ROYAL BOTANICAL GARDENS
NATURE SANCTUARIES

Grindstone Estuary Rehabilitation

Floodplain Restoration Techniques at Royal Botanical Gardens, Hamilton, Ontario, Canada

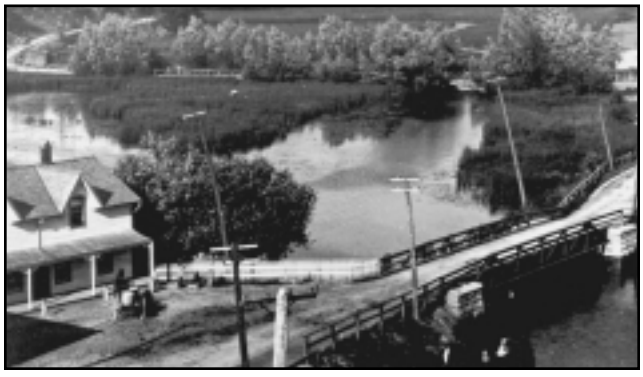
PROJECT Paradise
RESTORING GREAT LAKES COASTAL WETLANDS

FLOODPLAIN WETLANDS

Grindstone Creek (a 90 km^2 watershed) is a small, cold water tributary that drains into the northwest corner of Hamilton Harbour. At its mouth lies the Grindstone Estuary, a 60 hectare Lake Ontario coastal wetland and floodplain marsh complex. The estuary is owned by Royal Botanical Gardens, and represents a significant component of the more than 300 hectares of Class 1 wetlands owned and managed by RBG.

Floodplain wetlands, like those found in Grindstone Estuary, are some of the most threatened habitats in southern Ontario. Poor watershed management and floodplain infilling have destabilized the flood cycle and generated poor quality floodwater. These changes have promoted further floodplain degradation, allowing for the invasion of non-native species. A healthy floodplain system is driven by a gradual flood cycle peaking during the spring thaw, replenishing ponds within the wetland, and maintaining a connection to the adjacent creek for weeks at a time. Ponds that often exist within these wetlands, called “oxbows” are the remnants of historical creek channels, and represent essential pieces of fish and wildlife habitat.

Floodplains represent one of the most productive environments in the world due to their shallow, warm, enriched water, and abundant food supply. A distinct biotic community is associated with floodplain habitat, influenced by the timing of the spring flood cycle. Some of the associated fish and wildlife species include northern pike, leopard frog, and green heron. A unique and diverse plant community is also found comprised of species like river bulrush, swamp milkweed, and tussock sedge. The plant community, in combination with the floodwaters provides the framework on which these wetland habitats are built. The plants also have a secondary function as a natural water filter by removing nutrients, heavy metals, and suspended sediment, consequently improving water quality downstream.



At the turn of the century the Grindstone Estuary marshlands were thriving.

Today, RBG holds the majority of what remains of the once extensive wetlands and floodplains of Hamilton Harbour. Despite their importance, only a fraction of RBG wetlands remain unaltered today.

Decline and Recovery of RBG Wetlands

In the last century, the Grindstone Creek watershed has been subjected to many stresses, resulting in the loss of its floodplain ecosystem. Agricultural runoff, eroded soil, and sewage effluent have long affected Grindstone Creek. In recent times urbanization of the watershed has played the most significant role in the degradation of its floodplains. These factors have dramatically impacted the creek's water cycle and quality, destroying the native flora and fauna, and facilitating the invasion of non-native species such as carp, purple loosestrife and European manna grass.

Before the 1900s, these floodplain wetlands were covered by a variety of plant species and supported extensive fish and wildlife populations. The vegetation communities began to decline in the early 1900s as nutrient enrichment, sediment infilling, increased runoff and the destructive behaviour of introduced species such as carp, inhibited the growth of aquatic plants and destabilized the flood cycle. By the early 1900s, vegetation cover was reduced to 85%, and completely vanished by 1985. As the once abundant vegetation disappeared, the creek's banks slowly deteriorated, and the form and function of the floodplains was lost.

In 1989, following a study by the International Joint Commission (IJC) of highly degraded areas on the Great Lakes, restoration of fish and wildlife populations in Hamilton Harbour was initiated under the Hamilton Harbour Remedial Action Plan. RBG has taken a lead role in the Grindstone Estuary restoration in conjunction with many corporate and government agencies.

