WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
(November 1995)

Scientific Name: *Spartina alterniflora* Loisel.

Common Name: Smooth cordgrass

Family: Gramineae

Legal Status: Class B: (a) regions 1, 3, 4, 5, 6, 7, 9, 10
(b) region 2 except Padilla Bay of Skagit County
(c) region 8 except the bays and estuaries of Pacific County

Description and Variation: *Spartina alterniflora* is a rhizomatous perennial grass, 2 to 4 feet tall. Stems are hollow and hairless. Leaf blades are 1/4 to 3/5 inches wide. The leaves lack auricles and have ligules that consist of a fringe of hairs. Flowers are inconspicuous and borne in greatly congested spikes, 2 to 3 inches long (Hitchcock et al. 1969). The plant is deciduous; its stems die back at the end of each growing season (Ebasco Environmental 1992a).

In its native range, *Spartina alterniflora* exhibits varying growth forms in different salt marsh zones. A tall form occurs along creek banks and drainage channels. Landward of the tall form, an intermediate form occurs, which grades into a stunted form at the marsh interior (Smart 1982).

Spartina is a relatively small genus consisting of approximately 14 species, geographically centered along the east coast of North and South America, with outliers on the west coast of North America, Europe, and Tristan da Cunha. Members of the genus occur primarily in wetlands, especially estuaries (Partridge 1987). However, no *Spartina* species are native to the intertidal zone in Washington (Ebasco Environmental 1992a).

Economic Importance: *Beneficial*: In its native habitat, *Spartina alterniflora* is valued (Simenstad and Thom 1995; Landin 1991). The species is highly productive, exporting approximately 1300 g/m^2 of detritus annually to the estuarine system (Landin 1991). *S. alterniflora* is also highly regarded for erosion control, as well as fish and wildlife values in its native range (Simenstad and Thom 1995). In these native habitats, some waterfowl and wetland mammals eat the roots and shoots of this plant. In addition, stands of *S. alterniflora* can serve as a nursery area for mangroves, and estuarine fishes and shellfishes.

Because of their ability to trap sediment, *Spartina* species have been planted in many parts of the world for estuary reclamation (Partridge 1987). While *S. anglica* has been used more commonly for this purpose, *S. alterniflora* has been planted in some areas, such as the North Island of New Zealand (Partridge 1987).

In Pacific Northwest estuaries, species that are able to utilize *S. alterniflora* marshes could benefit from the expansion of this species. For example, juvenile chinook salmon have an affinity for salt marsh habitat, so they may benefit from the spread of salt marsh vegetation (Simenstad and Thom 1995).

There are also some economically beneficial uses for *Spartina alterniflora.* The species is palatable to livestock, so the plant's continued spread may increase available pasture. Efforts have also been made to use *S. alterniflora* in paper production (Ebasco Environmental 1993).

Detrimental: Some of the very traits that make *Spartina alterniflora* valued in its native habitat are the greatest cause for concern in Washington. To understand the different east/west perspectives on the values of *Spartina*, it is important to recognize that Atlantic/Gulf coast estuaries are fundamentally different than their Pacific Coast counterparts. The Pacific Coast is macrotidal, while the Atlantic/Gulf coasts are microtidal (Simenstad and Thom 1995). In addition, the Pacific Coast is more geologically active, and tectonic activity has a much greater influence on coastal marsh systems. Subsidence due to compaction of marsh soils that results from insufficient sediment supply is less important on the Pacific Coast (Thom 1992). Finally, on the East Coast, the prevailing wisdom is that salt marshes are the key to productivity of estuarine systems because of the contribution of their detritus. However, on the West Coast, secondary productivity from tidal mudflats is more important than detritus exported from salt marshes (Hedgepeth 1978 c.f. Pierce 1982).

In Washington, one of the greatest causes for concern over *S. alterniflora* is the species' ability to trap sediment. On the East and Gulf coasts, where *S. alterniflora* is a major component of salt marsh vegetation, sediment accretion rates can be as high as 13 mm/year, with higher stem densities resulting in higher sediment deposition rates and steeper beach profiles (Simenstad and Thom 1995; Gleason et al. 1979). Where *S. alterniflora* has been introduced to San Francisco Bay, sediment accretion rates have been estimated at 1.4 to 13.3 mm/yr. (Callaway 1990; Josselyn et al. 1993 c.f. Simenstad and Thom 1995). In contrast, a study of low intertidal salt marshes in Washington and Oregon that lacked *S. alterniflora* found that the sediment accretion rate ranged from 2.3 to 6.6 mm/yr., with a mean of 3.6 mm/yr. (Thom 1992). This higher rate of accretion rate associated with *Spartina* may change the fundamental nature of portions of Washington's coastline. Before *S. alterniflora* colonization, Pacific Northwest estuaries consisted primarily of bare, gently-sloping mud flats with shallow tidal channels. Fully developed *Spartina* marshes have steeply sloping seaward edges and deep, steep-sided tidal channels. *S. alterniflora* clones trap sediment, causing the clones to rise above the surrounding tideflat (Ebasco Environmental 1992a). Higher stem densities dissipate more wave action, resulting in greater sediment deposition and steeper beach profiles (Gleason et al. 1979).

