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Watershed Protection: Clean Lakes Case Study

Use of Aquatic Weevils to Control a Nuisance Weed in Lake Bomoseen, Vermont

Key Feature:	Use of a biological control for a nuisance macrophyte
Project Name:	Lake Bomoseen
Location:	Rutland County, VT USEPA Region 1
Scope/Size:	Watershed area 10,025 hectares (24,470 acres) Lake area 960 hectares (2,370 acres)
Land Type:	Ecoregion #60, Northern Appalachian Plateau and Uplands
Stressor:	Eurasian watermilfoil *(Myriophyllum spicatum)*
Stressor Source:	Accidental introduction
Data Sources:	State
Data Mechanisms:	Plant and invertebrate sampling
Monitoring Plan:	Yes
Control Measures:	Aquatic weevil *Euhrychiopsis lecontei*

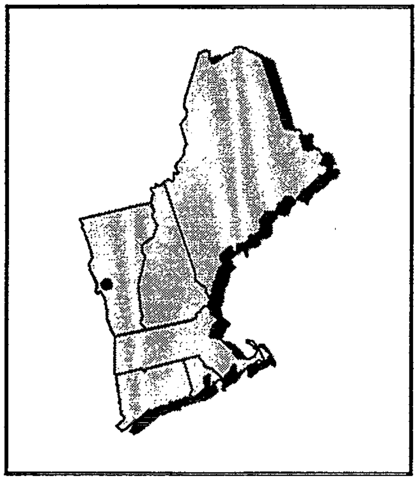

Figure 1. Location of Lake Bomoseen, Vermont.

Summary: Lake Bomoseen, located in western Vermont (Figure 1), has had a long history of weed problems. By the early 1980s, Eurasian watermilfoil (*Myriophyllum spicatum*) was the dominant weed species in the lake. Eurasian watermilfoil is an introduced species that is difficult to control due to its ability to survive in various environmental conditions. At one point the watermilfoil covered 240 hectares of the lake, impairing its recreational and commercial uses. In addition to Lake Bomoseen, the macrophyte has been documented to exist in approximately 42 other Vermont lakes. One of those is Brownington Pond (located in northeastern Vermont), which experienced a decline in its watermilfoil population in 1989. Following the discovery of this natural decline, the Vermont Department of Environmental Conservation (VTDEC) was awarded a U.S. Environmental Protection Agency (USEPA) grant to investigate the decline and its causes. It was hoped that the investigation would benefit other lakes with Eurasian watermilfoil problems.

Researchers from Middlebury College, working under contract for VTDEC, documented fluctuations in the Brownington Pond Eurasian watermilfoil population and then investigated possible causes, including the role of herbivores. The researchers concluded that a native aquatic weevil, *Euhrychiopsis lecontei*, was largely responsible. They proceeded to examine the specific effects of the weevil on the Eurasian watermilfoil and native plant species to determine the feasibility of the weevil as a biological control. The weevil was deemed appropriate and potentially effective as a control for the Eurasian watermilfoil and the weevil population in Lake Bomoseen was augmented (i.e., added to) in 1993 and 1994. Although an overall reduction in the Eurasian watermilfoil population dramatic enough to be noticeable to lakeshore owners has not yet occurred, the technique has shown promise in controlling the growth of the weed. Results from the monitoring of introduction sites have shown that over the last 4 years weevil survival has been good and that the plants have suffered extensive weevil-induced damage. These initial results indicate that, over time, the weevil might be able to reduce nuisance growth in Lake Bomoseen and could potentially be used in other lakes with similar problems.

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BACKGROUND

Lake Bomoseen is located in western Vermont in the towns of Castleton and Hubbardton in Rutland County (Figure 1). It is the largest lake that lies entirely within the state's boundaries, with a surface area of approximately 960 hectares (2,370 acres). The lake is mesotrophic and has an average and maximum depth of 8.2 m (26.8 feet) and 19.8 m (65 feet), respectively. It drains a 10,025-hectare (24,470-acre) watershed, has five major inlets, and empties to the Castleton River.

A portion of the lake's shoreline is contained within Bomoseen State Park. Most of the remaining area around the lake is privately owned. The lake has such recreational accommodations as a public beach, marinas, and public boat launches, in addition to the state park. There are approximately 1,000 residences around the lake, as well as restaurants and other commercial facilities (Holly Crosson, VTDEC, personal communication, 1997).

