Integrated Management of *Phragmites australis* at the Lower Cape May Meadows - Cape May Point Environmental Restoration Project

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I. INTRODUCTION

The conservation of fish, wildlife, and plant populations depends upon the integration of the best available biological information and ecological principles to develop goals, objectives, and subsequent management strategies and decisions. By applying a combination of biological, cultural, and chemical methodologies to an ecological problem, an effective integrated management plan can be established.

Invasive species are defined as a species that are: 1) non-native (or alien) to the ecosystem under consideration, and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112: Invasive Species). Invasive species should be managed to prevent new and expanded infestations and to restore or improve natural communities, while minimizing change to ecosystem structure and function.

Approximately 1,400 invasive plant species occur in New Jersey and common reed (*Phragmites australis*) is perhaps the most prevalent, and noticeable, in coastal salt marshes, especially those marshes that have been impacted by human activities. Management of *Phragmites* populations is necessary in situations where it has become well established and is spreading into or otherwise affecting native communities. Currently, there are no biological control mechanisms for controlling *Phragmites* and control via mowing and rhizome cutting has generally proven unsuccessful. *Phragmites* has been successfully controlled in many locations through the application of glyphosate-based herbicides. Some of the most effective restoration of marsh communities in areas once dominated by *Phragmites* has been realized through an integrated management approach involving herbicide application, prescribed burns and hydrological modifications.

Lower Cape May Meadows, located on the Atlantic Ocean side of Cape May County in southern New Jersey, is an internationally significant coastal wetland situated along the Atlantic flyway that provides a vital resting spot for shorebirds, birds of prey, and songbirds during their seasonal migration. This area also provides crucial habitat for residential birds, mammals and amphibians. The Meadows has been severely impacted by shoreline erosion, resulting in the direct loss of beach and unique freshwater wetland habitat. In addition to the actual loss of habitat acres, the erosion has resulted in degradation of the remaining freshwater wetland habitat through saltwater intrusion and topographical changes.

The Lower Cape May Meadows - Cape May Point Environmental Restoration Project (Project) area is comprised of approximately 340 acres, of which 95 acres have been invaded by *Phragmites*. As part of the Project, the U.S. Army Corps of Engineers (Corps) proposes to control *Phragmites*, plant 105 acres of emergent wetland vegetation, create fish reservoirs, restore water flow between ponds, and create 25 acres of tidal marsh.

The course of action proposed for *Phragmites* control at the Project site is an integrated management approach that would involve two phases of aerial and ground applications of a glyphosate-based herbicide during early fall, followed by a prescribed burn during the winter to remove dead biomass from the site. In conjunction with the *Phragmites* control efforts, hydrological modifications will be implemented on site to fully restore the freshwater marsh system.

II. CURRENT ISSUES SURROUNDING *PHRAGMITES*

Phragmites is a perennial grass (Poaceae) that is distributed across the continental United States. It has been a part of tidal marsh communities for at least 3,000 years (Orson *et al*., 1987), although until recently it was confined to the upper marsh edge and was a minor component of brackish tidal marshes (Orson, 1999). Today, most *Phragmites* is considered to be an invasive species, rapidly expanding into tidal marshes along the eastern seaboard. It can tolerate a wide range of conditions from salt and fresh water marsh habitat to dry uplands adjacent to wetlands. In New Jersey, common reed is most common in tidal and non-tidal marshes, but it is also prevalent in roadside ditches. Once established, *Phragmites* can spread at rates of 4 percent per year (Windham, 1995), mainly by vegetative reproduction.

Recent genetic work by Saltonstall (2002) has distinguished invasive *Phragmites* ("haplotype M" a non-native form indigenous to Eurasia) from native haplotypes. Native haplotypes that have been in North America for thousands of years are described as being rare or not common (Orson, 1999). The prevalence of *Phragmites* in marshes after the 1960's is believed to be the result of the spread of the more aggressive, non-native form (Saltonstall, 2002).

