DRAFT WRITTEN FINDINGS OF THE
WASHINGTON STATE NOXIOUS WEED CONTROL BOARD
(January 1997)

Scientific Name: *Spartina anglica* C.E. Hubbard

Common Name: common cordgrass

Family: Gramineae (Poaceae)

Legal Status: Class B: (a) regions 1, 3, 4, 5, 6, 7, 8, 9, 10
(b) region 2 except the bays and estuaries of Skagit, Island Counties, and except bays and estuaries north of Everett in Snohomish County

Description and Variation: *Spartina anglica* is a stout, rhizomatous salt marsh grass that spreads by clonal growth, often forming extensive meadows (Thompson 1991). The stiff plant may be 5 to 100 cm tall, with stout stems 5 mm or more in diameter. The leaves lack auricles and have ligules that consist of a fringe of hairs. Leaf blades, which may be flat or inrolled, are 5 to 12 mm broad and may be persistent or falling. Flowers occur in numerous, erect, contracted panicles, which consist of closely overlapping spikelets in two rows on one side of the rachis (Partridge 1987). *S. anglica* is closely related *Spartina* x *townsendii*; both result from a hybrid of *Spartina maritima* and *Spartina alterniflora*. However, *S. anglica* is the F2 generation and produces fertile seed, while *S.* x *townsendii* does not.

Perhaps as a result of its hybrid origins, there is considerable morphological variation in *S. anglica*. Variable characteristics include shoot density, vegetative vigor, density of inflorescences, flowering times, seed production, and seed germination (Hubbard 1965).

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* - *Spartina anglica* has been planted around the world for a variety of reasons. Because of its ability to trap sediment, navigational interests have used *S. anglica* to stabilize mudflats and reduce the source area for channel silting (Ranwell 1967). The species has also been planted to protect coastlines from erosion (Ranwell 1967; Gray et al. 1991). In addition, agricultural interests have planted *S. anglica* for estuary reclamation (Ranwell 1967; Partridge 1987; Gray et al. 1991). In England, *S. townsendii* is widely used by livestock, and experience from around the world indicates a wide variety of herbaceous mammals will eat *S. anglica* or *S. townsendii* (Ranwell 1967). *S. anglica* is also used as green manure in China; 50 kg of *S. anglica* are approximately equivalent to 0.5 kg of urea (Chung 1982).

Detrimental - Some of the very traits that make *Spartina anglica* valued are also the greatest causes for concern. In Washington, the greatest concern is the species' ability to trap large amounts of sediment. *S. anglica*'s stout stems and leaves slow tidal water, thus trapping sediment (mostly in the leaf axes). As portions of the plant age and fall off, the sediment is deposited at the base of the plant and then bound by the extensive rhizomes (Thompson 1991). *S. anglica* sediment accretion rates are higher than those of other salt marsh vegetation and other *Spartina* species (Lee and Partridge 1983). As a result, *S. anglica* causes tidelands to rise more than they would if they were unvegetated or vegetated by other species (Thompson 1991). No information is currently available on the sediment accretion rate of *S. anglica* marshes in Washington, but published data from other parts of the world create cause for concern. In Europe, sedimentation rates of 20 to 200 mm/yr. are reported (Ranwell 1967; Lee and Partridge 1983; Thompson 1991), and as much as six feet of accreted sediment occurs under some British *S. anglica* marshes (Ranwell 1967; Gray et al. 1991). Sedimentation rates of up to 260 mm/year have been reported in China, where *S. anglica* was intentionally introduced (Chung 1990 cited in Gray et al. 1991). In contrast, a study of low intertidal salt marshes in Washington and Oregon that lacked *Spartina* 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). Before *Spartina* colonization, Pacific Northwest estuaries consisted primarily of bare, gently-sloping mudflats with shallow tidal channels. *S. anglica* replaces gradually sloping mudflats with badly drained marshes (Gray et al. 1991) that commonly have steeply sloping seaward edges and deep, steep-sided channels. In addition, infestations of *S. anglica* may block some navigational channels (Ranwell 1967).

