DRAFT: WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
DRAFT August 2014

Scientific name: *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn.

Synonyms: *Arundo selloana* Schult. & Schult. f., *Cortaderia argentea* (Nees) Stapf, Cortaderia dioica (Spreng.) Speg., Arundo dioica Spreng., Gynerium argenteum Nees, Gynerium purpureum Carrière, Moorea argentea (Nees) Lem.

Common name: pampas grass, Uruguayan pampas grass

Family: Poaceae

Legal Status: Proposed Class C noxious weed

Images of *Cortaderia selloana*, left: mature plant in bloom, image credit John Ruter, University of Georgia, Bugwood.org; center left: Inflorescences in bloom; center right, close up of female inflorescence; right, leaves and sheaths, last three images by Joseph M. DiTomaso, University of California - Davis, Bugwood.org.

Description and Variation:

Overall Habit:

Cortaderia selloana, commonly called pampas grass, is a large perennial grass that grows in clumps called tussocks. Basal clumps of long, narrow leaves have sharp edges and grow to around 4 feet tall, and upright stems grow out of the tussock, up to 6 to 13 feet. Plumes of flowers bloom at stem tips, ranging in color from white, silver, cream, pink to violet. Plants either have all female flowers or all hermaphroditic flowers. The hermaphroditic flowers function primarily as a pollen source, and so are often referred to as male flowers. Female plants need to be pollinated by hermaphroditic plants to produce seed. After seeds develop and spread, stems with old flowers remain through the winter.

Roots:

Plants have dense fibrous roots that grow from shallow, short lateral rhizomes (DiTomaso et al. 2013). Lateral roots can spread to 13.2 feet (4 meters) in diameter and 11.5 feet (3.5 meters) deep (Domènech

et al. 2006), though old plants can have rhizomes spreading 19.7 feet (6 meters) or more in diameter (DiTomaso and Healy 2007).

Stems:
Stems, called culms, are stiff and grow to 6.6 to 13.1 feet (2 to 4 m) tall. The culms are usually 2 to 4 times as long as the inflorescence (Allred 2003) and are equal to or slightly longer than the tussock (Bossard et al. 2000).

Leaves:
Leaves are evergreen and form a rounded tussock (Grounds 1998). Leaf blades are up to 6.6 feet (2 m) long and have a prominent midrib. Leaf widths are noted as 1-3 inches (3-8 cm) wide (Bossard et al. 2000) or much thinner at 3 to 12 mm wide (Smith 2013). Leaf margins have sharp retrorse teeth, which readily cut skin. Leaves are bluish-green, their upper surfaces glabrous at base and their lower surfaces glabrous or hair toward the collar (Bossard et al. 2000). Leaf sheaths are variable in their hairiness and the ligules consists of a dense ring of hairs (0.08 to 0.12 inches long) (Smith 2013).

Flowers:
Cortaderia selloana inflorescence is a panicle, commonly referred to as a plume or plume-like, and ranges in length from 1 to 3 feet, occasionally to 4 feet, long (30 to 130 cm) (Bossard et al. 2000). Plants have a gynodioecious to near dioecious (or subdioecious) breeding system (Connor 1973, Costas-Lippmann 1976 in Ahmad et al. 2006). Plants are either female or are hermaphroditic (flowers with pistils and stamens), with the hermaphroditic flowers being almost entirely self-incompatible and functionally male (Connor 1973). Because they are functionally male, many sources refer to them as male flowers or male plants.

Panicles can be a variety of colors, from ivory, cream, white, or pink-flecked to pink and violet (Connor and Edgar 1974). Violet panicles are common in hermaphrodites because of anther color, but females can also be violet (Connor and Edgar 1974). Panicles of hermaphroditic plants begin emergence and anthesis earlier in the season than those of female plants, but this difference may only be 5-10 days, so there is plenty of overlap in flowering for the hermaphroditic flowers to pollinate the female flowers (Connor 1973). Pollen is dispersed by the wind.

