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Control of Eurasian Milfoil (*Myriophyllum spicatum*) using wind powered water circulators at Lake Cayamant, Quebec, CANADA.

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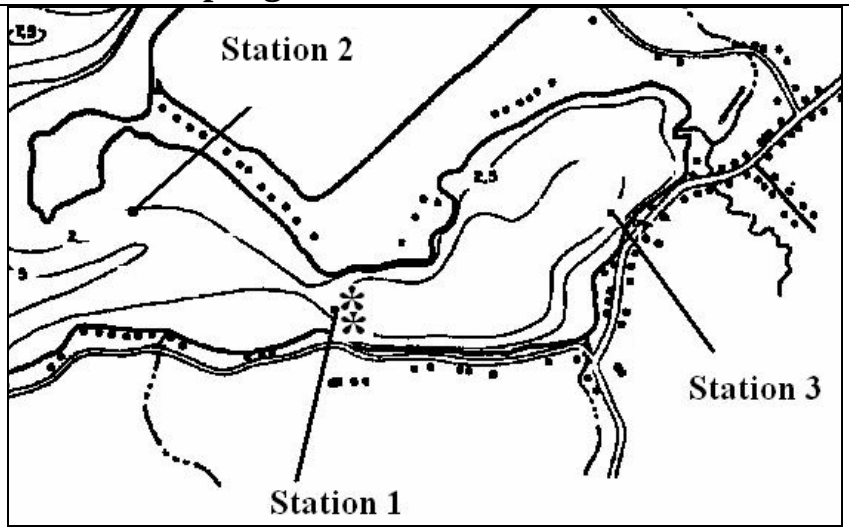
Introduction

The first observation of Eurasian Milfoil (*Myriophyllum spicatum*) at Lake Cayamant was made in 1997. Shortly after, most of the littoral zone of the eastern part of the lake including all of Village Bay was completely infested by the Milfoil. Due to density of Milfoil beds access to Village Bay by boat was extremely difficult if not impossible. In 2001 the municipality of Cayamant installed two wind powered water circulators in Village Bay for testing the efficiency of this new Milfoil control technique. During the first two years the windmills gave good results, showing a definite control on Milfoil growth and density up to a 30m radius. After consulting us, it was decided to relocate the windmills at the mouth of the bay to take advantage of the dominant westerly winds and waves.

Following the relocation of the two wind powered water circulators in a heavily infested area (15-25 stems/m^2) in November 2004, fishermen and residents observed a crash in the Eurasian Milfoil (*Myriophyllum spicatum)* community around the floating windmills during the 2005 summer period. Thus, the municipality of Cayamant ordered a study on the status of Milfoil to see if the crash was due to natural causes or was directly influenced by the usage of the windmills. Field observations and physical chemistry analysis were performed on three different sites in Village Bay of Lake Cayamant; one control site and two other sites influenced by the windmills.

Aquatic Ecologist: Dany Boudrias
Applied Ecology Technician: Isabelle Arshoun

Sampling sites and windmill locations



Results

Station no.1 August 17th 2005 / conditions : sunny

DEPTH (m)	**0**	**1**	**2**	**3**	**3,8**
Temperature (°C)	24.5	24.5	24.2	24.2	24.2
Oxygen (mg/L)	8.6	8.6	8.8	8.6	5.4

Total Phosphorous (μg/L)	Transparency (m)	pH
31	4.4 (taken in a deeper part of the lake)	8.30 8.27

Station no.2 August 17th 2005 / conditions : sunny

DEPTH (m)	**0**	**1**	**2**	**2,6**
Temperature (°C)	24.5	24.2	24.0	24.0
Oxygen (mg/L)	9.0	9.0	9.0	7.0

Total Phosphorous (μg/L)	Transparency (m)	pH
26	4.4	9.0 8.97

Station no.3 August 17th 2005 / conditions : sunny

Depth (m)	**0**	**1**	**2**	**3**
Temperature (°C)	24.0	24.0	24.0	24.0
Oxygen (mg/L)	8.5	8.2	8.3	1.6

Total Phosphorous (μg/L)	Chlorophyll-a (μg/L)	Transparency (m)	PH
10	4.2	4.4	8.54 8.05

Observations and description of water plant communities at each site

Station 1

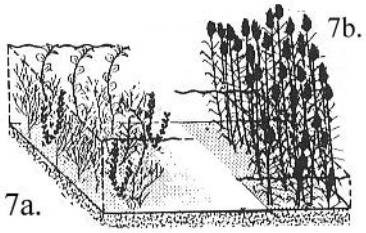
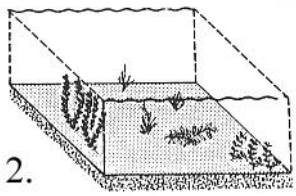
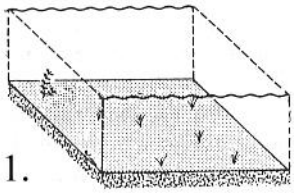
The observations described below were made in a radius ranging from 100 to 175m around the windmills, which can be considered as their approximate influence area.