CHARACTERIZING THE PROBLEM

Dense aquatic weed growth has been a consistent problem in Lake Bomoseen since the early 1940s. In 1977 the town of Castleton began to harvest the dominant exotic weed species in the lake, curly leaf pondweed (*Potamogeton crispus*). The weed harvesting was funded under section 314 of the Clean Water Act from 1977 to 1979. The harvesting then continued with state and local funds and was successful in the control of the pondweed until the early 1980s, when Eurasian watermilfoil (*Myriophyllum spicatum*, hereafter referred to as EWM) replaced *P. crispus* as the dominant species in the lake. Mechanical harvesting has remained the primary method for the control of EWM on Lake Bomoseen.

Since its accidental introduction in the mid-1900s, EWM has spread to at least 40 states and 3 Canadian provinces, making it one of the most widespread nuisance macrophytes in North America (Sheldon and Creed, 1995). Once introduced, EWM frequently becomes the dominant species in a lake. The widespread distribution of EWM can be explained by its ability to live in various environmental conditions; it can withstand a broad range of aquatic environments, from oligotrophic to eutrophic waters, and it grows in water depths from as shallow as 0.5 meter to as deep as 8 meters (26 feet). It also can grow in substrates ranging from poor, sandy sediment to highly organic soils and can survive in wide ranges of salinity, pH, and temperature conditions (Aiken et al, 1979; Nichols and Shaw, 1986; Smith and Barko, 1990, as cited in Sheldon and Creed, 1995).

EWM beds are groups of plants of similar height and leaf form (Figure 2). The plants grow quickly and, when they reach the water surface, grow laterally to form a canopy. In contrast to many other macrophytes that grow to variable heights and leaf shapes, EWM grows as thick walls of uniform height and leaf forms. Because of this, the dense EWM beds usually support a lower abundance and diversity of invertebrates than do native aquatic plant beds (Sheldon, 1995; Sheldon and Creed, 1995). In addition to its effects on aquatic life, EWM hinders the use of waters for recreational boating, swimming and, fishing.

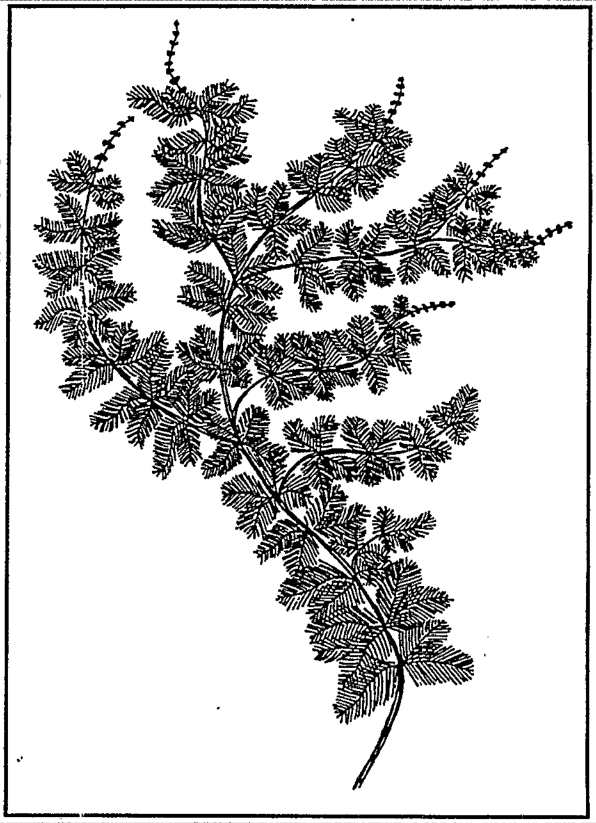

Figure 2. Eurasian watermilfoil.

IDENTIFYING POSSIBLE CONTROLS

In 1989, biologists with the Vermont Department of Environmental Conservation (VTDEC) noticed a natural decline in the population of EWM in Brownington Pond in the northeastern region of the state. In 1990, VTDEC was awarded a $575,000 grant from the USEPA under section 314 of the Clean Water Act. The purpose of this grant was to examine the possibility of using aquatic herbivores found in Brownington Pond as a biological control for other EWM populations. This Clean Lakes Demonstration Program grant was awarded for the purpose of highlighting new and unique techniques for lake restoration.

