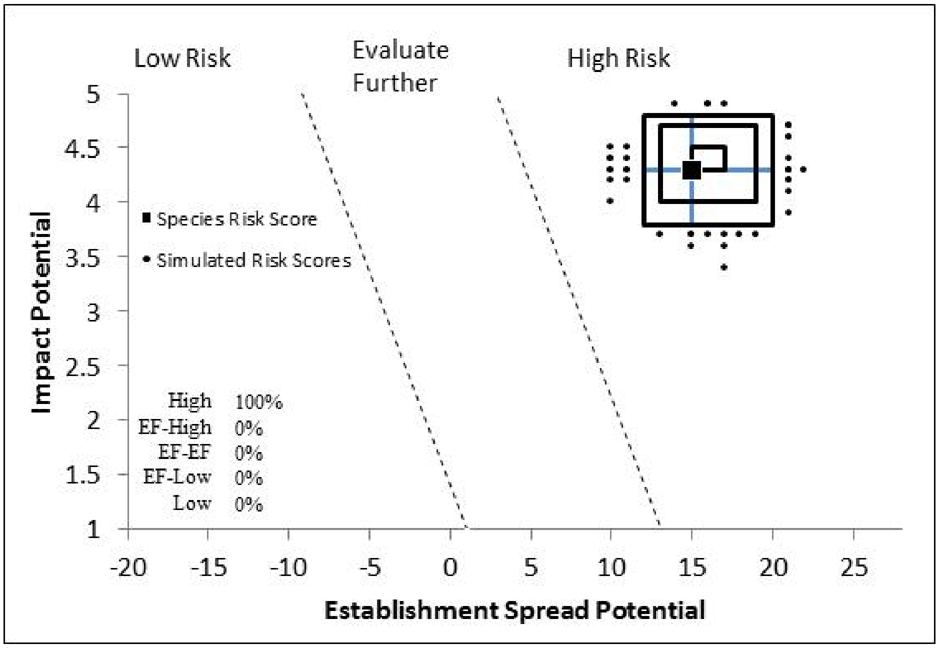



**Figure 3**. Model simulation results (N=5,000) for uncertainty around the risk score for *Cortaderia selloana*[a].




[a] 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 *Cortaderia selloana* is High Risk (Fig. 2). We are very confident in this result given the relatively high risk scores for establishment/spread and impact potential (Fig. 2), and the low level of uncertainty associated with our analysis (Fig. 3). Hawaiian researchers also obtained a result of high risk when they evaluated this species with the Australian weed risk assessment system (UH, 2013).

*Cortaderia selloana* and *C. jubata* are both invasive in the United States, but *C. selloana* has proven to be more invasive than *C. jubata* (Lambrinos, 2001), probably due to higher germination and seedling survivorship, and broader environmental tolerances (Lambrinos, 2002). *Cortaderia selloana* may spread even more rapidly in the United States if nursery practices continue promoting hermaphrodite plants, which could pollinate the female plants that were previously promoted by industry (Bossard et al., 2000). *Cortaderia selloana* has high water and nitrogen use efficiencies under low resource levels, but through morphological and physiological plasticity is able to respond to higher resource levels (Vourlitis and Kroon, 2013), making it fairly competitive in a wide range of environments.

*Cortaderia selloana* is a popular ornamental plant that is cultivated for its showy plumes (Lambrinos, 2001; Neal and Senesac, 1991; Okada et al., 2007; Wells et al., 1986). In a national plant finder database, a few dozen retail and wholesale nurseries list it for sale (Univ. of Minn., 2014). Because of its ornamental and economic importance in the United States, it may be difficult to regulate this species at either a federal or state level. One worker proposed that instead of banning the entire species, hermaphrodite plants could be banned and nurseries should be certified for selling female-only plants that were vegetatively produced from other female plants (Madison, 1994). This would help to slow down any invasion by limiting seed production, while still supporting the horticultural industry by not restricting the female plants, which are generally more attractive.

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**Appendix A**. Weed risk assessment for *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn (Poaceae). The following information came from the original risk assessment, which is available upon request (full responses and all guidance). We modified the information to fit on the page.