The windmills were located in an area with a depth of 2 to 2.5m. The density of the water plant community was of 2 to 3 stems per m^2. We found the majority of the Milfoil present in a state of degradation, with brown stems and foliage. When we created an ascending water current by rapidly pulling up a Secchi disc, the Milfoil plants would come apart easily as if dead. The brown coloration of the Milfoil at this location was an indicator that the plant could no longer photosynthesize and had reached a stage of early decomposition. The mean length of the remaining stems was 1.2m, namely much shorter than the average length the Milfoil can usually reach (3 to 6m). An important fact to underline is the presence of *Elodea canadensis* (Canada Water-weed). This specie was starting to colonise areas where Milfoil was once present. Considering that the few remaining Milfoils were practically dead, the dominant plant at this site was now Canada Water-weed.

Canada Water-weed

We also observed in the 4 to 5m depth area in the direction of station 3 (towards the inside of Village Bay towards the east) that no plants (Milfoil or others) were detected and only a blackish organic sediment layer was present. This confirms the complete mortality of Eurasian Milfoil. It would seem that the recommendation to relocate the windmills more towards the west of the mouth of Village Bay would have created an increased water circulation towards the EASTERN portion of the bay and would thus have the expected effects.

Type of macrophyte (aquatic plant) populations now found at site 1:

BEFORE relocation of windmills	Radius of 50 to 70m from windmills (2005) at 2 to 4m depth	Between 4 and 5m depth, up to 175m EAST of the windmills (2005)
 Very dense field of submerged and emergent Eurasian Milfoil	 Clusters of aquatic plants, including established Canada Water-weed	 Scarce population or absence of plants

Station 2

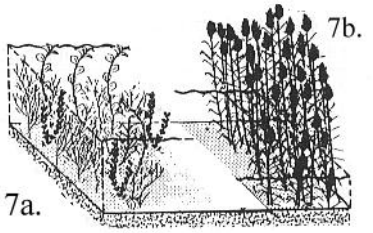
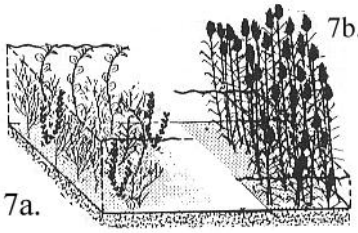
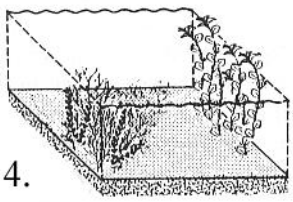
Moving from station 1 to station 2 we observed a transition zone of approximately 200m were a dominance of Canada Water-weed shifted towards a dominance of Large-leaved Pondweed (*Potamogeton amplifolius*) which finally ended with a dominance of Eurasian Milfoil.

When we reached station 2, Eurasian Milfoil was the dominant plant in the area. The Milfoil seemed to be in perfect health, displaying its usual characteristics such as; a high density of approximately 15-25 stems/m^2, all green without any signs of degradation as observed at station 1 and at least 2m in length. On the other hand, we did observe that it was generally shorter than what was observed previous years.

Large-leaved Pondweed

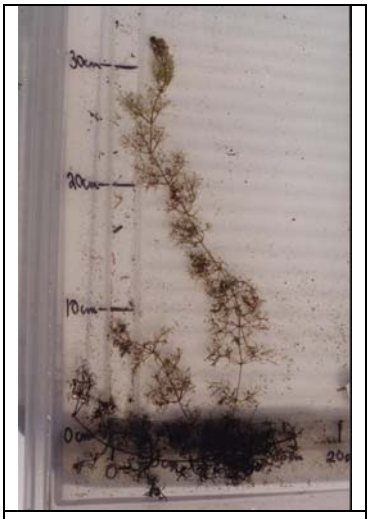
In previous years, not only would it reach the surface, but a mat of stem elongations would float on the surface of the water, which was not the case this year.