A secondary impact of increased sediment accretion may be changes in water circulation patterns. Sediment accretion associated with *Spartina anglica* infestations in England has been known to reduce tidal flow (Hubbard 1965). In addition, large, dense populations at or in river mouths may decrease flow and lead to increased flooding, especially during periods of heavy precipitation and/or above normal tides (Ebasco Environmental 1993).

The spread of *Spartina* can also impact the native flora and fauna of the intertidal zone. *Spartina* may displace native plants, such as *Zostera marina* (seagrass) at lower elevations, and salt marsh species, such as *Salicornia virginica, Triglochin maritimum*, *Jaumea carnosa*, and *Fucus distichus* at higher elevations (Wiggins and Binney 1987; Simenstad and Thom 1995). At this time, most evidence of species displacement is anecdotal, but displacement of several of these plants is of particular concern. Seagrasses (*Zostera* spp.), for example, provide important refuge and food sources for fish, crabs, waterfowl, and other marine life (Balthuis and Scott 1993). As unvegetated mudflats are replaced by salt marshes, bottom-dwelling invertebrate communities will be replaced by saltmarsh species. Studies indicate that populations of invertebrates in the sediments of *S. alterniflora* clones in Willapa Bay are smaller than populations in intertidal mudflats (Norman and Patten 1994b). Loss of habitat for bivalves is of particular concern to the $16 million oyster industry in Willapa Bay. Shorebirds and waterfowl will lose potentially important foraging and refuge habitat. In the Willapa National Wildlife Refuge, *S. alterniflora* has displaced an estimated 16% to 20% of critical habitat for wintering and breeding aquatic birds (Foss 1992). Juvenile chum salmon and English sole may lose prey resources and other important attributes of mudflat nurseries. In short, mud- and sandflat communities based on bottom-dwelling microalgae will decline, being replaced by food webs driven by the supply of *S. alterniflora* detritus (Simenstad and Thom 1995). A summary of potential impacts is summarized in Table 1.

Table 1. Potential impacts of *Spartina alterniflora* spread in Washington State (adapted from Callaway and Josselyn 1992).

Possible Impact	Cause
Competitive replacement of native plants	Higher seed production & germination; higher vegetative production
Effects of sedimentation	Greater stem densities, larger & more rigid stems
Changes in available detritus	Differences in quantity & quality of detritus
Decreased bottom-dwelling algae production	Lower light levels beneath *Spartina* canopy
Increased wrack deposition & disturbance to upper marsh	Greater stem production & subsequent deposition in high marsh
Changes in habitats for native wetland animals	Greater stem densities
Changes in bottom-dwelling invertebrate populations	Higher root densities & lower intertidal distribution
Loss of shorebird & wading bird foraging areas	Lower intertidal distribution

Changes associated with *Spartina* also have the potential to impact recreation. Loss of beach habitat and navigation routes, reduced water access, and other alterations to the estuarine ecosystem may result from the spread of *S. alterniflora.* Therefore, activities, such as fishing, hunting, boating, bird watching, botanizing, and shellfish harvesting, that are dependent on the extant intertidal ecosystem could be negatively impacted by the continued spread of *Spartina* (Ebasco Environmental 1993).

Geographical Distribution: *Spartina alterniflora* is native to the Atlantic and Gulf coasts of North America, occurring from Quebec and Newfoundland to Florida and Texas (Hitchcock 1971). A similar species, *S. brasiliensis* Raddi, occurs along the eastern seaboard of South America, and some taxonomists lump *S. brasiliensis* under *S. alterniflora* (Marchant 1970). In its native range, *S. alterniflora* is the dominant salt marsh plant, forming dense single species stands along the seaward edge of marshes (Metcalfe et al. 1986). It has been both intentionally and accidentally introduced to numerous other regions of the world, including Great Britain and the Atlantic coast of Europe, New Zealand, and the Pacific coast the U.S. (Marchant 1970; Hitchcock 1971; Partridge 1987).

