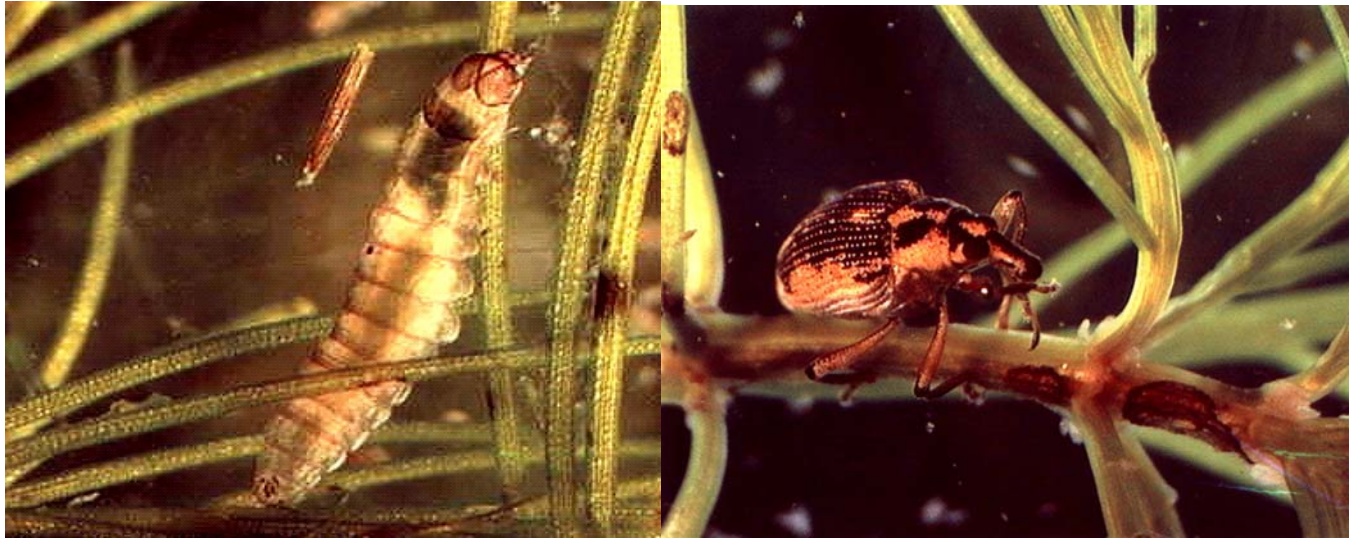


Cazenovia Lake's Eurasian watermilfoil Herbivores in 2006



Acentria ephemerella

Euhrychiopsis lecontei

Robert L. Johnson
Jason A. Toner
James A. Keith

Cornell University Research Ponds
Department of Ecology & Evolutionary Biology
Corson Hall, Cornell University
Ithaca, New York 14853

We submit this report, Cazenovia Lake's Eurasian watermilfoil Herbivores in 2006 authored by R. L. Johnson, Toner J. A., and Keith J. A. to the Cazenovia Lake Association, P.O. Box 55, Cazenovia, New York 13035, in fulfillment of a 2006 agreement to assess Eurasian watermilfoil herbivory in Cazenovia Lake.

Submitted by:

Robert L. Johnson
rlj5@cornell.edu

Department of Ecology & Evolutionary Biology
Corson Hall, Cornell University
Ithaca, New York 14853

December 10, 2006

This report summarizes a cooperative project between the Cazenovia Lake Association and the Cornell University Research Ponds in the Department of Ecology and Evolutionary Biology, Cornell University, Ithaca NY. The project focus is the identification of insect herbivores and an estimate of herbivore density feeding on the exotic aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*) in Cazenovia Lake.

Special thanks To Karen Katleski and Sharye Skinner for all their help in completion of this project, and for Captain Skinner and her boat.

Cover: Aquatic moth larvae *Acentria ephemerella* on the left and adult weevil *Euhrychiopsis lecontei* on the right

Contents

Title Page.....	2
Table of Contents.....	3
Figures and Tables.....	4
Executive Summary.....	5
Introduction.....	7
Methods.....	7
Results and Discussion.....	9
Cazenovia Lake Eurasian watermilfoil Herbivory.....	9
Relationship of Fish and watermilfoil herbivores.....	18
Importance of Rooted Aquatic Plants to Cazenovia Lake’s Ecosystem.....	24
Watershed and Land Use Recommendations.....	26
References.....	27