RESTORATION GOALS

The overall goal of the Grindstone Estuary rehabilitation project is to restore the creek channel and the form and function of the associated floodplain marsh ecosystem. This includes the restoration of emergent and submergent plant communities, and their associated fish and wildlife populations. However, the restoration of the estuary will always be limited by the overall integrity of the Grindstone Creek watershed. Watershed alterations have made floodplain marsh ecosystems the most threatened element of marsh habitat at RBG. Primary factors include the ditching of the associated creeks, alteration of water cycles, and loss of floodplain plants to invading, aggressive, non-native species.

The restoration goal is to be attained by restoring the fundamental system conditions to as close to historical conditions as possible, facilitating the re-growth of the plant community. A restored plant community is the cornerstone of a healthy marsh system, as it provides habitat and food for a diverse group of fish and wildlife populations. This will be attained by substantially reducing the input of nutrients and sediment from the watershed and sewage treatment plant, reconnecting the creek to its floodplains, redefining the stream channel, and eliminating aggressive, non-native species.

CARP AS WETLAND DESTROYERS

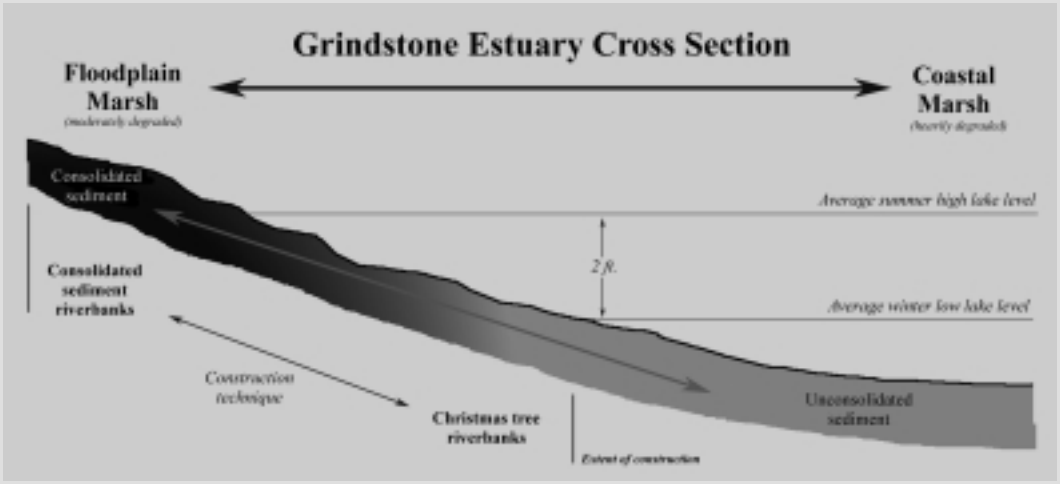
The common carp (*Cyprinus carpio)* is native to Asia, and is adapted to a river mouth marsh environment. Carp forage by rooting through the soft bottom for clams, snails, and insect larva. This foraging resuspends the bottom sediment, muddying the water, and uprooting aquatic plants (*see Fishway Fact Sheet).*

The common carp's bottom foraging behaviour can result in massive marsh vegetation destruction.

Reducing carp populations is the fundamental first step in the marsh restoration process. By doing so, improvements in water clarity, increases in food resources, and the recovery of natural wetland vegetation will be facilitated.

FLOODPLAIN MARSHES

The peak of a floodplain's water cycle occurs earlier in the spring than the peak of a lake's water cycle, because it is driven by the snowmelt. This early spring flooding creates habitat for a distinct group of plants, fish and wildlife, and dictates the time when these species appear. Floodplain and lake water cycles also create distinct bottom types (consolidated vs. unconsolidated bottom), a function of the amount of drying time that occurs after the water has receded. All of these differences dictate the restoration techniques employed at different locations throughout the estuary.



THE REHABILITATION DESIGN

To achieve the goals of the restoration project, a general rehabilitation strategy was developed encompassing three main elements. The vital first step to returning the estuary to a functional creek and floodplain system was to exclude carp. This was achieved by redefining and elevating its banks, separating the creek from the marsh areas. Next, an upstream water entry structure was added to supply the floodplain with water and retain its connection to the system. Finally, a downstream fish control structure was installed that allows the early spring native floodplain fish to enter and spawn, while excluding carp later in the season.

Annual fall low water levels reveal the remains of the channel, and the desolate exposed mudflats.