A secondary impact of increased sediment accretion may be changes in water circulation patterns. Sediment accretion associated with *S. anglica* infestations in England has been known to reduce tidal flow (Hubbard 1965). In New Zealand, where *S. anglica* was intentionally introduced, it has trapped so much sediment that the previously existing salt marshes behind the *Spartina* have become slight depressions. By this process, *S. anglica* impedes drainage, resulting in flooding from trapped, backed up water (Partridge 1987). Large, dense populations at or in river mouths may cause particular problems by decreasing flow and leading to increased flooding, especially during periods of heavy precipitation and/or above normal tides (Ebasco Environmental 1993).

Detrimental effects of *S. anglica* infestations extend beyond increases in sedimentation. Doody (1990 cited in Gray et al 1991) summarized the negative impacts of *S. anglica* in Britain as follows:

1) Invades mudflats rich in invertebrates and used by overwintering shorebirds and waterfowl;

2) Replaces more diverse plant communities;

3) Produces dense, monotypic stands that alter succession and are replaced in ungrazed areas by equally species-poor communities; and

4) Promotes agricultural reclamation that results in the destruction of species-rich salt marsh habitats.

For the most part, detailed studies have not been conducted on the specific impacts of *S. anglica* in Washington. However, studies are available from other parts of the world. In Britain, the spread of *S. anglica* has been associated with the decline of some bird populations by as much as 50 percent in affected areas. Birds most affected were those that prefer to feed on open mud. Studies of the dunlin (*Calidris alpina*) found that populations declined most in estuaries where S. *anglica* had spread the most, while population numbers remained unchanged where *S. anglica* populations were static. Control and removal of *S. anglica* infestations resulted in the return of the dunlin (Gray et al. 1991). The exact cause of these patterns has not been investigated thoroughly, but *S. anglica* may remove feeding areas and reduce feeding time, resulting in increased emigration and mortality (Gray et al. 1991).

Some of the impacts of *S. alterniflora,* another noxious *Spartina* of the intertidal zone in Washington, may also apply to *S. anglica*. *S. alterniflora* 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 salt marsh 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). Even in its native area, the benthic fauna of *S. anglica* marshes is generally depleted in comparison to nearby tideflats (Gray et al. 1991). As *Spartina* infestations expand, 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 *Spartina* detritus (Simenstad and Thom 1995).

Changes associated with *Spartina* also 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. anglica.* 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).

<u>Geographic Distribution</u>: A hybrid between the British *Spartina maritima* and the North American *S. alterniflora, S. anglica* originated on the British coast in the nineteenth century, and it is now widespread throughout British coastal areas. The natural distribution of *S. anglica* is thought to be between Poole, Dorset, and Pagham, Sussex and possibly northern France. All other populations around the world are intentional introductions (Raybould et al. 1991b). On the European coast, populations occur between 48° and 57.5° N (Ranwell 1967). Worldwide, *S. anglica* is known from Ireland, Denmark, Germany, Netherlands, Australia, New Zealand, China, and the United

States (Ranwell 1967; Chung 1982). Some introduced populations are quite large. In China, descendants of only 21 individuals spread to cover more than 36,000 hectares by 1980 (Gray et al. 1991). However, attempts to establish *S. anglica* in subtropical and tropical areas have failed (Ranwell 1967).

In Washington, *S. anglica* occurs in Skagit, Island, Snohomish, San Juan, Kitsap, Jefferson, and King counties (Adopt a Beach, unpublished data), with the largest populations in Island, Snohomish and Skagit counties. *S. anglica* has not been recorded from British Columbia or Oregon, but it does occur in San Francisco Bay (Spicher and Josselyn 1985; Ebasco Environmental 1992a).

Habitat: *Spartina anglica* is a plant of the intertidal zone. Because of its phenotypic plasticity, the species can tolerate a wide range of environmental conditions (Gray et al. 1991; Thompson 1991). The plant occurs on a variety of substrates, including clays, fine silts, organic muds, sands, and shingle (Gray et al. 1991). *S. anglica* can tolerate inundation for nine hours or more, which is greater than the tolerance of other species (Ranwell 1967; Thompson 1991). As result, *S. anglica* can occupy the seaward edge of salt marshes where there is little or no competing vegetation (Ranwell 1967; Gray et al. 1991). In Britain, *S. anglica* occurs as a belt of vegetation just seaward of other vegetation. Individual clumps may be found at higher elevations, with the species' upper limit probably determined by competition from other vegetation (Gray et al. 1991). At lower elevations, the distribution of *S. anglica* may be limited by wave action; the species is more successful in sheltered sites, possibly because wave action uproots seedlings (Chung 1982; Gray et al. 1991).

