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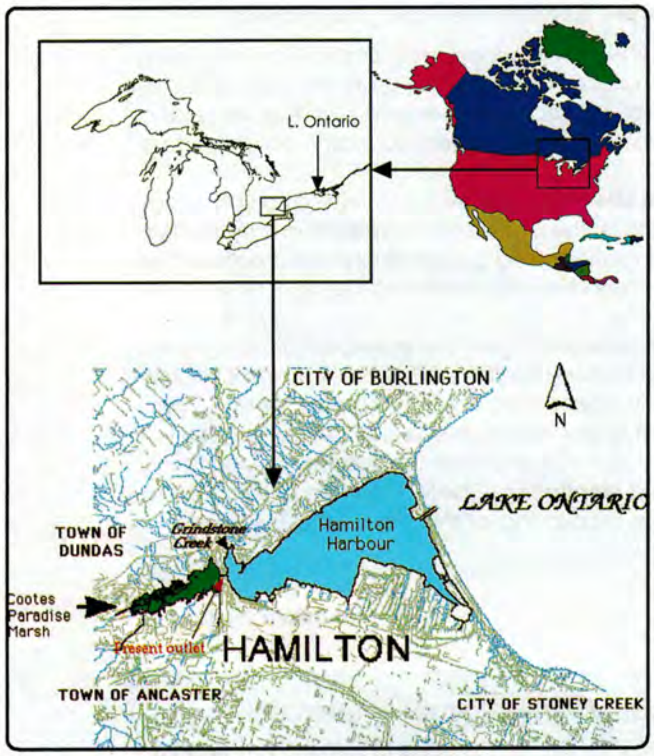
Volunteer-based experimental planting program to restore Cootes Paradise Marsh, an urban coastal wetland of Lake Ontario

PATRICIA CHOW-FRASER

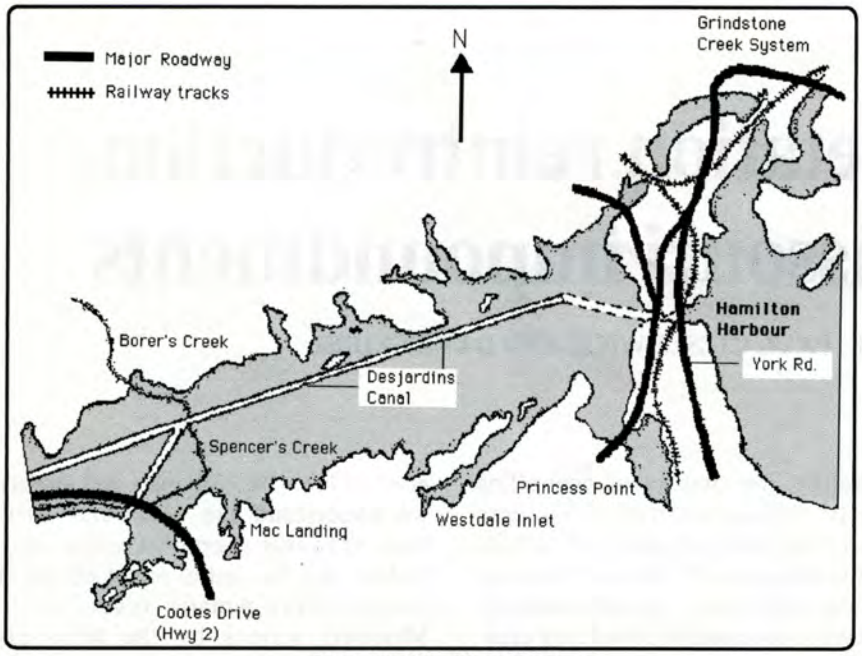
Prior to European settlement, the Canadian shoreline of Lake Ontario was lined with hundreds of coastal marshes that served as important stopovers for migratory birds, staging areas for shorebirds and waterfowl, and critical habitat for warmwater fish (e.g., northern pike and largemouth bass). During the 1900s, however, many of these wetlands were converted for agricultural and urban use. Of the estimated 30 percent that remain, many are in a degraded state with much reduced biodiversity. Cootes Paradise Marsh is an example of one of these degraded coastal wetlands with an illustrious past.

The marsh ecosystem is a 250-ha drowned river-mouth marsh located within a 800-ha fish and wildlife sanctuary, and is the largest remaining marsh in the western shoreline of Lake Ontario. It is bordered by the city of Hamilton and the towns of Ancaster and Dundas on the western-most tip of Lake Ontario (Map #1). This whole region was created approximately 12,500 years ago when retreating ice sheets formed a large sandbar at the western end of Lake Ontario. The marsh ecosystem, however, has gradually evolved over the past several centuries. In 1669, accounts of two Jesuits left no indication that there was any marsh at this location, but only a "little lake discharging itself." In the late 1790s, Cootes was described as being more like a river or a "marshy lake." By the early 1800s, the marsh had become known as "Coote's Paradise," named for Captain T. Coote, who used to hunt the plentiful game and waterfowl in the marsh while he was stationed at Niagara from 1782 to 1787. In their memoirs, people who lived in the area during the 19th century referred to Cootes Paradise as a "dense watery bog" where "wild rice, water lilies and flowers . . . were abundant," and where there were "immense flocks of ducks and wildfowl, and wild animals innumerable in old times." From these historical accounts, there is little doubt that the shallow lake that existed prior to the 1700s had become filled in with sediment and had evolved into a thriving marsh ecosystem a century later.