In recent years, non-native *Phragmites* has been expanding into low marsh habitat, displacing species such as smooth cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*) and common threesquare (*Schoenoplectus pungens*). The rapid expansion of *Phragmites* into tidal marsh habitat may be a result of hydrologic disturbance such as tidal restriction or other human generated effects (Chambers *et al*., 1999). At the Project site a history of mosquito ditching, the loss of consistent tidal inundation and storm induced salt water intrusion are thought to have led to the transformation from emergent wetlands to a *Phragmites* dominated community.

As *Phragmites* expands into a marsh it does so vegetatively, by sending out stolons (runners), which can grow up to thirty feet per year. The new roots and shoots compete with native grasses for nutrients as well as sunlight. Since *Phragmites* is much taller than the endemic grasses, native species are stressed by sunlight deprivation and are soon displaced. As dead plant material builds up, the overall marsh elevation changes, affecting the hydrology within the marsh. Physical characteristics of the marsh have been shown to change with the age of a *Phragmites* stand (Montalto *et al.*, 2002). Montalto *et al*. (2002) showed that marshes that had older stands of *Phragmites* were less saline, had lower water levels and less marsh surface variability than recently invaded marshes. The site conditions that result from these changes favor the establishment of *Phragmites*.

Plant species diversity is diminished in marshes that *Phragmites* invades and with this loss of native plant diversity is an overall decline in reproductive cover and wildlife food production.

Concomitant is a decline in numbers of bird species in *Phragmites* dominated marshes compared to native salt marshes (Benoit and Askins, 1999). Associated with decreased species richness is an increased fire hazard presented by the tall, highly-combustible plant in the winter and early spring. Also, the naturally dense stands tend to hold small pools of water that increase mosquito production. Lastly, dense stands of *Phragmites* can obscure vistas and historic viewscapes.

III. *PHRAGMITES* CONTROL ALTERNATIVES

Before any restoration effort can be undertaken, it is necessary to determine if the *Phragmites* present at the potential restoration site is native or non-native. Since native *Phragmites* haplotypes do not invade low-marsh habitat, the location of *Phragmites* within the tidal marsh provides the first indication of its type. Native and non-native *Phragmites* differ morphologically as well as ecologically. There is no evidence of native *Phragmites* haplotypes occurring in low marsh habitat or other continually inundated sites, so it is highly unlikely that any of the sites proposed for restoration contain native forms.

If no action is taken at areas targeted for restoration, *Phragmites* will continue to outcompete and replace more desirable vegetation. If no *Phragmites* control were implemented, wetlands would continue to be impaired and the resulting loss of ecological integrity would not be addressed. An integrated approach to *Phragmites* control that restores ecological function to a marsh benefits the entire marsh system. *Phragmites* control also reduces the fire risk to property, and reduces the amount of mosquito breeding habitat.

A. BIOLOGICAL CONTROL

Currently, biological control is not a technically feasible option for controlling *Phragmites*. Organisms that feed on *Phragmites* (moth larvae, aphids, leaf miners, gall midges, rodents, and birds) only cause incidental damage (Cross and Fleming, 1989). No organisms have been identified that significantly damage *Phragmites* without also impacting other plant species (Marks *et al*., 1994). Current research into biological control of *Phragmites* is being conducted by Bernd Blossey at Cornell University (Blossey, pers. comm., 2001). Several insects native to North America consume leaves and stems of *Phragmites* including shoot flies, midges, and a moth (*Rhizedra lutosa*), but the level of insect predation and subsequent damage is inadequate to reduce *Phragmites* stand density significantly or to retard further invasive expansion.