The following flower and fruit information, unless otherwise cited, is from Connor (1973).
Panicles of female flowers:
Panicles have numerous spikelets, 0.6 inches (15 to 17 mm) long, with, on average, six florets per spikelet-- significantly more florets per spikelet than hermaphrodites. Florets are 0.16 to 0.3 inches (4 to 8 mm) long, while glumes are white or membranous, lemma have long hairs, and awns are 0.1 to 0.2 inches (2.5 to 5 mm) long (Bossard et al. 2000). Female flowers have flat, white or transparent, sterile anthers and larger gynoecia (pistils) than hermaphroditic flowers.

Panicles of hermaphroditic flowers
As noted above, hermaphroditic plants are effectively self-incompatible and do not yield much germinable seed from open-pollination, so they act primarily as a pollen source and are often referred to as male flowers (Connor 1973, Costas-Lippmann 1976 in Okada et al. 2007). On average, hermaphroditic flowers have three florets per spikelet. Florets have large pollen-filled anthers and small gynoecia. While the lemmas of female flowers have abundant long hairs, hermaphroditic lemmas are glabrous or only slightly hairy. Hermaphroditic plumes may be confused with plumes of *Cortaderia jubata* (DiTomaso and Healy 2007).

Fruits:
The fruit is a caryopsis (a dry, one-seeded fruit), 1 to 3mm in size. The estimated mean number of seeds produced per plant, counted from escaped *C. selloana* plants on the Iberian Peninsula, was 416,399, ranging from 54,567 to 840,905 per plant (Saura-Mas and Lloret 2005).

Connor (1973) measured the relative fertility of the two types of flowers. Under open pollination, female flowers had a mean seed set of 98.69 (+/- 0.22) per 100 florets and a mean germination rate of 46.2% (+/- 9.06%). From hermaphrodites, mean seed set was just 47.32 (+/- 3.16) and mean germination rate was only 6.0% (+/- 3.02%). It was also noted that offspring from open-pollinated female plants were always conspicuously more vigorous than the offspring from the hermaphroditic plants. The contribution made to the whole population by progenies from hermaphrodites is estimated at less than 5 percent of that made by female plants. The net effect is that hermaphrodites act for the greater part as pollen parents only, with their contribution of seeds likely to be very small.

Seeds are wind-dispersed. The long hairs on the lemmas of the female plants appear directly related to its ability to be well-dispersed by the wind. Seed-bearing florets from hermaphrodites tend to fall directly to the ground and dispersal is very restricted, except in strong winds.

Cultivars:
In the horticultural trade, to maintain cultivar identity, plants are propagated through division or tissue culture (Robacker and Corley 1992). Female flowers of *Cortaderia selloana* are the showiest and so most named cultivars are female (Grounds 1998). In addition to female cultivars propagated by division or tissue culture, a few cultivars and most named selections are propagated by seed and consist of both types of flowers (Okada et al. 2007). Cultivars of *C. selloana* would be included in the Class C noxious weed listing.

There are a number of *Cortaderia selloana* cultivars in the horticultural trade, which include:

- *Cortaderia selloana* 'Pumila' is one of the smallest cultivars and probably produces the most plumes. The white to silvery-yellow plumes grow to 1.5m (5 ft), which is about twice the height of the leaf tussock (Grounds 1998, Brickell and Zuk 1997).
- *C. selloana* 'Monstrosa' is probably the tallest of the cultivated clones with plumes which are perhaps the whitest in the group, growing to 3m (10ft), though the leaf tussock is only 1.2m (4ft) tall (Grounds 1998).
- *C. selloana* 'Sunningdale Silver' is an old variety. It has full plumes and stout stems that are notably sturdy and wind resistant. Its silvery-white plumes grow to 10 ft (3m) or more with an overall width to 8 ft. (2.5m) (Grounds 1998, Brickell and Zuk 1997).
- *C. selloana* 'Carminea Rendatleri' is a tall variety, to 3m (10 ft.), having plumes that are pink flushed purple (Grounds 1998).
- *C. selloana* 'Carnea' produces shorter stems with paler pink plumes (Grounds 1998).
- *C. selloana* 'Rosea' and 'Roi des Roses' are not really pink but have plumes that are basically white with a pink flush (Grounds 1998).
- *C. selloana* 'Violacea' has violet tinted plumes (Grounds 1998).
- *C. selloana* 'Albolineata' (syn. 'Silver Stripe') is slow-growing and compact, with white-margined leaves and silvery-white plumes to 6 feet (2 m) tall (Brickell and Zuk 1997).
- *C. selloana* 'Aureolineata' (syn. 'Gold Band') has yellow-margined leaves, aging to dark golden yellow, growing to 7feet (2.2m) tall (Brickell and Zuk 1997).