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
|---|---|---|---|
| **ESTABLISHMENT/SPREAD POTENTIAL** | | | |
| ES-1 (Status/invasiveness outside its native range) | f - negl | 5 | *Cortaderia selloana* is native to Argentina, Brazil, Chile, and Uruguay (NGRP, 2013; Parsons and Cuthbertson, 2001). It was first introduced to Europe between 1775 and 1862 as an ornamental (Bossard et al., 2000). In Australia, it is spreading and is a "strongly invasive weed rapidly colonizing disturbed lands" (Parsons and Cuthbertson, 2001). It is also spreading in France (Charpentier, 2005), New Zealand (Gosling et al., 2000), Portugal (Marchante et al., 2005), Sardinia (Brundu et al., 2005), Spain (Domènech et al., 2005), the United States (Bossard et al., 2000; Cal-IPC, 2006), and in the Mediterranean region (Brunel et al., 2010). A detailed California study documents this species' naturalization and spread throughout the state (Lambrinos, 2001). Alternate answers for the Monte Carlo simulation were both "e." |
| ES-2 (Is the species highly domesticated) | n - low | 0 | This species is cultivated, not only as an ornamental plant, but also for its showy plumes (Lambrinos, 2001; Neal and Senesac, 1991; Okada et al., 2007; Wells et al., 1986). One study found evidence indicating that over the last 80 years, since the end of the plume industry fad, plume morphology has changed (Lambrinos, 2001). "The plumes have darkened, the spikelets and awns have shortened and the number of florets has decreased." Because this does not appear to be the result of human breeding and because we found no evidence that a reduction in the number of florets has resulted in reduced weed potential, we answered no with low uncertainty. |
| ES-3 (Weedy congeners) | y - negl | 1 | The genus *Cortaderia* has about 25 species (Parsons and Cuthbertson, 2001). Six species, including *C. selloana*, have been classified as weeds to some extent (Randall, 2012), although three of those were recently moved to the genus *Austroderia* (Linder et al., 2010). *Cortaderia jubata* and *A. richardii* appear to be significant weeds (Randall, 2012) and both are quarantine pests in Australia (Parsons and Cuthbertson, 2001). *Cortaderia jubata* changes community composition and converts chaparral communities to grasslands (Lambrinos, 2000). |
| ES-4 (Shade tolerant at some stage of its life cycle) | n - mod | 0 | *Cortaderia selloana* occurs in open, sunny places (Parsons and Cuthbertson, 2001). Seedling survival is low in shaded areas (cited in Bossard et al., 2000). One experimental study that germinated seeds in petri dishes under four different light levels (100, 50, 30, and 5 percent light) found that seeds germinated about 20 percent better under the three shade treatments than under full sun (Lambrinos, 2002). However, because the processes determining shade tolerance may not be the same as those affecting seed germination, we do not think this constitutes strong evidence of shade tolerance. |
| ES-5 (Climbing or smothering growth form) | n - negl | 0 | This species is a tussock-forming grass with leaves up to 2 meters long and some stems to 6 meters (Bossard et al., 2000; Parsons and Cuthbertson, 2001). Thus, it is not a vine. |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| ES-6 (Forms dense thickets) | y - low | 2 | Forms heavy infestations in California (Bossard et al., 2000). |
| ES-7 (Aquatic) | n - negl | 0 | This species is not an aquatic plant; it is a terrestrial tussock-forming grass (Bossard et al., 2000; Parsons and Cuthbertson, 2001; Starr et al., 2003). |
| ES-8 (Grass) | y - negl | 1 | This species is a grass (NGRP, 2013; NRCS, 2013). |
| ES-9 (Nitrogen-fixing woody plant) | n - negl | 0 | We found no evidence that this species fixes nitrogen. Furthermore, it does not belong to a plant family known to fix nitrogen (Martin and Dowd, 1990; Santi et al., 2013). |
| ES-10 (Does it produce viable seeds or spores) | y - negl | 1 | It reproduces and spreads by seeds (Connor, 1965; Domènech and Vilà, 2008a; Parsons and Cuthbertson, 2001; Wells et al., 1986). Propagated by seeds (Neal and Senesac, 1991). Two studies examined the range of conditions under which seeds germinate (Bacchetta et al., 2010; Domènech and Vilà, 2008a). Although one report said that viable seeds were rarely found (Bossard et al., 2000), we answered yes with negligible uncertainty because at least some viable seeds are produced and they are contributing to this species' spread. |
