2.0 PROGRAM ALTERNATIVES

2.1 DEVELOPMENT OF ALTERNATIVES FOR EVALUATION

National Environmental Policy Act (NEPA) Regulations Section 1502.14, and California Environmental Quality Act (CEQA) Guidelines Section 15126.6 require that an Environmental Impact Statement/Report (EIS/R) consider a reasonable range of feasible alternatives that would achieve most of the project's goals while reducing or eliminating some or all of the adverse environmental impacts of the project. The goal of the *Spartina* Control Program, as described in Chapter 1, *Introduction*, is:

> *"to arrest and reverse the spread of invasive, non-native cordgrasses to preserve and restore the ecological integrity of the intertidal habitats and estuarine ecosystem in the San Francisco Estuary."*

The lead agencies evaluated a number of approaches to meeting this goal. The approaches included programs that would limit the area of treatment, vary the treatment tools, and limit the target species proposed for treatment.

Alternatives that focused on limiting the treatment area or the species of cordgrass to be treated were eliminated from further consideration because it was determined that they would be ineffective in controlling, reducing, or eliminating the spread of these invasive weeds, and would not preserve native native salt marsh vegetation and habitat structure (see Section 2.3). Seed dispersal and hybridization from residual untreated cordgrass stands would reinfest treated areas and continue the spread of non-native invasive species and their hybrids throughout the Estuary and beyond, thereby rendering control efforts fruitless. Single-treatment method (tool) approaches (e.g. chemical treatment only) were rejected because they would not provide the flexibility needed to address site-specific constraints (for example, different size infestations or infestations near residences) and would ultimately result in an expensive and unsuccessful program. Therefore, the alternatives search focused on multi-tool approaches that could be used to treat all invasive cordgrass species throughout the Estuary in a flexible and cost effective way.

A number of potential treatment methods were considered, and many were carried through for inclusion in the alternatives evaluated in this EIS/R. These include a range of manual, mechanical, and chemical techniques. A discussion of control methods that were considered and rejected for further analysis follows the description of alternatives below.

Two "action" alternatives were formulated for evaluation in this EIS/R, Alternatives 1 and 2. Alternatives 1 and 2 incorporate all or most of the tools in the cordgrass control "toolbox," and would be expected to achieve all or most of the program goals. Both alternatives propose to implement the control methods in a modified program of "Integrated Vegetation Management" (IVM; described below) to remove or otherwise control invasive cordgrass species. These alternatives are identical except that Alternative 2 excludes chemical treatment methods from the toolbox, relying only on manual and mechanical methods.

Consistent with NEPA and CEQA requirements, a no-action alternative, Alternative 3, also was developed and evaluated. Under Alternative 3, no regional program to control non-native invasive cordgrasses would be adopted, and the current approach of limited uncoordinated control efforts would continue.

2.2 DESCRIPTION OF ALTERNATIVES

Alternative 1 – Regional Eradication Using All Available Control Methods (Proposed Action/Proposed Project)

Alternative 1, which proposes to use all available tools, is the NEPA "Preferred Alternative" and the CEQA "Project." This action is the implementation of a regionally coordinated strategy to arrest and reverse the spread of four invasive cordgrass species (*Spartina alterniflora*, *S. densiflora*, *S. patens* and *S. anglica)* from the San Francisco Estuary. The regional management strategy would prioritize treatment sites based on the most currently available knowledge regarding the biological and physical processes contributing to the spread of invasive cordgrass populations, the prevention of further spread, and the protection of important habitats. Over time, if full eradication proves infeasible under this alternative, the goal would be to reduce and maintain population levels as close to eradication as possible.

Proposed Control Methods

Control methods proposed for use under Alternative 1 include a range of manual, mechanical, and chemical methods. Some of these methods are aimed at killing or removing target cordgrass populations, while some are "support techniques," which facilitate implementation of a removal method or providing temporary control pending a more permanent solution. Each of these control methods is described below. Because the field of marsh weed eradication is new, a universally recognized set of terms has not yet been developed. For example, a machine that one person calls a "flailer," another might call a "macerater," and a technique called "smothering" by one person might be called "covering" by another. This document attempts to use terms most descriptive of the activity, however, a thorough reading of the text will be required to gain a full understanding of the methods being proposed. Photographs of some of the control methods are shown in **Figure 2-1,** and the methods are summarized in **Table 2-1**.

Hand-pulling and manual excavation. Manual removal methods are the simplest technology for removal of cordgrass. Manual removal includes pulling cordgrass plants out of marsh sediments or using hand-tools such as spades, mattocks, or similar tools to cut away as much cordgrass as possible within reach **(Figure 2-1a)**. Manual removal methods are effective primarily at removing aboveground plant parts, but are less effective at removing belowground rhizomes (a horizontal underground stem that sends out roots and shoots from buds) that rapidly regenerate shoots. Unless digging removes the entire marsh soil profile containing viable rhizomes and buds, its effect is equivalent to pruning (see *Mowing, burning, pruning, and flaming,* below). The vigor with which remaining rhizomes resprout and regrow is often proportional with the severity of the disturbance. Frequent re-digging and maintenance is needed to exhaust rhizome reserves of energy and nutrition, and the population of buds capable of resprouting.

Manual removal is most effective on isolated seedlings, or very young discrete clones (asexually reproduced colonies of cordgrass) or clumps, where they are infrequent. Manual excavation in tidal marshes is extremely labor-intensive. Most cordgrass colonies occur in soft mud in which footing needed for digging is impossible or hazardous, even for workers on platforms, mats, or snowshoe-like boots adapted for walking on mudflats. Dug plants with roots left in contact with moist soil may retain viability and regenerate in place or disperse to establish new populations.

Disposal of manually removed material, especially root/rhizome systems, is problematic. On-site disposal in marshes may cause additional marsh disturbance and may result in spread of invasive

FIGURE 2- 1 Examples of Methods that May be used to Control Non-native Cordgrasses

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cordgrass by regeneration of viable roots. Where manual removal occurs next to levees, salt ponds, or other nontidal environments, local disposal may be feasible. Disposal of manually removed materials may also be accomplished with specialized low-ground-pressure equipment (amphibious vehicles), but the number of passes needed to transport materials also increases marsh disturbance.

Mechanical excavation and dredging. Mechanical removal in marshes would use equipment specially designed for working in semi-terrestrial, semi-aquatic wetland environments. Excavation and dredging would be accomplished using (1) amphibious dredges fitted with excavators, clamshells, or "cutterhead" dredges, or (2) excavators working from mats (large wood pile supports placed flat on geotextile fabric placed over the marsh surface). Some locations would allow use of conventional shallow-draft, barge-mounted dredging equipment working within reach of marsh from the margins of navigable channels, particularly at high tide. Where cordgrass colonies lie within the limited reach of track-mounted excavators working from levees, mechanical removal also can be performed without entry of equipment to aquatic or wetland environments.

Another mechanical removal technique that may be used is maceration or pulping of sediments and plant remains on site using modified agricultural equipment, "chewing" them into particles too small to be viable or regenerate **(Figure 2-1b)**. Floating maceration equipment has been used in inland waterways to control submerged aquatic vegetation. The Control Program may support research and development of this method for use in the baylands environment, and would utilize this method if it were shown to be effective and reliable with mitigable impacts. Possible impacts of this method are evaluated in this EIS/R.