Figures and Tables

Figure 1. Cazenovia Lake map noting indigenous herbivore survey locations sampled in 2006. Coordinates for locations are UTM (NAD 27 datum and true north).....	8
Figure 2. Cazenovia Lake map noting indigenous herbivore population densities at survey locations sampled in 2006 (See Figure 1).....	11
Figures 3a – 8a. Mean moth numbers \pm 1 SE (includes only larvae + pupae life stages of the moth) and Mean weevil numbers \pm 1SE (includes all life stages, eggs, larvae, pupae and adults) recorded at locations per 25cm length apical stem (n = 25 apical stems searched unless noted).....	12
Figures 3b – 8b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at locations shown as a mean rating \pm 1SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.....	12
Figure 9. Relationship of <i>Acentria ephemerella</i> and <i>Euhrychiopsis lecontei</i> densities to sunfish abundance (measured as Catch per Unit Effort) in several lakes in New York.....	18
Figure 10. This illustration shows a shallow lake with two possible outcomes determined by the presence or absence of submersed plants. In the upper drawing, we see an aquatic plant – dominated clear state and at the bottom a phytoplankton - dominated turbid state. Drawings by J. M. Riggs, adapted from Scheffer, M. 2001 <i>TheScientificWorld</i> 1: 254-263.....	25
Table 1. Mean numbers of weevils (all life stages – eggs, larvae, pupae, and adults) and moths (Larvae and pupae) recorded on milfoil apical stems and a rating of mean damage to those apical stems at Cazenovia Lake locations in 2006. See Methods for details.....	10
Table 2. Chautauqua Lake estimate of fish community from data collected by electrofishing in 2003 accompanied by a graph of fish species collected per minute (CPUE).....	19
Table 3. Findley Lake estimate of fish community from data collected by electrofishing in 2003, accompanied by a graph of fish species collected per minute (CPUE).....	20
Table 4. Dryden Lake estimate of fish community from data collected by electrofishing in 2003, accompanied by a graph of fish species collected per minute (CPUE).....	21
Table 5. Otisco Lake estimate of fish community from data collected by electrofishing in 2004, accompanied by a graph of fish species collected per minute (CPUE).....	22
Table 6. Skaneateles Lake estimate of fish community from data collected by electrofishing in 2004, accompanied by a graph of fish species collected per minute (CPUE).....	23

Executive Summary

The Cornell University Research Ponds in the Department of Ecology and Evolutionary Biology performed aquatic plant and insect herbivore research in 2006 for the Cazenovia Lake Association in order to understand the relationship of insect herbivores on the exotic plant pest Eurasian watermilfoil (*Myriophyllum spicatum*) within the aquatic plant community of Cazenovia Lake. Research in 2006 monitored the density of naturally occurring insect herbivores feeding on Eurasian watermilfoil and evaluation of the effects on plant growth. Additionally, because of the concern on Cazenovia Lake of herbivore interactions with fish, we include in this report previously reported fish community data that we have re-analyzed from an earlier report for Chautauqua Lake (Lord *et al.* 2004). We include graphs using several additional data points of fish populations from our other studies to provide an updated analysis of possible effects of sunfish populations on insect herbivore populations. We included this information because of the concern that fish predation may influence herbivore densities and therefore lessen herbivore damage to Eurasian watermilfoil in Cazenovia Lake.

Findings:

- The two important Eurasian watermilfoil herbivores *Acentria ephemerella*, an aquatic moth and *Euhrychiopsis lecontei*, an aquatic weevil are present in Cazenovia Lake (Table 1).
- There is variability in insect herbivore populations between the locations around the lake (Table 1, Figure 1).
- We found weevils in five of the six sampling locations ranging in density for the six from 0 to 2.75 weevils per apical stem of watermilfoil (Table 1, Figures 2 – 8a).
- We found moths at a lower density that ranged from 0 to 0.16 moths per apical stem (Table 1, Figures 2 – 8a).
- Data concludes that there is potentially a large weevil population in the lake and a persistent moth presence (Table 1).
- We re-analyzed our electrofishing data reported in the 2003 Chautauqua Lake report to the Chautauqua Lake Association, Inc (Lord *et al.* 2004) to correct an error in the reported number of bluegill counted and measured at Findley Lake (Table 3). This reported (catch/hour) number of 25 (Lord *et al.* 2004), an error, should be listed as 331 bluegills bringing the total of sunfish in Findley Lake to 461 out of an all fish species total of 998 fish (catch/hour).
- Our evaluation of the data, in Tables 2 – 6, shows high sunfish populations in several lakes including Findley, while at the same time we also have high herbivore populations. This suggests that high sunfish abundance, although a factor is not an impediment for successful biological control of watermilfoil and we need to look further at this very complex interaction.
- Populations of the weevil at locations A, B, E, and F on 6/20/06 were relatively high and similar to many lakes in NY indicating potential to control watermilfoil growth at those locations (Johnson and Blossey).

- Weevil populations at 2.36 and 2.75 per apical tip are high enough to control growth but down from the 3 to 4 per tip that we believe is necessary to decrease watermilfoil long-term. Findley Lake, NY, the only lake in NY to have a long-term decline had 3 - 4 weevils per apical stem. Other researchers believe levels of 2 -3 per apical tip will cause declines (Ward and Newman 2006).
- Moth populations at a high of 0.16 at location B is down from the 0.6 moths per apical stem shown to cause long term declines in Cayuga Lake, NY, greenhouse and lake enclosure experiments (Johnson and Blossey 2002).