| ES-11 (Self-compatible or apomictic) | n - mod | -1 | The evidence we found is somewhat conflicting on this trait. The species is gynodioecious, meaning individual plants are either female or hermaphroditic (Parsons and Cuthbertson, 2001). One report stated that although plants are structurally gynodioecious, they are effectively dioecious as the female plants are cross-pollinated by the bisexual plants (Parsons and Cuthbertson, 2001) and the bisexual plants primarily produce pollen (Bossard et al., 2000). However, another study reported that ovaries in bisexual flowers set seed, and hermaphroditic plants set one-third of the seed that female plants do (Connor, 1965), but this doesn't address self-compatibility as these seeds may have been produced through outcrossing. Another study reported that "hermaphrodites mostly set no seed when selfed" and that hermaphrodites were highly self-incompatible as determined by vigor of the selfed progeny (Connor, 1973). "The species is self-incompatible" (Connor and Charlesworth, 1989). Based on the weight of the evidence, we answered no with moderate uncertainty. |
| ES-12 (Requires special pollinators) | n - negl | 0 | This species is wind pollinated (Lambrinos, 2001). |
| ES-13 (Minimum generation time) | b - mod | 1 | *Cortaderia selloana* is a long-lived perennial grass that reproduces by seeds and rhizome fragments (Domènech et al., 2006; Parsons and Cuthbertson, 2001). Although some plants may produce inflorescences in their first season, most flower in either the second or third season (Parsons and Cuthbertson, 2001). This species produces flowers in its second or third year (Bossard et al., 2000). Plants grown for a breeding study produced flowers in their first season (Connor, 1973). Tillers are produced from short rhizomes even in a plant's first season (Parsons and Cuthbertson, 2001). Because this is a clumping grass, vegetative reproduction effectively increases the size of a plant (the genet). Vegetative reproduction occurs during cultivation when rhizome fragments and plant crowns are moved and reestablish (Parsons and Cuthbertson, 2001). Because some plants produce inflorescences in their first season, we answered "b." Alternate answers for the Monte |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| | | | Carlo simulation were "c" and "a." |
| ES-14 (Prolific reproduction) | y - negl | 1 | "The bisexual plants produce some seed but the female plants, having many more florets per spikelet, are considerably more prolific, producing up to 100,000 seeds per panicle when pollinated by the bisexual plants" (Parsons and Cuthbertson, 2001). Females produce as many as 1,000,000 seeds per plant (Domènech and Vilà, 2008b). Produces as many as 1 million seeds per individual (Lambrinos, 2002). Laboratory-derived estimates of germination on soils from four different habitats ranged between 69 percent and 79 percent (Lambrinos, 2002). Even if a plant covered several square meters, these data indicate that seed production easily exceeds our threshold of 5000 seeds per square meter. |
| ES-15 (Propagules likely to be dispersed unintentionally by people) | y - negl | 1 | "Rhizome fragments, severed during cultivation, tend to take root and establish new colonies wherever they are deposited. Grubbed crowns, carelessly dumped in tips and waste places, re-establish easily if moisture is available, and provide a potential seed source for future spread" (Parsons and Cuthbertson, 2001). It is believed that many, if not most, of the escapes from cultivation in California have occurred as a result of fragmentation of the parent plant (Bossard et al., 2000). Because this species is cultivated, it may be dispersed through garden waste that is dumped; however, a simulation study concluded that this method of spread is not as important for wind-dispersed species (Timmins et al., 2010). |
| ES-16 (Propagules likely to disperse in trade as contaminants or hitchhikers) | y - negl | 2 | *Cortaderia selloana* was grown commercially for its decorative plumes in the late 1800s in the United States (Lambrinos, 2001). Thus, seeds are highly likely to be associated with the plumes. Dried plumes of pampas grass (exact species is unknown) are available for sale on the internet (e.g., Anonymous, 2013a). The seeds cling to kiwi fruit destined for export (Knowles and Tombleson, 1987 cited in ISSG, 2013). |