- *C. selloana* 'Rendatleri' has purplish pink panicles. Both its height and width are up to 8 feet (2.5m) (Brickell and Zuk 1997).
- *C. selloana* 'Rosea' (syn. 'Rosa Feder') produces lightly pink-tinted panicles (Brickell and Zuk 1997).

Look-alikes:

Another *Cortaderia* species, *Cortaderia jubata*, jubata grass, also called pampas grass, looks very similar to *C. selloana* and the two species can be difficult to tell apart, especially when young or not in flower. *Cortaderia jubata* is also being considered for a 2015 Class C noxious weed listing (see *Cortaderia jubata* written findings for a detailed description). *Cortaderia selloana* tussocks typically grow larger than *Cortaderia jubata* and have a more fountain-like appearance (DiTomaso et al. 2013). The "Grass Manual of the Flora of North America" (Allred 2003) separates the two species in a dichotomous key as follows:

> 1a: Sheaths hairy; panicles elevated well above the foliage; culms 4-5 times as long as the panicles . . . *C. jubata*
>
> 1b: Sheaths glabrous or sparsely hairy; panicles elevated only slightly, if at all, above the foliage; culms 2-4 times as long as the panicles . . . *C. selloana*

Left, *Cortaderia jubata* plant habit, image: John M. Randall, The Nature Conservancy, Bugwood.org; center, leaf sheath hairs; right, *C. jubata* infestation in California, center and right images: Joseph M. DiTomaso, University of California - Davis, Bugwood.org.

Another species that is somewhat similar in appearance to *Cortaderia selloana* is Ravenna grass, *Saccharum ravennae*, a species that is being considered for a 2015 Class A noxious weed listing. *Saccharum ravennae* appears to have a limited distribution in Washington State, with escaped plants known to exist in Benton County, around the cities of Richland and Kennewick and a few escaped plants in Yakima and Franklin Counties. *Saccharum ravennae* can be purchased online so it may also be found in planted landscapes. *Saccharum ravennae* is also a tussock forming grass with tall stems having inflorescences at the tips but does have traits that differentiate it from *C. selloana* including:

- Shorter leaves on the flowering stems that occur up to the base of the inflorescence
- Flowering stems have a reddish coloring
- Leaves with serrated edges that are not as sharp or cutting as *C. selloana*
- Hairs at the base of the leaves that are on the top of the leaf blade

(See written findings for Ravenna grass, *Saccharum ravennae* for more information).

Images of *Saccharum ravennae*, Ravenna grass. Left, plant in September with blooming flowers; center, leaf sheath and base of sheath showing hairs; right, red coloring on flowering stems, all images WSNWCB.

Habitat:

Cortaderia selloana can invade a wide variety of habitats, including disturbed and undisturbed areas (Domènech and Vilà 2007). Disturbed habitats where it grows include abandoned farmlands, pastures, roadsides, shrublands road-cuts and logged forests. Undisturbed habitats where it grows include coastal shrub and grasslands (including serpentine soils), coastal sand dunes, bluffs, marshes and wetlands, inland riparian areas, and shrublands. It can grow in other interior sites (away from the coast) where sufficient moisture is available (DiTomaso and Healy 2007, Domènech et al. 2006). As found in their native habitats, plants can tolerate standing water for prolonged periods (DiTomaso and Healy 2007).