Working under contract for VTDEC, researchers from Middlebury College mapped and studied the decreases and increases in EWM in Brownington Pond from 1990 through 1995. The study investigated a variety of factors (e.g., herbivores, water chemistry, and sediment chemistry) that could have influenced the fluctuations. The results of the plant and invertebrate sampling suggested that herbivorous insects played a primary role in the EWM declines observed in 1989 and 1992. The researchers were able to eliminate other factors as reasons for the declines, and the focus turned toward the herbivore populations in the pond.

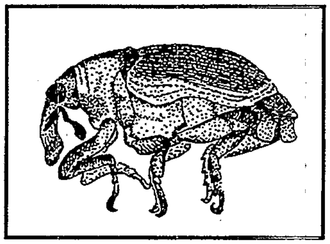

Figure 3. An adult milfoil weevil (illustration courtesy of Susan Warren, VTDEC).

The two main EWM herbivores present in Brownington Pond were an aquatic weevil native to North America, *Euhrychiopsis lecontei* (Figure 3), and the caterpillar *Acentria ephemerella*. In examining the herbivores, the researchers noticed variations in the abundance of the aquatic weevil between 1990 and 1994 and compared the variations to those of the EWM. They noticed that the fluctuations in the weevil populations compared to the EWM populations were similar to those exhibited by predator-prey or host-parasitoid models (Creed and Sheldon, 1995). The evidence suggested that the naturally occurring weevil populations might have played a role in the decline of the Brownington Pond EWM population.

The Middlebury College researchers conducted laboratory and field experiments to further examine the relationship between EWM and the weevils, as well as their relationships to other herbivores and macrophytes. It was discovered that *Phytobius leucogaster*, another species of aquatic weevil, did feed on the EWM but had no significant negative effect on its growth (Sheldon, 1995). It was also discovered that the *Acentria* larvae reduced EWM growth in laboratory experiments (due to stem-cutting during feeding and retreat construction (Creed and Sheldon, 1994)). However, extensive caterpillar damage was not observed in Brownington Pond (Creed and Sheldon, 1994).

By researching the feeding behaviors of the weevil, the researchers were able to determine that all of its life stages can cause damage to the plant. The first instar larvae cause extensive destruction to the growing tip of the plant, thus preventing new stem growth. The late instar larvae hollow out the stem by feeding on its vascular tissue, thus reducing the plant's ability to transport the nutrients necessary for growth. The late instar larvae also destroy the lacunal system of the EWM, which serves as a gas reservoir for respired carbon dioxide (Nichols and Shaw, 1986, as cited in Creed and Sheldon, 1994) and also permits gas exchange between the plant roots and shoots (Grace and Wetzel, 1978, Nichols and Shaw, 1986, as cited in Creed and Sheldon, 1994). The adult weevils can damage the plant by feeding on its upper leaves, which can affect the plant's energy balance by transferring photosynthesis responsibilities to deeper leaves (Creed et al., 1992). The feeding may also make the plant more susceptible to infections by bacteria and fungi (Sheldon and Creed, 1995; Creed et al., 1992).

In addition to these direct effects, larval tunneling can also cause the plant to lose buoyancy and collapse into deeper waters, where it is subject to conditions different from those at the surface. This indirect effect of loss of buoyancy could in fact be more significant than the direct loss of leaf and stem tissue discussed above (Creed and Sheldon, 1995; Creed et al., 1992). It can cause the plants to sink out of well-lit surface water, possibly to depths with insufficient light for photosynthesis (Creed et al., 1992). Plants that lose buoyancy due to weevil feeding could also entangle and sink other, undamaged plants.

The Middlebury College researchers conducted laboratory feeding trials to quantitatively assess the effects of the weevils on the EWM. The plants were collected and cleaned of all invertebrates, eggs, and other material. Data were collected concerning the plants' appearance, weight, and length. The plants were then placed in clear cylinders and either zero, two, or four adult weevils were added to each cylinder. The results of the laboratory experiments showed that the wet weight of the EWM averaged 50 percent less in the two-weevil containers than in the no-weevil containers and 130 percent less in the four-weevil containers (Sheldon, 1995). In addition, the final plant shoot lengths were an average of 25 percent shorter in the two-weevil containers and 60 percent shorter in the four-weevil containers (Sheldon, 1995).