B. MECHANICAL CONTROL

Mechanical control of *Phragmites* in wetland areas is only marginally successful and is usually not technically feasible on project sites due to the size of the projects and moist substrate conditions. Public Service Electric and Gas Company, through its Estuary Enhancement Program, has experimented with mechanical control of *Phragmites*. However, control via mowing and rhizome cutting has generally proven unsuccessful. Multiple mowing (up to 6 times per year) has been effective at limiting the vigor of *Phragmites*; however, this management technique does not eliminate *Phragmites*, nor does it encourage beneficial vegetation (e.g., *Spartina alterniflora*) establishment. In addition, mechanical control reduces migratory bird habitat by eliminating or degrading nesting, brooding, or feeding areas due to mowing that occurs throughout the summer and may result in soil compaction, which can reduce invertebrate populations. Additionally, the operation of heavy equipment in wetland areas is both difficult and costly. Mowing only removes the aboveground vegetation and is needed repeatedly throughout the growing season over at least three consecutive years in order to reduce plant vigor. Moreover, repeated mowing in of itself does little to promote re-establishment of desirable wetland plant communities. Further, mowing operations may result in nest damage or loss, as well as injury or mortality to wildlife unable to escape the mower's path.

C. FIRE CONTROL

Controlled, prescribed burns can kill *Phragmites* roots and rhizomes in dry, peaty areas (Payne, 1992). However, burning alone would be ineffective because the usually moist soil conditions in which *Phragmites* grows would prevent below ground biomass from being killed. Consequently, treatment of *Phragmites* at the proposed sites by mechanical or fire methods alone may stimulate plant growth and accelerate invasive expansion. At the very best, mowing and burning alone does not eliminate *Phragmites* from a site, but merely retards growth temporarily.

D. WATER CONTROL

Water control is another option of managing *Phragmites*. In order for *Phragmites* to be effectively controlled, stands have to be submerged for long periods of time during the growing season, typically up to four months. Within estuarine emergent wetlands water control (i.e., long-term inundation of the *Phragmites*) is not feasible since inundation is regulated by tidal cycling. Flooding has been most effective when used in conjunction with other management techniques such as cutting or herbicide applications. It is unlikely that short-term flooding, on its own, would effectively eliminate *Phragmites.* Therefore, water control alone would not be an effective option for the proposed Project.

E. CHEMICAL CONTROL

Chemical control of *Phragmites* through aerial application of a glyphosate-based herbicide to the mature stands during late summer / early fall in combination with a prescribed burn and hydrologic alteration is the most effective and economical technique available to control *Phragmites* at this time. Glyphosate-based herbicide, applied at a rate of 4 pints of active ingredient per acre, kills most of the rhizomes from which the *Phragmites* plant grows. A follow-up prescribed burn eliminates the dead biomass within the wetland. A second spray of herbicide at a rate of 2 pints of active ingredient per acre is generally recommended to eradicate any remaining *Phragmites* not treated in the first application. A second spraying is recommended since many stalks within the *Phragmites* understory are not exposed to the initial application. Spot treatment of large expanses (i.e., several hundred acres) of *Phragmites*-dominated wetlands is not technically feasible or cost-effective. Chemical control of

Phragmites dominated wetlands has proven to be an effective method of control in New Jersey.

IV. EVALUATION OF GLYPHOSATE-BASED HERBICIDES AND SURFACTANTS

Glyphosate-based (hereafter Glyphosate) herbicides (common trade names include; Roundup®, Rodeo®, Accord®, and Glypro®) are broad-spectrum, nonselective, post emergent herbicides that are assimilated by plant leaves and transported within the plant to growing tips of stems and roots as well as to rhizomes and tubers. Glyphosate interferes with plant growth by inhibiting the production of an enzyme (5-enolpyruvyl shikimate-3-phosphate synthetase), which is necessary for the production of essential aromatic compounds (Schönbrun *et al*., 2001). This synthetic pathway only occurs in higher plants, algae, bacteria and some fungi (Schönbrun *et al*., 2001). Since animals, including insects, birds, mammals and most aquatic organisms do not have this amino synthesis pathway, Glyphosate is relatively nontoxic to them (Solomon and Thompson, 2003).