ELEVATING THE BANKS

The first stage of the Grindstone Estuary rehabilitation project was to elevate the existing upstream creek banks and to redefine and elevate the lower estuary banks. Flooding, and hence the input of water and fish into the floodplain areas, could then be controlled. Bathymetric maps, hydraulic and hydrologic principles were used to determine the location and height of the banks in the expansive lower estuary.

The creek banks in all rehabilitation zones were elevated to a final height slightly greater than the highest recorded high-water mark for each location. The elevated banks will also contain up to one in fifty year floodwater levels in the creek, and only allow fish to enter the floodplain at controlled locations.

The building material used in the construction of the creek banks was dependent on the location's position within the estuary. The furthest downstream sites in the estuary are subject to Lake Ontario water levels and remain submerged at the average winter low water mark. This constant saturation of the surrounding bottom makes the sediment too unconsolidated to be used in the construction. In these areas, recycled Christmas trees were used as the main structural element. The trees were packed tight enough to restrict the passage of fish between them, but to allow the passage of water through the tree matrix. Over time, sediment from the creek will be deposited in this framework, rebuilding a natural riverbank and allowing the growth of plants.

Further upstream, the bottom elevation lies between the high and low water marks for the lake, therefore the sediment is exposed as mudflat later in the season. This partially dries and consolidates the sediment, allowing it to be used to construct the banks in combination with Christmas trees as a stabilizing, structural element.

The furthest upstream rehabilitation site is the Hendrie Valley floodplain ponds. Sediment on the margins of the ponds is only exposed to water in the early spring and as a result, is consolidated enough to be used as the sole structural element in the bank elevation. Natural revegetation of the bank will quickly occur from the existing seed bank to help stabilize the sediment.

Todd Carnahan Photo

The water and fish control structure is installed in the Sunfish Pond Christmas tree exclosure.

FLOODPLAIN WATER CONNECTION

The next stage of the rehabilitation project was to construct mechanisms to allow the controlled passage of water and fish into and out of the newly defined floodplains to retain their connection to the system.

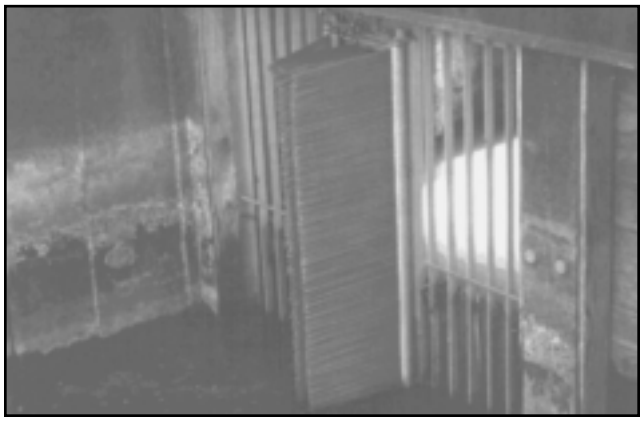
Near the upstream end of each rehabilitation site, input structures were installed to allow floodwater from the creek to enter into the floodplain. This took the form of an excavated channel fitted with a culvert to solidify the channel under the continued passage of water. The installed culvert contained built-in fish exclusion grates to restrict the passage of fish wider than five centimeters, targeting all adult carp.

The current flood cycle of Grindstone Creek rises and falls rapidly, reducing flood duration and frequency. To compensate for this culverts were placed below the current river bank level to increase the frequency of floods, thus stabilizing flood patterns and mimicking a more natural flood cycle. This restored system will allow for a longer duration of floodwater entry into the floodplain, while restricting the volume of excessively nutrient and sediment-laden water entering the floodplain.

The upstream entry of water into the floodplain will allow it to flow downstream with the natural gradient, penetrating throughout the floodplain. This will provide a supply of freshwater, promoting circulation and preventing stagnation. It will also provide a limited amount of fresh sediment and seeds. Channels created by the downstream flow of water will help to diversify the habitat within the floodplains by sculpting the bottom.

THE "FENCE"

At the downstream end of each floodplain, a structure developed by RBG, dubbed the FENCE (Floodplain Enhancement Node and Carp Excluder) was installed to function as a controlled passage for water and fish into and out of the floodplain. Water will most often flow out of this structure, except during lake seiche effects when rising lake levels will cause water to flow into these structures, replenishing the marshes of the lower estuary. The volume of water capable of leaving this structure is greater than that entering the upstream culvert, therefore preventing floodwaters from exceeding the height of the elevated riverbanks.



