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Marsh Revegetation Program of Cootes Paradise, Lake Ontario, Canada

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Introduction

Prior to the increase in human populations and subsequent development of Canadian Great Lakes shorelines, an inlet located on the western-most end of Lake Ontario known as Hamilton Harbour was a pristine natural bay with habitats that supported a richly diverse assortment of vegetation, fish, and wildlife. Since 1926, a quarter of the water area of this 5400 hectare region near Hamilton, Ontario has been filled to meet the demands of a growing urban and industrial center (CCIW 1991). Cootes Paradise, a 400-hectare shallow water marsh located on the west end of the harbor, is a severely degraded area within the harbor (Holmes 1988). The marsh has been recognized by the Canadian Wildlife Service as the second most important staging area for waterfowl on the lake (Chow-Fraser & Lukasik 1997, Holmes 1988).

Point source and non-point source (NPS) pollution from various land uses have contributed to higher water levels, excess nutrients, and high turbidity in the marsh, all of which are the primary factors responsible for the deterioration of Cootes Paradise. Restoration of this marsh centers on rehabilitation of vegetation, fish, and wildlife populations (Chow-Fraser & Lukasik 1997).

The restoration of Cootes Paradise is a small-scale project (spatially) embodied within a large-scaled (both spatially and temporally) comprehensive Remedial Action Plan (RAP), the ultimate goal of this being improvement of the condition of Hamilton Harbour's watershed. The water quality of the harbor is "degraded to the point that recreational activities, the aquatic ecosystem, fish and wildlife habitat, and other factors related to water quality have been damaged," and has qualified as one of 42 Great Lakes Areas of Concern (AOC) by the International Joint Commission (IJC) in 1985 (S.C.R.P. 1996).

The RAP, which emphasized multi-disciplinary and multi-agency collaboration in its problem definition, planning, implementation, and restoration, is overseen and implemented by Canada's provincial and local governments. The overall objective of the large-scaled bi-national Great Lakes Water Quality RAP Agreement between Canada and the U.S. is to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin ecosystem," (S.C.R.P. 1996).

Fish and Wildlife Habitat Restoration Project – Marsh Revegetation Program

Since discussion of all comprehensive efforts of the Hamilton Harbour RAP is beyond the scope of this paper, attention is given primarily to the ongoing marsh revegetation program, a component of and priority program of the Fish and Wildlife Habitat Restoration Project (FWHRP) of Cootes Paradise within the RAP (CCIW 1991). In 1991, a FWHRP Steering Committee was created, comprised of a diverse assortment of 48 stakeholder members, some of whom include: scientists and managers from the Royal Botanical Gardens (RBG) (which owns and manages the marsh); private environmental consultants; local officials from all three tiers of government; and biologists from McMaster University.

The objectives of the FWHRP formulated by the Steering Committee area as follows ("Project Paradise" 1997):

- Improve water quality;
- Alter fish community to enhance biodiversity of desired species;
- Recover lot wetlands;
- Restore aquatic plant communities;
- Create habitats for shorebirds, waterfowl, reptiles, and mammals;
- Improve aesthetics;
- Provide enjoyable educational opportunities;

An Ecosystem in Need of Recovery

A highly productive and diverse vegetative community in the shallow Cootes Paradise ecosystem that existed prior to the 1930's once approached 90% cover. The diverse plant community consisted of cattail (*Typha alatifolia*), burreed (*Sparganium eurycarpum*), and wild rice (*Zizania aquatica*), as well as many species of submersed and floating aquatic plants. This diverse assortment of vegetation provided optimum spawning and nursery habitat for warmwater and coldwater fish, and supported abundant waterfowl and small mammal populations. Currently, vegetative cover has declined to 10% cover and consists mainly of hybrid cattails (*Typha glauca*) (a cross between original species *Typha latifolia* and *Typha angustifolia*), and manna grass. Residual populations remain of a dozen other emergents, water lilies (*Nymphaea sp.*), and essentially no submersed species (Chow-Fraser & Lukasik 1997, White et al. 1997).