Map #1. Cootes Paradise Marsh.

Until the early 1800s, water took a sinuous path through the marsh and flowed out through the northeastern tip into the Grindstone Creek system before entering Hamilton Harbour (Map #2). At the beginning of the 19th century, increased demand for a year-round route to supply the developing town of Dundas led to the opening of the Desjardins Canal, which at first ran along the north shore and exited through the natural outlet. However, construction of the railroad linking Toronto to Hamilton in 1850 essentially blocked off the original outflow and necessitated the dredging of a new outlet below York Road. Within another ten years, the canal was forced out of business due to heavy



Map #2. Hamilton Harbour.

siltation. Today, the only remnant of the canal is the stretch of willows growing on dredgeate and some protruding pine posts that marked the route of the canal.

During the first part of the 20th Century, Cootes Paradise was still primarily an emergent marsh (Photo #1) with cattail (*Typha latifolia*) and wild rice (*Zizania aquatica*) growing as far east as the outflow. Examination of vegetation maps over the next six decades shows a steady decline in marsh plants from a cover of 85% in 1934 to less than 15% in 1985 (Map #3). By 1990, there was only a fringe community located on the western

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(continued from page 13)

Photo 1. Aerial photo of Cootes Paradise in 1928, showing Desjardins Canal as it curved toward new outflow.

end of Cootes Paradise that was dominated by manna grass (*Glyceria maxima*). The native cattail species, *Typha latifolia*, had become displaced by the introduced European species, *T. angustifolia*, and the putative hybrid *Typha Xglauca*. Like other marshes in southern Ontario, the loss of emergent cover had been accompanied by a reduction in the diversity of species in general, and a replacement of native species by a number of exotic invasives such as purple loosestrife (*Lythrum salicaria*) and the common reed (*Phragmites australis*).

Reasons for degradation

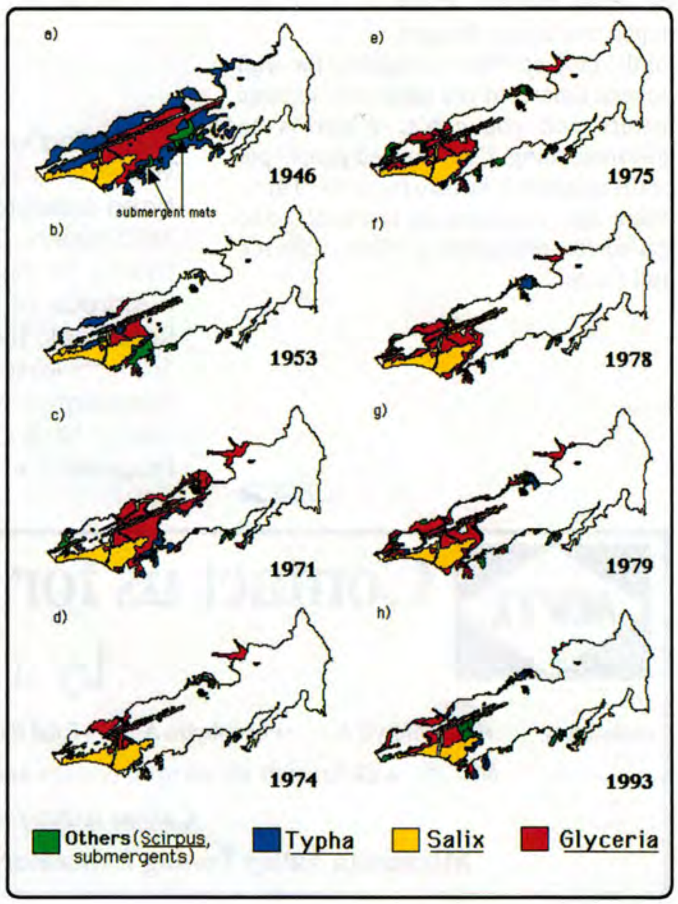
Among the various factors implicated for the degradation of Cootes Paradise Marsh, sustained high water levels has been considered one of the most influential. Water depths in the marsh have been increasing partly because of a process that geologists refer to as "crustal rebound." Essentially, the eastern end of Lake Ontario has been rising while the western end has been subsiding in response to the retreat of glaciers from the area over 10,000 years ago. The net effect has been an increase in mean water level of about 18 cm over the past century, with resulting water depths that are too high to support emergent aquatic vegetation in the marsh.

Another important factor is disturbance by the common carp (*Cyprinus carpio*). Carp is native to Europe, and was introduced into the Great Lakes in the latter part of the 19th Century. It is much more tolerant of polluted water than native Great Lakes fishes, and has few natural predators once it matures. When carp spawns in spring, it enters flooded vegetation and churns up the bottom sediment; later in the summer, it forages for benthic invertebrates associated with roots of aquatic plants and often uproots them. Its dominance has been perpetuated since top predators require submergent vegetation to spawn, and submersed plants are generally eliminated in turbid environments. Hence, degraded marshes tend to support very large populations of common carp, almost to the exclusion of the native fishery.