| ES-17 (Number of natural dispersal vectors) | 1 | -2 | Seed and fruit description for ES-17a through ES-17e: Seeds are narrowly elliptical at about 0.6 mm by 2 mm (Parsons and Cuthbertson, 2001). |
| ES-17a (Wind dispersal) | y - negl | | Seeds are wind-dispersed (MPI, 2012; Saura-Mas and Lloret, 2005) and have been found at distances of up to 40 meters from isolated maternal plants (Saura-Mas and Lloret, 2005). "The seed-bearing florets of the female plant are particularly hairy and readily dispersed by wind, often being carried for up to 25 km. In contrast, the almost hairless florets from bisexual plants tend to fall close to the parent plant" (Parsons and Cuthbertson, 2001). Florets from female plants are more readily dispersed by wind than those from hermaphroditic plants (Connor, 1973). |
| ES-17b (Water dispersal) | n - low | | We found no evidence. Because this species is well characterized, we used low uncertainty. |
| ES-17c (Bird dispersal) | n - low | | We found no evidence. Because this species is well characterized, we used low uncertainty. |
| ES-17d (Animal external dispersal) | n - low | | We found no evidence. Because this species is well characterized, we used low uncertainty. |
| ES-17e (Animal internal | n - low | | We found no evidence. Because this species is well |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| dispersal) | | | characterized, we used low uncertainty. |
| ES-18 (Evidence that a persistent (>1yr) propagule bank (seed bank) is formed) | n - high | -1 | We found no evidence that seeds persist for more than a year. One report stated that seeds lack dormancy (cited in Lambrinos, 2002). A seed burial experiment with the congener *C. jubata* showed that all seeds lost their viability within four months. Given this evidence, we expect that *C. selloana* is unlikely to form a persistent seed bank. |
| ES-19 (Tolerates/benefits from mutilation, cultivation or fire) | y - low | 1 | In its native range, *C. selloana* is resilient to fire, recovering nearly all of its biomass within two years of a fire (Sirolli and Kalesnik, 2011). Rhizome fragments and the plant crown itself quickly reestablish if enough moisture is available (Parsons and Cuthbertson, 2001). |
| ES-20 (Is resistant to some herbicides or has the potential to become resistant) | n - negl | 0 | *Cortaderia selloana* exhibits some tolerance (vs. resistance) to certain herbicides used in nursery operations to treat container and field weeds associated with it (Neal and Senesac, 1991). Herbicide trials targeting *C. selloana* did not identify any resistance or tolerance (Rolando et al., 2011). "Various herbicides can be used to treat pampas infestations successfully" (Gosling et al., 2000). This species is not listed by Heap (2013) as being herbicide resistant. |
| ES-21 (Number of cold hardiness zones suitable for its survival) | 6 | 0 | |
| ES-22 (Number of climate types suitable for its survival) | 6 | 2 | |
| ES-23 (Number of precipitation bands suitable for its survival) | 10 | 1 | |
| **IMPACT POTENTIAL** | | | |
| **General Impacts** | | | |
| Imp-G1 (Allelopathic) | n - mod | 0 | One laboratory study reported that aqueous extracts weakly inhibited germination and radicle growth of *Lactuca sativa* (Chou and Young, 1975). Because *C. selloana* is well studied and we found no other evidence of allelopathy, we answered no with moderate uncertainty. We generally do not consider laboratory evidence of allelopathy to be very strong or conclusive because laboratory evidence of allelopathy often does not reflect real-world conditions. |
| Imp-G2 (Parasitic) | n - negl | 0 | We found no affirmative evidence that this species is parasitic. Because it is not a member of one of the plant families known to contain parasitic species (Heide-Jorgensen, 2008; Nickrent, 2009), we used negligible uncertainty. |
| **Impacts to Natural Systems** | | | |
