Restoration and Reclamation Review
Student On-Line Journal
Vol.4, No.5, Spring 1999
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University of Minnesota, St.Paul, MN

Carp Control Techniques for Restoration of Aquatic Plants in Ontario

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The main emphasis of this paper is to characterize the damage *Cyprinus carpio* (carp) cause to aquatic plant populations and to discuss several restoration techniques which have and are being used to control the large carp populations. For the purpose of this paper, I have chosen to focus on restoration projects within a large wetland area near the town of Hamilton, Ontario, Canada. The entire area is called Cootes Paradise and the waterway in particular is called the Desjardins Canal. The shores of the canal are lined with wetlands and have exceptionally high biodiversity for plant and animal species (Cootes Paradise, 1999). The Royal Botanical Gardens (RBG) owns this property and has been instrumental in preserving the Canal as a protected resource of the community. The area is used for study and observation by the students of McMaster University, which is located in the town of Hamilton. Carp have long been studied because they play a key role in reducing stands of both emergent and submerged vegetation. Carp are large bottom-feeding fish native to Asia and Europe, and were deliberately introduced to many North American locations during the early 1800's (Auger, 1996). In southern Ontario, carp were first introduced during 1880 at a fish breeding pond in Cedar Grove, York County. People originally believed the fish would make an excellent addition to mill ponds because of their prolific nature, as well as their domestic and economic value. From 1880 onward, various ponds throughout southern Ontario and the U.S. basin states were stocked with carp. In ponds near Newmarket, Ontario, carp escaped into the Holland River during a sudden overflow of water in 1896. This event was only one of several means by which this fish became established in the Great Lakes basin. As their numbers increased, carp were considered a nuisance because of their ability to degrade aquatic habitats through the displacement of emergent and submerged vegetation and re-suspension of sediments (Sidorkewicj et al, 1996).

Vegetation is uprooted as carp search for food, as well as some extent during spawning activities (Threinen & Helm, 1954). Their diet consists of mollusks, insects, worms, crustaceans, algae and aquatic plants (dead or living) and seeds. During feeding, carp suck in and expel water, mud and debris. Aquatic plants become uprooted, nutrients are released and sediments are re-suspended causing an increase in water turbidity. High turbidity can reduce aquatic plant growth by limiting light penetration (Tatrai, 1997).

The spawning activities of carp can also displace vegetation. Spawning generally occurs throughout the Great Lakes from May to August, peaking mid-May to June (Crivelli, 1981).Carp usually spawn in groups of one female and three to four males although larger groups may also occur. During spawning, carp move into shallow, vegetated areas, where splashing and physical activity can uproot and flatten aquatic plants. Damage from feeding and spawning are more extensive from larger carp populations. Damage to aquatic vegetation varies with both the depth of water and the type of plant community. It is more probable that aquatic vegetation will be displaced at lower water levels (Tatrai, 1997). Deep water (> 1.0 m) inhibits feeding and spawning while shallow water (18-50 cm) facilitates these behaviors. The vulnerability of perennial plants to displacement is determined by the strength of the root system and it's ability to resist uprooting in different soil types (Crivelli, 1983). Susceptibility of annual plants appears more dependent on the timing of seed during periods of prime carp activity (May to August).

Though carp activities play a large part in the displacement or reduction of aquatic vegetation, they are not the only disturbance (Breukelaar, 1994). Shoreline development, recreation activities, pollution, natural water level fluctuations, and wind and wave action also play a role. However, the presence of large numbers of carp is a concern because of their ability to negatively impact both plant and animal communities in shallow, freshwater environments. When carp populations increase, they affect the species and abundance of aquatic vegetation and thus indirectly affect waterfowl (King & Hunt, 1967).