Growths of submergent macrophytes have been further compromised by high water turbidity that is promoted by wind resuspension, carp bioturbation and cultural eutrophication. Eutrophication has resulted from eight decades of sewage effluent being discharged into the marsh from the Dundas Sewage Treatment Plant. Even though the current input of phosphorus from the treatment facility is relatively low, excessive inputs in the past are keeping Cootes Paradise in a very polluted state.

Wetland restoration

In the early 1980s, the International Joint Commission declared the Hamilton Harbour ecosystem, which includes Cootes Paradise, to be one of 43 environmental "Areas of Concern" (AOC) in the Great Lakes Basin. In 1987, Canada and the United States signed a Protocol to develop Remedial Action Plans (RAP) for each of the AOCs. In response to this initiative, a writing team in Hamilton



Map #3. Plant growth in Cootes Paradise.

summarized the technical information available on the watershed and generated a RAP to restore much of the integrity of the harbour ecosystem. One of the RAP goals was to restore Cootes Paradise Marsh to bring back the fish and wildlife habitat that had existed a century ago. In 1990, the Fish and Wildlife Habitat Restoration Project Steering Committee was formed to oversee the development of this restoration plan.

Three major institutions emerged to champion the Cootes restoration project. They were the Royal Botanical Gardens (RBG), owner and manager of Cootes Paradise Marsh, the Department of Fisheries and Oceans (DFO), and McMaster University. Biologists from DFO and RBG, who had built up an excellent base of data, knowledge, and expertise on various components of the ecosystem, were members of the original RAP writing team. Even with this knowledge base, however, they lacked sufficient scientific information to develop a full restoration plan. With severe reductions in the science departments of both institutions during the early 1990s, they turned to biologists at McMaster University to fill the void. Scientific collaboration between RBG and McMaster on the marsh was not new. The two institutions border the marsh to the north and south, and had a close partnership during the 1940s and 1960s, delivering educational programs and conducting research on Cootes Paradise Marsh. A three-year $2.1 million grant from the Tri-Council Eco-Research Program, funded through Environment Canada's Green Plan, provided much of the impetus to renew the partnership in 1993. The McMaster Eco-Research Program for Hamilton Harbour, better known as *Ecowise*, became the chief funding agency for the research and public outreach that are described in this report.

Wetland restoration

Wetland-restoration science is at an early stage of development, especially for large Great Lakes wetlands such as Cootes Paradise Marsh. The restoration of Cootes Paradise is a major undertaking and has few precedents as guidance. Ecowise researchers proposed to test various approaches, make predictions on outcomes of management strategies, and help monitor results of implemented plans. We worked closely with restoration managers and partners on the project, helping to transfer knowledge to policy and management by comparing and cooperating on other restoration projects. The identification of common driving factors in marshes along a gradient of degradation has been very effective in understanding not only the Cootes Paradise ecosystem, but marsh ecosystems in general.

One aspect of the Cootes Paradise Restoration Plan is to exclude carp from the marsh to prevent further destruction of aquatic plants. The Steering Committee opted to exclude carp by constructing the Cootes Paradise Fishway at the Cootes Paradise outflow. This structure includes a series of grates that prevents large fish from entering the marsh. To permit access of fish other than carp to enter the marsh to spawn, an elaborate system has been devised. When fish approach the grates, they can either swim back toward the harbour, or enter a series of large baskets. They remain there until the baskets are hoisted up to a sorting table where RBG staff sort the fish, releasing carp into the Harbour and others into Cootes Paradise. In this way, large carp are differentially excluded from the marsh while other fish, especially valuable sportfish, are permitted access.

Since the Fishway would not become fully operable until 1997, biologists who wanted to conduct planting trials during the early 1990s had to find other ways to exclude carp. In 1991, biologists from RBG, DFO and McMaster University experimented with small exclosures for this purpose. Exclosures consisted of a metal frame on which plastic or wire fences were attached. These were installed in a largely unvegetated area of the marsh, and then rooted plants from existing cattail beds were placed into peat pots and transferred into exclosures. After two months of growth, cattails transplanted in the exclosures had increased tenfold (Photo 2 top), whereas those that had been transplanted into similar sized plots without any protective fences had become greatly reduced in number (Photo 2 bottom). This pilot study demonstrated that cattail transplantation could be successful in Cootes Paradise as long as exclosures were used.

Photo 2. Top: plants protected by exclosure. Bottom: plants unprotected.

Objectives of the Experimental Planting Program

During 1993, I represented McMaster University on the Steering Committee of the Restoration Project. The committee realized that a planting program would be too labour-intensive and costly to implement if paid workers were to do all the planting and exclosure installation. I had worked with ten Grade 6 volunteers and their teacher the previous summer and this experience convinced me of the value of using community volunteers in a long-term, large-scale restoration project. With approval from the Steering Committee, I initiated a planting program plant stock from a nursery in Wisconsin because there were no nurseries locally that could provide the plant material. From this project, we learned that plastic snowfence could not prevent muskrats from chewing through the panels to graze on the new transplants, and so we switched to weld-wire fence in subsequent programs. We also decided to switch to locally grown stock for two reasons. First, the purchased material was not ecotypically adapted to the conditions of Cootes Paradise, and, secondly, the high cost of purchasing material was not sustainable in the long run.