| Imp-N1 (Change ecosystem processes and parameters that affect other species) | y - negl | 0.4 | In Spanish pastures, *C. selloana* significantly reduces soil nitrogen and increases the C/N ratio underneath itself, relative to plots at least four meters away from plants (Domènech et al., 2006). Cover of nitrogen-fixing species between invaded and non-invaded sites was significantly different (Domènech et al., 2006). "It also produces large amounts of highly flammable material, seriously increasing the fire risk" (Parsons and Cuthbertson, 2001). It presents a fire hazard due to the buildup of dried leaves, flowering stalks, and leaf bases (Bossard et al., 2000). |
| Imp-N2 (Change community | y - negl | 0.2 | In invaded sites, it changes the relative frequencies of plant |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| structure) | | | growth forms, reduces total plant cover, and increases the total height of plant communities (Domènech et al., 2006). Forms extensive monospecific stands in coastal sage scrub drainages and riparian areas in California (Vourlitis and Kroon, 2013). |
| Imp-N3 (Change community composition) | y - negl | 0.2 | In invaded sites, species richness and diversity are significantly lower than in uninvaded sites (Domènech et al., 2006). Excludes plants through shading and root competition: the root system of a single plant is estimated to occupy 103 cubic meters of soil (Parsons and Cuthbertson, 2001). It "replaces natural plant communities" (Parsons and Cuthbertson, 2001). Competes with native plants (Bossard et al., 2000). "Displaces native plant communities in coastal habitats" in California (Motooka et al., 2003). "It becomes dense and can suppress the growth of other species. Replaces ground cover, shrubs, and ferns" (MPI, 2012). Competes with and replaces native plants in South Africa (Wells et al., 1986). In some communities, it may be replaced slowly by native species (Gosling et al., 2000). |
| Imp-N4 (Is it likely to affect federal Threatened and Endangered species) | y - low | 0.1 | This "species has become a major conservation concern [in Spain] because its invasion of old fields prevents their restoration back to wetlands where some rare or endemic species occur" (Pausas et al., 2006). Furthermore, given the impacts to community composition and structure described under Imp-N3 and Imp-N2, *C. selloana* seems likely to pose a threat to Threatened and Endangered species. |
| Imp-N5 (Is it likely to affect any globally outstanding ecoregions) | y - negl | 0.1 | This species has already invaded globally outstanding ecoregions in the United States, particularly in California (Bossard et al., 2000; Ricketts et al., 1999). In California, it is negatively affecting coastal communities, which are generally regarded as sensitive (Bossard et al., 2000; Vourlitis and Kroon, 2013). |
| Imp-N6 (Weed status in natural systems) | c - negl | 0.6 | *Cortaderia selloana* is a natural areas weed in South Africa (Wells et al., 1986). It naturalizes along stream banks, edges of mangroves, forest trails, and seasonably wet habitats (Henderson, 2001; Parsons and Cuthbertson, 2001). This taxon is an increasing problem in wet schlerophyll forest in Australia and a serious weed in forested areas of the Auckland Conservancy in New Zealand (Parsons and Cuthbertson, 2001). Plants are targeted for eradication when they appear on New Zealand Islands (Beauchamp and Ward, 2011; Timmins and Braithwaite, 2002). It is prioritized for sustained control on Rangitoto Island, New Zealand (Wotherspoon and Wotherspoon, 2002), and. managed in natural areas in Spain (Andreu et al., 2009) and New Zealand (Popay et al., 2003). Gosling et al. (2000) reviewed control strategies for this species and *C. jubata* in natural areas. Alternate answers for the Monte Carlo simulation were both "b." |
| **Impact to Anthropogenic Systems (cities, suburbs, roadways)** | | | |
| Imp-A1 (Impacts human property, processes, civilization, or safety) | y - high | 0.1 | Several negative comments about *C. selloana* have been posted on Dave's Garden forum, including the following: "It was at least 12' tall last summer and taking over the yard like a cancer. It left a carpet of white fuzz in my front and back |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| | | | yards and clogged my pool filter. I was forced to remove it because it was growing into and breaking a sprinkler head" (Dave's Garden, 2013). "If it is planted in front of or beside an AC unit, beware--once the plant is big enough its leaves may be sucked in by the fan's turbines causing serious damage or, as was the case with two of my neighbors, complete destruction beyond repair" (Dave's Garden, 2013). We answered yes, but used high uncertainty because we didn't find more support for this impact. |