The main causes for the decline in abundance and diversity of vegetation in the marsh are high water levels, excess nutrients, and high turbidity. The mean water level in Cootes Paradise is dependent on the water levels of Lake Ontario, and is currently 18 cm higher than 100 years ago. This rise is mainly due to artificial alterations of water levels for navigational purposes into the harbor from the lake. A natural process called crustal rebound (lake tilt) has also contributed to increasing water levels on the western end of Lake Ontario in response to glacial retreat. This has resulted in the western end subsiding and the eastern end rising over the last 10,000 years. The existing water levels are nearly too high to support emergent aquatic vegetation in the marsh (Chow-Fraser & Lukasik 1997).

Excess nutrient inputs of nitrogen and phosphorus into the marsh originated mainly from the Dundas Sewage Treatment Plant, three main creeks, and combined sewer-overflows (overflow outlets where sewage combines with excess stormwater). High turbidity levels have resulted from excess inputs of particulates from these combined sewer-overflows and the three creeks. These particles are suspended and resuspended by wind, waves, and by a large non-native carp population that churns up bottom sediments by their spawning and foraging practices (Chow-Fraser & Lukasik 1997). Efforts to control these factors detrimental to the marsh and to Hamilton

Harbour are being remedied through other programs within the RAP as well as through revegetation of Cootes Paradise.

Marsh Revegetation Techniques

The restoration plan of the FWHRP focuses on revegetating a diverse community of aquatic plants that are tolerant of the current water levels. Eventually, the plant community will serve as nursery habitat for desired fish species such as crappies, pike, and bass. The first step in the restoration plan was to re-establish emergent plants that would reduce wave action and trap some suspended sediments, thereby decreasing water turbidity and improving water clarity. Submersed vegetation was to be incorporated later either naturally or by planting as these species do not recolonize in the highly turbid water (Chow-Fraser 1997).

In order to determine the effectiveness of different planting techniques for this particular marsh, the Steering Committee conducted a series of experiments from 1991 to 1993. One such technique was the construction and installation of "exclosures", or cages, in areas devoid of aquatic plants in order to protect future plantings from the likes of fish species such as carp and various wildlife intruders. The initial site chosen for the series of transplant experiments in the Cootes Paradise marsh was in an area called Mac Landing. Mac Landing is a southern inlet to the marsh and once supported a healthy community of emergent plants. Also, and existing boardwalk there served as a favorable place to construct and assemble the exclosures (Chow-Fraser 1997).

The exclosure design was an 8-foot square consisting of four panels of plastic snowfence on a frame of metal. The exclosures were then inserted by McMaster University biologists approximately three feet into the sediment, while the fenced portion protruded about 4-5 feet above the sediment. Adult cattails from nearby stands were transplanted both into the exclosures and into nearby unprotected control plots. At the end of the growing season in August 1991, the cattails were found to be healthy and tripled in number within the exclosures. The cattails in the control areas were damaged and growth was reduced (Chow-Fraser 1997).

Recognizing that this type of approach was labor intensive and would have been expensive if contractors were used, the Steering Committee appropriated funds to develop a volunteer planting program for a very small area of the marsh. This volunteer planting program had three site-specific goals: to replant an area of the marsh; to learn more about marsh restoration; and to promote community commitment and interest in participating in Cootes Paradise restoration activities. Pamphlets were made and distributed, meetings were held, and community response was very positive. Fortunately, several of the recruited volunteers were students from nearby McMaster University, and were able to participate in the experimental design for the project.

A set of treatments using exclosures were designed to determine the effects of water depth as well the use of a silk screen on the re-establishment of waterweed and two emergent species of cattail and arrowhead. Also, a comparison of performance was made between locally collected (from an Ottawa nursery) and non-locally collected Wisconsin [nursery] grown arrowheads. Trials were incorporated into the following experimental design (Chow-Fraser 1997):