The planting experiments were divided into two phases: planting of the emergent in 1994, and planting of the submergent stock in 1995. Emergent stock included seedlings of cattail (*Typha angustifolia* and *T. latifolia*), arrowhead (*Sagittaria latifolia*), softstem bulrush (*Scirpus validus*), swampdock (*Rumex verticillatus*), bottonbush (*Cephalanthus occidentalis*), sweetflag (*Acorus calamus*), swamp loosestrife (*Decodon verticillatus*) and water arum (*Calla pallustris*). These were provided by the Classroom Aquatic Plant Nursery Program, which was carried out collaboratively between Ecowise, RBG and the Bay Area Restoration Council (BARC; see Chow-Fraser and Lukasik, 1995), the advocacy branch of the Hamilton Harbour RAP. Seeds had been collected from Cootes Paradise the previous fall and distributed to school teachers in the region. The seedlings were grown in a standard potting mix and returned to the McMaster greenhouse several months before they were used in the CVPP. By comparison, there were fewer submergent taxa, and these included the pondweed *Potomageton pectinatus* and *Pectinatus foliosus*, as well as the waterweed, *Elodea canadensis*. They were grown from cuttings of plants collected in a nearby wetland (Valens Reservoir), potted in sediment obtained from Cootes Paradise, and kept underwater in the McMaster greenhouse for about six weeks prior to planting.

Planting methods and field conditions

All of the emergent plants were planted in 8-ft square exclosures, in water depths ranging from mudflat to 45 cm, between mid-July and late August in 1994. The total number of seedlings planted in each exclosure varied between 100 to 385, depending on the size of the plants used, and the numbers of each species that were provided by the Classroom program. In addition to installing exclosures individually as was done in 1993, we also used adjoining exclosures in the 1994 program to save on materials and space (Photo #5). In total, 38 exclosures were planted that contained different combinations of the eight taxa. Two types of panels were employed: one type consisted of weld-wire fence alone, while the other had weld-wire fence wrapped in siltscreen on T-bar frames (Photo #6). The siltscreen was effective in reducing water turbidity by about a third to a half compared with unscreened exclosures. Plants in peat pots were inserted securely into the sediment.

Photo 5. Overview of planting exclosures at the end of 1994. Exclosures to the south have already been dismantled (bottom left).

All of the submergent plants were planted over two days in August 1995. They were placed into twelve 24-ft square siltscreen exclosures in water depths that ranged from 45-60 cm at the time of planting (see Lougheed et al., 1998, for details of exclosure construction; Photo #7). Use of siltscreen was deemed essential for submergent plants since they spend their entire lives below the water surface

Photo 6. Volunteers use the boardwalk to construct panels of exclosures in 1994.

with local citizens that became known as the Community Volunteer Planting Program (CVPP). Although the paramount goal was restoration, the CVPP had specific objectives that fell into four general categories ecological, experimental, social and educational.

- **Ecological:** to reestablish desirable native marsh plants in Cootes Paradise Marsh.
- **Experimental:** to determine the tolerance of different plant species to different water depths and light conditions.
- **Social:** to directly involve the local community in the restoration efforts, thereby instilling a sense of stewardship and collective responsibility of the marsh; to create a lasting alliance between the academic community and the general public; and to tap into a largely unexploited resource for the often low-tech, low-budget, and labour intensive restoration activities that included both implementation and monitoring.
- **Educational:** To raise the awareness of community members, especially young people, about the degradation history of Cootes Paradise Marsh, its lost and threatened ecological functions, and the current restoration efforts of the Hamilton Harbour RAP.

Description of Planting Site and Plant Stock

The CVPP site was located in one of the inlets on the south shore of Cootes Paradise Marsh known as Mac Landing (Photo #3). The series of aerial photos over Mac Landing illustrate how marsh vegetation expanded and contracted from

Photo 3. Aerial showing McMaster University in background and planting site in Mac Landing.

Photos 4a-d, at right: From top: (a) Mac Landing, 1950; (b) Mac Landing, 1960; (c) Mac Landing, 1972; (d) Mac Landing, 1978.

1950 to 1978, presumably in response to fluctuating water levels. The 1950 photo shows the adverse effects of several years of high water levels on emergent vegetation in the late 1940s (Photo #4a). By 1960, virtually the entire inlet supported aquatic plants partly because there had been relatively low water levels during this time and partly because a carp removal program conducted in the mid-1950s netted out more than 100,000 carp (Photo #4b). During the early 1970s, some of the emergent plants had retreated, but Mac Landing still had large areas of emergent marsh (Photo #4c). In 1974, exceptionally high water in Cootes Paradise wiped out most of the emergent plants, and even though low water levels returned in 1977 and again in 1988 and 1995, the cattail has not regained its former prominence to this day (Photo #4d).