Glyphosate does not accumulate in animal tissue and is not generally active in the soil since it is strongly adsorbed by the soil. Glyphosate remains unchanged in the soil for varying lengths of time, depending on soil texture and organic matter content. The half-life (time it takes one half of the herbicide to breakdown) of glyphosate can range from 3 to 130 days. Soil microorganisms breakdown glyphosate. The main break-down product of glyphosate in the soil is aminomethylphosphonic acid, which is broken down further by soil microorganisms. In natural waters, half-lives ranged from 6 to 21 days. In field studies, measured half-lives average less than 60 days in soils and 1.5 to 14 days in water (Giesy *et al*., 2000).

Glyphosate has no known effect on soil microorganisms. Glyphosate (including the Accord® and Rodeo® formulations) is no more than slightly toxic to fish, and practically non-toxic to amphibians and aquatic invertebrate animals. It does not build up (bioaccumulate) in fish. However, Tate *et al*., (2000) found adverse affect on *Pseudosuccinea columella* snails after three generations were continually exposed to glyphosate. Glyphosate had little effect on the first- and second-generation snails. However, third-generation snail embryos developed much faster than other embryos. Furthermore, Tate *et al*., (2000) found that hatching rates were inhibited for snails continually exposed to high doses of glyphosate.

Glyphosate is essentially non-toxic to birds and mammals. Glyphosate and its formulations have not been tested for chronic effects in terrestrial animals. Based on the results of animal studies, glyphosate has not been shown to cause genetic damage or birth defects, and has little or no effect on fertility, reproduction, or development of offspring. Most incidents reported in humans have involved skin or eye irritation in workers after exposure during mixing, loading or application of glyphosate formulations. Nausea and dizziness have also been reported after direct exposure. There is insufficient information available at this time to determine whether glyphosate causes cancer, although there may be a correlation between long-term occupational exposure to glyphosate and increased incidences of non-Hodgkin’s lymphoma (De Roos, *et al*., 2003; and, Hardell *et al*., 2002).

Glyphosate may enter aquatic systems through direct application to aquatic vegetation, accidental spraying, spray drift, or surface runoff. It dissipates rapidly from the water column as a result of adsorption and possibly biodegradation. Based on its water solubility, glyphosate would not be expected to bioconcentrate in aquatic organisms (U.S. Environmental Protection Agency, 2002).

As mentioned above, Rodeo® would not have any adverse impacts on aquatic invertebrates, reptiles or amphibians that could potentially be sprayed during the aerial application. The State-listed (endangered) southern gray treefrog (*Hyla chrysoselis*), is known to occur at the Project site. Although there are currently no data available from the scientific literature regarding the effects of Rodeo® on southern gray treefrogs, Mann and Bidwell (1999) tested the toxicity of glyphosate on four species of southwestern Australian frogs. They found that Glyphosate was nontoxic to the tadpole stage of the four species and that adults were less sensitive than tadpoles. In addition, two reports on the effects of Vision® (Canadian version of Roundup®) on amphibians in Canadian forested wetlands (Thompson *et al*., 2004; and, Wojtaszek *et al*., 2004) support Mann and Bidwell's (1999) findings that glyphosate herbicides are safe to amphibians when used as directed. Chen *et al*.(2004) and Edgington *et al.* (2004), in two laboratory studies, found adverse effects of Vision® on larval amphibians. These adverse effects were elevated under high pH conditions.

Numerous scientific studies have investigated the potential direct and indirect effects of Glyphosate on amphibian and fish communities (Jiraungkoorskul, *et al*., 2003; Smith, *et al*., 2003; Ailstock, *et al*., 2001; Kilbride and Paveglio, 2001; Tate, *et al*., 2000, Johnson and Leopold, 1998; Cole, *et al*., 1997, Hildebrand, *et al*., 1982). Only Jiraungkoorskul, *et al*. (2003) and Tate (2000) found adverse effects of Glyphosate on their study species, but both of these studies involved long-term continuous exposure to glyphosate. Jiraungkoorskul, *et al*. (2003) found that Nile tilapia (*Oreochromis niloticus*) that were exposed to glyphosate for three consecutive months were adversely affected and Tate *et al*., (2000) found an adverse affect on *Pseudosuccinea columella* snails after three generations were continually exposed to glyphosate. These individual studies and numerous review articles (e.g. Solomon and Thompson, 2003; Smith and Oehme, 1992) support the notion that, when used appropriately and according to label instructions, glyphosate herbicides are a safe option for *Phragmites* control.