Recommendations:

- Encourage plant control measures that promote a healthy carpet of low-growing native submersed plant species in order to continue a rooted plant dominated clear-water state in Cazenovia Lake.
- Encourage growth of robust low growing plant species to out-compete, not only watermilfoil, but also any increase in filamentous or planktonic algae.
- Utilize management practices that encourage an increase in herbivory on Eurasian watermilfoil by limiting plant control measures in lake areas of low demand or areas to be set aside as non-managed. This will allow insects to establish large populations that can control watermilfoil growth and promote a more diverse plant community in those areas (example: location E at State Land).
- Harvest the high value or high demand areas first and leave the low use areas to the herbivores.
- Limit or eliminate early harvesting at low use areas, because watermilfoil grows back faster after the first cutting in June than it will if the first cutting is in July.
- Continue measures as described in your brochure “Life on the lake” <http://www.cazlake.org> to further limit nutrient movement, primarily nitrogen and phosphorus into the lake from point and non-point sources. In addition, improve measures to prevent soil movement into the lake from the watershed.
- Consider at some time in the future a project to monitor aquatic plant species and abundance at known GPS locations. This will provide a historical record and baseline of aquatic plant community composition and relative abundance to help in tracking changes over time and location.
- Consider the addition of herbivores to selected locations protected from harvesting on Cazenovia Lake as part of a small pilot project to demonstrate the potential for biological control of watermilfoil growth.

Introduction

The Cornell University Research Ponds (in the department of Ecology and Evolutionary Biology, Cornell University) conducted research on Cazenovia Lake in 2006. The research was monitoring of the species and densities of invertebrate insect herbivores on the plant pest, Eurasian watermilfoil throughout the lake. Two major watermilfoil herbivores, the aquatic moth *Acentria ephemerella* and the weevil *Euhrychiopsis lecontei* are present in almost if not all lakes in New York State (Johnson and Blossey 2002). The insect's population density varies, as does their control of the growth of watermilfoil by feeding on the plant pest. A main concern at Cazenovia Lake is the presence of sunfish or other pan fish and if that has a negative impact on herbivore populations thereby limiting biological control of watermilfoil growth. Another research group from the Department of Environmental and Forest Biology at SUNY College of Environmental Science and Forestry, Syracuse is monitoring fish populations in Cazenovia Lake. With information on fish species and populations along with our insect populations, the potential for herbivore control of watermilfoil on Cazenovia Lake can be estimated.

Methods

Eurasian watermilfoil herbivore and watermilfoil damage surveys

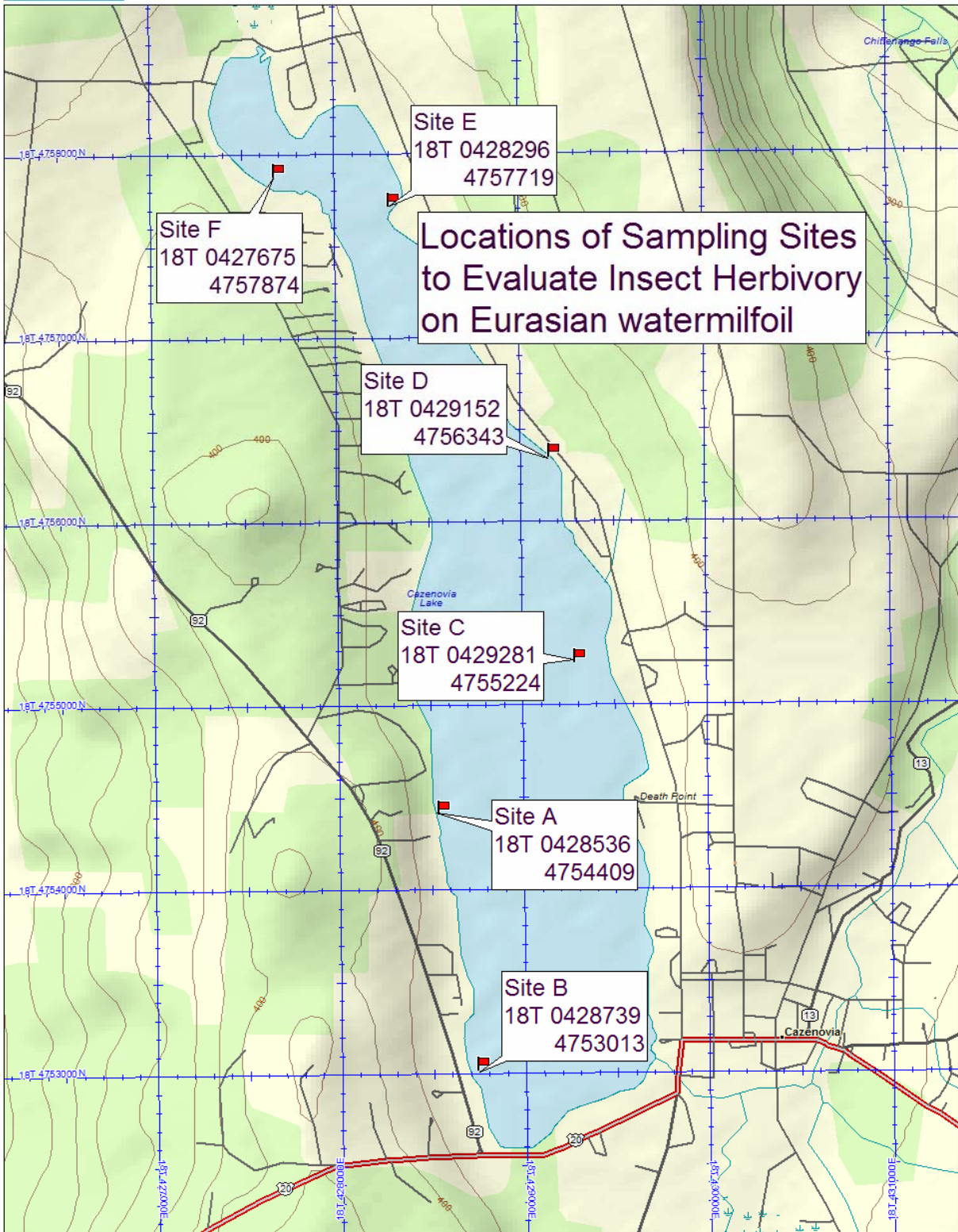
In 2006, we measured indigenous watermilfoil herbivore numbers and herbivore damage to watermilfoil as we evaluated the effectiveness of the moth and the weevil to limit the growth of this weed pest in Cazenovia Lake.