A preliminary program was run in 1993 to establish the best way to recruit and use volunteers to construct and install exclosures, and to plant the macrophytes (see details in Chow-Fraser and Lukasik, 1995). We used snowfence to construct the exclosure panels, and purchased

Photo 7. View of submergent-plant exclosures in 1995. All panels were covered with siltscreen to help reduce water turbidity.

and must have good light penetration. *P. pectinatus*, *P. foliosus* and *Elodea* were planted in triplicate, with approximately 200 plants per exclosure. The remaining had mixtures of *P. foliosus*, *P. pectinatus*, *Elodea* and a species of floating pondweed, *P. natans*. Planting submergents was more challenging than planting emergents because the former took place in water that was too deep and turbid to afford good visibility. To avoid stepping over pots that had been planted, the field crew devised a highly organized scheme in which volunteers inserted their pots along imaginary grid-lines in the sediment, with the aid of markings on exclosure panels to guide them. This planting ritual required a lot more coordination and dexterity on the part of t he volunteers, but also led to a lot more laughter during the post-planting festivities.

Results of the Emergent Planting Program

Monitoring

Growth of transplants was monitored weekly from May to July in 1995, and then biweekly thereafter until September. The monitoring team kept track of the progress of different taxa – initially counting the number of individuals of each species, and then, later, estimating the percent area occupied by a particular species when the growth became too dense to count individually. The inventory included taxa that we had planted as well as those taxa such as swamp buttercup (*Ranunculus hispidus*), manna grass (*Glyceria maxima*), and beggar's tick (*Bidens* sp.) that colonized on their own. In September, a detailed inventory was taken that included an estimate of the number of individuals of each species and their height, the areal cover of each species within the exclosure, and the total number of cattail spikes per exclosure. Since the ultimate goal of the program was to restore the area, we did not take any measurements that required harvesting the plants or that would cause any structural damage.

In 1993, the planting site had been essentially devoid of any emergent vegetation (Photo #8). At least part of the reason for this is because water levels had been extremely high that spring. The September 1993 aerial photo shows the site after the pilot program had been carried out, revealing the barren character of the inlet (Photo #9). Since water levels in 1994 were more favourable for emergent plants, the plants that we had introduced as well as others grew extremely well at the CVPP site. This is evidenced by the expansion of aquatic plants into unvegetated areas in the 1994 aerial photo (Photo #10).

Photo 8. View of planting site (boardwalk in background) in 1993 before program commenced.

Photo 9 (at left). September, 1993, following installation of first set of exclosures.

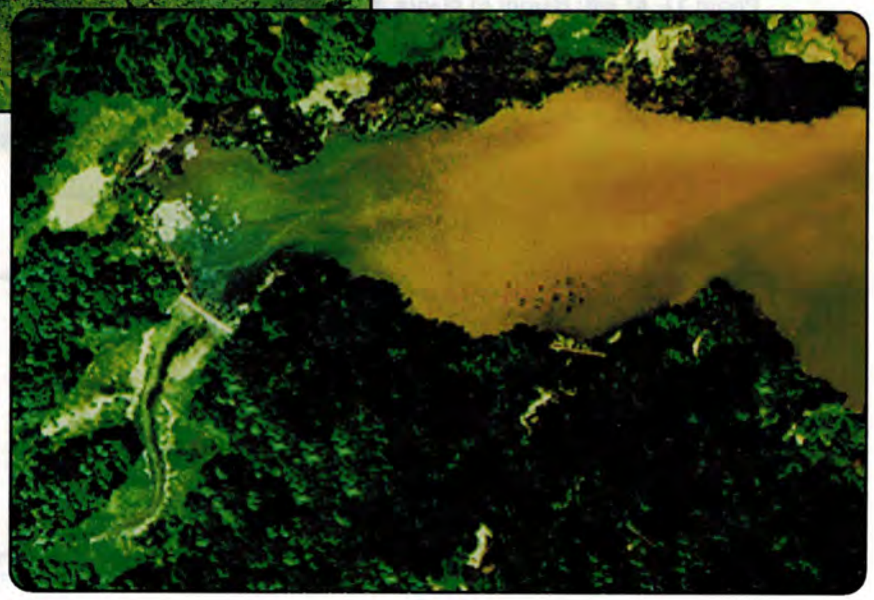


Photo 10 (below). July 1994, at beginning of planting program.

Effect of water depth and exclosure type

Water depth had a tremendous effect on the ability of the species to survive in the exclosures. None of the button bush, sweetflag and water arum that had been planted in water depths > 10 cm survived to 1995. The remaining five taxa exhibited variable depth tolerance, depending on the type of exclosures used (Figs. 1 and 2). For instance, *Typha* would not grow in deeper areas unless they were placed in exclosures, either with or without silt-screen. When placed in screened exclosures, however, they grew well at depths in excess of 40 cm. This was also true for *Sagittaria* and *Rumex*, which were able to grow in relatively deep water when they were enclosed in siltscreen panels. By comparison, none of the *Scirpus* and *Decodon* grew at depths > 30 cm, whether they were in screened or unscreened exclosures.

I also examined the effect of exclosure type on size of *Typha*, *Scirpus*, and *Rumex* in the various depth categories (Fig. 3).