This structure can be opened to allow native fish into the floodplains, then closed to exclude carp later on.

The FENCE consists of grates that restrict access to fish wider than five centimeters, targeting all adult carp. A pivoting brush system in the centre provides a unidirectional passage out for larger fish that are restricted by the grates, while preventing carp from entering the marsh.

In early spring, the brushes, oriented to the creek-side of the structure, are opened, allowing large fish to pass through. Native fish such as northern pike and bowfin, as well as smaller species such as yellow perch, black crappie and golden shiner, all spawn in the productive environment of floodplain ponds early in the season. In early April, before carp begin their spawning migration, the brushes are closed to a wedge shape, thus preventing the passage of large fish into the floodplain. Any large fish that still remain in the floodplain are able to exit into the creek by pushing through the flexible brushes from the inside. The brushes immediately close once the fish swims out into the creek, maintaining the exclusion of carp.

RESTORATION SITES

Restoration in the Grindstone Estuary has been focused on three main areas. Furthest upstream, the Hendrie Valley pond complex represents true floodplain marshes. The lower estuary consists of three redefined floodplain areas, Osprey and Blackbird Marshes, and Sunfish Pond. The third restoration site, Long Pond, is an isolated water body connected to the top of Sunfish Pond by a stone culvert.

HENDRIE VALLEY PONDS

The Hendrie Valley Ponds are located half a kilometer upstream of the estuary on the south side of Grindstone Creek. They consist of a total of four ponds and comprise an area of 7 ha. One pond is 150 m downstream and separate from the complex formed by the other three ponds. These ponds once represented the only remaining true floodplain marsh in the harbour ecosystem. Unfortunately, years of degradation of the watershed have altered the natural water cycle and created a poor quality floodwater supply, allowing for the invasion of aggressive, non-native species such as carp and European manna grass. These stressors, consequently, have seriously affected the ecological functioning of the ponds. Due to its higher elevation in the watershed, this site represented a moderately degraded channel and bank system, as the banks were well-defined, but the unnatural water cycle decreased the stability of flooding and allowed carp to enter.

Restoration was initiated in 1994 and has been restricted to the upper complex, with the main goal being to restore the functioning of the ponds as northern pike spawning and nursery habitat. These restoration initiatives also aimed to reduce the amount of nutrient and sediment-laden floodwaters from entering the ponds, and to allow the regeneration of native

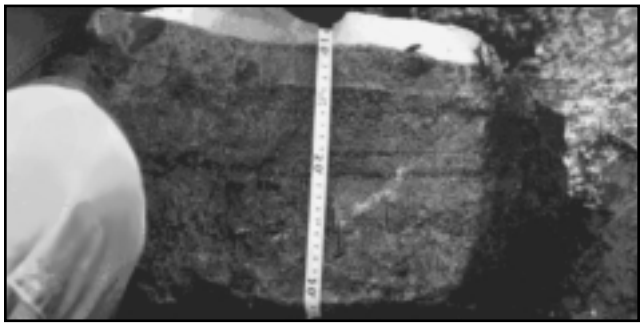
vegetation communities for fish and wildlife habitat. These goals were attained through the implementation of the following restoration initiatives:

- Elevation of present riverbanks to protect the marshes from poor quality floodwater.
- Restoration of the natural water cycle by installing an upstream floodwater access mechanism, and inserting a downstream water control structure.
- Elimination of invasive, non-native species (carp, European manna grass) through the installation of a FENCE / water control structure.
- Reconstruction of floodplain channels formerly maintained by beavers and muskrats throughout the emergent vegetation, diversifying the pond habitat, and creating spawning habitat for northern pike.