DiTomaso and Healy (2007) note that bare, sandy soil is the most favorable type for seedling establishment though Domènech and Vilà (2007) found the percentage of sand in the soil does not influence its presence. Research also found that seedling survival and establishment are enhanced by soil disturbances (Domènech and Vilà 2006).

Geographic Distribution:

Worldwide, *Cortaderia selloana* has naturalized in many countries:

- Africa - Portugal (Azores, Madeira Islands), Spain (Canary Islands), Libya, Tunisia, South Africa (Eastern Cape, Gauteng, KwaZulu-Natal, Mpumalanga, Western Cape), Reunion
- Asia – Azerbaijan, Georgia
- Australia – New South Wales, Queensland, South Australia, Tasmania, Victoria
- New Zealand
- Europe – United Kingdom, Italy (Sardinia), Slovenia, France (including Corsica), Portugal, Spain
- South America – Chile (Juan Fernandez)

(USDA ARS 2014).

Native Distribution:

Cortaderia selloana is native to the lowlands of Argentina, Brazil and Uruguay, where it grows in damp soils along river margins and in poorly drained depressions (Lambrinos 2004, and Connor and Charlesworth 1989 in Bossard et al. 2000). Part of the year the crown of the plant is under water while the rest of the year the plant is stressed by drought (Madison 1992).

Distribution in North America:

In the United States, USDA ARS (2014) documents *C. selloana* being naturalized in: Hawaii, Washington, Oregon, California, Arizona, New Mexico, Alabama, Georgia, Louisiana and South Carolina. USDA NRCS' PLANTS Database (2014) further documents it in Utah, Texas, Louisiana, Tennessee, Virginia and New Jersey. EDDMapS (2014) provides county distribution of *C. selloana* and further documents plants in Florida, North Carolina and Rhode Island. Also, volunteer plants are reported online as growing around some planted *C. selloana* plants in Philadelphia, most notably sheltered by a freeway on-ramp (Gendler n.d.).

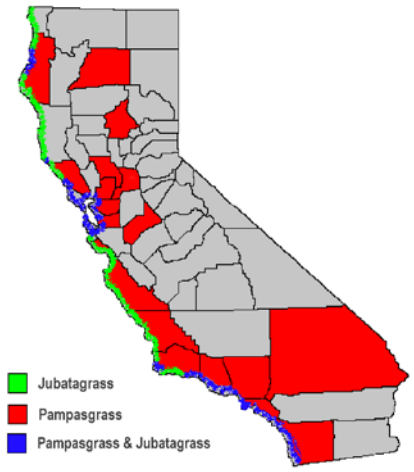
Herbarium records also document *C. selloana* on Vancouver Island in British Columbia (Marr KM7463, Consortium of PNW Herbaria 2014).

Maps: Left, EDDMapS (2014) county distribution map of *Cortaderia selloana*; Right, map of herbarium collections of *C. selloana* in Washington, Oregon and British Columbia (Consortium of Pacific Northwest Herbaria 2014).

Infestations of *C. selloana* in the United State are most notable in California, where it is used as an ornamental throughout the state and has formed infestations in coastal ecosystems and spread into some interior areas. *Cortaderia selloana* was first introduced to California in 1848 and commercial production began in 1874 (in both California and Europe) (Bossard et al. 2000). Joseph Sexton, a nurseryman in Santa Barbara grew plants for their plumes, selling them to be used as decorations for items including hats and parade floats (Lambrinos 2004, Madison 1992). He found that if he harvested the plumes just before they opened and placed them in the sun, they would expand and remain puffed out (Madison 1992). At the turn of the century, it came to be planted as a landscape ornamental, used in gardens and also as a hedge or windbreak (Madison 1992 and Hornback 1994 in Okada et al. 2007). It was also for a time (1940s-1950s) used for erosion control and in forage trials (Lemon and Taylor 1949, Hafenrichter 1950, Green and Cornelius 1957 in Okada et al. 2007).