History: *Spartina anglica* is the product of a cross between two other *Spartina* species: *S. maritima* and *S. alterniflora*. *S. maritima* is a native of Britain, whereas *S. alterniflora* is a North American native that was probably introduced to Britain via ship traffic (Hubbard 1965). The original cross is thought to have occurred in Hampshire, Britain around 1870 (Raybould et al. 1991b), and it resulted in a sterile hybrid, *S.* x *townsendii*. The hybridization brought together maternal and paternal chromosomes that were too dissimilar to pair up during meiosis, so sterile gametes were produced. However, when the chromosomes replicated to produce two copies of each parental chromosome, the chromosomes were then able to form bivalent pairs in meiosis, which resulted in a fertile polyploid (having more than two complete sets of chromosomes per nucleus) (Thompson 1991). This fertile hybrid is *S. anglica*. Although *S.* x *townsedii* and *S. anglica* differ in their chromosome number and fertility, they are very difficult to differentiate morphologically (Hubbard 1978).

S. anglica spread rapidly in Britain. By 1907, it was brought to the attention of the Royal Commission on Coast Erosion, which resulted in a research program on *Spartina* for coastal protection and reclamation. A report to the Dutch government in 1923 led to the export of *Spartina* plant fragments from Poole Harbor, Britain to the Netherlands. The Dutch felt their research trials were successful and, in 1929, published a pamphlet, "Economic Possibilities of Rice Grass," which was quoted in newspapers around the world. This publicity led to numerous requests for *Spartina* plant fragments and seed. Between 1924 and 1936, more than 175,000 fragments and many seed samples from Poole Harbor were sent to more than 130 sites around the world (Hubbard 1965).

Because *S. anglica* in Britain has very low genetic variability, it appears that two closely related genotypes or an extremely restricted range of genotypes have colonized a wide area via natural spread and deliberate introductions (Raybould et al. 1991b).

In Washington, the U.S. Department of Agriculture and Washington State University introduced *S.* x *townsedii*/*S. anglica* to the Stillaguamish estuary in Port Susan Bay in 1961 or 1962 (Spicher and Josselyn 1985). The original introduction was made to provide forage for cattle, and it was supposed to be the sterile *S.* x *townsendii* (Spicher and Josselyn 1985; Ebasco Environmental 1992a). However, the plants are now known to be the fertile *S. anglica* (Spicher and Josselyn 1985; Frenkel and Kunze 1984 cited in Aberle 1990). It is not clear whether the original planting was actually *S. anglica* or if it was *S.* x *townsendii* and a natural chromosome doubling then produced *S. anglica* (Ebasco Environmental 1992a).

S. anglica has spread rapidly since its introduction to Puget Sound. Populations have spread as far south as Vashon Island and as far north as San Juan Island. *S. anglica* from Puget Sound was also intentionally introduced to San Francisco Bay in 1977 (Spicher and Josselyn 1985).

Physiology: Unlike many temperate grasses, *S. anglica* has a C_4 photosynthetic pathway. (C_4 refers to the number of carbons produced in the first step of photosynthesis). At optimal temperatures, C_4 species have greater nitrogen and water-use efficiency than comparable C_3 species, which may help explain the high salinity tolerance of *S. anglica.* In addition, like other C_4 species, *S. anglica* can photosynthesize at a much greater rate than C_3 plants when the temperature is above 10° C. However, unlike other C_4 species in northwest Europe, *S. anglica* can maintain photosynthetic rates at 5° to 10° C. that are equivalent to C_3 rates. Therefore, it does not have the temperature constraints that limit other C_4 plants to lower latitudes (Gray et al. 1991; Thompson 1991).

Growth and Development: Spring through early fall is a time of rapid growth and flowering for *Spartina anglica*. In late fall, the flowering culms generally die; however, flowering may extend to the following year during mild winters. In November, *S. anglica* produces overwintering buds in the leaf axils, which is followed by rhizome development in response to short days (Gray et al. 1991). Rhizome biomass peaks in early winter to make up 50% of *S. anglica*'s belowground biomass (Gray et al. 1991).