Studies on the impact of carp in aquatic systems have been conducted since the late 1950's. A common theme in each study to understand the degree to which carp affect the total abundance of submerged vegetation, how carp affect the composition of species in the plant community, and the recovery of aquatic vegetation after carp are eliminated or controlled. In general, multiple studies have shown that the total abundance of submerged vegetation is significantly reduced by carp. Studies have shown anywhere from 30% -75% less vegetation compared to controlled areas where carp were excluded (King & Hunt, 1967). The influence of carp on species composition in plant communities is less clear. There are many conflicting reports regarding which plant species, if any, are more resistant to the disturbances of carp. The results indicate that the plant species *Potamogeton pectinatus* and *Potamogeton crispus* appear resistant mainly because they are relatively deeply rooted species. It is clear that once carp are controlled, re-establishment of vegetation is quite high (King & Hunt, 1967). Several studies have shown *Chara* sp. (a large rooted algae) increased by 95% one year after the carp were removed (King & Hunt, 1967).

Several techniques have been developed to control the movement of carp populations at aquatic restoration projects throughout Desjardins Canal. The four addressed in this paper are as follows: Cootes Paradise fishway, carp exclosures, water filled dams, and fencing systems.In the spring of 1995, the city of Hamilton commissioned Beak Consultants (a local firm) to construct a fishway on the Cootes Paradise side of the Desjardins Canal (McMaster, 1996).

Considered a remedial technique, it was just one of many initiatives to rehabilitate fish and wildlife communities in the Hamilton Harbour area. The fishway prevents carp from entering Cootes Paradise marsh in the late winter and early spring while providing both upstream and downstream access for the other fish species such as pike, walleye and bass. The goal was to help re-establish aquatic plants and reduce sediment suspension. It also lead to long-term control of the carp population by restructuring the fish community to create a higher piscivorous (fish-eating fish) population to feed on young carp. The fishway is made up of three separate sections and spans the entire width of the Desjardins Canal:

1. A south end section allows all fish except carp to enter into Cootes Paradise. To reach the marsh, fish swim into one of six chambers where they become trapped. City employees stationed at the fishway raise the chambers and sort out the carp while allowing all other fish to proceed through this first section.

2. A middle section consists of several grate openings. The openings allow small fish to move freely from Cootes Paradise to Hamilton Harbour, but restrict access to 95% of the adult carp. Removal of these grates in early September enables any remaining carp to leave Cootes Paradise during their fall migration to winter in the Harbour. In mid-February, the grates are reinstalled before the ice leaves the marsh and the carp return from the Harbour.

3. A north end section allows all fish to travel in one direction from Cootes Paradise to the Harbour on the opposite side of the wetland from the Desjardins Canal.

The first year of operation was in 1996. For several weeks the carp were successfully turned back at the fishway. Signs of healthy marsh conditions such as improved water clarity, increased numbers of yellow perch, large mouth bass and young pike were evident and growth of submerged plant colonies along the shoreline and open water increased (McMaster, 1996). However, two mature carp were detected during routine monitoring activities at the end of the first month. Unfortunately, as more carp entered the marsh, some were identified as those which had been captured, marked and sorted at the fishway several weeks earlier.

Since carp exclusion is an essential first step in the restoration process, divers immediately conducted an under water inspection to determine how exactly the carp were entering the protected area. Carp were entering Cootes Paradise through gaps in the barrier, probably dislodged from a severe storm, which occurred in late May of that year. This storm brought a massive amount of debris down the watershed and into the fishway. The debris scoured away at the rock apron that was put in place to seal the sorting baskets against the marsh bottom. The scouring action combined with natural settling of the sediment allowed small gaps between the rocks to occur and the carp squeezed through entering the marsh.

After much deliberation, it was decided by those directly involved with the restoration project that the rock apron needed to be reinstated and fortified with additional rock and metal plates. An automatic debris remover needs to be designed and installed on the upstream side to handle large volumes of storm related flotsam.

The second technique, developed and maintained by biologists at McMaster University, are the Cootes Paradise carp exclosures. They have been proven an effective way to protect re-vegetated areas of Cootes Paradise damaged from carp and the grazing activities of other wildlife including muskrat, deer and waterfowl (Auger, 1996). The exclosures provide a pen-like structure to keep out the carp. On the day of planting the new vegetation, the panels are inserted a meter deep into the sediment surrounding the entire planting area. Great care is taken not to enclose any carp.