In field experiments, weevils were added to 30.5-centimeter-diameter, 2-meter-tall cylindrical enclosures in two lakes in which weevils were not present. Forty days after the addition of the weevils, the EWM plants in the three experimental weevil enclosures were compared to those in the three control enclosures. Plant weights were lower for the plants with weevils. In addition, the macrophyte formed canopies in the control enclosures and the surrounding areas, but in the weevil enclosures there were no plants at the water surface (Sheldon and Creed, 1995). The plants had collapsed, and most were at least 1 meter below the surface (Sheldon and Creed, 1995).

In addition to the effects on EWM, the Middlebury College researchers also investigated the effects of the weevils on other aquatic macrophytes, including several native watermilfoil species. They found that the weevils had no significant negative effects on the native, non-watermilfoil species, with no evidence of weevil feeding or egg-laying (Sheldon and Creed, 1995). Although the weevils did feed and lay eggs on portions of the native watermilfoil *M. sibricum*, the resulting damage was not considered significant (Sheldon and Creed, 1995; Sheldon, 1995).

Based on the results from the Middlebury College laboratory and field experiments, the weevil was deemed acceptable by VTDEC as an experimental biological control because of the possibility that it might be able to control EWM and the low risk it posed to non-target native aquatic plants.

INTRODUCTION OF A BIOLOGICAL CONTROL AGENT

In the summer of 1993, VTDEC issued a Biological Control Permit under the state's Aquatic Nuisance Control Permit Program allowing the release of weevils into two Vermont lakes, including Lake Bomoseen[1] (Sheldon, 1995). Rearing of the weevils took place at VTDEC's environmental laboratory in Waterbury and at Middlebury College.

In the summer of 1993, more than 5,000 weevils were added to three unharvested sites in Lake Bomoseen— Cedar Mountain, Neshobe Island, and Eckley Point[2] (Figure 4). In the summer of 1994, approximately 15,000 additional weevils were introduced to the same three sites by both VTDEC and Middlebury College. The distribution of the weevils released in 1994 was 9 percent eggs, 77 percent larvae, 13 percent adults, and 1 percent pupae (Hanson et al., 1995).

Weevils were added to the three unharvested sites in Lake Bomoseen at least once a week throughout the summers of 1993 and 1994. Data were collected concerning the numbers and life stages of weevils released at each location, and any notable weevil damage was recorded at each site on each release date. Each augmentation area was paired with a site that acted as the control "no-weevil" site for later comparison during the monitoring efforts.

[1]The introduction of weevils into Lake Bomoseen was actually an augmentation because weevils were already present in the lake (although in low abundance).

[2]Data for Eckley Point are excluded. It was suspected that factors other than the introduced weevils influenced the condition of the EWM at that site.