The first herbarium record of naturalized *C. selloana* in California was collected in 1929. The specimen was collected near a pond in Mandeville Canyon, Los Angeles (Lambrinos 2001). Since then, *C. selloana* has spread from two foci in the San Francisco Bay Area and in southern California, moving up the deltas of the Sacramento and San Joaquin rivers as well as along the coast during the 1960s and 1970s (Lambrinos 2001). Over this time, herbarium collections of *C. selloana* have increasingly been of plants invading native plant communities or of large self-sustaining populations (Lambrinos 2004). Lambrinos (2004) points out

that there was an early perception that only *Cortaderia jubata* was invasive in California so was listed as a noxious weed and *C. selloana* was not invasive and it continued to be sold in nurseries.



Distribution map of *Cortaderia selloana* (in red), *C. jubata* (in green), and their overlap (in blue) in California (Okada and Jasieniuk 2013).

To gain a better understanding of the introduction of invasive *C. selloana* plants in California, Okada et al. (2007) conducted genetic testing of escaped and cultivated plants, including cultivars and selections, throughout the state. Landscape plantings of *C. selloana* were genetically determined to be the sources of escaped invasive plants. Cross-pollination within landscape planting or between closely spaced plantings can produce progeny that escape cultivation. Unnamed *Cortaderia selloana* selections are a major horticultural source of landscape plantings contributing to invasive populations. But as the authors point out, the unnamed selection may not be inherently invasive; it may rather reflect the selection's abundance in the landscape plantings in California. The planting of ornamental *C. selloana* is increasing the propagule pressure, which has the effect of increasing the probability of seeds finding suitable habitats for naturalization.

In Hawaii, Starr et al. (2003) report that *Cortaderia selloana* is used as a landscaping plant in cool mid-elevation urban areas. Plants have also naturalized, with infestations found in wet, dense native rainforest areas to high elevation arid habitat. It has been noted to be highly invasive on Maui. Both planted and naturalized plants are being removed (Starr et al. 2003).

Listings:

- *Cortaderia selloana* is on the European and Mediterranean Plant Protection Organization (EPPO)'s list of Alien Invasive Plants.
- In Australia, it is a prohibited pest plant whose propagation and supply is prohibited.
- New Zealand listed as a noxious weed, on their National Pest Plant Accord list, so sale and purchase is prohibited.
- Noxious weed in Tasmania (DiTomaso and Healy 2007).
- Starr et al. (2003) noted that efforts were being made to add *C. selloana* to the Hawaii State Noxious weed list, but it is currently (2014) not on their noxious weed list.
- New Mexico's Watch List
- California Invasive Plant Council Inventory as a species of 'High Invasiveness'

History and Distribution in Washington:

Cortaderia selloana and its cultivars have been planted in landscaped areas across the state. The first herbarium records of naturalized *C. selloana* in Washington are from Seattle, growing at the base of some boulders near Interstate 5, collected on October 30, 2000 (Zika 15618, WTU) and in Snohomish County near the Snohomish River on dry, disturbed ground collected on September 18, 2002 (Zika 17876 and F. Weinmann, WTU) (Zika and Jacobson 2005).

Other herbarium records have documented escaped plants in scattered locations in Washington, though primarily in western Washington (see map). In 2007, *Cortaderia selloana* and *C. jubata* were added to the WSNWCB's monitor list (grouped together as *Cortaderia* spp.) to track new and expanding naturalized

populations. There was concern about *C. selloana*'s ability to naturalize and spread in Washington given how it was naturalizing in California.

In the fall of 2013, the Thurston County Noxious Weed Control Board discovered a large infestation of *C. selloana* in Olympia, Washington that had established within the last couple of years (Thurston County NWCB 2013). Plant samples were collected and identified by Dr. David Giblin, Collections Manager of the UW Burke Herbarium and Dr. Sarah Spear Cooke, Restoration Ecologist and State Noxious Weed Control Board member and Dr. Rich Old, WSU weed identification specialist, as *Cortaderia selloana*. In total, 484 plants were mapped on site, in a variety of stages of growth, from seedlings to flowering and fruiting plants. County noxious weed board coordinators and land managers were alerted to the discovery of the escaped plants in Olympia and with their survey efforts, additional escaped plants where found in Tacoma, Bellingham and Grayland.