Glyphosate-based herbicides approved for aquatic use do not contain surfactants and their manufacturers recommend the use of nonionic surfactants with the glyphosate application to improve its efficacy. The rate of uptake by a plant is dependent on physical properties of the leaves, so surfactants are often added to reduce surface tension between the leaf and the spray droplet. Surfactants that are typically used in the application of glyphosate-based herbicides are X-77®, R-11®, Agri-Dex®, and LI-700®. These nonionic surfactants are typically used at concentrations ranging from 0.5% to 5%. There are few toxicity data for surfactants, although there is evidence that Glyphosate mixed with LI-700® is less toxic than Glyphosate with X-77® or Monsanto's Roundup® formulation (Solomon and Thompson, 2003).

Glyphosate contains the contaminant N-nitroso glyphosate (NNG) at 0.1 ppm or less. The potential for NNG to cause cancer is unknown. However, no effects attributable to NNG were seen in tests of glyphosate. The health risk of NNG has not been assessed because exposure is practically non-existent.

V. PROPOSED *PHRAGMITES* CONTROL METHODOLOGY AT CAPE MAY MEADOWS

Approximately 95 acres of wetlands within the project areas (totaling approximately 340 acres) are currently dominated by *Phragmites*. *Phragmites*-dominated wetlands at the project site are characterized into two types: Monospecific stands where *Phragmites* accounts for greater than 75% of the stand vegetation; and, Mixed communities where Phragmites dominates but comprises less than 75% of the community. In Mixed communities, associate species included whorled marsh-pennywort (*Hydrocotyle palustris*), swamp loosestrife (*Decon verticillatus*), marsh fern (*Thelypteris palustris*), swamp rose mallow (*Hibiscus palustris*), common threesquare (*Schoenoplectus pungens*), and umbrella sedges (*Cyperus* spp.). The two community types are interspersed and not readily distinguishable into discrete units.

To restore the *Phragmites*-dominated wetlands, the following steps are proposed: (1) aerial application of the herbicide, Rodeo®, to approximately ½ of the *Phragmites*-dominated wetlands during September 2004; (2) prescribed-burn of sprayed areas between October 2004 and March 2005 (following herbicide treatment) to remove organic material; (3) herbicide treatment of the rest of the *Phragmites*, as well as any persistent, residual areas of *Phragmites* not killed during the initial treatment during September 2005; and, (4) prescribed burn of the remainder of *Phragmites* areas between October 2005 and March 2006 to be conducted with the assistance of the New Jersey Forest Fire Service.

Southern gray treefrogs breed in marshes, bogs and other wetlands between April and August with tadpoles undergoing metamorphosis within one to two months. The *Phragmites* integrated management plan, described above, calls for the application of glyphosate in late September when few, if any, larval treefrogs would be present. In addition, most adult frogs will have moved into upland areas which will not be treated with herbicide. Furthermore, southern gray treefrogs and other amphibians and reptiles would be unaffected by the proposed winter prescribed fire at the Project site because they would be secure in their hibernacula. Winter *Phragmites* fires burn quickly and rarely scorches the ground beneath them, especially in wetland situations.

Based on the results of a rare plant survey (U.S. Army Corps of Engineers, 2002), the Corps has evaluated a number of rare plant protection methods that could be implemented in an effort to protect existing populations of rare plants from potential adverse impacts resulting from the *Phragmites* treatment activities. Specifically, the Corps has considered a phased approach, avoidance, manipulation of herbicide application regime, physical barriers, transplanting, and seeding as rare plant protection options. In addition to a brief description of these various options, the following sections provide a discussion of how each option would be implemented in the Project area.

