3.12. CUMULATIVE IMPACTS

Cumulative impacts are the result of the additive and synergistic impacts combined with other past, present, and reasonably foreseeable future actions. This discussion summarizes the potential cumulative impacts associated with the proposed project. Potential cumulative impacts are primarily discussed on a regional programmatic basis since the impacts of site-specific projects would not be known unless case-by-case, project specific analyses are performed.

Cumulative effects of the various cordgrass control efforts that comprise the *Spartina* Control Program (Control Program) are discussed in sections 3.1 through 3.11. This section analyzes the potential cumulative effects of regional non-native cordgrass control efforts, combined with proposed or reasonably foreseeable tidal restoration projects, mosquito abatement activities, and other weed control projects.

3.12.1 Projects Considered for Cumulative Impacts Analysis

Three types of projects potentially have significant cumulative interactions with the Control Program: (1) other aquatic weed control programs in the Bay-Delta (Sacramento Delta) region; (2) mosquito abatement activities in tidal marshes of the Bay region; and (3) restoration and management projects affecting tidal marshes of the San Francisco Estuary.

Tidal Marsh Restoration Projects

Regional wetland planning efforts among government resource agencies and research institutions have recommended large-scale restoration of non-tidal diked baylands to a regionally balanced mosaic of tidal marsh, unvegetated shallow-water habitat, and pans (Goals Project 1999). Large-scale regional mitigation plans, such as the San Francisco International Airport expansion proposal, and large-scale public acquisitions of salt ponds (in negotiation), indicate the likelihood of significant increases in the size of individual tidal restoration projects (compared with the past 20 years), and the cumulative area subject to mudflat-salt marsh succession within the next 20 years. Sheltered mudflats and immature tidally restored baylands are highly susceptible to invasion and early dominance by Atlantic smooth cordgrass and its hybrid swarm. Major seed and pollen source populations of Atlantic smooth cordgrass hybrids surround the diked baylands (mostly salt ponds) along the East Bay to the vicinity of Mowry Slough. Recent monitoring data indicate that all recent (1990s) tidal restoration sites from the Central Bay south to Newark Slough are either heavily invaded, or completely dominated by Atlantic smooth cordgrass and its hybrids. For example, tidal marsh vegetation at Cogswell Marsh and Whale's Tail mitigation marsh, are dominated by invasive Atlantic smooth cordgrass hybrids. At Oro Loma Marsh, Atlantic smooth cordgrass hybrids also are dominant over Pacific cordgrass. There are no known examples of recently restored tidal marshes in the East Bay that have not become dominated by Atlantic smooth cordgrass, and there is no evidence that selective planting or weeding of restored marshes is effective at screening out Atlantic smooth cordgrass when its seed rain from adjacent sources is abundant and uncontrolled.

These expanding newly restored tidal marsh populations of invasive non-native cordgrass, in turn, increase the seed rain and pollen load to adjacent marshes and other newly restored tidal marshes. The cumulative interaction between tidal marsh restoration and non-native invasive cordgrasses (particularly Atlantic smooth cordgrass) indicates a potential for exponential increase in invasion rates. The cumulative impact of the Control Program with tidal marsh restoration would depend primarily on the sequencing of tidal restoration and eradication of invasive cordgrasses. If tidal marsh restoration at a large, regional scale proceeds in advance of effective suppression of invasive non-native cordgrass (primarily Atlantic smooth cordgrass, the only significant invader of early-succession, low tidal marsh), demand for cordgrass control would increase exponentially in proportion with dominance of non-native vegetation over thousands of acres of former salt ponds. If large-scale tidal restoration precede effective control and eradication work, the impacts of that eradication work would be far greater because the areas to be treated would be increased substantially. In addition, it is likely that the invasion would proceed irreversibly if thousands (or tens of thousands) of acres of additional tidal marsh became productive seed sources of hybrid Atlantic smooth cordgrass, and particularly if youthful tall stands became colonized by endangered California clapper rails.

If tidal marsh restoration were planned to be contingent on effective suppression of non-native cordgrass invasion rates (reduction of seed and pollen rain to insignificant local levels), the feasibility of the Control Program would be relatively high, and the cumulative impacts of wetland restoration and invasive cordgrass eradication would be limited.

The potential for uncoordinated tidal restoration to generate irreversibly large populations (and uncontrollably large seed output) could occur within a decade after tidal restoration. This estimate is roughly consistent with observed changes in the spread and dominance of Atlantic smooth cordgrass in San Francisco Bay from 1990 when focused scientific studies of the invasion were first published (Callaway 1990) to 2002, and quantitatively estimated rates of smooth cordgrass invasions in Willapa Bay (Feist and Simenstad 2000), and assessments of San Francisco Bay's vulnerability to invasion by non-native cordgrasses (Daehler and Strong 1996).

The geographic distribution of tidal marsh restoration would have cumulative effects with the Control Program equal to sequencing. If tidal marsh restoration is geographically concentrated around the centers of distribution of the Estuary's invasive cordgrasses (e.g. San Bruno, Hayward Shoreline, Corte Madera) prior to adequate control, the feasibility of subsequent control would be low, and impacts of control would be high. If tidal marsh restoration is initially geographically concentrated in areas of low contemporary invasion rates (e.g. south of Mowry Slough and Palo Alto, nearly all of San Pablo Bay), feasibility of control would be high, and impact would be relatively low. The high degree of subsidence (low initial elevation for tidal restoration) in the Santa Clara Valley also constrains the "window" for efficient and successful tidal restoration in the South Bay (Siegel and Bachand 2002).

IMPACT CUM-1: Effects of Wetland Restoration Projects on Spread of Non-native Cordgrass

Proposed wetland restoration projects could accelerate the spread of non-native cordgrass, which, in turn, could interfere with the effectiveness of the Control Program. This would result in significant and adverse effects on Estuary biological resources, hydrology, and geomorphology.