Twenty-one samples of *Cortaderia* plants from Washington were collected by the Thurston County Noxious Weed Board and tested by Jasieniuk and Karn (2014) to genetically determine which species were present at these locations in western Washington. Their microsatellite genotyping resulted in all Washington samples studied determined to be *Cortaderia selloana*. Testing showed that all 21 samples were from genetically distinct individuals, whereas *C. jubata* samples would have been identical. The high genetic diversity found in the Washington samples is characteristic of *C. selloana*, since it is an obligate, out-crosser (Jasieniuk and Karn 2014).

Left, infestation of seedlings and blooming pampas grass, *Cortaderia selloana* in Olympia Washington, image WSNWCB; right, infestation in Tacoma of naturalized seedlings, image by Rick Johnson, Thurston County NWCB.

Biology:

Growth and Development:

Seeds of *Cortaderia selloana* can germinate in a wide range of environmental conditions (Domènech and Vilà 2008, Lambrinos 2002). Seedlings generally establish in the spring (Bossard et al. 2000) and young plants typically begin to flower at an age of 2-3 years (DiTomaso and Healy 2007). Plants flower from late summer to early fall, but also occasionally in winter (DiTomaso and Healy 2007). Stems and flowers from the previous year are dingy tan and often remain standing for +/- 1 year (DiTomaso and Healy 2007). Individual plants are capable of surviving 15-20 years (DiTomaso and Healy 2007).

Once established, *C. selloana* plants can survive in a range of habitat conditions. *Cortaderia selloana* has the capacity for high morphological and physiological plasticity in response to variations in nitrogen and water availability (Vourlitis and Kroon 2013). Unlike *C. jubata*, *C. selloana* can tolerate winter frost; it also tolerates warmer summer temperatures, more intense sunlight, and moderate drought. (Bossard et al. 2000, Stanton and DiTomaso 2004). Factors studied from Stanton and DiTomas (2004) suggest that a combination of physiological and morphological traits allow *C. selloana* to be more invasive than *C. jubata*.

Stanton and DiTomaso (2004) discuss *Cortaderia selloana*'s adaptability to different environments may be due to its outbreeding system that results in greater genetic diversity. This diversity may contribute to its ability to invade a broader range of habitat and climates, allowing it to spread further inland and not be constrained to coastal environments like *C. jubata*. They found *C. selloana* to have a greater temperature tolerance, potentially contributing to its success as an ornamental as well as its invasive potential in inland California areas (Stanton and DiTomaso 2004).

Reproduction:
Plants naturally reproduce by seed, though in the horticulture industry plants are typically propagated by division of mature plants to retain specific cultivar characteristics. In recent years, some nurseries have propagated pampas grass from seed instead of by division (Bossard et al. 2000). Since it is impossible to distinguish hermaphroditic plants from female plants before they flower, the result is an increase in the proportion of hermaphroditic plants in the population, and consequently there has been an increase in the amount of viable seed produced (Bossard et al. 2000). For example, in New Zealand, selection for female plants has not been as rigorous. That has resulted in more seed being produced, and it has become a significant weed problem (McKinnon 1984 *in* Bossard et al. 2000).

Seedling establishment generally occurs in the spring and requires sandy soils, adequate moisture, and light (Bossard et al. 2000). Seed germination was found to be higher in sandy soil textures and decreased in soils which contained increased levels of clay (Domènech and Vilà 2008). Light requirements for seed germination though were found not to be very stringent by Domènech and Vilà (2008). In research studying temperature and salinity, seeds germinated at every temperature tested but did best at 25 C. Also, salinity did not prevent germination but it affected germination rate and vigor (Bacchetta et al. 2010). For seedlings, Bossard et al. (2000) note that seedling survival is low in shaded areas or in competition with grasses or sedges (Bossard et al. 2000).

Vegetative spread may occur when fragmented tillers receive adequate moisture and develop adventitious roots at the base of the shoot (Bossard et al. 2000). This was not noted in the literature to be a common occurrence but it is possible.