Mechanical excavation working to the full depth of the rhizome system (up to 1 foot) in tidal marshes has the potential to be significantly more effective than manual excavation. Similarly, maceration techniques that almost completely destroy both aboveground and belowground living mass of cordgrass have high potential effectiveness. Both techniques also have significant limitations in the San Francisco Estuary, however. Excavators working from levees have an inherent limitation of short reach or access distance, usually a working distance of less than 20 feet for the size equipment that typical levees could bear. Floating barges with clamshell or cutterhead dredges, in contrast, would need to work at high tides within about 70 feet of the leading edge of cordgrass vegetation. Excavators have sufficient reach to dispose of excavated marsh soil and biomass in non-wetland areas, on levees, or in aquatic habitats such as salt ponds, which lack vegetation.

Heavy equipment often is used within the Estuary's tidal marshes for purposes other than eradication of cordgrass, including removal of large debris hazards and contaminated materials, and construction or maintenance of ditches or canals. Most of this work is done on mats, to distribute the weight of equipment and protect underlying vegetation. These actions are usually aimed at operations that are highly localized (points or narrow alignments) in the marsh, and usually on the relatively firm marsh plain. Even there, equipment may become mired in soft spots, and removal of mired equipment can damage the marsh. In contrast to maintenance-type work, removal of invasive cordgrass involves a mosaic pattern for operations, and occurs most often in the low marsh and mudflats, which do not easily support mats and geotextile fabrics. Thus, control methods based on excavators working on mats would be most applicable to localized, large patches of invasive cordgrass on the marsh plain. Some tidal flats invaded by cordgrass occur on sandy deltas with intertidal sand bars (e.g., San Leandro, San Lorenzo Creek) where equipment could be staged, but this situation is unusual in San Francisco Bay, where bay mud prevails over sand in most tidal flats. The feasibility of using mechanical excavation or dredging methods at a particular location would be determined based on site-specific conditions.

Excavated or dredged materials would be disposed either to a suitable upland location or to an approved diked bayland site. Cutterhead dredges can discharge slurries of sediment, bay water, and detritus into barges, or pipe them to either upland or behind-dike disposal sites. Clamshell-dredged material can also be "slurried" and piped to barges or a suitable disposal location.

Where feasible, the Control Program would "beneficially re-use" excavated or dredged materials from cordgrass eradication sites to facilitate restoration of diked baylands. The ground surface of abandoned commercial salt evaporation ponds, where thousands of acres of tidal marsh restoration is proposed, are usually subsided below the desirable level for restoration, and requires filling. In addition, salt pond conditions following discontinuance of salt production operations are usually dry or hypersaline or both; these are lethal to cordgrass. Disposal of dredged material from navigational and flood control projects to diked bayland restoration projects has proven both feasible and cost effective. Based on the similarity of the operations, Control Program planners are optimistic that disposal of materials from eradication projects to assist wetland restoration may also be feasible. "Disposal" of material from cordgrass eradication sites would thus serve the dual purpose of restoring a site lost to invasive non-native cordgrass and expediting restoration of commercial salt ponds to native tidal marsh, both consistent with the Baylands Ecosystem Habitat Goals. The Control Program would coordinate with the San Francisco Estuary Baylands Ecosystem Restoration Program (sponsored by the U.S. Environmental Protection Agency and the California Resources Agency), and would actively seek opportunities to "pilot" this approach. The Control Program would carefully monitor and evaluate the efficacy of any such pilot effort.

Mowing, burning, pruning, and flaming. Cordgrasses are well adapted to disturbances that "crop" or otherwise remove aboveground biomass. A single event that removes living or dead aboveground cordgrass biomass generally stimulates cordgrass growth, and as soon as a cordgrass stand refoliates, it begins to "recharge" its roots and rhizomes with new food reserves. If vegetation is removed with frequency, roots and rhizomes are prevented from regenerating reserves of energy and nutrition and cordgrass begins to die back as its organs of regeneration and storage become exhausted. If the cordgrass is mown close to the mud surface, it also severs the connections between leaves and roots that transport gases to roots growing in extremely anoxic (oxygen-deprived) waterlogged sediment and further stress the plant.

Repeated close mowing **(Figure 2-1c)** may be used to increase physiological stress to a point that cordgrass cannot regenerate; frequent burning would have similar effects. The use of pruning, burning, and mowing for cordgrass eradication in open mudflats and marshes would require very frequent treatment of all aboveground growth until the cordgrass rhizome/root systems become exhausted. For robust stands of Atlantic smooth cordgrass, this may require more than monthly treatment for more than one growth season.

Controlled burning may be used in some situations to remove vegetation prior to other treatments, or to prevent pollen and seed dispersal in founder colonies invading new sites. Burning would be used only in suitable locations, and only during periods of low-wind conditions (especially early morning), when fire hazards in succulent vegetation of tidal pickleweed marshes would be manageable. Ignition, however, may be difficult in cordgrass stands on mudflats.

Selective pruning (partial mowing with "weed-whackers" **[Figure 2-1c]** or flaming with hand torches) may be used to remove flowerheads and seedheads of discrete colonies to prevent flow of pollen from contaminating seed production of native cordgrass, and to prevent seed production within founding colonies. However, pruning would have little or no effect on the clone's growth rate and must be followed up with other methods to control spread.

Mown vegetation without viable seeds or propagules may be left in place or removed from the site. Vegetation containing viable seeds or propagules would require removal from the treatment site and disposal in a suitable area not conducive to cordgrass growth.

Crushing and mechanical smothering. This method uses amphibious track vehicles to trample new plant shoots and stems, and cover them with a layer of sediment **(Figure 2-1d)**. The objective is to smother the plant by preventing the use of stems to transport oxygen to its roots and rhizomes. Fine-textured bay mud losing aeration from cordgrass stems quickly becomes anoxic, increasing root-toxicity of waterlogged soil conditions (black, sulfide-rich mud). The method would typically be used in the fall, and ideally a period of time after mowing, when young shoots and stems have developed. This method has been used with some success in Washington State, but has not yet been used in the San Francisco Estuary.

Covering/blanketing. This is another technique that is aimed at exhausting the reserves of energy and nutrition in cordgrass roots and rhizomes and increasing environmental and disease stress **(Figure 2-1e)**. Covering typically involves pegging opaque geotextile fabric completely around a patch of cordgrass. This excludes light essential to photosynthesis (transformation of solar energy to food energy), and "bakes" the covered grass in a tent of high temperature and humidity.

This technique may be used for discrete colonies (clones) where the geotextile fabric can be fastened to the marsh surface securely with stakes for a sufficiently long period of time. High tides, high winds, and tide-transported debris common in tidal marshes often make this difficult or impossible in some situations. Care must be taken to cover the entire clone to a distance sufficient to cover all rhizomes. If rhizomes spread beyond the reach of the blanketing cover, rhizome connections to exposed, healthy stems can translocate (pipe) foods to the stressed, starving connected portions of the clone under the fabric, and increase overall survival. Staking geotextile tents on soft mudflats is very difficult, and may make this method infeasible in many situations.

Wrack (piles or lines of drifted debris and detritus from tidal sources) also is capable of smothering cordgrass and other salt marsh plants. Wrack can be created artificially by placing temporary debris piles on the marsh surface, but cannot be stabilized for long – usually no longer than the highest December-January or June tides, or storm surges. Their duration at any position in the marsh depends on the frequency and height of tides. The lower in the intertidal zone, the less stable the position of a wrack pile is likely to be. This technique would be used only for small colonies, and would depend on locally available accumulations of organic tidal debris.