In 2006, we sampled six locations in Cazenovia Lake (Figure 1. below). We sampled through the plant-growing season to estimate herbivore density on, and damage to watermilfoil caused by naturally occurring populations of insect herbivores in Cazenovia Lake.

At each sampling location, we randomly collected a series of aquatic plant samples using a grapple hook formed by connecting the "heads" of two garden rakes back-to-back. In the boat, we blindly selected 25 watermilfoil stems from our rake-toss samples (no more than five from each rake toss) by choosing them from their basal ends. We then pinch off the top 25 cm of each stem, (the apical stem) for our sample. We place each apical stem into an individually labeled plastic zipper bag and store all samples in a cooler chest for transport to our laboratory.

In the laboratory, we refrigerate all samples until we examine each apical stem. Apical stems and herbivores are stored in the refrigerator for up to two weeks, and we freeze any samples for later analysis if we cannot examine within two weeks. At the time of examination, we place each apical stem under a stereoscopic dissecting microscope. We dissect each stem and evaluate the entire sample, recording numbers and types of herbivores found, evidence of herbivore use (e.g., retreats, cocoons, or pupae chambers), and plant tissue damage (leaflet damage, stem mining, missing or grazed apical meristems).

For each apical stem sampled, we identify, count and record all life stages (eggs, larvae, pupae and adults) of each herbivore species found. We qualify and quantify all watermilfoil tissue damage using a standard scoring system. Finally, we calculate the numbers of moths and weevils per apical stem, including individuals in all life stages. Using this standard protocol, we are able to determine which herbivore is responsible for a particular type of damage and to assess the amount of plant damage caused by each herbivore.



© 2003 DeLorme
www.delorme.com

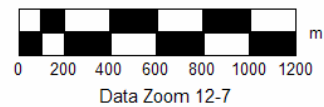
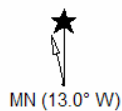


Figure 1. Cazenovia Lake map noting indigenous herbivore survey locations sampled in 2006. Coordinates for locations are UTM (NAD27 datum and true north).

Results and Discussion

Cazenovia Lake Eurasian watermilfoil Herbivory

We continued, throughout the watermilfoil-growing season in 2006, to assess the indigenous herbivore densities on Eurasian watermilfoil and plant damage by herbivory at six locations in Cazenovia Lake. The aquatic weevil *Euhrychiopsis* occurred at moderate to high densities.

The desired result of insect herbivory on watermilfoil is increased insect populations and the structural damage caused to the watermilfoil plant. We list these results in Table 1, and depict them with graphs in Figures 3b – 8b. Damage in several locations was moderate, especially where we recorded large numbers of herbivores. A damage rating of 3 or more reflects a plant that has no viable growing parts and has decayed. That was not achieved in Cazenovia in 2006. A rating of less than 1 means the plant is in excellent condition. The location in Cazenovia with the most noticeable damage to watermilfoil and where native plant species out competed watermilfoil was E. Location E was the one area where the weevil population stayed up at a high population density between 6/20/06 and 7/27/06. Two other areas started out with high populations, B with 2.36 weevils per apical stem and F with 1.28 weevils per apical stem but dropped precipitously by the next sampling. We believe those specific areas more than likely at sometime during the five weeks between samplings experienced some cutting event. We base this belief on the loss of herbivore numbers and healthy regrowth of milfoil at those locations. We often record similar results in other lakes conducting mechanical harvesting.