S. anglica spread generally occurs in three phases. An initial colonization period occurs for one to two years, followed by slow clonal growth as seedlings establish. Once established, plants experience a burst of prolific clonal expansion. Throughout the different phases, seed production varies. Pioneer populations often produce little seed, but seed production increases with marsh development (Thompson 1991).

Die-back of unknown cause(s) is apparent in many mature *Spartina* meadows in Britain. (Hubbard 1965; Gray et al. 1991; Thompson 1991). This phenomenon occurs most frequently in badly drained, waterlogged marshes that have highly anaerobic soils, a high proportion of fine particles, and a high sulphide content. Toxic levels of sulphide and anoxia in rhizomes have been implicated in the death of these plants (Gray et al. 1991).

Reproduction: A rhizomatous perennial, *Spartina anglica* spreads via seed, rhizomes, tillering, and rhizome fragments (Ebasco Environmental 1992a). In Washington, the species can flower as early as April (personal observation), and flowering continues through the summer. Seed production in the species is quite variable - both temporally and spatially. In England, flowers emerging in July and August ripen seed within approximately 12 weeks, while those flowering in September may not have time to mature (Mullins and Marks 1987). *S. anglica* appears to have a self-incompatibility system, although some unknown conditions cause this system to break down, resulting in seed set. Higher than average temperatures and humidity may result in a breakdown in incompatibility, but detailed studies have not been done (Gray et al. 1991).

S. anglica seeds are relatively short-lived. In England, seeds are only viable for one season under field conditions, with germination rates of 0.6 to 5 percent (Ebasco Environmental 1992). Laboratory studies have indicated that seeds stored at 4° C. in a refrigerator remained viable for at least four years. Maximum germination occurred in the dark, with the germination rate increasing as temperatures increased from 7° to 25° C (Hubbard 1970).

Seeds buried between 1 and 3 cm have the best chance of establishing. At shallower depths, seeds are subject to desiccation, while deeper burial may result in decreased viability (Groenendijk 1986 cited in Gray 1991). On bare mud, *S. anglica* seedlings may grow densely, occurring at densities up to 13,000/m^2. Densities are lower in meadows (up to 9750/m^2), with many of the seedlings dying. In most cases, meadows are maintained by rhizome formation and tillering, rather than seedling establishment (Gray et al. 1991).

Response to Mechanical Methods: 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. Attempts to remove a 1 m x 2 m *S. alterniflora* 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).

Response to Cultural Methods: 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 submersion. 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).

Response to Herbicides: Rodeo™ (glyphosate) is the only herbicide presently labeled for use on *Spartina anglica* in Washington. Most efficacy studies with Rodeo™ have been conducted with *S. alterniflora* rather than *S. anglica.* Reports of *S. alterniflora* 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. *Spartina* 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.

The first significant efforts to control *S. anglica* with Rodeo™ were carried out during the 1996 control season. In most cases, the *Spartina* was mowed first, then Rodeo™ was applied to regrowth. Results on the long-term effectiveness of this treatment are not yet available.

Research is currently being carried out on *S. alterniflora* regarding 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.

Biocontrol potential: Because *Spartina anglica* is a new species, there is a relative absence of herbivores or diseases that affect the plant, even in its native habitat (Gray et al. 1991). However, because of its low levels of genetic variability and the fact that it spreads largely by vegetative means, *S. anglica* is potentially vulnerable to parasite and pathogen infestation (Thompson 1991).

Recently, there has been a rise in infection with the ergot fungus (*Claviceps purpurea* (Fr.) Tul.) on *S. anglica* populations in Britain. Ergot infects flower parts and replaces grain with sclerotia (a hardened mass of filaments), which could potentially reduce seed production (Ebasco Environmental 1992c). In England, ergot has reached epidemic proportions, with more than 90% of the flowering heads infected in some populations (Gray et al. 1991). Ergot infects many other grasses besides *Spartina*, including rye, wheat, barley, and oats. However, since *C. purpurea* is host-specific, the strain that occurs on *S. anglica* is probably a distinct taxon. Therefore, ergot might have potential as a biocontrol agent, but additional research is needed.

Rationale for listing: *Spartina anglica* is an aggressive exotic salt marsh plant that has already colonized a significant areas of Puget Sound. Without question, *Spartina* 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. The only way to test the full extent of the impacts would to wait until *S. anglica* 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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