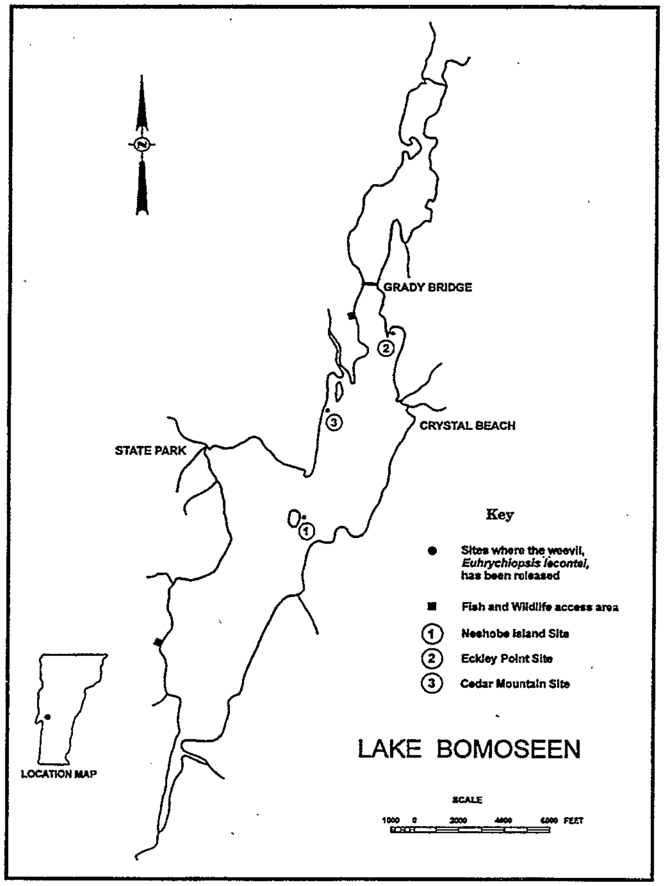

Figure 4. Lake Bomoseen introduction sites.

RESULTS

Monitoring was conducted through 1995 at the augmentation sites. Monitoring consisted of collecting stem samples for weevil counts during the summers and quantitative plant and invertebrate samples at the end of each summer. The stem samples were examined, and all weevil eggs, larvae, pupae, and adults were counted and removed. Three random plant samples were collected at the end of the summers from each of the six unharvested areas for examination of plant health and growth. Weevils were counted and, along with other invertebrates, removed. The plants were then dried and weighed. In addition to collection of samples, visual observations were made of the sites to assess the effects of the weevils. Throughout the sampling periods, apparent weevil damage was noted at all sites in Lake Bomoseen.

The results of the quantitative analysis of the collected samples suggest that the weevil is successfully established in the Lake Bomoseen sites. Since the initial release on June 30, 1993, over 20,000 weevils have been placed in Lake Bomoseen. Data collected in 1993 and 1994 show that the total number of weevils collected at the augmentation sites was greater than in the "no-weevil" sites and greatly increased from one year to the next (Table 1). These findings indicate that the weevil is surviving and thriving in the environment. Table 2 shows that the EWM biomass at the Cedar location was substantially less in the augmentation area as compared to the "no-weevil" control area (although a similar result was not observed at the Neshobe location). There was less EWM in both augmentation sites at the end of 1994 compared to 1993 (Table 3).

Table 1. A comparison of overall total number of weevils collected on stem transects in Lake Bomoseen at augmentation and control sites between 1993 and 1994.

	Augmentation sites		No-weevil control sites	
Location	1993	1994	1993	1994
Cedar	34	73	25	32
Neshobe	28	80	23	54

Source: Sheldon, 1995.

Table 2. Results of 1994 quantitative invertebrate and plant sampling in Lake Bomoseen (means ± 1 S.E.) after 2 years of augmentation.

	Augmentation sites		No-weevil control sites	
Location	dry wt (g)[a]	# weevils [b]	dry wt (g)	# weevils
Cedar	21.32 (1.96)	0.67 (0.44)	30.22 (2.88)	2.33 (0.44)
Neshobe	34.59 (7.94)	1.33 (0.44)	27.96 (6.46)	1.00 (1.33)

[a]Weights are total dry weight of *Myriophyllum spicatum*.
[b]Number of weevils per sample plant.
Source: Sheldon, 1995.

Table 3. Comparison of 1993 and 1994 EWM biomass at weevil augmentation sites in Lake Bomoseen.

Location	1993 dry weight (g)[a]	1994 dry weight (g)[a]
Cedar	27.38 (5.76)	21.32 (1.96)
Neshobe	62.50 (10.60)	34.59 (7.94)

[a]Values are mean (±1 S.E.) total dry weight.
Source: Sheldon, 1995.

CONCLUSIONS

Although the conclusions drawn from the Lake Bomoseen results are preliminary, the increased weevil populations and the decreased EWM biomass at the weevil introduction sites in Lake Bomoseen suggest that the weevil may be able to limit the nuisance plant over time. Laboratory and field experiments have documented the correlation between weevil populations and negative effects on EWM and have illustrated the weevil's apparent specificity in feeding on EWM as opposed to other native aquatic plants (Creed and Sheldon, 1993, 1994, 1995; Creed et al., 1992; Newman et al., 1996a; Sheldon, 1995; Sheldon and Creed, 1995). These preliminary results suggest that *Euhryhchiopsis lecontei* could potentially act as a biological control for the introduced macrophyte EWM and could provide a unique management opportunity for lakes with problems similar to those experienced by Lake Bomoseen.