Seedlings of seven different taxa of emergent plants have been successfully transplanted into forty-four exclosures (Auger, 1996). These include two species of cattail (*Typha latifolia* and *T. angustifolia*), arrowhead (*Sagittaria latifolia*), softstem bulrush (*Scirpus validus*), swamp dock (*Rumex verticillatus*), buttonbush (*Cephalanthus occidentalis*), sweetflag (*Acorus calamus*), and swamp loosestrife (*Decodon verticillatus*). Red-winged blackbirds have built nests in the vegetation in at least two exclosures. In addition, toads and spiders have increased in abundance inside the exclosures. Since plants within the exclosures are also colonizing areas outside the exclosures, researchers anticipate that the space between sets of exclosures will eventually fill in with vegetation.

The biologists responsible for the exclosures are now experimenting with different techniques to re-vegetate open-water areas of the marsh with submergent vegetation. They have added Terrafix siltscreen to the panels of twelve larger exclosures to plant the submergent species. The purpose of the siltscreen is to reduce turbidity.

The third technique is a water-filled dam. The Royal Botanical Gardens (RBG) is currently involved with the restoration of Cootes Paradise and Grindstone Creek marshes in Hamilton Harbour (Auger, 1996). To facilitate the establishment of aquatic vegetation the RGB used an Aqua Dam. The Aqua Dam is a water-filled polyethylene and geotextile berm, which permits temporary impoundment, dewatering and exposure of marsh bottom for planting, seed germination and the expansion of existing vegetation stands.

The Aqua Dam has been tested at a few different sites with what seemed to be great potential, but unfortunately was compromised by a few design flaws. For instance, at one of the larger sites the water was drained and seedlings were germinating well, when a malfunction occurred and the area flooded prematurely destroying the work up to that point. The manufacturer's are redesigning and hope to re-test at a later date.

The fourth technique is a fencing system. Implemented and managed by the City of Oshawa, this fencing system limits carp access to specific sites within an area called the Second Marsh along the Desjardins Canal. A partially submerged carp control fence extends from a barrier beach to several flow deflecting islands and continues into cattail bed creating a carp exclusion area of approximately half of the marsh (Auger, 1996). The control system consists of a continuous chain link fence. Mesh openings restrict mature carp from accessing the eastern portion of the marsh while smaller fish species continue to access the entire marsh.

The fencing was installed recognizing the seasonal use of the marsh by carp. To effectively implement carp control, the fence post and chain link mesh were installed during the winter prior to ice break up and the movement of carp into the marsh. A section of the fencing will be removed each fall to allow any trapped carp, or other species, to exit the exclusion area before winter ice build-up. During the first season of its use, it was found that regular monitoring and maintenance of the barrier was required to ensure its effectiveness (Auger, 1996). For instance, a gap was found in the fencing allowing carp to access the protected side of the marsh.

Ultimately, the selection of carp control technique will depend upon the goals, objectives, funding support, community support and physical features on the project site. Other items to consider are cost, durability/maintenance, labor, regulatory review, natural forces, and construction materials.

The pros & cons of the four techniques mentioned in this paper, are outlined as follows:

Cootes Paradise Fishway: **Pros:** long-term control, provides largest area of protection, relatively efficient, 50 year life-span, enables migration, permanent structure.	**Cons:** Very high start up cost, operating cost, and occasional maintenance costs, manual sorting of fish, regular monitoring.
Carp Enclosures: **Pros:** effective protection, low start-up cost, repair costs minimal, low level of construction, easily removable in spring, reduces turbidity when siltscreen used.	**Cons:** Short term control, protection area depends on size of enclosure, siltscreen may wear, debris accumulation, regular monitoring.
Water filled Dams: **Pros:** effective, large area protected, removable.	**Cons:** Concept requires further development, high start up cost, costly repairs.
Fencing Systems: Pros: Short to long term control, large area of protection, moderate start up costs, repair costs minimal, removable.	Cons: Ineffective when carp are not trapped on both sides of fence, gaps in fencing require repair, debris accumulation, regular monitoring, carp may burrow under, may obstruct movement of wildlife.

The implementation of carp control to assist in aquatic plant establishment is an ongoing process that will require a great deal of discipline to obtain the desired results. The four techniques discussed provide various options for management depending on the magnitude and complexity of the situation. The information in this paper provides the reader with an understanding of the complexity of the issue and hopefully a direction to follow in planning a restoration project in which carp control is an essential pre-requisite.

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