We were somewhat surprised by the high populations of weevils present and the persistent presence of moths in Cazenovia Lake after hearing of possible high populations of bluegills and knowing of the long-term mechanical harvesting of the watermilfoil. Our research shows many lakes with high abundance of watermilfoil also have a high population of weevils. Although weevils cause a lot of damage to watermilfoil and control its growth, this decrease in growth is often not seen by lakeshore residents as an adequate control. Therefore, lake managers attempt additional methods of control to keep areas of high use “weed” free. In these situations, it is advantageous to try to use the insect herbivores to control watermilfoil in low value or low use areas. This is done by conserving insect numbers or populations in protected areas to build up their numbers to effective levels that damage watermilfoil.

We also note the presence of northern watermilfoil, *Myriophyllum sibiricum* and water marigold, *Megalondonta beckii* both native uncommon plants in New York waters. Their presence suggests that Cazenovia Lake has areas with diversity and rare native plants and is not a monoculture of Eurasian watermilfoil.

The presence of moderate to high numbers of weevils and the presence of moths throughout the lake would suggest some increased control by these two insect herbivores is possible. The first obvious action would be to protect areas in the lake that do not need to be mechanically harvested or areas where harvesting will be limited. These areas will naturally build up in indigenous populations of herbivores that will feed on Eurasian watermilfoil.

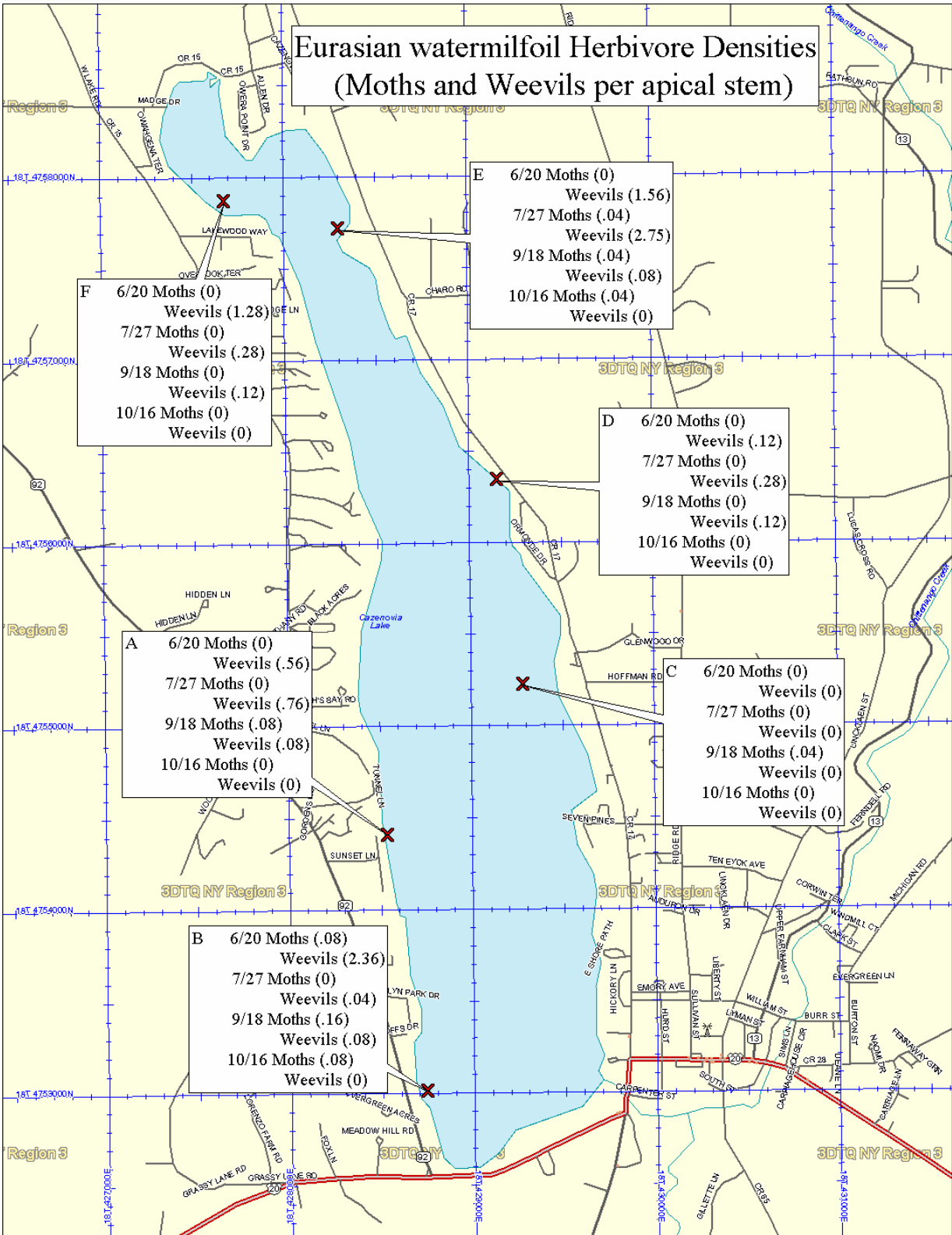
Watermilfoil control by the weevil at population densities similar to those recorded here at Cazenovia is seen in many lakes in New York State. Watermilfoil control by the weevil is an annual decline of watermilfoil biomass that generally returns to the same biomass the following year. Weevil control is very similar to mechanical harvesting. The weevil allows the plant to grow toward the surface by entering the lake at the end of May and by mid-June lays eggs on the growing tips of watermilfoil. Then the hatched larvae mine the stem causing the top part of the plant to stop growing and break off preventing the growing tip from reaching the surface to flower. The weevil attempts to knock the plant