OTHER EXAMPLES OF WEEVIL-ASSOCIATED EURASIAN WATERMILFOIL DECLINES

Fish Lake, Wisconsin

At least three lakes in Wisconsin have experienced EWM crashes that are believed to be associated with the aquatic weevil *Euhrychiopsis lecontei*—Devil's Lake in Sauk County, Lake Wingra in Dane County, and Fish Lake in Dane County (Lillie and Helsel, 1997). Of the three, Fish Lake is the best documented case of an EWM crash.

Fish Lake, a 100-hectare (247-acre) seepage lake located in the northwest corner of Dane County, was the subject of an extensive fish research-management study conducted by the Wisconsin Department of Natural Resources (WDNR). The study included monitoring of EWM beds from 1991 to 1995.

During the early years of the study, EWM covered approximately 40 hectares (100 acres) or nearly 40 percent of the total lake bottom (Lillie, 1996). In 1991, EWM represented 93 percent of the total plant biomass in the lake; that percentage decreased to 77 percent by 1994 (Lillie, 1996). EWM biomass in all vegetated sites of the lake decreased from 532 g/m^2 in 1991 to 268 g/m^2 in 1994 (Lillie, 1996). These substantial declines in biomass and its relative dominance indicated that the population in Fish Lake was in the process of crashing by 1994. These declines continued in 1995.

During the study, a large population of weevils was documented to exist in Fish Lake. Given the occurrence of the weevil in the lake and documented feeding habits of the weevil (Creed and Sheldon, 1993, 1994; Creed et al, 1992; Newman et al, 1996a), it is possible that the weevil is largely responsible for the continual decline of EWM populations in Fish Lake.

McCullom Lake, Illinois

McCullom Lake is a 99-hectare (244-acre) glacial lake in the City of McHenry in northeastern Illinois. A Phase I Diagnostic/Feasibility Study was conducted for McCullom Lake from 1989-1992 under a grant from U.S. EPA's Clean Lakes Program. This study identified many factors affecting the lake's ecology and recreation, including colonization of the lake by EWM.

In 1993, the City of McHenry received a Phase II Restoration/Implementation grant from the Clean Lakes Program, thereby enabling it to implement the restoration and protection strategies identified in the Phase I study. An important part of the Phase II project was to re-establish a balanced community of aquatic plants since EWM had spread to about 70 percent of the lake by the summer of 1994 and was choking out many of the native plant species.

Because of the lake's small watershed (249 hectares [616 acres]) and limited motorized watercraft access, the potential for EWM re-infestation was deemed comparatively small—but only if the existing EWM growth could be completely eliminated (or close to it). Consequently, a "one-time" herbicide application was planned to selectively remove the existing EWM plants. Future re-infestations would be controlled at an early stage through hand pulling and other non-herbicide control strategies.

However, just prior to the herbicide application in early spring 1995, almost no trace of EWM could be found. Soon after, the aquatic weevil *Euhrychiopsis lecontei* was identified on a few floating fragments of EWM. These fragments (and the isolated EWM beds that later emerged) exhibited extensive damage characteristic of weevil activity.

The EWM has remained suppressed well below nuisance levels through 1996 and 1997. The McCullom Lake Clean Lakes Program grant recently has been extended for an additional year to continue monitoring the EWM and weevil communities and to document their interactions. (Source: Robert Kirschner, personal communication)

Cenaiko Lake, Minnesota

Ongoing research supported by the Minnesota Department of Natural Resources (MNDNR) and conducted by researchers at the University of Minnesota is examining the possibilities of the weevil *Euryhchiopsis lecontei* as a biological control agent for EWM. Researchers have examined nine lakes (eight in Minnesota and one in Wisconsin) that had existing EWM and weevil populations.

Of the nine sites, the most pronounced weevil infestation was found in Cenaiko Lake in Anoka County, Minnesota. Weevils caused severe damage to the EWM plants in Cenaiko Lake, most likely resulting in the plants' decreased abundance. EWM biomass (wet weight) at Cenaiko Lake declined from 974 g/m^2 in July 1996 to 239 g/m^2 in September 1996 (Newman et al., 1996b). Researchers estimate that the biomass in June 1996 (before sampling) was close to 2,000 g/m^2 (Newman et al., 1996b). In July 1996, EWM was approximately 50 percent of the total plant biomass in the lake; by September 1996, this value had decreased to 14 percent.