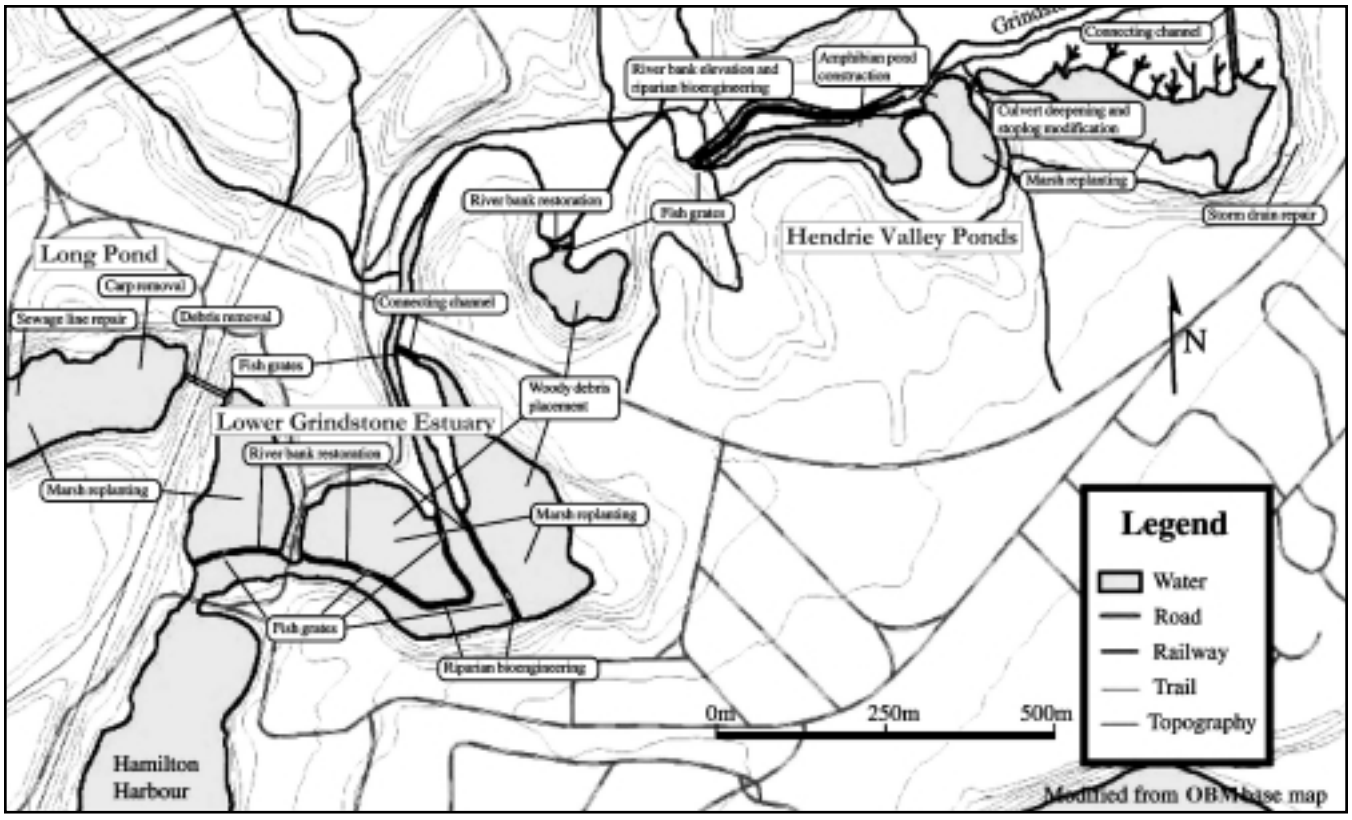
The Hendrie Valley Ponds have rapidly improved in the last several years, boasting nearly 100% plant coverage in the upper pond complex. It has become a vital piece of habitat for increasing numbers of northern pike, beavers, muskrats, and several species of waterfowl, and will continue to do so in years to come.

THE FLOODPLAINS OF THE LOWER ESTUARY

The lower segment of the Grindstone Estuary is comprised of a 7.4 hectare area located immediately upstream of Hamilton Harbour, and bounded by Valley Inn Road and Plains Road. The Grindstone Creek channel through this portion of the estuary is accompanied by three heavily degraded floodplain marsh areas. Similar to the upstream floodplain ponds, this area suffers from an altered water cycle, poor quality floodwater, and invasion of carp. Years of erosion resulting from the loss of stabilizing plants, the actions of carp, the forces of currents, and the deposition of sediment, have all but eliminated the banks of the creek channel and allowed rapid



Years of erosion in the watershed have led to the rapid infilling of the floodplain marshes.



Lower Grindstone Creek Channel, River Bank, and Floodplain Restoration.

sediment infilling in the marsh areas. With little river-holding capacity, the floodplain area had become an expansive, muddy, and shallow open water system.

In 1999, restoration efforts were initiated in the lower estuary to improve water quality, re-establish the native vegetation community, and restore habitat for fish and wildlife populations. The following remediative actions were undertaken:

- One and half kilometers of riverbank was re-created and elevated to redefine the creek channel and separate the floodplain marshes from the creek using recycled Christmas trees and excavated sediment.