MITIGATION CUM-1: The potential for cumulative impacts may be reduced by implementing the following: The Coastal Conservancy and US Fish and Wildlife Service shall internally review each proposed wetland restoration project other than control to assure that they are properly sequenced with cordgrass treatment and do not contribute to the increased spread of invasive cordgrass to newly restored wetlands. In addition the ISP/Coastal Conservancy and USF&WS shall encourage all agencies with permitting authority to utilize their discretion to assure proper sequencing of restoration projects with the Control Program.

Aquatic and Wetland Weed Control

There are no other systematic or resource agency-sponsored control or eradication programs for any of the other invasive non-native plants of the San Francisco Estuary. The most serious invader of brackish tidal marshes, broadleaf (perennial) pepperweed is not yet subject to systematic, regional control efforts, as it is in some interior agricultural/rangeland areas in western states. Local, independent control efforts for this species are limited to volunteer manual removal, and attempts at using salinity variation to limit its seed set or growth. A regional control program for this species could be possible in the future because of the severity of its impacts to brackish marshes and endangered species (Goals Project 1999, Baye et al. 2000), but none has yet been proposed, and none is currently foreseeable.

The aquatic weed control projects of the Delta are primarily freshwater weeds with relatively weak hydrologic or ecological linkage to the tidal marshes of San Francisco Bay and the few North Bay sites where cordgrass eradication projects could occur. Egeria (*Egeria densa*) and water-hyacinth (*Eichhornia crassipes*) infestations (submerged and floating freshwater weeds, respectively) are also treated with glyphosate and physical removal methods. The impacts of their control projects occur in freshwater river, pond, riparian, and perennial marsh habitats of the Delta (east of Antioch), not intertidal marsh and mudflats of the San Francisco Estuary. The foreseeable extent of aquatic weed control is on the order of 1,000-2,000 acres in the Delta region. Unless aquatic weed control was to spread into Suisun Marsh, it would not likely have significant cumulative interactions with the Control Program. As sea level rises, estuarine salinity gradients would extend east, making this impact increasingly unlikely. The short- and long-term prospects for significant cumulative impacts between interior freshwater weed eradication programs, and the Control Program, would be minimal.

Mosquito Abatement Activities in Tidal Marshes and Diked Baylands

Mosquito Abatement Districts conduct survey and mosquito control operations in all nine Bay Area counties, and in practically all tidal marshes. Many survey and ground-level control operations are aimed at detecting and mitigating mosquito production in poorly drained portions of tidal marshes. This occurs year-round. Most ground-level actions depend on the use of amphibious or all-terrain vehicles (primarily the Argo) to travel across tidal marsh plains. The impacts of marsh vehicle tracks and ditching due to mosquito abatement work are likely to overlap with similar cordgrass eradication impacts.

The geographic distribution of mosquito abatement activities covers the entire Estuary, which is far more extensive than that of the Control Program. Mosquito abatement vehicle use and trampling damage is unevenly distributed in tidal marshes. Well-drained tidal marshes (marshes with extensive channel networks, or low-elevation cordgrass marshes) produce few or no mosquitoes, and are seldom or never subject to mosquito abatement vehicles. Relatively high-elevation tidal marshes with locally obstructed drainage (such as pickleweed plains with small salt pans or waterlogged, incipient pans) are subject to frequent vehicle access. Atlantic smooth cordgrass invasions occur most frequently in sheltered mudflats, low-elevation salt marsh, and channel banks, which are well-drained and poor mosquito habitat. However, the two may coincide. All invasive cordgrass species in San Francisco Estuary can also occur in the vicinity of poorly drained high marsh, which may be needed for access by vehicles used in eradication operations. Therefore, there could be a small potential for compound vehicle trampling damage to occur to marsh plain vegetation where both mosquito abatement and cordgrass eradications coincide. These would most likely occur along the East Bay salt marshes, from San Leandro to Newark.

Almost all mosquito abatement operations in tidal marshes of the San Francisco Estuary rely on biological or physical control methods; chemical pesticide spraying in tidal marshes generally is prohibited. Ditching, insect pathogens (bacterial strains such as *Bacillus thuringiensis israeliensis*), and insect "hormones" (growth regulators; such as Altosid, that prevent sexual maturation) are the methods used to control salt marsh and diked wetland mosquitoes in the Bay region. Because mosquito abatement districts spray non-insecticide agents in tidal marshes instead of synthetic chemical pesticides, the risk of compound, cumulative impacts among insecticide and herbicide (glyphosate) applications would be very low or non-existent.

IMPACT CUM-2: Cumulative Damage to Marsh Plain Vegetation

The risk of significant damage to marsh plain vegetation from cumulative vehicle damage would be relatively low, but could occur in rare cases.

MITIGATION CUM-2: Mosquito abatement operations in tidal marshes of the San Francisco Estuary generally rely upon biological or physical vector control methods where practicable. Synthetic chemical pesticide applications (such as resmethrin) in tidal marshes are limited, and used only as appropriate on a site-specific basis. Ditching, insect pathogens (bacterial strains such as *Bacillus thuringiensis israeliensis*), naturally-derived pesticides (such as pyrethrin), and insect "hormones" (growth regulators; such as Altosid, that prevent sexual maturation) are the main methods used to control salt marsh and diked wetland mosquitoes in the Bay region. Because the bulk of vector control operations undertaken by mosquito abatement districts rely upon non-insecticidal agents in tidal marshes or limited amounts of naturally-derived or synthetic chemical pesticides, the risk of compound, cumulative, synergistic impacts among insecticide and herbicide (glyphosate) applications would be very low or non-existent.