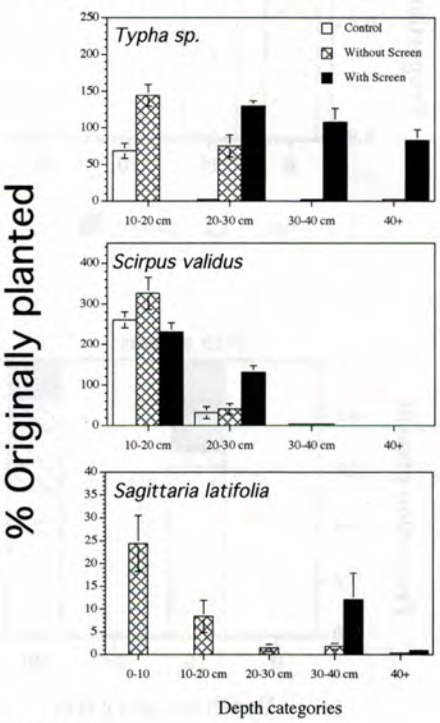


Figure 1.

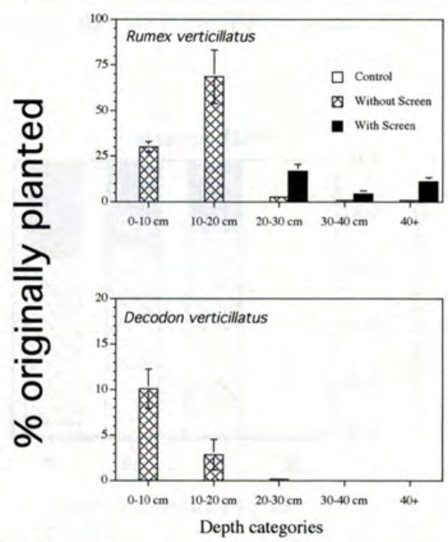


Figure 2.

Regardless of depth, there were proportionately more of the larger plants in the siltscreen exclosures compared with unscreened exclosures, suggesting that plants were able to grow to a larger size in less turbid water. An alternate explanation is that the siltscreen selected for tall plants since the screen prevented sunlight from reaching the plants until they outgrew the height of the panels. In general, only one or two individuals produced spikes in 1995. Subsequent inspections in 1997, however, showed that many more individuals had mated and produced spikes (Photo #11).

Photo 11. At left: Height of plants following one year of growth in exclosures. At right: Ramets of cattails with spikes observed in 1997 survey. Plants were still growing inside exclosures.

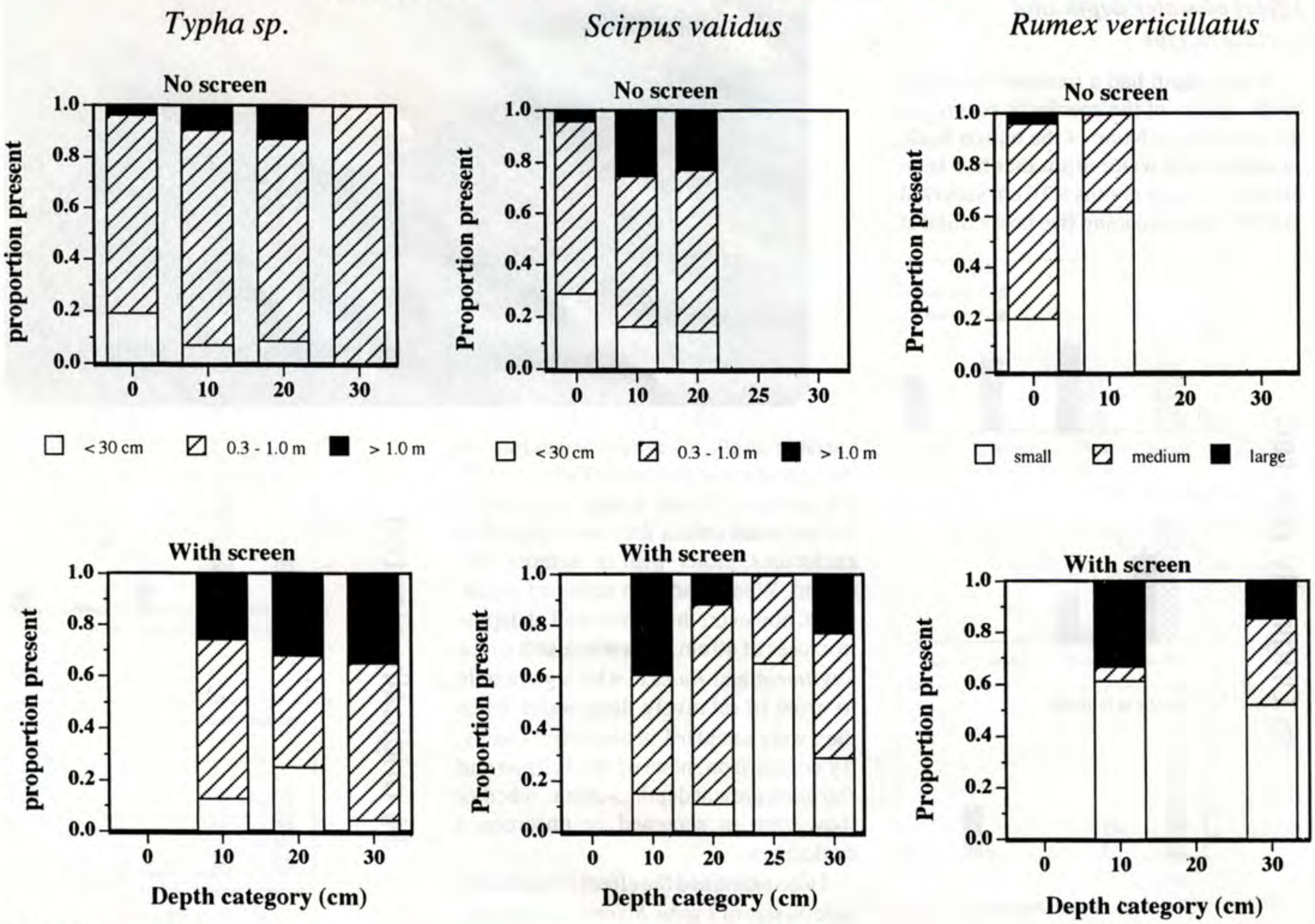


Figure 3.