In California, *S. alterniflora* is known from San Francisco Bay and Humboldt Bay (Daehler and Strong 1994; Spicher and Josselyn 1985). The only known Oregon population occurs in the Siuslaw estuary, where it was experimentally established in the late 1970's from stock obtained in Georgia (Frenkel 1987; Frenkel 1990).

Washington's largest population is in Willapa Bay (Pacific County), where *S. alterniflora* clones/meadows cover an estimated 1850 acres, and seedlings occupy another 6500 acres (Washington Department of Natural Resources 1992, unpublished data). Populations are also found in Grays Harbor County in the Copalis River estuary and at Damon Point in Grays Harbor. In addition, the plant has invaded areas of Puget Sound and the Strait of Juan de Fuca, including: Sequim Bay (Clallam County), Thorndyke Bay and Kala Point (Jefferson County), and Padilla Bay (Skagit County) (Adopt a Beach, unpublished data; Ebasco Environmental 1992). As of 1991, 19 *S. alterniflora* stands covered an estimated 48,100 m^2 in Padilla Bay (Riggs 1992).

Habitat: *Spartina alterniflora* is a plant of the intertidal zone, where it colonizes mud- or sandflats in saline or brackish water. Found in areas of low to moderate wave energy, the species can colonize a broad range of substrates, ranging from sand and silt to loose cobble, clay, and gravel. The species can tolerate a wide range of environmental conditions, including: inundation up to 12 hours a day, pH levels from 4.5 to 8.5, and salinity from 10 to 60 ppt, although 10-20 ppt is optimal (Landin 1990).

In its native range, *S. alterniflora* typically exclusively dominates low salt marshes (Bertness 1991), growing from 0.7 m below mean sea level to approximately mean high water (Landin 1990). In Willapa Bay, the plants have been observed growing between 1.75 and 2.75 m above mean lower low water (MLLW), and transplants have been known to survive within 1 m above MLLW (Sayce 1988). *S. alterniflora* occurs both on the periphery of Willapa Bay and up some of the rivers, within areas of saline tidal influence (Kunz and Martz 1993).

In areas of Washington, such as Padilla Bay, *S. alterniflora* appears to grow at lower tidal elevations than native salt marsh species; no other plants are found on the seaward side of *S. alterniflora* (Balthuis and Scott 1993; Wiggins and Binney 1987). *Spartina* usually occurs in a single species stand, although there can be community overlap at the edge of some salt marshes (Wiggins and Binney 1987; Kunz and Martz 1993). In these areas, *Spartina* may occur with *Salicornia virginica* (pickleweed), *Triglochin maritimum* (seaside arrowgrass), *Jaumea carnosa* (fleshy jaumea), *Distichlis spicata* (saltgrass), and *Deschampsia caespitosa* (tufted hairgrass) (Kunz and Martz 1993; Sayce 1988; Simenstad and Thom 1995; Riggs 1992; Wiggins and Binney 1987; Balthuis and Scott 1993).

History: *Spartina alterniflora* was apparently first introduced into Willapa Bay in 1894 in a shipment of eastern oyster spat originating from the east coast of North America. Initially, the species established on the west side of Long Island (Sayce 1988). However, the plant was not accurately identified until 1940's, when the plants flowered (Scheffer 1945; Sayce 1988). The clumps, which covered several acres at that time, had first been noted around 1911 (Scheffer 1945). During the first 50 years, the population expanded slowly, but from 1945 to 1988 the plant became established throughout the bay (Sayce 1988).

In Puget Sound, *S. alterniflora* was introduced to stabilize shorelines and increase vegetative cover. The Dike Island Gun Club planted *S. alterniflora* in Padilla Bay in the 1940's to stabilize an island in the south bay. By 1991, the plant covered an estimated 12 acres. *S. alterniflora* was also introduced to Thorndyke Bay, Kala Point, and Sequim Bay to increase vegetative cover (Ebasco Environmental 1992).

Growth and Development: *Spartina alterniflora* is a rhizomatous perennial, which, under favorable conditions, can reach sexual maturity in three to four months (Smart 1982). Mature plants produce seed in the fall. Seeds require soaking for approximately six weeks to germinate, with most seeds germinating in the spring. The seeds are short-lived (roughly 8 months), so the species does not have a persistent seed bank (Sayce and Mumford 1990). Germination rates are variable. Callaway and Josselyn (1992) found that roughly 37.3% of seeds collected in San Francisco Bay germinated, while Sayce (1988) found only a 0.04% germination rate for seeds collected in Willapa Bay. However, different pre-treatments were used in the two studies, and the pre-treatment of the Willapa Bay seeds may have been insufficient to break dormancy. In Willapa Bay, millions of germinating seeds are visible in the high intertidal drift zone during the winter. These seeds are probably broadcast throughout the bay with spring tides (Simenstad and Thom 1995).