Monitoring of Cenaiko Lake did not begin until June 1996 when a dense population of weevils was discovered during reconnaissance studies for introduction sites (Newman et al., 1996b). Cenaiko Lake was then added to the list of regular sampling sites. Plant samples collected at Cenaiko Lake, as well as at other sites, were processed for invertebrates, plant biomass, and stem damage.

Because monitoring is still ongoing, sampling and data are limited for this study. However, the preliminary results indicate the weevils in Cenaiko Lake may be responsible for the natural decline of EWM.

REFERENCES

Aiken, S. G., P.R. Newroth, and I. Wile. 1979. The biology of Canadian weeds. 34. *Myriophyllum spicatum* L. *Canadian Journal of Plant Science.* 59:201-215. Cited in Sheldon and Creed, 1995.

Creed, R.P., Jr., S.P. Sheldon, and D.M. Cheek. 1992. The effect of Herbivore Feeding on the Buoyancy of Eurasian Watermilfoil. *Journal of Aquatic Plant Management* 30:75-76.

Creed, R.P., Jr., and S.P. Sheldon. 1993. The effect of feeding by a North American weevil, *Euhrychiopsis lecontei*, on Eurasian watermilfoil (*Myriophyllum spicatum*). *Aquatic Botany* 45:245-256.

Creed, R.P., Jr., and S.P. Sheldon. 1994. The effect of two herbivorous insect larvae on Eurasian watermilfoil. *Journal of Aquatic Plant Management* 32:21-26.

Creed, R.P., Jr., and S.P. Sheldon. 1995. Weevils and watermilfoil: Did a North American herbivore cause the decline of an exotic weed? *Ecological Applications* 5(4): 1113-1121.

Grace, J.B., and R.G. Wetzel. 1978. The production biology of Eurasian watermilfoil: a review. *Journal of Aquatic Plant Management* 16:1-11. Cited in Creed and Sheldon, 1994.

Hanson, T., C. Eliopoulos, and A. Walker. 1995. *Field Collection, Laboratory Rearing and In-lake Introductions of the Herbivorous Aquatic Weevil,* Euhrychiopsis lecontei, *in Vermont*. Vermont Department of Environmental Conservation, Waterbury, VT.

Kirschner, R. 1997. Personal communication. Natural Resources Department, Northeastern Illinois Planning Commission, Chicago, IL. July 16, 1997.

Lillie, R.A. 1996. A quantitative survey of the floating-leafed and submersed macrophytes of Fish Lake, Dane County, Wisconsin. *Transactions of the Wisconsin Academy of Arts and Sciences* 84:111-125.

Lillie, R.A., and D. Helsel. 1997. A native weevil attacks Eurasian watermilfoil. *Wisconsin Department of Natural Resources Research Management Findings* 40(March): 1-4.

Nichols, S.A., and B.H. Shaw. 1986. Ecological life histories of the three aquatic nuisance plants, *Myriophyllum spicatum, Potamogeton crispus*, and *Elodea canadensis*. *Hydrobiologia* 131:3-21. Cited in Creed and Sheldon, 1994.

Newman, R.M., K.L. Holmberg, D.D. Biesboer, and B.G. Penner. 1996a. Effects of a potential biocontrol agent, *Euhrychiopsis lecontei*, on Eurasian watermilfoil in experimental tanks. *Aquatic Botany* 53:131-150.

Newman, R.M., D.W. Ragsdale, and D.D. Biesboer. 1996b. *Can Eurasian Watermilfoil Be Managed in Minnesota by Biological Control With Native or Naturalized Insects?* Third progress report to the Minnesota Department of Natural Resources, Ecological Services, St. Paul, MN.

Sheldon, S. 1995. *The Potential for Biological Control of Eurasian Watermilfoil (*Myriophyllum spicatum*) 1990-1995*. Final report. Department of Biology, Middlebury College, Middlebury, VT.

Sheldon, S.P., and R.P. Creed, Jr. 1995. Use of a native insect as a biological control for an introduced weed. *Ecological Applications* 5(4):1122-1132.

Smith, C.M., and J.W. Barko. 1990. Ecology of Eurasian watermilfoil. *Journal of Aquatic Plant Management* 28:55-64.

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