- Culverts fitted with carp exclusion grates were inserted at the upstream end of the banks to supply water.

- FENCE / water control structures were placed at the downstream end of the banks, providing the ability to manipulate water levels within the marshes, preventing the entry of carp, and allowing the passage of native fish into the marshes.

- The natural recolonization of vegetation, supplemented by plantings by staff, in the future will provide additional stability from erosion and a naturally vegetated appearance as the trees decompose and sediment accumulates within the tree matrix.

The construction of new riverbanks in the lower Grindstone area resulted in the creation of three newly defined floodplain marshes: Blackbird Marsh, Osprey Marsh, and Sunfish Pond. Vast improvements in water quality have since been realized. With continued carp exclusion, the gradual recolonization of these marshes with vegetation will provide for the recovery of native fish and wildlife populations.

The newly defined banks of the creek isolate Osprey Marsh to the left and Blackbird Marsh to the right.

LONG POND

Long Pond is a 6 hectare pond located upstream of Sunfish Pond, and formerly acted as the connecting channel from Cootes Paradise to Hamilton Harbour. This pond was isolated from Cootes Paradise in the 1850s following the establishment of the new Desjardins Canal. Subsequently, railway beds were built at both ends of the pond to permanently isolate it from Cootes, leaving only a small tunnel under the east end to connect it to the rest of the Grindstone Estuary. This tunnel had become clogged over the years with large woody debris, restricting the outflow of water, and hindering the upstream migration of fish into the pond. This blockage held the water level in the pond artificially high, resulting in slumping of the steep banks, increased sedimentation, and the lack of a natural water cycle. The impacted water cycle, large numbers of carp, and the inflow of sewage and freeway runoff have contributed to the poor water quality and lack of vegetation throughout the pond.

Restoration efforts in Long Pond began in 1999, aiming to re-establish a natural vegetation community for the spawning and nursery habitat of fish and wildlife. In order to do so, the following actions were taken:

- Debris and sediment blocking the connecting channel between Sunfish Pond and Long Pond was removed to facilitate the flow of water and allow the passage of migrating fish into and out of the pond.

- A water control structure was installed at the outflow culvert to restore the natural water cycle. This will allow water levels to rise in the spring with snowmelt and increased precipitation, flooding emergent vegetation for fish and wildlife. Water levels then naturally diminish throughout the summer and fall months, stimulating emergent plant re-growth.

- Three thousand carp were initially removed from the pond, and are now completely excluded by the Sunfish Pond berm and the FENCE structure within it.

- Regeneration of native vegetation communities will be supplemented with plantings by RBG as future environmental conditions permit.

In coming years, Long Pond is expected to become an important sanctuary for species that can occur nowhere else at RBG due to its isolation and deeper waters. Formerly the home to western Lake Ontario's largest population of the regionally rare White Crappie, it is anticipated that this pond will once again be able to provide habitat for this and many other rare species.

MONITORING IN THE ESTUARY

The monitoring of plant communities, as well as fish and wildlife populations in the estuary, is an integral component of the restoration efforts put forth by the RBG Science Department. It allows RBG's scientists to quantify the impacts of these restoration activities, and determine what progress has been made and where future improvement may be needed. To monitor ecological responses to restoration activities, particularly changes over time, population levels, and breeding success, RBG conducts several monitoring programs. These programs are listed below, as well as the RBG fact sheets that describe each one in more detail:

- Fish (*Coastal Marshes, Natural Fish Hatcheries*)
- Waterfowl (*Waterbirds of Cootes Paradise*)
- Amphibians (*Amphibians of Cootes Paradise*)
- Vegetation (*Marsh Vegetation in Cootes Paradise*)

This information is locally important, as well as part of a larger monitoring project conducted by many agencies working toward the restoration of the Great Lakes and their coastal wetlands. On an international level, this information will substantially contribute to marsh research and restoration around the world.

Vegetation monitoring is conducted to determine the extent and diversity of the new plant growth.

RESULTS OF RESTORATION

The recent nature of much of the restoration work limits the number of significant results that have been measured. Two areas, the Hendrie Valley Ponds and the 1999 Christmas tree pilot project have had enough post-restoration time to generate measurable results.