While seeds are important for colonizing new areas, they appear to be unimportant in maintaining established stands. Studies in Rhode Island suggest that *S. alterniflora* seedlings are unable to survive under adult canopy, and seedling success increases with the size of bare patches (Metcalfe et al. 1986). Therefore, the expansion of established stands is due to vegetative growth. In some areas, *S. alterniflora* has demonstrated the ability to rapidly colonize bare areas due to a high intrinsic growth rate and rapid propagation of stems via rhizomes (Smart 1982). Estimates of lateral growth taken in Washington indicate that clones expand at approximately 0.5 to 1.7 m/yr. (Riggs 1992; Simenstad and Thom 1995; Sayce 1988).

On the West Coast, *S. alterniflora* is able to extend to lower intertidal elevations than native species, so it frequently grows without competition from macrovegetation (Callaway and Josselyn 1992; Riggs 1992). In the low oxygen environment of this habitat, many plant species are unable to utilize nutrients in the substrate. However, *S. alterniflora* is able to mobilize nutrients under low oxygen conditions through rhizosphere oxidation. (The rhizosphere is the soil zone of increased microbial activity surrounding the roots). *S. alterniflora* has a large amount of internal gas spaces (aerenchyma) that extend from the leaves to the root tips. These spaces function as conduits for gas exchange between the plant and the rhizosphere. In oxygen-poor soils, rhizosphere oxidation is strongly influenced by aerenchyma size and number. Seedlings may do poorly due to insufficient aerenchyma. Since large stands of *Spartina* have more aerenchyma, they are better able to utilize nutrients and increase productivity (Bertness 1991). Therefore, as Washington's *Spartina* populations expand, they may become better able to survive at lower elevations of the intertidal zone due to increased aerenchyma.

<u>Reproduction</u>: *Spartina alterniflora* can spread by seed, rhizome, or vegetative fragmentation (Daehler and Strong 1994). However, the plant does not produce seed in several areas where it has been introduced. No flowers have been observed in New Zealand or in Padilla Bay, and the Willapa Bay population was not observed to flower for almost 50 years after its introduction (Partridge 1987; Kunz and Martz 1993; Riggs 1992; Scheffer 1945). Low soil temperature can delay or suppress flowering and reduce seed production in *Spartina.* Since the waters of the Washington coast are cooler than those in the species' native range, temperature may be regulating flowering and seed set here (Ebasco Environmental 1992a). Observed increases in seed production in Willapa Bay may be linked factors that increase water temperature, such as El Nino events or sedimentation in the bay, which decreases water depth in areas, leading to increased water temperatures (Ebasco Environmental 1992a).

In Willapa Bay, the plant flowers from July to October, with seed set beginning in early September (Sayce and Mumford 1990). The species is protogynous, meaning that female flowers mature before male flowers (Bertness and Shumway 1992). This strategy helps ensure outcrossing. Experiments in San Francisco Bay indicate that self-pollinated seeds fail to germinate (Daehler and Strong 1994). Since the *S. alterniflora* populations on the West Coast were probably established from a relatively small number of genetic individuals, variability in reproductive output among clones may be due to inbreeding depression (Daehler and Strong 1994).

<u>Response to Mechanical Control Methods</u>: Seedlings can be pulled out effectively. Care must be taken to remove both shoots and roots. Seedlings generally begin tillering late in their first growing season. Once the plant has tillered, hand-pulling may break off portions of root, allowing the plant to resprout. Repeated pullings will eventually kill small plants (Spartina Task Force 1994). However, pulling or digging established clones is difficult and largely ineffectual. Findings from attempts to remove a 1 by 2 m clone in Willapa Bay indicate it is difficult to remove all roots and rhizomes, and the amount of wet mud that is removed in the digging process makes the technique unmanageable (Aberle 1990).

Covering small *Spartina* clones with woven geotextile fabric has been successful in some areas. With this technique, clones are mown to ground level and covered out 3 to 4 feet beyond the edges of the clone. The covering must be anchored in place. To be effective, covering should be left in place for one to two growing seasons. This method is most suitable for small infestations. (Spartina Task Force 1994).

Mowing infestations can contain growth, limit seed set, and eventually kill the plants. To be effective, clones must be mowed repeatedly, beginning with initial spring green-up and continued until fall die-back. For clones under 10 feet in diameter, one to three mowings during the growing season may be effective. Larger clones need to be mowed nine to ten times over two seasons for eradication. In some cases, mowing will be required for a third or fourth year (Spartina Task Force 1994).