down and during the month of July and August the plant shows little new growth if weevil populations are in the range of 2 - 4 weevils per apical stem (Johnson and Blossey 2002).

The moth controls plant growth earlier in the season by preventing the watermilfoil from elongating toward the surface to form a dense canopy thereby allowing native plant species to compete with watermilfoil. Moth populations need to overwinter in the lake and start feeding in early May (Johnson and Blossey 2002).

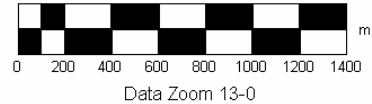
Table 1. Mean numbers of weevils (all life stages – eggs, larvae, pupae, and adults) and moths (larvae and pupae) recorded on milfoil apical stems and a rating of mean damage to those apical stems at Cazenovia Lake locations in 2006. See Methods for details.

Location	Collection Date	Number of apical stems	Weevils per apical stem	Std Error weevils	Moths per apical stem	Std Error moths	Damage Rating	Std Error Rating
A	6/20/2006	25	0.56	0.27	0.00	0.00	1.36	0.22
A	7/27/2006	25	0.76	0.28	0.00	0.00	1.88	0.16
A	9/18/2006	25	0.08	0.06	0.08	0.06	2.44	0.12
A	10/16/2006	25	0.00	0.00	0.00	0.00	2.64	0.10
B	6/20/2006	25	2.36	0.57	0.08	0.06	1.92	0.20
B	7/27/2006	25	0.04	0.04	0.00	0.00	1.04	0.18
B	9/18/2006	25	0.08	0.06	0.16	0.09	2.32	0.11
B	10/16/2006	25	0.00	0.00	0.08	0.06	2.56	0.12
C	6/20/2006	25	0.00	0.00	0.00	0.00	0.48	0.15
C	7/27/2006	25	0.00	0.00	0.00	0.00	1.36	0.17
C	9/18/2006	25	0.00	0.00	0.04	0.04	2.56	0.10
C	10/16/2006	25	0.00	0.00	0.00	0.00	2.24	0.09
D	6/20/2006	25	0.12	0.07	0.00	0.00	1.36	0.19
D	7/27/2006	25	0.28	0.14	0.00	0.00	1.36	0.15
D	9/18/2006	25	0.12	0.12	0.00	0.00	2.24	0.09
D	10/16/2006	25	0.00	0.00	0.00	0.00	2.20	0.18
E	6/20/2006	25	1.56	0.34	0.00	0.00	2.16	0.16
E	7/27/2006	24	2.75	0.55	0.04	0.04	2.63	0.17
E	9/18/2006	25	0.08	0.06	0.04	0.04	2.52	0.10
E	10/16/2006	25	0.00	0.00	0.04	0.04	2.44	0.14
F	6/20/2006	25	1.28	0.37	0.00	0.00	1.92	0.17
F	7/27/2006	25	0.28	0.12	0.00	0.00	1.84	0.19
F	9/18/2006	25	0.12	0.07	0.00	0.00	2.28	0.09
F	10/16/2006	25	0.00	0.00	0.00	0.00	2.20	0.10



© 2003 DeLorme
www.delorme.com

MN (13.0° W)



Data Zoom 13-0

Figure 2. Cazenovia Lake map noting indigenous herbivore population densities at survey locations sampled in 2006 (See Figure 1).