Flooding and draining. Flooding and draining techniques entail constructing temporary dikes or other structures to impound standing water or remove water to kill emergent vegetation. Cordgrasses are intolerant of permanently flooded or stable, dry conditions, and are generally absent in the diked nontidal salt marshes of the Estuary. Salt evaporation ponds, managed waterfowl ponds, and completely diked pickleweed marsh exclude cordgrasses, native and non-native alike. Atlantic smooth cordgrass and English cordgrass are capable of invading tidal marsh pools (salt pans) subject to irregular tidal influence (Campbell et al. 1990, P. Baye, pers. observ.), but they are not likely to survive in typical diked wetlands.

When tidal marshes are diked and drained rather than flooded, they undergo rapid physical and chemical changes. Organic matter decomposes when microbes are exposed to air; clays shrink when dewatered; and sulfides formed in oxygen-free mud transform to sulfates forming strong acids (Portnoy, 1999). Therefore, diking and draining, although conceivably effective for killing cordgrass, would adversely impact marsh soils and restoration, and the longer salt marsh soils are diked and drained the more difficult these adverse soil changes are to reverse. For these reasons, diking and draining only would be used in critical situations where no other method is feasible, and only after careful evaluation and planned mitigation. Diked salt marsh soils that remain permanently flooded undergo relatively slower and less significant changes. Diked flooded salt marshes would eliminate existing standing vegetation, but are readily re-colonized by youthful salt marsh vegetation if the diking is brief.

Isolating the treatment area for flooding or draining may be accomplished by constructing temporary dikes or by closing openings in existing dikes. Temporary constructed dikes need not be large to accomplish treatment. Low earthen berms (about one foot above marsh plain elevation), constructed using low-ground pressure amphibious excavators, could be built around large colonies of cordgrass within open marsh plains. Alternatively, water-filled geotextile tubes ("inflatable dams"), analogous with inflatable cofferdams used in aquatic construction/dewatering operations, may be used **(Figure 2-1f)**. Upon completion of treatment, berms would be graded down to marsh surface elevation, and inflatable dams removed. Temporary dike structures may be difficult to construct in tidal mudflats. Mudflat sediments are usually too soft to "stack" into berms, and firmer material placed on fluid or plastic muds simply subsides into the flats. Similarly, inflatable dams may not be feasible for softer tidal flats.

Many populations of non-native cordgrasses have invaded marshes restored by breaching dikes within former diked baylands, where most of the original dikes remain. In these situations, a dike-enclosed tidal marsh could be temporarily re-closed ("choked") by placing a sheetpile barrier in the existing breach, thus creating a temporary lagoon and effecting mass cordgrass eradication. Water control structures (adjustable tidegates) may be installed to enable marsh managers to maintain water depths lethal to cordgrass, suitable diving duck habitat, and adequate water quality. Marsh recolonization is expected to proceed rapidly following restoration of tidal flows.

An alternative form of treatment, intermediate between flooding and draining, would be to combine impoundment of water with deliberate solar evaporation, creating hypersaline lagoons. Hypersaline conditions would make the habitat transformation even more rapidly lethal for invasive cordgrass. Restoring tidal flows to temporary salt ponds, however, may require dilution of brines, which could increase cost.

The Control Program would evaluate each potential impoundment treatment opportunity individually and apply the method with the fewest adverse impacts in each situation.

Herbicide application. Herbicides have proven highly effective in eradicating populations of cordgrasses. Glyphosate, the herbicide proposed for use in the Control Program, is the only herbicide currently approved by the US Environmental Protection Agency for use in estuarine aquatic habitats.

<u>Description of proposed herbicide and additives</u>. Glyphosate is the active ingredient in the retail products "Rodeo" (Dow Chemical Company) and "Aquamaster" (Monsanto Corporation). Glyphosate works by poisoning the plant's protein production system and disrupting the plant's metabolic functions, particularly energy use and growth. It is a non-selective herbicide, generally affecting all species of vascular plants. It is derived from an amino acid (building-block of protein); technically, it is a "phosphono amino acid," specifically N-(phosophomethyl) glycine. It is systemic in action, transferred through the plant's vascular system from the tissues that absorb it to all parts of

Table 2-1. Summary of Proposed Treatment Methods

	Hand-pulling and Manual Excavation	Covering/Blanketing	Flooding/Draining	Burning
Alter-native	**1, 2, and 3**	**1, 2, and 3**	**1, 2, and 3**	**1, 2, and 3**
Appropriate Setting	Seedlings, particularly in newly infested areas. Appropriate for small clumps and isolated clones, or sparse infestations.	Small to medium size clones. Larger stands are not easily covered due to the labor-intensive nature of transporting and installing the fabric.	Infestations in diked areas recently restored to tidal action by breaching dikes, areas behind sand or shell spits, and areas that can be isolated by temporary earthen or inflatable berms.	Close clusters of medium to large clones or meadows. Reduces biomass and can be used in conjunction with other control methods.
Removal Technique	Removal of plant and below ground material up to 3.9 feet deep.	Covering blocks light from reaching the plants and interrupts photosynthesis.	Create dike, pump water in or out. Hypersaline water is quickly lethal. Flooding or draining for periods of weeks leads to plant mortality.	Colonies are ignited to incinerate above-ground portions of plants or clusters of plants in a self-sustaining fire.
Equipment Requirements	Shovels, trowels, bags, wheelbarrows, handcarts, sleds, trucks for transport of removed material.	Geo-textile fabric or black plastic, grommets, stakes.	Sheetpiles, inflatable dikes that fill with water during an outgoing tide. Dams, trucks, cranes, pumps.	Propane may be used as fuel for ignition. Stems and leaves of *Spartina* fuel the fire if sufficiently dry. Hay can be used to sustain burning between clumps of plants.
Workforce Requirements	Depends on the age and density of the population. An approximate 10-person workforce would be required to pull or dig out a low-density seedling area of about 0.25-acre in an 8-hour day.	Approximately 2-5 persons would be required to place covers over treatment areas, depending on the size of the area. One person would be effective for periodic monitoring for tears or movement of covers.	A crew of 3-4 persons would be required to place, inflate and remove inflatable dikes. Crane required for sheetpile. One person would periodically monitor dike.	A crew of 3-4 persons and presence of fire department officials would be required.
Timing	This method can take place during any season, but is most frequently done in the spring. 1-2 visits per location per year are needed to prevent reestablishment or resprout.	Placing covers early in the growing season would eliminate the need for mowing. Covers must remain in place for two growing seasons to kill plants.	Sheetpile or Inflatable dike could be placed or removed during any season. However, removal should not occur during the fall or early winter when seed dispersal is greatest. Dikes could stay in place for as long as 2 years.	Most effective from the early fall-winter at warm and dry times of year when plants would dry more thoroughly between high tides. Burning would occur once per growing season on calm days with low or no wind.
Effectiveness	Depends on the diligence of the work crew. Any portion of rhizome left behind can potentially sprout and re-establish the clone. Complete removal results in eradication.	Covering has been successful in the S.F. Estuary on small patches up to 36 feet in diameter. Failure results from improper installation, or covering too large of an area. Improperly sealed seams allow plants to grow through the covers. Wind or tidal action may dislodge covers. Sediment may accumulate on top of the covering, hampering removal of fabric.	No information available.	Most appropriate for the prevention or reduction of seed set. Effects may be temporary. Burning does not kill *Spartina;* resprouted plants have greater stem density after burning and plants can resprout from rhizomes and buried roots. Colonies may be resistant to sustaining a burn due to daily wetting by the tide, and the presence of dried salt on the plant.