<u>Response to Cultural Control Methods</u>: Diking can be used as a containment measure, since dikes confine the lateral spread of rhizomes. Dikes also remove tidal action, thereby inhibiting nutrient flow and oxygen exchange. In addition, dikes can be used to flood areas, which will eventually bring about *Spartina* death. However, flooding will also kill other species that cannot tolerate prolonged flooding. From a practical standpoint, diking is not appropriate for large areas; it would work best in small lagoons that only need to be diked on one side (Aberle 1990).

<u>Response to Herbicides</u>: Rodeo™ (glyphosate) is the only herbicide presently labeled for use on *Spartina alterniflora* in Washington. Reports of control with Rodeo™ are varied, ranging from 100% (Crockett 1991) to 0% (Balthuis and Scott 1993). Differences in reported control results may be due to the use of different surfactants. *S. alterniflora* leaves have high levels of salt and sediment, which may prevent glyphosate absorption. Finding an adjuvant that overcomes the effects of these antagonistic ions is likely to increase Rodeo™ absorption (Norman and Patten 1994c). Additional research is needed on this front.

Research is currently being carried out on the efficacy of simulated aerial spraying and hand-held wiping treatments. Simulated aerial spraying has not been highly effective, perhaps due to the lack of an effective surfactant. Hand-held wiping treatments have had better results. Wiping treatments in May are ineffective, but Rodeo™ (33%, v/v) applied with 5% LI 700 in June, July or August has provided over 90% control (Norman and Patten 1994a; Norman and Patten 1994b; Norman and Patten 1994c; Norman and Patten 1995a).

In general, data from herbicide trials (Norman and Patten 1995b) in Willapa Bay suggest:

- Treatment efficacy is influenced by time of application: June > July > August > May.
- Treatment efficacy is influenced by application method: hand-held wipe > hand-held backpack > simulated aerial.
- Treatment costs: hand-held backpack > hand-held wipe > simulated aerial.

<u>Bio-Control Potentials</u>: *Spartina alterniflora* was introduced to Washington without any of the insect predators that damage it in its native range. Insects native to the Pacific Northwest cause

little damage to the species, resulting in plants that average greater vigor and stature than specimens within the species' native range (Strong 1990).

A leafhopper, *Prokelisia marginata* (Homoptera), has been suggested as a potential biocontrol agent for *Spartina* (Ebasco Environmental 1992c). *Prokelisia* occurs on *S. alterniflora* populations on the East Coast and in San Francisco Bay. It is unclear whether *Prokelisia* is indigenous to California, where it occurs on the native *S. foliosa*, as well as *S. alterniflora* (Ebasco Environmental 1992c; Daehler and Strong 1994). The insect feeds on phloem, and it may limit seed production or affect the rate of vegetative spread (Bertness and Shumway 1992; Daehler and Strong 1994). However, research indicates that the insect does not limit viable seed production in San Francisco Bay. More studies are needed to determine what impact the insect may have on vegetative spread, since phloem feeders have been known to decrease tillering rates in some grasses (Daehler and Strong 1994).

The ergot fungus, *Claviceps purpurea*, also has potential as a biocontrol agent. Ergot occurs on *Spartina* in the southeastern U.S. and has also been observed in Willapa Bay (Gessner 1978; Ebasco Environmental 1992c). Ergot infects flower parts and replaces grain with sclerotia (a hardened mass of filaments), which could potentially reduce seed production (Ebasco Environmental 1992c). Ergot infects many other grasses besides *Spartina*, including rye, wheat, barley, and oats. Therefore, any biocontrol strain would need to be host-specific to *Spartina* (Ebasco Environmental 1992c). The *Spartina* ergot fungus that occurs in the Southeast is chemically different than ergots found on other hosts and may be a different biotype (Gessner 1978). More research is needed before ergot could be used for biocontrol in Washington.

<u>Rationale for listing</u>: *Spartina alterniflora* is an aggressive exotic salt marsh plant that has already colonized a significant portion of the intertidal zone in Willapa Bay. Substantial sections of Puget Sound are also vulnerable to colonization by this species. Without question, *S. alterniflora* invasions in Washington bring about change to the intertidal zone (Simenstad and Thom 1995). While the exact ecological and economic consequences of these changes is uncertain, the potential for damage is extensive (see Table 1). The only way to test the full extent of the impacts would to wait until *S. alterniflora* is widely established, at which point, the species would be virtually impossible to control (Spicher and Josselyn 1992). The Washington State Noxious Weed Control Board views this possibility as an unacceptable risk. Therefore, prevention of seed production in all designated areas is required to help contain this species and prevent its further spread.

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