Cazenovia Lake

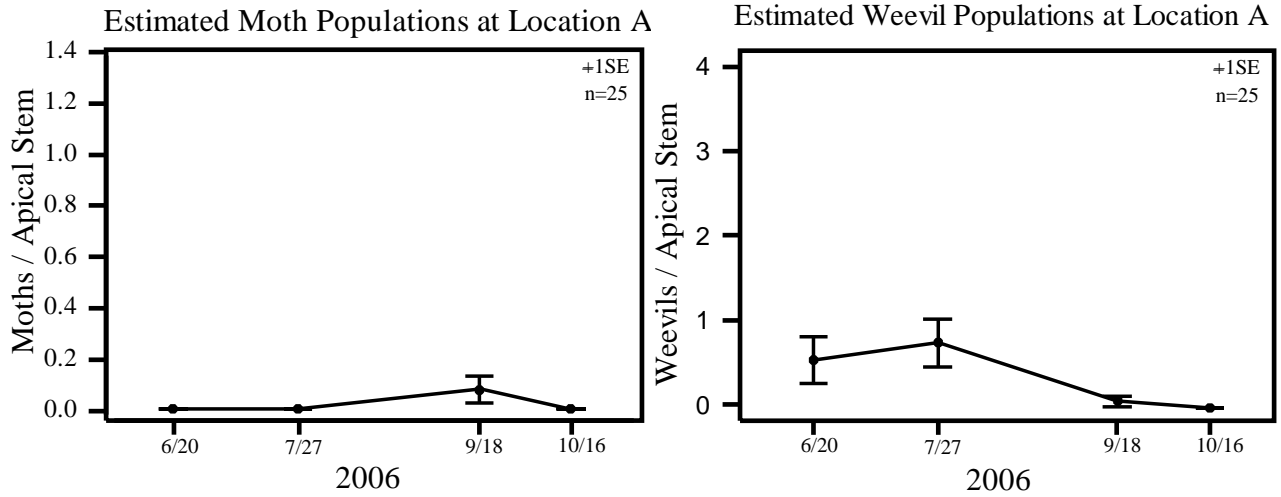


Figure 3a. Mean moth numbers \pm 1 SE (includes only larvae + pupae life stages of the moth) recorded at location A per 25cm length apical stem (n=25 apical stems searched unless noted). Mean Weevil numbers \pm 1 SE (includes all life stages, eggs, larvae and adults) recorded at location A per 25cm length apical stem (n=25 apical stems searched unless noted).

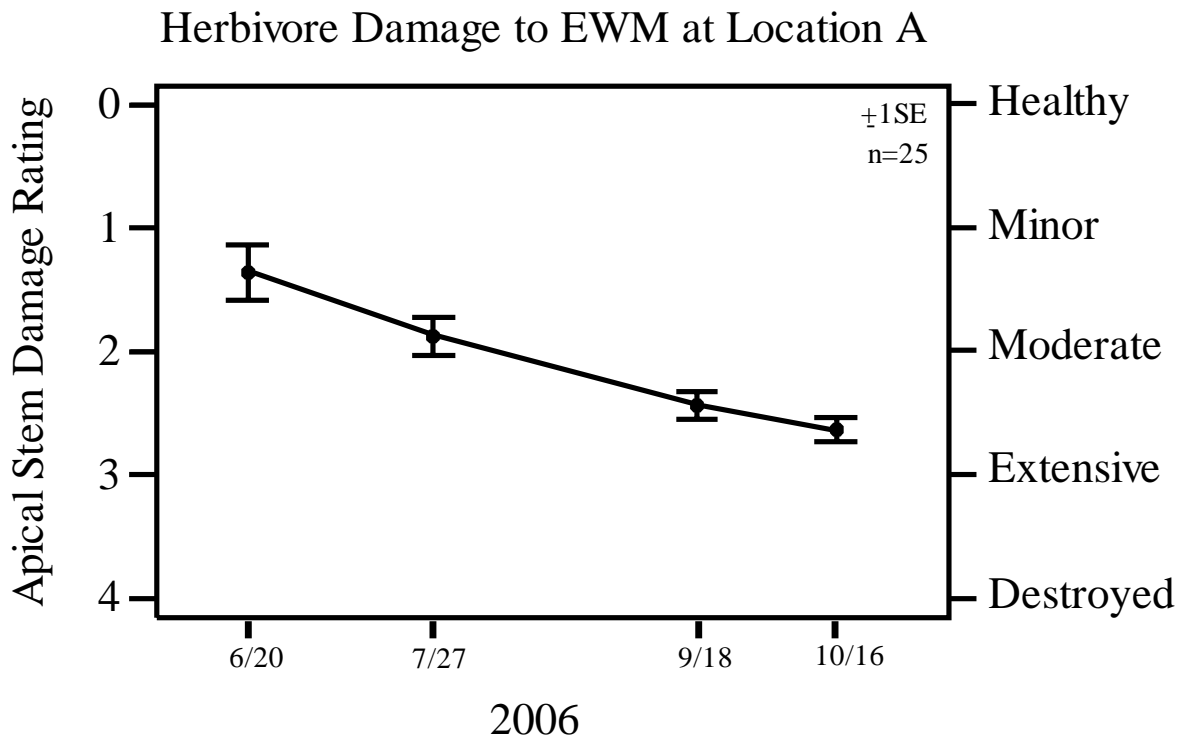


Figure 3b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at location A shown as a mean rating \pm 1 SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.