| Imp-A2 (Changes or limits recreational use of an area) | y - low | 0.1 | "Invasion of forest roads, walking tracks, landscapes and foreshores reducing recreational and aesthetic values" (Parsons and Cuthbertson, 2001). Reduces aesthetic and recreational value of conservation areas (Bossard et al., 2000). |
| Imp-A3 (Outcompetes, replaces, or otherwise affects desirable plants and vegetation) | n - mod | 0 | On the Dave's Garden forum, 7 of 21 commenters rated this species negatively, but only one of these indicated it negatively affected desirable plants. This person said they had to have this plant removed because it was encroaching on their asparagus bed (Dave's Garden, 2013). We answered no with moderate uncertainty because we didn’t find multiple accounts of this type of impact. |
| Imp-A4 (Weed status in anthropogenic systems) | b - high | 0.1 | *Cortaderia selloana* naturalizes in disturbed areas such as pipeline cuts, roads, and waste places in Australia (Parsons and Cuthbertson, 2001). An "increasing problem in urban bushland in Australia" (Parsons and Cuthbertson, 2001). Several negative posts on the Dave's Garden forum indicate that many people consider this species a weed (Dave's Garden, 2013). Two commenters note that windblown fluff produced by the plants (the seeds) clog their pool filters and stick to some of their garden plants. Others note that the serrated leaves are very sharp and will easily cut human skin, while others complained about the allergies the plants induce (Dave's Garden, 2013). Two of the commenters note that they had the plants removed from their yards (Dave's Garden, 2013). Although we found enough evidence to rate this plant a weed of anthropogenic areas, we did not answer “c” because the amount of evidence documenting control in anthropogenic areas was not strong enough. However, we used high uncertainty and chose “c” for our alternate answers for the Monte Carlo simulation. |
| **Impact to Production Systems (agriculture, nurseries, forest plantations, orchards, etc.)** | | | |
| Imp-P1 (Reduces crop/product yield) | y - low | 0.4 | Large populations of *C. selloana* reduce forest growth (Parsons and Cuthbertson, 2001). In one field experiment, *C. selloana* reduced stem volume in a newly established *Pinus radiata* plantation by up 76 percent and resulted in 9 percent tree mortality (Richardson et al., 1996). |
| Imp-P2 (Lowers commodity value) | y - negl | 0.2 | Heavy infestations block access to forest plantations (Bossard et al., 2000). "In grazing studies with sheep and goats *C. selloana* was rarely eaten, and it was the least preferred forage among several alternative species" (cited in Lambrinos, 2006); thereby lowering the grazing value of the land. Results from one study indicated that pampas grass utilizes fertilizer intended to improve tree productivity in *Pinus radiata* forests (Gadgil et al., 1992). Control of *Cortaderia* spp. weeds in |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| | | | New Zealand forest plantations with herbicides is costly and only provides a temporary solution (Knowles, 1991). |
| Imp-P3 (Is it likely to impact trade) | y - negl | 0.2 | This species is a regulated quarantine pest in Australia and prohibited entry (Parsons and Cuthbertson, 2001). This species is listed in New Zealand's National Pest Plant Accord and accordingly is banned from sale, propagation, and distribution in the country (MPI, 2012). Regulated weed in South Africa, where it must be controlled or eradicated where possible (Henderson, 2001). Because plumes are commercially used and sold in dried floral arrangements (e.g., Anonymous, 2013a), it may impact trade. "Also the great quantity of fluffy seed has caused problems for kiwifruit growers since it clings to the fruit and causes it to be rejected for export" (Knowles and Tombleson, 1987 cited in ISSG, 2013). |
| Imp-P4 (Reduces the quality or availability of irrigation, or strongly competes with plants for water) | n - mod | 0 | We found no evidence. |