Alternatives: 1- Regional Eradication Using All Available Control Methods 3- No Action – Continued Limited, Regionally Uncoordinated Treatment
2- Regional Eradication Using Only Non-Chemical Control Methods

Table 2-1. Summary of Proposed Treatment Methods (continued)

	Pruning, Mowing & Flaming	Crushing & Mechanical Smothering	Mechanical Excavation & Dredging	Mechanical ripping/ flailing/maceration
Alternative	**1, 2, and 3**	**1, 2, and 3**	**1, 2, and 3**	**1, 2, and 3**
Appropriate Setting	Small to medium area. To reduce biomass and facilitate other methods, or to remove seedheads to prevent cross-pollinating. Use repeatedly to stress and kill plants.	Meadows, large individual clones >25 feet in diameter or clusters of clones. May be used in conjunction with mowing.	Meadows, large individual clones >25 feet in diameter or clusters of clones in the mid to lower tidal zone where the site can be accessed by floating dredge, or in the upper marsh where accessible by excavator.	Meadows, large individual clones >25 feet in diameter or clusters of clones.
Removal Technique	Pruning- clip seedheads Mowing- cut plant at, near, or just below the soil surface for best results Flaming- use handtorch to burn seedhead.	Small amphibious vehicles with tracks trample new shoots and culms (stems) and covers them with a thin layer of sediment. This sediment smothers the plant, preventing the use of stems to transport oxygen to roots and rhizomes.	Cutterhead dredge (or other type) on floating barge or excavator removes entire plant and root mass to a depth of 1 foot, and disposes in upland disposal or approved tidal marsh restoration site.	Amphibious vehicles with tracks rip and shred root mass below the soil surface to a maximum depth of 1 foot.
Equipment Requirements	Clippers, weedeaters, small mechanical cutters, handtorches.	Small amphibious tracked vehicles. Trailer or barge for transport.	Dredge or excavator, trucks to remove material (if not slurried and piped to destination)	Amphibious track vehicle equipped for subsoil implements for ripping roots.
Workforce Requirements	Varies depending on method & height and density of vegetation. Approximately 2-3 persons required to treat a 0.25-acre area with weedeaters over 8 hours.	1-2 amphibious vehicles per site depending on infestation. One operator will be needed for each vehicle, and 1-2 persons needed for transporting the equipment.	One operator per vehicle, and 1-2 persons needed on site during operations.	One operator per vehicle, and 1-2 persons may be needed on site during operations.
Timing	Mowing can be done during any season. Biomass is less in late fall and winter, facilitating this method. Seedheads form in summer and fall. Eradication by mowing alone would require up to 4-6 treatments annually, for a minimum of 2 years.	Mechanical smothering is used during the fall and winter as close to the period of dormancy as possible. Culms from the previous growing season will have died back for the winter and be brittle and easily broken. Trampling would occur once per season.	Any time of year.	Ripping can take place any time of year. Ripping during the late fall and winter is facilitated by winter dieback which results in significantly less above ground biomass.
Effectiveness	Results of field tests are variable, and dependent on the frequency and the start date. Repeated application eventually weakens rhizomes and reduces energy reserves. One application may invigorate a plant. Therefore, multiple treatments are necessary.	No information available.	Large-scale demonstration work in Washington indicates a high level of efficacy.	Large-scale demonstration work in Washington indicates a high level of efficacy.

Alternatives: 1- Regional Eradication Using All Available Control Methods
2- Regional Eradication Using Only Non-Chemical Control Methods
3- No Action – Continued Limited, Regionally Uncoordinated Treatment

Table 2-1. Summary of Proposed Treatment Methods (continued)

	Herbicide, Ground or Boat Application	Herbicide, Aerial Application
Alter-native	**1 and 3**	**1 and 3**
Appropriate Setting	Small, medium, and large individual clones and meadows. Application of herbicide may be used in conjunction with seedhead clipping and mowing.	Large, heavily infested areas, meadows, or difficult to access sites.
Removal Technique	Glyphosate/surfactant/colorant solution is sprayed, wiped, or painted on foliage, or applied as a paste on cut stems.	Spray apparatus attached to a helicopter consists of a boom with multiple nozzles for broadcast delivery, or a spray ball.
Equipment Requirements	Glyphosate, surfactants, colorants, backpacks, hand spray apparatus, spray truck, airboat, hovercraft.	Glyphosate, helicopter with boom or spray ball.
Workforce Requirements	1-2 persons needed for small infestations. Backpack crews in heavily infested areas with difficult access would range from 2-6 persons. Typical crews for large infestations would include 2-3 persons per ground application vehicle, or 1-3 persons per boat with support from 1-3 trucks.	Crew of approximately 2 persons.
Timing	Glyphosate is most effective when applied at flowering or soon thereafter.	Late summer through early fall.
Effectiveness	Optimal conditions and proper application techniques dictate the efficacy of glyphosate. The length of time from application to high tide, wind and weather conditions, application method, and timing of application in the plant's life cycle are all important factors. Efficacy can range from 0-100 percent.	See previous method.

Alternatives: 1- Regional Eradication Using All Available Control Methods; 2- Regional Eradication Using Only Non-Chemical Control Methods; 3- No Action – Continued Limited, Regionally Uncoordinated Treatment the plant. Although it is highly toxic to plants, glyphosate has exceptionally low toxicity to mammals, birds, and fish[1].

Additives including surfactants and colorants, would be added to glyphosate to improve its performance in the aquatic environment. Surfactants, also known as sticker/spreaders, are similar to detergents in their action, reducing water surface tension to allow wetting and penetration of the plant tissues. The surfactants proposed for use by the Control Program – Agri-dex, R-11 Spreader Activator, and LI-700 – are approved by the U.S. Environmental Protection Agency (U.S. EPA) for use in aquatic habitats, and have been selected for the Control Program as among the least toxic of the available surfactants. It should be noted that R-11 would only be used if the other surfactants are ineffective. If R-11 is proposed for use in a specific treatment project, the ISP staff would first coordinate with NOAA Fisheries. Colorants would be added to the glyphosate/surfactant solutions to enable spray crews to see where they have sprayed after initial evaporation of the solution. "Blazon Blue Spray Pattern Indicator" is the commercial name for the colorant proposed for use by the Control Program. Sections 3.2, *Water Quality*, 3.3, *Biological Resources*, and 3.6, *Human Health and Safety*, evaluate the possible environmental effects of glyphosate, surfactants, and colorants.

<u>Application rates and methods</u>. To be effective, glyphosate must be applied to completely cover the plant surface. Glyphosate becomes inactive (physiologically ineffective, but chemically stable) when it contacts clay or fine silt particles, or organic films. It becomes tightly bound to chemically attractive surfaces of microscopic mineral particles, and cannot be absorbed by living tissues in this bound condition. In tidal marsh conditions, where fine silts and clay films are regularly deposited on plant surfaces, this can be a problem for efficacy of glyphosate. However, it also provides a buffer against impacts to non-target plants and organisms, which may be insulated from glyphosate in "dirty" environments, such as the sediment rich water column (see Section 3.3.2, *Analysis of Potential Effects on Biological Resources – Glyphosate Herbicide Application*).