Seeds are very light and can be dispersed in the wind and by human activity (DiTomasto et al. 2013). Saura-Mas and Lloret's (2005) research on wind dispersal of seeds found wind-effected seed from 1 to 20 meters away from the sources, and there was no effect at distances greater than 20 meters. The distance from the source plant significantly reduced the number of seeds reaching the soil.

Control:
When working with *Cortaderia selloana*, it is important to protect yourself when handling the plants. Leaf edges of pampas grass are very sharp, so make sure to wear leather gloves and protective clothing.

Seed germination appears to be positively affected by soil disturbance (Domenech and Vilà 2006), so any control method that disturbs the soil could encourage seed germination. Plant or seed bare ground with native or non-invasive, non-native plants to provide competition (DiTomaso et al. 2013). Instead of planting *C. selloana* in ornamental plantings, use non-invasive alternatives, such as *Calamagrostis acutiflor*a 'Karl Foerster' or *Stipa gigantean*, giant needle grass.

Unless noted otherwise, control recommendations are from DiTomaso et al. (2013).

Mechanical Methods:
Cut and bag inflorescences prior to mechanical control to prevent spreading seed (Harradine 1991). Pulling or hand-grubbing seedlings can provide effective control. For larger plants, a Pulaski, mattock or shovel are the safest and most effective tools for removing established clumps. The entire crown and top section of the roots will need to be removed to prevent resprouting. A large chainsaw or weed eater can expose the base of the plant and allow for better access. DiTomaso et al. (2013) note that detached plants left lying on the soil surface may take root and reestablish under moist soil conditions. Some managers recommend turning the removed clump upside down so the roots dry out in the air and don't touch the soil. Also, monitor area for seedlings that may germinate after control has taken place.

Using volunteers to control *Cortaderia* species in California has been shown to be effective. Manual control performed by volunteers in remote places of California's Santa Cruz Mountains has been very successful (Moore 2000).

Excavation equipment has been used in New Zealand on plants and while effective, did damage surrounding desirable plants, so these tools may be better suited for use outside of sensitive habitats (Gosling et al. 2000).

If it isn't possible to remove all plants before flowers develop, consistently removing plumes before seed matures will help to prevent population expansion (Bossard et al. 2000, Harradine 1991). However, plants that have had plumes removed may develop more plumes during the flowering season. Bag and remove pulled plumes to prevent seed developing on site.

Cultural Methods:
Soil disturbance that creates bare ground can promote *Cortaderia* invasion, so it is important to minimize disturbance or provide competition to seedlings. Apply mulch to exposed bare ground to smother seeds and prevent germination. Also, planting or seeding desirable, non-invasive plants can provide competition to reduce germination and seedling establishment. Oversowing seeds of pasture species following logging or site preparation is commonly used to control weeds such as *Cortaderia* spp. in New Zealand plantation forests (Gosling et al. 2000).

Cortaderia selloana can resprout from burning (Bossard et al. 2000), so fire alone cannot be used to control infestations.

Biological Control:
There are no known biological controls for *Cortaderia selloana.* Grazing is not recommended for control in California as plants will resprout (DiTomaso et al. 1999), though cattle have been used in New Zealand and Australia to control populations (Harradine 1991). In New Zealand, cattle provided control if they were introduced at an early stage in tree rotation of plantation forests and grassed the stand three or four times per year (New Zealand Forest Service 1985 in Gosling et al. 2000) Grazing can be limited by a

number of factors including terrain, fencing, access to water and the availability of suitable livestock (Gosling et al. 2000).

Chemical methods:
A combination treatment of cutting or burning plants to remove the top growth and then treating the regrowth when it's about 7 to 8 inches (20 cm) tall with a systematic herbicide can be effective (Harradine 1991). This method can reduce the amount of herbicide used compared to using herbicide alone (DiTomaso et al. 1999).