| Imp-P5 (Toxic to animals, including livestock/range animals and poultry) | n - low | 0 | Although this species may not be preferred by grazers (cited in Lambrinos, 2006), we found no evidence it is toxic to animals (e.g., Burrows and Tyrl, 2001). |
| Imp-P6 (Weed status in production systems) | c - negl | 0.6 | It is invading pastures in coastal areas of Catalonia, Spain (Domènech et al., 2006). "[I]t has become a very serious and increasing problem in many of the commercial pine plantations of the North Island of New Zealand" and in Australia (Parsons and Cuthbertson, 2001). New Zealand plantation forest researchers have conducted herbicide trials to identify herbicides that are effective against *C. selloana* and still satisfy international requirements for sustainably managed forests (Rolando et al., 2011). Herbicides are applied to plantations before, during, and immediately after planting of pine trees (Rolando et al., 2011). Cattle and herbicides are used to control *C. jubata* and *C. selloana* in New Zealand forest plantations (Knowles, 1991; West and Dean, 1990). If cattle are used, managers must supplement the cattle with more nutritional forage (Knowles, 1991). 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, 2013). |
| **Plant cold hardiness zones** | | | |
| Geo-Z1 (Zone 1) | n - negl | N/A | We found no evidence that it occurs in this zone. |
| Geo-Z2 (Zone 2) | n - negl | N/A | We found no evidence that it occurs in this zone. |
| Geo-Z3 (Zone 3) | n - negl | N/A | We found no evidence that it occurs in this zone. |
| Geo-Z4 (Zone 4) | n - negl | N/A | We found no evidence that it occurs in this zone. |
| Geo-Z5 (Zone 5) | n - low | N/A | One point in a mountainous region of Argentina, but this is likely an artifact of data interpolation or misidentification as no other evidence that indicates this species can occur in this zone. |
| Geo-Z6 (Zone 6) | y - high | N/A | One point in a mountainous region of Argentina, but this may be an artifact of data interpolation or a misidentification as no other evidence indicates this species can occur in this zone. |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| | | | One commenter on the Dave's Garden forum said they grew this plant in Zone 6a in Connecticut (Dave's Garden, 2013). Two other horticultural sources indicated some cultivars of this species is hardy to Zone 6 (Page and Olds, 2001; Wade, 2012). We answered yes with high uncertainty, but believe that plants in this zone may only be able to survive under human cultivation. |
| Geo-Z7 (Zone 7) | y - high | N/A | A few points in a mountainous region of Argentina. Two points near the edge of this zone in New Zealand. This plant is reported to be hardy to Zone 7 (Dave's Garden, 2013). |
| Geo-Z8 (Zone 8) | y - negl | N/A | The United Kingdom, France, New Zealand, and the United States (Washington). |
| Geo-Z9 (Zone 9) | y - negl | N/A | Argentina, Australia, New Zealand, the United Kingdom, and United States (California). |
| Geo-Z10 (Zone 10) | y - negl | N/A | Argentina, Australia, New Zealand, the United Kingdom, and the United States (California). It tolerates winter frost (Domènech et al., 2006). |
| Geo-Z11 (Zone 11) | y - negl | N/A | Australia, Guatemala, and the United States (California). |
| Geo-Z12 (Zone 12) | y - high | N/A | A couple of points in Central America. In the United States, there is one non-georeferenced occurrence for a residential area in Kula (Oahu, Hawaii; GBIF, 2013). This species is cultivated on Oahu and Maui in Hawaii (Anonymous, 2013b). Because these last two occurrences are not point occurrences, and because of the granularity of our climatic data for these islands where climate is heavily influenced by elevation and rain shadows, it is very difficult to determine which hardiness zones correspond to these occurrences. Consequently, we answered yes but with high uncertainty for this zone. |
| Geo-Z13 (Zone 13) | y - high | N/A | There were also three occurrences reported for San Jose, Costa Rica (GBIF, 2013). In the United States, grown at the Waimea Arboretum & Botanical Garden on Oahu, Hawaii (GBIF, 2013). We used high uncertainty because not only is this evidence weak, but because elevation and cultivation by people may be affecting its ability to survive in this zone. |
| **Köppen-Geiger climate classes** | | | |