Glyphosate mixtures may be applied as sprays to plant surfaces, pastes applied to cut stems, or solutions wiped or painted on foliage. Spray mixtures may be administered from manually transported tanks (backpack sprayers **[Figure 2-1g]**) or spray equipment mounted on trucks **[Figure 2-1h]**, track vehicles, boats, or helicopters (broadcast sprayers **[Figure 2-1i]**). California Department of Pesticide Regulations-certified applicators, or persons under their direct supervision, would perform all herbicide applications. Glyphosate solutions would be prepared and applied consistent with the commercial product labels. For treatment of cordgrass in aquatic environments, the product labels specify a 1 to 2 percent solution applied with hand-held equipment, or 2.2-3.7 quarts of product per acre as a broadcast spray. Surfactants and colorants are added halfway through the mixing process. Surfactants must be added at a rate of 2 or more quarts surfactant to 100 gallons solution (0.50 percent). The colorant, Blazon, is typically added at a rate of 3 quarts per 100 gallons of solution, or 16 to 24 ounces per acre broadcast sprayed **(Table 2-2)**. The exact solution concentration and application rates for each constituent are determined based on site-specific conditions.

High mortality to cordgrasses, especially Atlantic smooth cordgrass (because of its broad leaf area), often results from adequate spray coverage of glyphosate. Aerial application of glyphosate is most effective on large areas of cordgrass (cordgrass meadows), where access by terrestrial or aquatic

[1] Glyphosate inhibits the activity of the enzyme 5-enolpyruvylshikimic acid-3-phosphate synthase (EPSP), which is necessary for the formation of the aromatic amino acids tyrosine, tryptophan, and phenylanine. These amino acids are important to the synthesis of proteins that link primary and secondary metabolism. EPSPs are present in the chloroplast of most plant species, but are not present in animals. Animals need these three amino acids, but obtain them by eating plants or other animals.

Table 2-2. Glyphosate Herbicide Mixture Component Concentrations and Application Rates for Treatment of Cordgrass in an Aquatic Environment

Application Method	*Glyphosate Product*[1]	*Glyphosate Salt*[2, 3]	*Non-Ionic Surfactant*[4]	*Colorant*[5]
Handheld sprayer	1-2% solution[6] (1-2 gal./ 100 gal. solution)	5.4-10.8 lbs. glyphosate salt/100 gal. solution	Minimum 2 qt./ 100 gal. solution	3 qt./ 100 gal. solution
Low volume directed spray	5-8% solution[7] (5-8 gal./ 100 gal. solution)	27-43.2 lbs. glyphosate salt/100 gal. solution	Minimum 2 qt./ 100 gal. solution	3 qt./ 100 gal. solution
Broadcast sprayer	2.2-3.7 qt./acre[5]	3-5 lbs. glyphosate salt/acre	Minimum 2 qt./ 100 gal. solution	0.5-1.5 qt./ acre

1. Rodeo and Aquamaster
2. N-(phosphonomethyl)glycine, isopropylamine salt, active ingredient in Rodeo and Aquamaster
3. Calculated from volume application rate at conversion ratio of 5.4 lbs. glyphosate salt per gallon of liquid Rodeo or Aquamaster
4. Agridex, R-11 Spreader Activator, or LI-700
5. Blazon Spray Pattern Indicator
6. Label-specified rate for "Perennial Weeds: Cordgrass"
7. Label-specified rate for low volume, directed spray using hand-held equipment for spot treatment for trees and brush. Applicable to perennial weeds and cordgrass per personal communication, November 25, 2002, Monsanto Company.

equipment is restricted. Glyphosate is least effective on cordgrass colonies on mudflats where foliage is covered with silt films at the time of application, and few hours elapse before the sprayed leaf surfaces are submerged by rising tides. Best results are achieved on "clean" foliage at the upper reaches of the low marsh and above, particularly during neap (weak) tides.

Glyphosate treatment typically would occur in late summer through mid-fall, while the plants are in peak flowering stage (or later), and still green. Where appropriate, spraying would be scheduled to accommodate the mating and nesting seasons of the California clapper rail, which begins in winter and extends through summer. Application of glyphosate also would be timed to provide sufficient drying time before inundation by the tides, and would not occur during periods of high winds (greater than 5 to 10 miles per hour), when winds are directed towards residential areas or other receptors, or if precipitation is expected within 5 to 6 hours of spraying.

For ground based and aerial applications, every effort will be made to control drift during treatment. Aerial applications will conform to the Specimen Label as well as the Supplemental Labeling for Aerial Application in California Only, following all included recommendations for Spray Drift Management and Aerial Drift Reduction Advisory Information. The most effective way to reduce drift potential is to apply larger droplets. Therefore, ISP Field supervisors will engage in careful management of droplet size, taking into account spray pressure, number of nozzles, nozzle orientation, nozzle type, boom length and application distance. Using lower pressure spray equipment also reduces potential for overspray and drift. Therefore applicators will be advised to reduce pressure in equipment or use low-pressure equipment whenever possible. Drift control agents also should be added to the tank mix when wind conditions are condusive to drift. If spraying is to be done near discrete sensitive receptors,and there is the potential for drift, those receptors will be shielded by physical structures.

Additionally, wind speeds will be observed during the treatment period and monitored for exceedences of the label-recommended 10 mph wind speed guidelines. Aerial applications will also avoid temperature inversions, and periods of low relative humidity to minimize evaporation potential. Application of glyphosate would frequently be preceded by pruning or mowing several weeks before to (1) reduce the surface area of vegetation, thus reducing the amount herbicide needed, and (2) stimulate the plants into accelerated growth, thus increasing the plant's metabolism of the glyphosate. Spraying may also be used as a "follow-up" treatment after repeated mowing or burning, or after mechanical removal.

Potential glyphosate herbicide treatment sites would be selected based on site conditions, the severity of infestation, evaluation of short- and long-term environmental impacts compared to other treatment methods, efficiency, and proximity of the treatment site to sensitive receptors.

Program Approach

The Control Program will use a modified "integrated vegetation management" (IVM) approach to prioritize and implement control efforts. Applying this approach, the Control Program will use all available scientific information regarding the Estuary, the invasive cordgrasses, and the likely economic, sociological, and ecological consequences of both the invasion and the treatment program, to develop a management strategy that is effective, economical, and protective of public and environmental health. IVM is typically premised on the assumption that a pest or weed can be managed rather than eradicated. Based on the preponderance of information available at this time, the Control Program is proceeding on the assumption that full eradication of the invasive cordgrasses, particularly Atlantic smooth cordgrass, will be necessary to accomplish control. This seemingly extreme approach is based on the apparent impossibility of controlling pollen flow and hybridization with native Pacific cordgrass. For the purpose of the Spartina Control Program, the practical criterion for eradication of the Spartina alterniflora hybrid swarm will be elimination of genotypes (genetic individuals) exhibiting, or capable of reproducing, the robust, invasive hybrid phenotypes with distinctive ecological traits of S. alterniflora. The ISP does not assumes that all genes originating in the S. alterniflora genome must be extirpated in the introgressant population to protect the genetic and ecological integrity of S. foliosa. This working hypothesis will be re-evaluated in during the SPC in coordination with scientific advisors. The IVM approach will be adapted to accommodate this more restrictive objective. However, if future research shows a reduced threat, or if eradication proves infeasible in the coming several years, the Control Program objective would revert to long-term management rather than eradication. For additional information regarding IVM, the reader may refer to Ebasco 1993b, Bottrell and Smith 1982, Hoglund *et al.* 1991, and Thill *et al.* 1991.