The active ingredient glyphosate provides the most consistent control of *Cortaderia jubata* on plants of all sizes in fall and early summer. Treatments that can be used successfully are a broadcast spray at 2 to 3.3 qt product/acre (2.25 to 3.7 lb a.e./acre), a high-volume spray to wet treatment (2% v/v solution) or a low-volume (8 to 10% v/v solution of product) or a wiper treatment (33 to 50% of concentrated product).

Monitor sites as mature plants may resprout and need follow up control after their initial treatment (Gosling et al. 2000).

Currently herbicide treatment information on *Cortaderia selloana* is not available in the Pacific Northwest Weed Management handbook, but check back as information is continually updated. Contact your county noxious weed control board or weed district coordinator with questions.

Cortaderia selloana escaped plants growing in Grayland, Washington, image: Thurston County Noxious Weed Control Board.

Impacts:

Detrimental:
Infestations of both species can cause detrimental impacts such as crowding out native plants, altering wildlife habitat, reducing access to recreational areas and being a potential fire hazard (Lambrinos 2000 in Stanton and DiTomaso 2004, Herradine 1991). In Tasmania and New Zealand, *Cortaderia selloana* is widespread on public and private land, and is growing in several National, State and Coastal Parks (Williamson 1991 in Harradine 1991). New Zealand has documented *Cortaderia* species invading a wide range of sensitive habitats (Gosling et al. 2000). In California it is found crowding out native plant species in coastal ecosystems, particularly in sensitive coast dune areas (Hornback 1994, Bossard et al. 2000). Domènech et al. (2006) found mean species richness and diversity to be significantly higher in non-invaded areas compared to areas invaded with *C. selloana*. *Cortaderia* species also reduce the aesthetic and

recreational values of these areas. Hornback (1994) likened the infestations of *C. jubata* along the California coast to monotonous prairies of dun-colored plumes that look like old dishrags on sticks.

Cortaderia species can also cause negative economic impacts. It has been found, particularly in New Zealand, Tasmania and Australia, to be a problem in forestry plantations. (Bossard et al. 2000, Harradine 1991). On conifer plantations, controlling *C. selloana* during seedling establishment is necessary to increase the early survival and growth of seedlings which will maximize the timber yield (Rolando et al. 2011). When grown with *C. selloana*, conifer seedlings had reduced stem volume and a higher mortality rate compared to when grown alone or with other weeds. *Cortaderia selloana* reduced conifer seedling growth by restricting light availability to tree crowns (Richardson et al. 1996). Also, on older plantations, *C. selloana* increases fire hazards and impedes access for silviculture (Harradine 1991). The cost of controlling *Cortaderia* species on plantations can also be significant. It was estimated to increase silviculture tending costs by 144% in New Zealand, with control treatments which barely ensure tree survival, costing $NZ350 per hectare in 1983 (Gadcil et al. 1984 in Harradine 1991). In California there have also been costs for logging companies controlling *C. jubata* in their coastal logging operations (Hornback 1994).

Soil nutrient levels may also be altered by *Cortaderia selloana*. One study in Spain found a significant decrease in soil nitrogen of *C. selloana* invaded areas and the C/N ratio was also significantly different between invaded and uninvaded areas, being higher in invaded areas (Domènech et al. 2006).

Cortaderia species can also be painful plants to work around and handle. Their sharp, saw-toothed leaves can injury people (DiTomaso et al. 1999), quickly and easily cutting skin.

Beneficial:
Flower plumes were originally introduced to be used in fresh or dried flower arrangements. Plants are commonly used in landscapes/ornamental plantings as a statement plant due to its size. Many cultivars have been developed for ornamental purposes.

Rationale for Listing:
Cortaderia selloana is a nonnative species used in ornamental plantings in Washington and is a known invasive species in California and is escaped in Oregon. Last year, escaped populations of *C. selloana* were discovered in Washington State, with one infestation having almost 500 plants. Due to its apparent recent spread, its ability to crowd out desirable plant species and the range of conditions it can establish and survive, listing *C. selloana* as a Class C noxious weed will increase awareness about the invasiveness of this species as well as provide education on best management practices. Adding it to the state noxious weed list would also give county weed boards the option to require control where it is a growing problem.

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