Phasing refers to the staggering of herbicide application over time. The primary benefit of a phased approach is that it allows the Project sponsors to evaluate the results of the treatment plan, and to refine the application methods and/or rare plant protection measures accordingly. Therefore, in order to maximize the benefits associated with this method, the Corps attempted to divide the number of rare plant populations located within the *Phragmites*-dominated areas into two equal groups, whenever possible, with the intent of modifying the second year's treatment method and/or rare plant protection measures to account for any problems identified after the first year of treatment.

Two other primary factors that were considered during the development of the phased approach included public access and financial constraints. The project area consists of two public areas that are used at all times of the year. Consequently, the project sponsors determined it would be best if each phase of the treatment plan included some property from both the Park and Refuge; therefore, at no one time would the public be totally restricted from one area. In addition, implementation of a phased approach involving numerous scattered/isolated areas of treatment is cost prohibitive. Therefore, it was not always possible to equally divide rare plant locations over the two-year treatment plan if it required excessive fragmentation of the overall area to be treated.

Based on the ecological benefits, sponsor's objectives, and financial constraints, the Corps has determined to conduct their *Phragmites* treatment plan in a two phased approach over the next two years. In coordination with Allied Biological Inc. (ABI), the survey area was divided into Phase I and Phase II using readily identifiable breaks in the landscape, such as trails and distinct community type changes. Each phase includes both *Phragmites*-dominated (treatment) areas and non-*Phragmites*-dominated (non-treatment) areas.

Avoidance requires that the protected area, species, and / or features are not directly impacted by the proposed action. For the Project, avoidance would mean that herbicide would not be directly sprayed on the rare plant species' locations. This method provides the maximum level of protection to rare species' locations located within *Phragmites*-dominated areas targeted for herbicide treatment, during either phase. Accordingly, the Corps has incorporated the Project-specific avoidance measures identified below in their rare plant protection plan.

In order to implement appropriate avoidance measures, the boundaries of all significant populations of moderate priority species and high priority species within the treatment zones would be clearly marked in the field with highly visible flagging tape and/or high visibility snow/exclusion fencing.

Buffer zones will be established between the edges of *Phragmites*-dominated treatment areas and sensitive resources such as rare plant locations and forested communities during aerial spraying activities. These restricted-aerial buffer zones will begin at the population boundary and extend the appropriate distance, depending on species (i.e., 100 feet for high priority species and 50 feet for significant populations of moderate priority species). Once aerial spraying is completed, the area between the outer buffer zone limit to a distance of 10 feet from the rare plant population boundary would be treated by ground application. The remaining 10-foot-wide *Phragmites*-dominated area would be treated with herbicide using backpack sprayers.

VI. CONCLUSIONS

The proposed *Phragmites* control and wetland restoration at the Lower Cape May Meadows - Cape May Point Environmental Restoration Project incorporates an integrated management approach using chemical, physical, and hydrologic methodology. This integrated management approach minimizes the use of herbicide, while ensuring effective and efficient control of a non-native, invasive plant species. The chemical (Glyphosate) proposed for control of *Phragmites* is relatively non-toxic; does not bioaccumulate; biodegrades or is bound readily to soil; is water soluble; and has been researched extensively over the last 20 years. The Lower Cape May Meadows - Cape May Point Environmental Restoration Project will restore approximately 95 acres of freshwater wetlands adjacent to a marine and estuarine wetland system. This project will provide high quality habitat for a variety of migratory birds including wading birds, waterfowl, shorebirds, raptors, and neotropical migrants. In addition, control of Phragmites within the wetland will eliminate a wildland fire fuel and reduce fire hazard within the area. The project will also reduce mosquito breeding habitat within the wetlands ultimately resulting in a reduced need for insecticide spraying within the wetlands.

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