While current "best science" sets the initial course of the Control Program, new information regarding *Spartina* and its effect on the ecosystem—here and in other areas—is continually being screened. In addition, the ISP and others are conducting research to increase knowledge and improve decision-making. During the coming years, the Control Program will follow the developing scientific understanding of such critical issues as cordgrass hybridization and the resulting changes in plant biology; the effects of non-native cordgrass invasion on California clapper rail populations, song sparrows, and other species; the spread of Pacific smooth cordgrass onto mudflats; and the successional processes that will occur at locations invaded by non-native cordgrasses. Such information will be used to help guide future Control Program planning decisions.

Prioritization Strategy. Particularly during the initial months of the *Spartina* Control Program, it would be important to carefully select which sites would be treated and when. Consistent with the IVM approach, the first priority of the Control Program would be to prevent the establishment of new cordgrass populations in areas that they do not currently exist. This is particularly important in areas where it may then spread rapidly to other locations – such as near the Golden Gate, where it may spread to West Marin estuaries (**see Figure 1-5**) – or near a proposed tidal marsh restoration site where it would quickly infest the newly restored habitat. Maps of non-native cordgrass locations developed by the Invasive *Spartina* Project (see **Figure 1-4**) provide an accurate picture of the "edges" of the current infestation, and help to identify the sites or regions that should be targeted first. In addition, the Control Program receives reports from landowners and naturalists on a regular basis when new stands of non-native cordgrasses and hybrids are discovered.

In addition to identifying and eradicating "outliers," the Control Program would target the control of pollen and seed spread from Atlantic smooth cordgrass and hybrid colonies. This may include mowing, clipping, burning, or spraying plants that threaten to disperse seed and pollen, but for which there is not ready budget for a more complete eradication effort. Control of pollen and seed production would be a priority for hybrid colonies that are identified as exceptionally productive of seed or fertile pollen. Once the spread of cordgrass to new areas is under control, the Control Program would begin to direct some resources towards treating sites that are already heavily infested. To help gain needed experience with the efficacy of the various treatment methods in the local environment and to investigate new treatment techniques, some heavily infested sites would be targeted early on as "pilot" studies.

A primary consideration for site prioritization is the presence of California clapper rail at many of the non-native cordgrass-infested sites. **Figure 3.3-1**, in the *Biological Resources* section of this report, shows the location of known clapper rail nesting sites relative to non-native cordgrass stands. This EIS/R includes several proposed mitigations and a stringent set of best management practices to reduce the Control Program's short-term impacts on the clapper rail. However, these measures require review by the U.S. FWS under Section 7 consultation. Once approved, it still may be necessary for projects at sites with clapper rail populations to undergo additional independent review before implementing control measures. In anticipation of delays implementing control at sites with clapper rails, the Control Program would initially focus funding and operations in other areas, while agreements and permits are being obtained.

Site-specific selection of control methods. After the priority sites are identified, a number of factors would be considered to determine what control methods would be implemented at each site. **Table 2-1** summarized many of the considerations. Control of noxious weeds from the perspective of IVM focuses on the harmonious use of several management methods to reduce the damage caused by the infestation. No single treatment technique is expected to be completely effective on its own; most frequently the methods are combined according to site-specific needs to achieve the desired control objective with minimized adverse impacts. **Figure 2-2** illustrates a number of ways in which methods might be combined to accomplish eradication in specific situations.

A site-specific plan would be developed for each treatment site based on specific site conditions, adjacent land uses, feasible treatment methods, costs, and budget. The plan would identify which methods would to be used, time schedules, and necessary phasing and coordination. Depending on the methods selected, the plan would identify and address such issues as sediment contamination, endangered species, adjacent land uses, sensitive receptors, site safety and access, spill prevention, and so on. In all cases, the Control Program would rely heavily on partnerships with the landowners and land managers to plan and complete the work.

In the first few years, the Control Program would necessarily rely most heavily on those methods for which equipment and supplies are readily available. It is expected that this may mean greater use of herbicides in the first years than would be used later, when specialized dredges, track vehicles, boats, etc. have been acquired.

AREA A: Tidal Marsh - Remote, discrete colonies (more than 10 ft. wide) within marsh plain or small tidal creeks, far from vehicle access on levees. Colonies are too large for efficient manual excavation, and too remote for efficient access across multiple tidal creeks by equipment.

Primary options: (a) smothering/covering by fabric, followed by herbicide treatment of survivors; (b) mowing followed by herbicide treatment of resprouts/survivors; (c) wicking or spraying of herbicide over intact colonies. Alternative options: burning (difficult ignition), trampling, both followed by herbicide treatment of survivors.

AREA B: Muted (Microtidal) Marsh - Locally extensive, coalescing colonies are shown within a •forebayŽ and channels of low marsh, backed by a higher marsh plain. Most colonies shown are beyond the reach of excavation equipment working from levees, but vehicle access along levees allows relatively efficient marsh vehicle use. Restricted tidal flows help limit potential spread of vegetative fragments (propagules). Colonies shown are too extensive for efficient manual excavation or smothering/covering.

Primary options: (a) mechanized removal by flail (maceration) or shredding/disking, followed by herbicide treatment of survivors; (b) wicking or spraying of herbicide over intact colonies. Alternative options: drowning (mowing in fall followed by persistent flooding, impoundment by closing tidegates during the growing season); wicking or spraying of herbicide over intact colonies; burning, smothering/covering, or trampling of isolated colonies, all followed by herbicide treatment of survivors.

AREA C: Major Tidal Slough or Flood Control Channel - Extensive, wide, continuous bands of Atlantic smooth cordgrass along sloping intertidal channel banks, some discrete colonies. Soft, sloping mud substrates make marsh vehicle use difficult, except where channels have accreted to gently sloping plains. Relatively little Atlantic smooth cordgrass lies within reach of excavation equipment working from levees.

Primary options: (a) dredging from barge in navigable channel, with disposal in suitable nontidal diked baylands; (b) mechanized removal by flail (maceration), or mowing followed by herbicide treatment of survivors. Alternative option: wicking or spraying of herbicide over intact colonies.

AREA D: Young Tidal Marsh Restoration, Former Diked Bayland - Widespread colonies on sheltered mudflats, but concentrated along marsh edge (near levee) and banks of developing tidal channels. Very soft, recent mud deposits below Mean High Water.

Primary options: (a) excavators working from levee, depositing excavated cordgrass/mud on levee top, within limited reach from levee; (b) mechanized removal by flail (maceration), or mowing followed by herbicide treatment of survivors. Alternative option: wicking or spraying of herbicide on intact colonies.

AREA E: Fringing Tidal Marsh - Relatively firm high marsh plains with few channels, depressions, or pans. Localized colonies in depressions, pans, and lower marsh plain elevations. Commonly old borrow ditches lie between levee and marsh; marshes generally lie close to levees, allowing potential marsh vehicle access.

Primary options: (a) smothering/covering by fabric, followed by herbicide treatment of survivors; (b) mowing followed by herbicide treatment of resprouts/survivors; (c) mechanized removal by flail, or mowing followed by herbicide treatment of survivors; (d) wicking or spraying of herbicide over intact colonies. Alternative options: burning (difficult ignition), trampling, both followed by herbicide treatment of survivors; temporary impoundments around larger colonies, followed by herbicide treatment of survivors.