These comparisons confirm the need to limit the planting of emergent plants in water depths of less than 30 cm in the marsh. All of the emergents performed best on mudflat, except for bulrush, which is a deeper-water form which grew significantly better in 10-cm water. Use of siltscreen may enhance the growth of species such as cattail, arrowheads and sweetflag in deeper water, although they may not be useful for swampdock and buttonbush, and may actually hamper the growth of bulrush in mudflats. (In a follow-up survey, it was discovered that the above-surface light conditions in the screened exclosures was significantly lower than that in the unscreened exclosures, and this may have led to reduced growth in the bulrush.)

Panel removal

Even before the planting program began, I had been preoccupied with how and when to remove the panels. These exclosures were primarily intended to eliminate disturbance by carp, and would not be required after the Cootes Paradise Fishway became operational. I wanted to see if plants would respond differently when panels were removed in early spring as opposed to the fall. Panels from four of the 1993 exclosures (containing Wisconsin stock) were removed in the spring of 1995, whereas four of the 1994 exclosures (containing Cootes Paradise stock) were removed in the fall of 1995.

The response of the plants aside, it was much easier to remove the panels in early spring before plants inside the exclosures had started to grow, and when the sediment was still cold and sufficiently firm to walk on. Within weeks of the removal during spring, both cattails and arrowheads emerged among the colonizing manna grass that had begun to overtake the entire area by the end of the previous growing season (compare Photo #12 a and b). In the most recent inspection in July 1998, both arrowheads and cattails could still be found. When panels from the 1994 exclosures were removed during the fall of 1995, arrowheads had attained such a great height during the summer that they promptly fell over (compare Photo #13 a and b). Within a few days, a lot of the plants had suffered grazing damage from deer and muskrats. Nevertheless, in the 1998 inspection, there was still a great deal of healthy plants inside the area once occupied by the exclosures, although the plants were not as tall (Photo #13c). From this comparison, it appears that panel removal in either the spring or fall would be suitable although spring removal requires less work, and does not lead to any immediate damage.

Photo 12. Top: View of CVPP site below boardwalk shortly after beginning of planting in 1993. Bottom: View of site after the monitoring program in 1995; exclosure panels had been removed during spring.

Results of the Submergent Planting Program

Monitoring

Growth of the submerged plants in the large exclosures was monitored once from an airplane in July 1996. In late August, the monitoring team noted the percent area covered by the four taxa in each exclosure, as well as the general condition of the panels because the exclosures had failed to overwinter intact. The degree of colonization appeared to be related to the structural integrity of the exclosures. The four exclosures that had received the least damage contained varying amounts of primarily one species. *Potomageton pectinatus*, Sago pondweed (Photo #14 a). Since this was independent of the original species planted in the exclosure the year before, it suggests to me that Sago pondweed had successfully colonized all of the moderately intact exclosures because it is the most turbidity-tolerant (Photo #14b).

Long-term effectiveness of the planting program

The short-term success of the planting program is confirmed by the tremendous growth of transplants a year following the planting program (Photos #15a and #15b). The best evidence of the long-term success of our planting program is shown in the 1997 aerial photo (Photo #16). Despite relatively high water levels that year, most of the plants that had been transferred continued to grow there and even expanded beyond the exclosure walls. There is now established populations of at least two species of cattails (*T. latifolia* and *T. angustifolia*), softstem bulrush, and arrowheads. However, swampdock, which grew well in the 1995 and 1996 seasons, has become very scarce, as have all of the remaining taxa that we planted. Since these species did not survive in the long-term and were also problematic to keep in greenhouse cultures, they should probably be dropped from future large-scale planting programs. The July 1997 photo also shows a resurgence in growth of the cattail beds outside the planting site in Mac Landing and this may be attributed to successful exclusion of carp through the Cootes Paradise Fishway several months earlier.

Photos 15 a, b. Above: View of CVPP site above the boardwalk in 1993, before planting commenced. At left: View of same area after planting program had finished. Photo taken in September 1995.