The Hendrie Valley Ponds, where restoration first began in 1994, have progressed the furthest. The exclusion of carp and regulation of water, nutrient, and sediment inputs have dramatically improved the water quality and dynamics within the floodplain ponds. The muddy water has cleared, and the plant community has rebounded. Emergent communities of cattails, giant burreed and white water lilies abound, submergent plants such as coontail and Canada waterweed have re-colonized the deeper waters, and fish and wildlife are flourishing.

New aquatic plant growth covered the entire area within the pilot-scale Christmas tree berm in Blackbird Marsh.

In 1999, a pilot Christmas tree berm project was implemented in a small region of Blackbird Marsh to determine if it would be an effective restoration technique. An astonishing increase in emergent plant densities resulted in the marsh, evolving from a barren mudflat into a completely vegetated system inhabited by giant burreed, softstem bulrush, and cattails. The success of the pilot project led to the full-scale implementation of the project the following year.

Surfing the Web- Interesting Sites

Royal Botanical Gardens, **www.rbg.ca**
University of Guelph, **www.aquatic.uoguelph.ca**
Environment Canada - Great Lakes Information, **www.on.ec.gc.ca/water/greatlakes/intro-e.html**
Environment Canada's Green Lane, **www.ec.gc.ca/envhome.html**
Great Lakes Wetlands Information, **www.great-lakes.net**
Fish and Wildlife Habitat Restoration Project, **www.rbg.ca/fwhrp/**

GRINDSTONE ESTUARY SUMMARY

- The Grindstone Estuary is a 60 hectare floodplain and coastal marsh complex owned and managed by Royal Botanical Gardens.
- Floodplain marshes are among the most threatened habitat types, with the Grindstone Estuary component representing the majority found in Hamilton Harbour.
- A number of human-induced stresses have degraded the Grindstone Estuary over the years. Watershed urbanization and farming has destabilized the water cycle and contaminated the creek. Aggressive non-native species such as carp, European manna grass, and purple loosestrife have invaded and disrupted the ecosystem.
- Floodplain marsh restoration initiatives, under the Hamilton Harbour Remedial Action Plan, began in 1994 and are being conducted by RBG in partnership with other agencies.
- The floodplain rehabilitation strategy consists of three main elements: redefining and elevating the creek banks to separate the creek from its floodplain, creating an upstream water connection, and installing a downstream fish control structure allowing early spring spawning native fish into the floodplain and excluding carp later in the season.
- The three rehabilitation locations in the estuary include the upstream Hendrie Valley floodplain ponds, the marshes of the lower estuary, and Long Pond which connects to the top of Sunfish Pond.
- The Hendrie Valley pond complex, the most progressed rehabilitation site, has shown dramatic improvements in water quality, and plant and wildlife communities. A stream bank re-creation pilot project in the lower estuary transformed the floodplain from barren mud to 100% native plant cover.

For more information, contact:

Royal Botanical Gardens, Project Paradise
P.O. Box 399, Hamilton, Ontario, L8N 3H8
Tel: 905-527-1158
Fax: 905-577-0375

Fish and Wildlife Habitat Restoration Project
605 James St. North, 3rd Floor
Hamilton, Ontario, L8L 1K1
Tel: 905-521-9334
Fax: 905-528-6282

Bay Area Restoration Council
McMaster University
Life Sciences Building, Room B130F
Hamilton, Ontario, L8S 4K1
Tel: 905-525-9140 ext. 27405
Fax: 905-522-6066 (address to BARC)

Hamilton Harbour RAP Office
Environment Canada
P.O. Box 5050, Burlington, Ontario, L7R 4A6
Tel: 905-336-6279/6278
Fax: 905-336-4906

Project Partners

Bay Area Restoration Council (BARC)
City of Hamilton
Department of Fisheries and Oceans
Eco Action
Environment Canada
Friends of the Environment Foundation
Great Lakes Sustainability Fund
Halton Region Conservation Authority
Hamilton Harbour Commissioners
Hamilton Harbour Remedial Action Plan Stakeholders
Hamilton Naturalists' Club
Hamilton Region Conservation Authority
McMaster University
Ontario Ministry of Natural Resources
Petro Canada
Royal Botanical Gardens
The Regional Municipality of Halton
Waterfront Regeneration Trust

ROYAL BOTANICAL GARDENS Canada

Grindstone Estuary Fact Sheet prepared by Tys Theysmeyer, Noel Boucher, and Shari Faulkenham. Published by Royal Botanical Gardens. Thanks to: Len Simser.