AREA F: Mudflats - Both extensive coalesced colonies (young marsh) and widely spaced discrete colonies of variable size. Very soft muds.

Primary options: (a) mechanized removal by flail, or mowing, trampling followed by herbicide treatment of survivors; (b) wicking or spraying of herbicide over intact colonies. Alternative option: shallow dredging from shallow-draft barge at high tide, barge disposal, permanent disposal in non-tidal diked bayland.

AREA G: Estuarine Beaches - Generally firmer substrates with high sand or shell content; near levee access.

Primary options: (a) low-ground pressure excavators, shallow excavation/removal (within reach of firm substrates) with disposal on levees or nontidal diked baylands; (b) mechanized removal by flail, or mowing, trampling followed by herbicide treatment of survivors; (c) wicking or spraying of herbicide over intact colonies.

AREA H: Backbarrier Marsh - Semi-enclosed mudflat or marsh behind sand or shell spits, sheltered from bay waves. Generally near levees and beaches with firm substrates and vehicle access.

Primary options: (a) flooding/drowning (temporary impoundment, berm or inflatable dam across free end of spit); (b) low-ground pressure excavators, shallow excavation/removal (within reach of firm substrates) with disposal on levees or nontidal diked baylands; (c) mechanized removal by flail, or mowing, trampling followed by herbicide treatment of survivors. Alternative option: wicking or spraying of herbicide over intact colonies.

Figure 2-2. Examples of Options for Combining Treatment Methods in Various San Francisco Estuary Environments

***Timing of treatment methods*.**

A number of factors influence the times during which certain treatment methods can be used. The two most significant factors for planning project implementation are diurnal fluctuation of the tides (for sites within the normal tidal spectrum), and the seasonal nesting and fledging of California clapper rails (for sites occupied by clapper rails). These two factors combined severely restrict the possible "treatment window" for many sites, and necessitate careful planning for efficient use of resources and effective treatment. As illustrated in **Figure 2-3**, during the 2003-year, most of the morning minus tide events (tide levels below 0.0 ft) occur during months that some level of California clapper rail nesting and fledging is expected to occur. Therefore, control work that must be implemented in the mornings during low tide (e.g., herbicide application) is restricted to a handful of days in the fall. A greater number of minus tide events occur in the afternoon in non-clapper rail "season," however afternoon conditions, such as high winds, are not conducive for many treatment methods. Conversely, high tide events may be targeted for implementation of methods that rely on boat access or dredging techniques.

***Post-treatment monitoring and management*.** Treated cordgrass eradication sites would be monitored to verify that (a) surviving remnants of treated clones have not regenerated; and (b) the site is not reinvaded by dispersal from seed or vegetative fragment sources. Ultimately, eradication objectives must be integrated with local marsh management or restoration objectives. These may include: (a) restoration to pre-invasion mudflat or unvegetated channel conditions; (b) natural or accelerated succession to tidal marsh plain and creeks, such as in tidal marsh restoration sites; (c) restoration of pre-invasion native cordgrass-pickleweed dominated vegetation composition and structure. Each of these target conditions entails different approaches for monitoring and management following treatment, and different levels of effort and efficiency.

Where invasive cordgrass had caused sufficient sediment accretion to shift from cordgrass marsh to pickleweed-dominated marsh in treated areas, with rare and conspicuous establishment of cordgrass after treatment, or none, monitoring would be relatively simple. Post-treatment re-invasion would be easy to detect and reversed by low-level maintenance (manual removal, spot-spraying or cut-stump herbicide paste application). No other vegetation management would be required.

In relatively high-energy environments with rare establishment of any vegetation, such as open and exposed bay mudflats, post-treatment monitoring would also be relatively efficient and simple. No revegetation would be appropriate where the target condition is restoration of mudflat or unvegetated channel.

Minus Tide Events (Less than 0.0 ft)	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***
Morning Low Tides (4 am to 11 am)	0	0	5	7	19	19	18	14	6	0	0	0
Afternoon Low Tides (11 am to 6 pm)	12	10	14	7	4	1	0	0	0	2	6	8

Key: Black Squares indicate peak California clapper rail nesting and fledging periods
Gray Squares indicate potential California clapper rail nesting and fledging periods
White Squares indicate periods considered unlikely for California clapper rail nesting and fledging

Figure 2-3. Number of Minus Tide Events (less than 0.0 ft) in 2003, with Peak and Potential California Clapper Rail Nesting and Fledging Periods (Source: *Goals Project* 2000 and *Tides and Currents Nautical Software* 1996)

Monitoring and post-treatment management would also be relatively simple near the range limits of invasive cordgrass species, where colonies are typically isolated, surrounded by native tidal marsh vegetation, and have very low or negligible rates of re-invasion because of long dispersal distances from seed sources. Local replanting with native Pacific cordgrass, pickleweed, or other appropriate local native vegetation may be appropriate in some cases, but spontaneous recruitment of native vegetation would normally be indicated.

More challenging would be eradication in tidal restoration sites or tidal channels with predominantly low marsh, or substrate elevations in the tidal range of low marsh. Most problematic would be this type of site surrounded by seed or fragment dispersal sources of invasive cordgrass, particularly Atlantic smooth cordgrass. If post-treatment vegetation management results in a new generation of non-native invasive cordgrass (by seedling establishment), then simply eradicating existing infestations would be pointless. It would be equally self-defeating to manage sites dedicated to tidal marsh restoration as non-tidal ponds or marshes indefinitely simply to preclude re-invasion. Planting treatment sites with native Pacific cordgrass would compound this problem rather than mitigate it, because plantings would interfere with detection of re-invading non-native cordgrass, and would probably generate significant proportions of hybrid invasive seed if surrounding infestations (smooth cordgrass pollen sources) are substantial. Spontaneous recruitment of hybrid cordgrass in treated areas is an important indicator of the effectiveness of regional control. For large treatment sites managed to be restored to native Pacific cordgrass while surrounding infestations persist, post-treatment monitoring and management should be coordinated with targeted reduction/eradication of key seed source populations, subregional suppression of invasive seed production, and scheduling of re-establishment of tidal marsh vegetation.

In practice, it would be difficult to separate tidal marsh management, restoration, monitoring, invasive cordgrass eradication, and post-eradication monitoring and management. It would be even more difficult to achieve success without closely integrating them beginning at early stages of implementation.

First Year (2003) Operations

The Control Program would implement a number of pilot and demonstration projects during the first control season, beginning approximately September 2003. The first year projects would be selected to be consistent with the Control Program's IVM strategy, focusing on preventing spread of non-native cordgrass to uninfested locations, removing cordgrass from newly infested locations, and reducing spread of pollen and seed. First-year projects would also be selected to accomplish a number of other important objectives, including:

1. Determining or demonstrating the effectiveness of specific control methods,
2. Providing assistance to local agencies currently dealing with cordgrass control for flood control or other public agency purposes,
3. Acquiring water quality and fate and transport data for herbicides, and
4. Coordinating with and supporting other important research and monitoring efforts (e.g., song sparrows and invertebrate monitoring).

Certain restoration projects may also be implemented in the first year to help develop a mitigation base for adverse impacts to California clapper rail habitat.