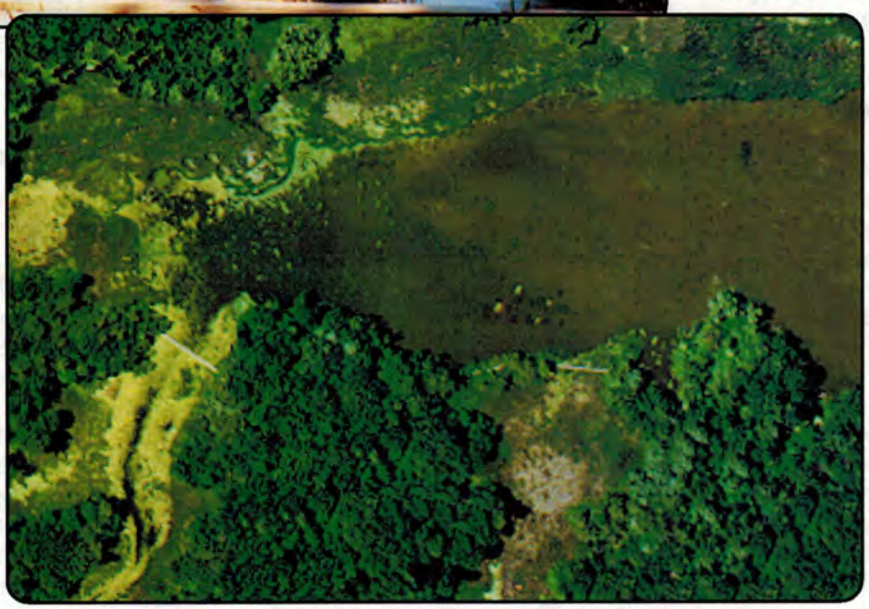


Photo 16. July, 1997 – three years following planting program, and after the first year of carp exclusion.

Classroom Aquatic Plant Nursery program, and for many hours of helpful discussions. Mr. Ken Hall, former Executive Director of BARC, contacted the teachers initially and provided funds to purchase materials for the Classroom program. I am also indebted to Art Yeas of the McMaster greenhouse who provided plant material and lots of helpful advice on culturing plants. Finally, I want to honour the many students who served as volunteer team leaders in the 1993, 1994 and 1995 CVPP, carried out the field monitoring, and helped design the CVPP logo. Without their time, energy, and commitment, this project would have remained just another good idea. A special thanks to Dr. Brad White who got the whole thing started by dragging me into Cootes Paradise on my first day on the job.

NALMS

For further reading

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Panel removal

Even before the planting program began, I had been preoccupied with how and when to remove the panels. These exclosures were primarily intended to eliminate disturbance by carp, and would not be required after the Cootes Paradise Fishway became operational. I wanted to see if plants would respond differently when panels were removed in early spring as opposed to the fall. Panels from four of the 1993 exclosures (containing Wisconsin stock) were removed in the spring of 1995, whereas four of the 1994 exclosures (containing Cootes Paradise stock) were removed in the fall of 1995.

The response of the plants aside, it was much easier to remove the panels in early spring before plants inside the exclosures had started to grow, and when the sediment was still cold and sufficiently firm to walk on. Within weeks of the removal during spring, both cattails and arrowheads emerged among the colonizing manna grass that had begun to overtake the entire area by the end of the previous growing season (compare Photo #12 a and b). In the most recent inspection in July 1998, both arrowheads and cattails could still be found. When panels from the 1994 exclosures were removed during the fall of 1995, arrowheads had attained such a great height during the summer that they promptly fell over (compare Photo #13 a and b). Within a few days, a lot of the plants had suffered grazing damage from deer and muskrats. Nevertheless, in the 1998 inspection, there was still a great deal of healthy plants inside the area once occupied by the exclosures, although the plants were not as tall (Photo #13c). From this comparison, it appears that panel removal in either the spring or fall would be suitable although spring removal requires less work, and does not lead to any immediate damage.

Photo 12. Top: View of CVPP site below boardwalk shortly after beginning of planting in 1993. Bottom: View of site after the monitoring program in 1995; exclosure panels had been removed during spring.

Results of the Submergent Planting Program

Monitoring

Growth of the submerged plants in the large exclosures was monitored once from an airplane in July 1996. In late August, the monitoring team noted the percent area covered by the four taxa in each exclosure, as well as the general condition of the panels because the exclosures had failed to overwinter intact. The degree of colonization appeared to be related to the structural integrity of the exclosures. The four exclosures that had received the least damage contained varying amounts of primarily one species. *Potomageton pectinatus*, Sago pondweed (Photo #14 a). Since this was independent of the original species planted in the exclosure the year before, it suggests to me that Sago pondweed had successfully colonized all of the moderately intact exclosures because it is the most turbidity-tolerant (Photo #14b).

Long-term effectiveness of the planting program

The short-term success of the planting program is confirmed by the tremendous growth of transplants a year following the planting program (Photos #15a and #15b). The best evidence of the long-term success of our planting program is shown in the 1997 aerial photo (Photo #16). Despite relatively high water levels that year, most of the plants that had been transferred continued to grow there and even expanded beyond the exclosure walls. There is now established populations of at least two species of cattails (*T. latifolia* and *T. angustifolia*), softstem bulrush, and arrowheads. However, swampdock, which grew well in the 1995 and 1996 seasons, has become very scarce, as have all of the remaining taxa that we planted. Since these species did not survive in the long-term and were also problematic to keep in greenhouse cultures, they should probably be dropped from future large-scale planting programs. The July 1997 photo also shows a resurgence in growth of the cattail beds outside the planting site in Mac Landing and this may be attributed to successful exclusion of carp through the Cootes Paradise Fishway several months earlier.