| Geo-C1 (Tropical rainforest) | y - high | N/A | One point in Mexico. In the United States, this species is cultivated on Oahu and Maui in Hawaii (GBIF, 2013), which include this climate class. Using high uncertainty because of the limited amount of evidence and because these may represent misidentifications. |
| Geo-C2 (Tropical savanna) | y - high | N/A | A couple of points near edge with steppe in Bolivia. One point in Honduras and Costa Rica each. Using high uncertainty because of the limited amount of evidence and because these may represent misidentifications. |
| Geo-C3 (Steppe) | y - negl | N/A | Argentina, Bolivia, Spain, and a couple of points in the United States. |
| Geo-C4 (Desert) | y - high | N/A | Three points on edge in Spain. Four points in Argentina. Two points near edge with steppe in the United States. |
| Geo-C5 (Mediterranean) | y - negl | N/A | Australia, Chile, Spain, and the United States (California). |
| Geo-C6 (Humid subtropical) | y - negl | N/A | Argentina, Australia, Brazil, United States (Georgia, South Carolina). |
| Geo-C7 (Marine west coast) | y - negl | N/A | Argentina, Australia, France, New Zealand, and the United Kingdom. |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
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| Geo-C8 (Humid cont. warm sum.) | y - high | N/A | Reported to grow in the United States in Kansas, Ohio, Indiana, and Iowa, which occur primarily in this class (Dave's Garden, 2013). We used high uncertainty because these plants may only be able to survive under cultivated conditions. |
| Geo-C9 (Humid cont. cool sum.) | n - negl | N/A | We found no evidence that it occurs in this climate class. |
| Geo-C10 (Subarctic) | n - negl | N/A | We found no evidence that it occurs in this climate class. |
| Geo-C11 (Tundra) | n - negl | N/A | We found no evidence that it occurs in this climate class. |
| Geo-C12 (Icecap) | n - negl | N/A | We found no evidence that it occurs in this climate class. |
| **10-inch precipitation bands** | | | |
| Geo-R1 (0-10 inches; 0-25 cm) | n - high | N/A | Two points in Argentina. We answered no because we didn't find strong evidence that it could occur in this band. If it did occur, it would likely be in protected microhabitats and possibly associated with human habitation. |
| Geo-R2 (10-20 inches; 25-51 cm) | y - low | N/A | Argentina, Spain, and the United States. |
| Geo-R3 (20-30 inches; 51-76 cm) | y - negl | N/A | Australia, Spain, and the United Kingdom. Occurs in areas of Spain receiving an average annual precipitation of 739 mm (Domènech et al., 2006). |
| Geo-R4 (30-40 inches; 76-102 cm) | y - negl | N/A | Australia, France, and the United Kingdom. |
| Geo-R5 (40-50 inches; 102-127 cm) | y - negl | N/A | Australia, New Zealand, and the United Kingdom. |
| Geo-R6 (50-60 inches; 127-152 cm) | y - low | N/A | New Zealand, United Kingdom, and the United States (SC, GA). |
| Geo-R7 (60-70 inches; 152-178 cm) | y - mod | N/A | A few points in Chile, New Zealand, and the United Kingdom. |
| Geo-R8 (70-80 inches; 178-203 cm) | y - mod | N/A | We found no specific evidence that it occurs in this precipitation band, but we answered yes because it occurs in wetter and drier bands. |
| Geo-R9 (80-90 inches; 203-229 cm) | y - mod | N/A | We found no specific evidence that it occurs in this precipitation band, but we answered yes because it occurs in wetter and drier bands. |
| Geo-R10 (90-100 inches; 229-254 cm) | y - mod | N/A | Two points in New Zealand. |
| Geo-R11 (100+ inches; 254+ cm)) | y - mod | N/A | Two points in Chile. |
| **ENTRY POTENTIAL** | | | |
| Ent-1 (Plant already here) | y - negl | 1 | This species is cultivated and naturalized in the United States (Jepson Flora Project, 2013; Lambrinos, 2001; Okada et al., 2007). |
| Ent-2 (Plant proposed for entry, or entry is imminent ) | - | N/A | |
| Ent-3 (Human value & cultivation/trade status) | - | N/A | Introduced as a fodder grass to New Zealand (Parsons and Cuthbertson, 2001). "Major dispersal however, has always been by man in the course of trade" (Okada et al., 2007; Parsons and Cuthbertson, 2001). |
| Ent-4 (Entry as a contaminant) | | | |
| Ent-4a (Plant present in Canada, Mexico, Central America, the Caribbean or China ) | - | N/A | |

| Question ID | Answer - Uncertainty | Score | Notes (and references) |
|---|---|---|---|
| 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 | |