A preliminary list of possible first year project sites includes Pickleweed Park, Corte Madera Creek, and Blackie's Pasture, Marin County; India Basin, San Francisco County; Colma Creek-San Bruno

Marsh and Bayfront Park, San Mateo County; Bair Island, Ravenswood Slough, and Mowry Slough South, Santa Clara County; Alameda Flood Control Channel/Upper Coyote Hills Slough, Oro Loma Marsh, San Lorenzo Creek Mouth, and Emeryville Crescent, Alameda County; Point Pinole, Contra Costa County; and Southampton Marsh, Solano County. Some details regarding each of these sites, including the reasons they were selected, are provided in **Appendix I**. Consideration of most of these sites is in the very early stages, and site-specific plans have not been finalized.

If all potential first year projects were implemented, approximately 60 acres of non-native cordgrass would be treated. However, the Control Program anticipates that only six to ten of the fourteen identified projects may be implemented due to difficulty identifying and coordinating with landowners and partners. Approximately 40% of the first year projects would include manual and mechanical treatment methods, and up to 90% would include some level of herbicide treatment, either in the first year or as follow-up treatment in the next year. Projects not completed this year would be included in the program next year, pending availability of funding.

ALTERNATIVE 2: Regional Eradication Using Only Non-Chemical Control Methods

This alternative is identical to Alternative 1, with the important exception that herbicides treatment methods would not be used. Without the use of herbicides, it would be necessary to rely entirely on mechanical and manual methods, including mowing, discing/shredding, excavation, and dredging.

Under Alternative 2, in the short term (first year), over 60% of the 60 acres of eradication proposed under Alternative 1 (see discussion above) would not occur, because mechanical mowers and dredges are not anticipated to be available in that period. Removal of small outlying patches of invasive cordgrass would still occur using manual techniques, such as digging and smothering.

In the longer term, once equipment is available to treat large expanses of invasives, mowing, discing/shredding, excavation, and dredging would be used on those areas, some or all of which would otherwise be treated with chemicals. Identifying a precise number of acres that would be treated by mechanical methods rather than chemical methods is not possible, because under Alternative 1, the acreage proposed for chemical treatment may decline as newer and more effective mechanical equipment becomes available. In addition, as described under ***Site Specific Selection of Treatment Methods****,* on p. 2-15, above, treatment specific treatment methods cannot be determined until specific characteristics of each priority site are identified. However, ultimately, it can be assumed that, under this alternative, substantially larger areas would need to be treated with mechanical methods. In addition, because combined treatment with mechanical and chemical methods would not be possible, it would be far more difficult to assure the death of individual plants, resulting in the possible need for repeated mechanical treatment of areas as plants regenerate from roots and rhizomes.

It is unlikely that this alternative would meet all of the goals of the project. In some locations of moderate to heavy infestation the use of mechanical equipment would be infeasible, such as in areas of soft substrate, especially along channel banks or inappropriate such as in areas that support special status species.

ALTERNATIVE 3: No Action – Continued Limited, Regionally Uncoordinated Treatment

Under this alternative, the Conservancy and the Service would not implement a regionally coordinated treatment effort to control invasive cordgrass in the San Francisco Bay Estuary. Local agencies and landowners would continue to implement control measures on their properties. The scope, extent and persistence of these measures is not known, however, for the purposes of this analysis, it is assumed that approximately 100 acres of infested baylands would be treated annually. All treatment methods described in Alternative 1 would be used under this alternative. Mitigation measures are assumed to be similar to those described for Alternative 1 – mitigation measures for biological resources would continue to be required through Endangered Species Act permits. It also is assumed that, after about 10 to 15 years, most local landowners would cease treatment as infestations would become too widespread for control to be effective or worthwhile. The background for this conclusion is presented in Section 3.1.2, *Geomorphology and Hydrology*, under the discussion of the impacts of Alternative 3. At that point in time, the only treatment that would continue would be that necessary to maintain navigational and flood control channels.

Alternative 3 is the CEQA No-Project Alternative and NEPA No-Action Alternative. It is a reasonable scenario of the continuation of the existing policy extended into the future. As such, it forms the basis for comparison of the impacts of approving the proposed project with the impacts of not approving the project. This alternative would not implement a regionally coordinated treatment effort for any non-native cordgrass species at any scale. Local agencies and landowners may continue to implement control measures on their properties; however the scope, extent and persistence of these efforts is not known.

2.3 ALTERNATIVES AND TREATMENT METHODS CONSIDERED AND ELIMINATED FROM FURTHER EVALUATION

Pursuant to NEPA Section 1502.14(a) and CEQA Guidelines Section 15126.6(a) and (b), several alternatives and treatment methods were not carried forward for further analysis.

Treatment on Public Property Only

Under this approach, resources would be directed toward treating non-native cordgrass populations only on public properties that are designated for the protection of habitat and conservation of wetland species and communities. These properties would include the National Wildlife Refuge, wildlife preserves, restored marshes, bird sanctuaries, and some shoreline parklands. This alternative is not carried forward for further analysis in the EIS/R because responsible agencies likely would spend considerable funds and energy treating infestations, yet be unable to control the exponentially escalating input of seed, pollen, and vegetative propagules from neighboring infestations on private lands.

Eradication of Species with Limited Distribution

The goal of this approach would be to eradicate only three of the non-native cordgrass species: Chilean cordgrass, salt-meadow cordgrass, and English cordgrass. These species currently have small population sizes and limited distributions; therefore the likelihood of full eradication is high.

However, This approach would not address the existing and expanding problem of Atlantic smooth cordgrass invading low intertidal mudflat habitats.

Biological Control

The introduction of bio-control agents (e.g., insects or pathogens) to control weedy, non-native vegetation may, in some cases, offer permanent and self-perpetuating control of the invasive species, while minimizinge risk to human health and the environment. In order to be approved for use in natural environments by U.S. EPA, California Department of Fish and Game (CDFG), and United States Department of Agriculture (USDA), bio-control agents must pass rigorous host-specificity tests to determine that damage to non-target species would not occur. In Washington State, the plant-hopper, *Prokelisia marginata*, has been released for the purpose of controlling Atlantic smooth cordgrass populations in Willapa Bay. However, use of this insect species or other bio-control agents to reduced populations of non-native cordgrass have has not been approved for use, or for release in California. Bio-control is not considered by experts to be a practical treatment of non-native cordgrass species in California because it has the high potential to attack genetically similar populations of native Pacific cordgrass. The issues surrounding host-plant specificity are difficult to overcome and are not likely to be resolved in the near future. Therefore, the Control Program would not involve the use of bio-control methods, and these methods are not analyzed further in the EIS/R.

Chemical Methods Only

A chemical-only approach is too rigid to allow for opportunities to minimize environmental impacts in all situations, such as sites where rare or endangered plants, or essential vegetation cover for endangered wildlife, are present within or adjacent to stands of non-native cordgrass. The modified IVM approach allows for adaptive adjustment of treatment methods to site-specific needs of vegetation and plant community structure, wildlife conservation, and other receptors. The need for non-herbicide methods is also indicated for circumstances where treatment occurs directly adjacent to, or even within, residential areas where citizens may object to herbicide use. The potential benefits of herbicide use are fully exploited in the proposed alternative, and are not reduced compared with a "chemical-only" approach. Some potential herbicide impacts and limitations in specific circumstances (examples above) are eliminated with the proposed alternative.

Although chemical methods have been proven effective in controlling populations of non-native *Spartina,* there are substantial public concerns over potential ecological, public health, and safety effects of releasing herbicides and surfactants into the local environment. In addition, there are infestation locations where these chemical methods would not be feasible or appropriate. Therefore, this alternative is not carried forward in this EIS/R.

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