Type of macrophyte (aquatic plant) populations now found at site 2:

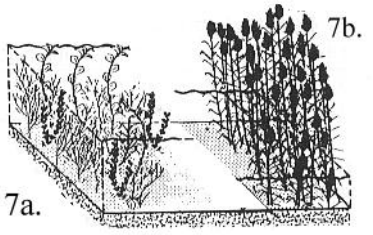
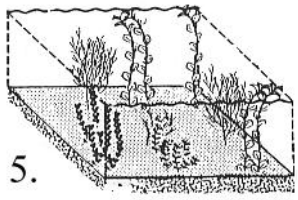
BEFORE relocation of windmills (Before 2004)	Station 2 (2005)	Transition zone between station 1 and station 2 (2005)
 Very dense field of submerged and emergent (or floating) Eurasian Milfoil	 Very dense field of submerged but not emergent Eurasian Milfoil	 Clusters of Canada Water-weed covering the bottom in transition with Large-leaved Pondweed

Station 3

In Village Bay, where the windmills were for more than four years, we observed a greater diversification of water plant populations. The Milfoil was still present, but we did find Large-leaved Pondweed (*Potamogeton amplifolius*), Canada Water-weed (*Elodea canadensis*) and Purple Bladderwort (*Utricularia purpurea*). Within the vegetation, we found gelatinous masses belonging to the bryozoan family (living organisms). The water plant communities were completely submerged with the exception of certain areas with less than 2m depth where a few stems of Milfoil and Pondweed reached the surface. The density of the communities was variable, but in general the density was of approximately 5 to 7 stems/m^2.


Purple Bladderwort

Type of macrophyte (aquatic plant) populations now found at site 3:

BEFORE relocation of windmills	2005
 Submerged fields of Milfoil of average density becoming emergent as we move away from station 1. Scarce population or absence of plants around windmills (20-30m radius)	 Heterogeneous prairie of aquatic plants

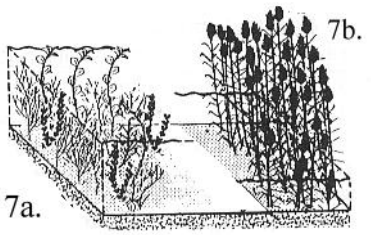
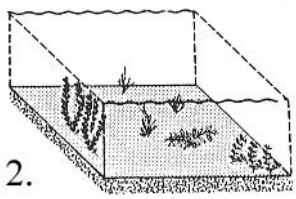
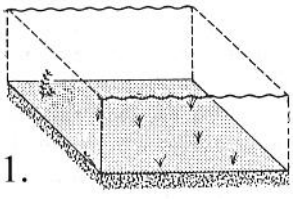
DISCUSSION

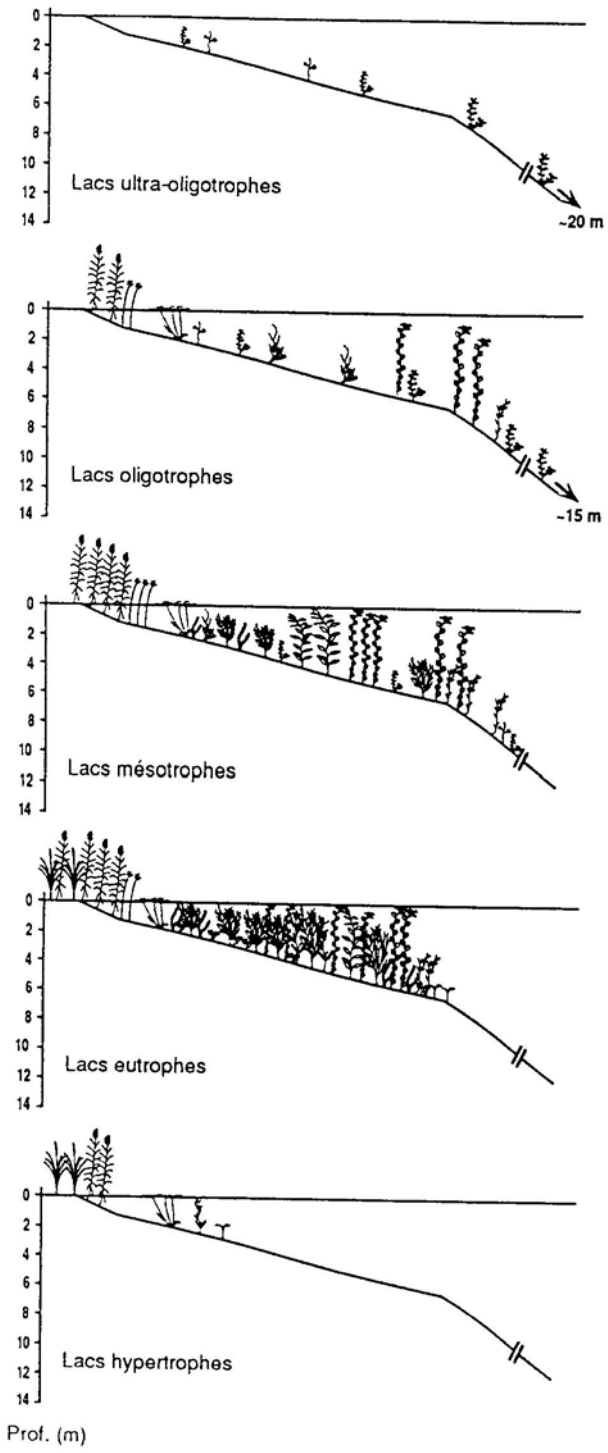
It was somewhat difficult to interpret the physical chemistry results obtained. The results varied from one site to the other without any net tendencies, with or without the windmills. We should then concentrate on the field observations which are more conclusive.