Trial	*# Exclosures & Planting Design*	*Species*
Effect of water depth on plant establishment	3 @ 20 cm depth	30 waterweed; 30 cattail; 30 arrowhead;
	3 @ 30 cm depth	30 waterweed; 30 cattail; 30 arrowhead;
	3 @ 40 cm depth	30 waterweed; 30 cattail; 30 arrowhead;
Silk screen	2 with silk screen	30 waterweed; 30 cattail; 30 arrowhead;
	2 without silk screen	30 waterweed; 30 cattail; 30 arrowhead;
Stock Comparison	2 on exposed mudflat	Ottawa arrowhead seed stock;
	2 on exposed mudflat	Wisconsin arrowhead seed stock;

Upon completion of the experiments in September 1993, much was learned from the results. Muskrats were able to chew through the plastic snowfence of the exclosures and eat most of the plants inside 8 of the 9 depth trials. A small percentage of the cattails and arrowheads planted in 20 cm of water had nonetheless become established, although no emergent plants became established at 30 cm depths (exclosure panels were later constructed with weld-wire fence to prevent future muskrat intrusions). The silk screen trial showed that their use could ameliorate some negative effects of deep water on establishment. While no arrowheads survived in one of the unscreened exclosures, all arrowheads protected by the silk screen survived in water depths above 40 cm. All plants within the silk screen grew shoots from runners and plant numbers increased more than threefold to 100 (only 30 were planted)! Results of the stock comparisons between Ottawa and Wisconsin grown arrowheads showed that survival was equal (Chow-Fraser & Lukasik 1997).

Monitoring of the progress of plants continued as they became established, and exclosure panels were eventually removed during the spring, as it was discovered the plants did not survive when some panels had been removed in the fall. The exclosure panels were used again for plantings at other sites, and were placed adjacent to each other connecting them to create larger vegetative "islands." In between plantings crew leaders taught volunteers some water quality monitoring techniques such as secchi disk readings. These pilot experiments, designs, and methods used increased knowledge, community involvement, and area of established plants as well as served as an impetus for the larger-scaled volunteer planting program of 1996 coordinated by the Bay Area Restoration Council (Chow-Fraser & Lukasik 1997).

Program volunteers planted over 4 hectares of emergent vegetation including species of cattails, arrowhead, soft-stem bulrush, swamp dock, bottonbush, sweetflag, swamp buttercup, waterweed, and pondweed. Plants were provided from the RBG aquatic plant nursery, which contained over

300,000 plants specific to this restoration program. This program also included the uprooting and removal of the exotic species Purple Loosestrife, which favors disturbed site conditions ("Cootes Paradise" 1997).

Assessment of Restoration Effectiveness

Although the restoration of this marsh is still in the implementation phase and has yet to be fully evaluated, the techniques and methods used in trying to achieve FWHRP goals appear to be successful so far. According to the Fish and Wildlife Habitat Rehabilitation Newsletter (October 1997), emergent vegetation inhabits both shallow and open-water areas of the marsh, consisting most commonly of great bur-reed (*Sparganium eurycarpum*) and water smartweed (*Polygonum amphibium*). These species as well as white water lily (*Nyphaea tuberosa*) grow from seeds and are spreading outward into the open water (Environment Canada Newsletter 1997).

Remarkably, establishment and growth of submerged species throughout the marsh have been rapid. Monitoring of transects in 1996 showed almost no presence of submergents. The same transects in 1997 revealed hundreds of individual submergents. Notably, horned pondweed (*Zanichellia palustris*), a plant rare to Ontario and not present in Cootes Paradise for many years, was present in large numbers. This plant is an annual, which indicates that it likely germinated from the dormant seed bank (Environment Canada Newsletter 1997).

RBG biologists predict that an increased number of waterfowl will feed on the enhanced food source now available to them by the enhanced aquatic plant community. These predictions should prove accurate according to Weller (1978) who states that the increase in species richness (diversity) and vegetative patterns have been known to strongly influence waterbird species composition as well as populations, and is probably the most simple index to habitat quality. According to Weller (1978), since marsh management has historically been poorly founded as a predictive science, measuring the success of this particular restoration effort may be validated by the increases in aquatic plant numbers and diversity.

An integral component in the success of this (and all) restoration programs has been accomplished largely due to the integrated approach and cooperative structure between professionals and community volunteers. Consulting with, educating, and involving the community throughout the process has allowed the community to play an important role in the success of the programs (S.C.R.P. 1996).

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