As observed by lake-side residents this summer, Milfoil stems were generally shorter than previous years with or without the windmills. We believe that the hot and very dry weather of this summer may have been the limiting factor in bringing nutriments to the lake. We have to recognise that Lake Cayamant is a mesotrophic lake, i.e. a lake in transition becoming richer in nutrients. However, if we could eliminate all the septic installations around the lake, we could rapidly limit the damage and reverse the aging process towards an oligotrophic lake (poor in nutrients) since the sediment layer in the lake is generally very thin. The hot and dry summer has allowed for the riparian lands receiving the drainfields to dry out. This means that the ground surrounding the drainfields of the septic installations was dryer than usual, thus not allowing the domestic wastewater to reach the shore and therefore the lake. This could have been an attenuating factor for Milfoil growth since it needs important amounts of nutrients to thrive (not only absorbed through its root system but also through its foliage). A hypothesis that could explain the phenomenon observed this summer goes as follows:

- With a reduction in nutrient inputs (reduction of phosphates) each individual were in direct competition with one another, thus directly affecting the overall growth of the Milfoil beds.
- Opportunities for native species to establish themselves were created since density and stem length of Milfoil were reduced due to a lack of nutrients.
- The native plants started to compete against Milfoil for sunlight and nutrients thus affecting Milfoil growth.

As for the surrounding areas near the windmills we have observed more than just a reduction of Milfoil communities, in fact a radical change in different types of plant communities can now be seen.

BEFORE relocation of windmills	Radius of 50 to 70m from windmills (2005) at 2 to 4m depth	Between 4 and 5m depth, up to 175m EAST of the windmills (2005)
 Very dense field of submerged and emergent Eurasian Milfoil	 Clusters of aquatic plants, including established Canada Water-weed	 Scarce population or absence of plants



The change in types of plant communities demonstrates that the effect of the windmills is real. What we now observe around the windmills is a shift towards typical plant communities found in oligotrophic lakes, the ULTIMATE GOAL of this restoration project that began more than 5 years ago.

← Type of plant communities found around the windmills in 2005

← Type of plant communities in 2005 without the windmills

← Type of plant communities before 2005 without the windmills

CONCLUSION

The field observations allowed us to see that there is a change in water plant communities going from a dominance of Eurasian Milfoil towards a non or less-problematic indigenous plant community. Lake stewards should not aim to completely eliminate aquatic plants as they are part of a healthy aquatic ecosystem.

Canada Water-weed is usually a non-invasive specie but we do find many very nutrient-rich lakes that have an overgrowth problem of this plant which impedes upon navigation activities (as with Milfoil). We do not expect that this will occur at Lake Cayamant because of the presence of the windmills that continue to fulfill their purpose. To this day, the windmills have IN ALL CASES reduced the density of the plant communities in their area of influence.

The lake restoration technique using floating windmills is very promising for lake associations that have the same or similar problems. This technique has also been used in eutrophic and hyper-eutrophic lakes for algae control with the same positive response as with Lake Cayamant. A solar powered version of this technology (equivalent to 2-3 windmills in terms of overall efficiency) is also available for a quicker response. The Aero-Solar has been used in multiple lake restoration programs. Aside from plant and algae control, the Aero-Solar can be used for fish spawning bed restoration and as an alternative to dredging in deeper lakes and shallow areas.