Cazenovia Lake

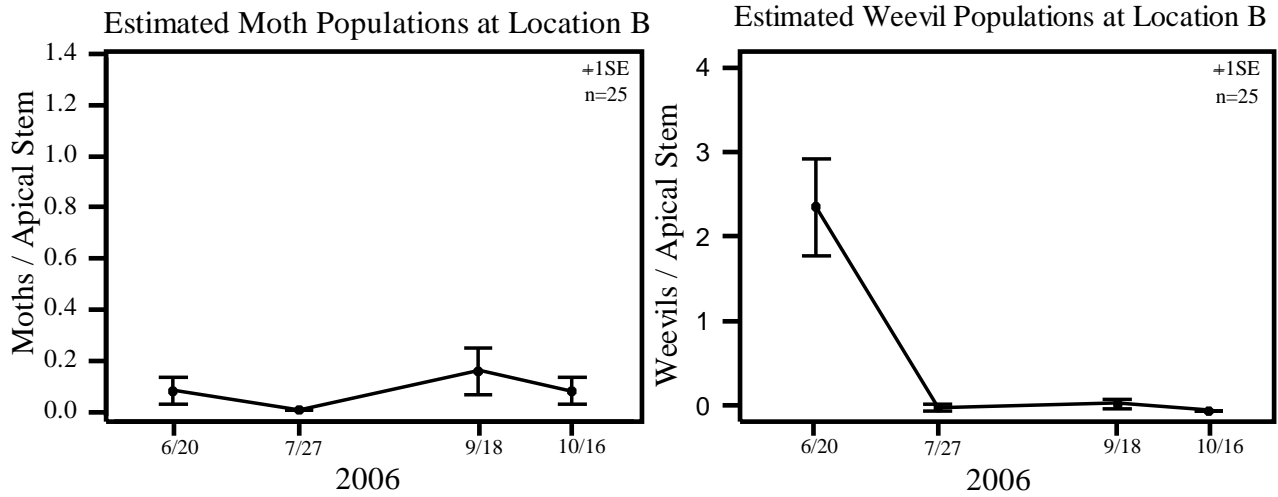


Figure 4a. Mean moth numbers \pm 1 SE (includes only larvae + pupae life stages of the moth) recorded at location B per 25cm length apical stem (n=25 apical stems searched unless noted). Mean Weevil numbers \pm 1 SE (includes all life stages, eggs, larvae and adults) recorded at location B per 25cm length apical stem (n=25 apical stems searched unless noted).

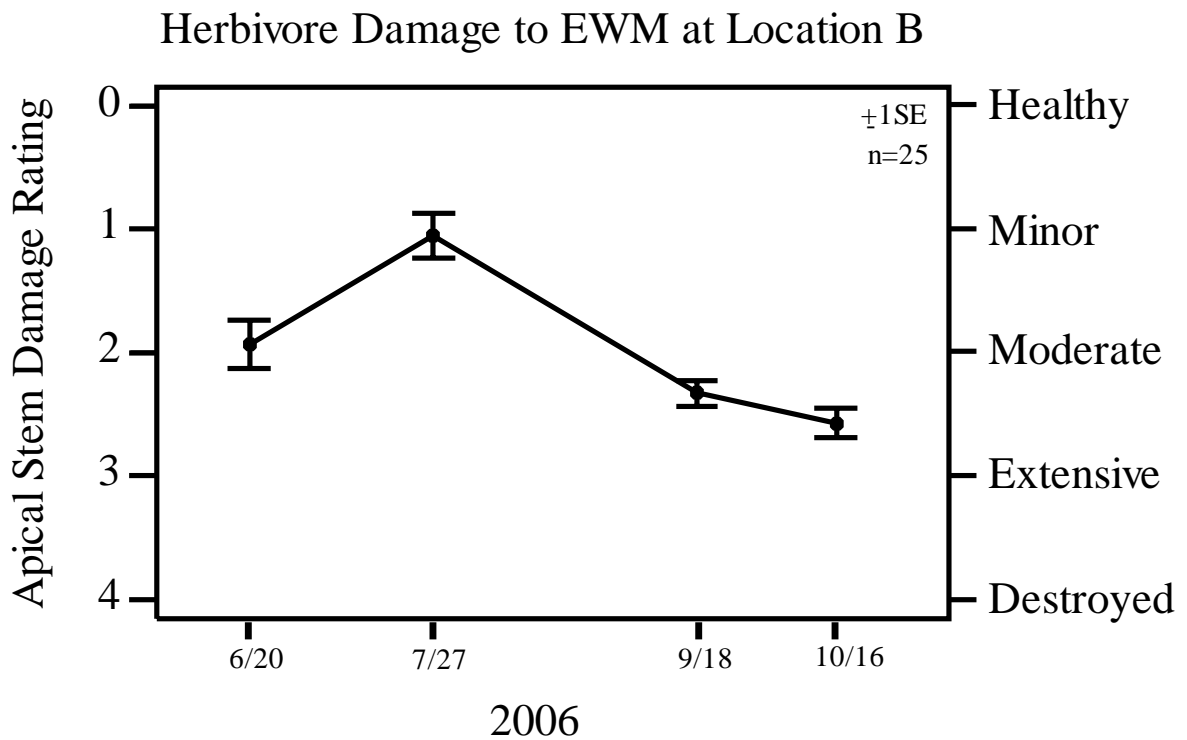


Figure 4b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at location B shown as a mean rating \pm 1 SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.

Cazenovia Lake

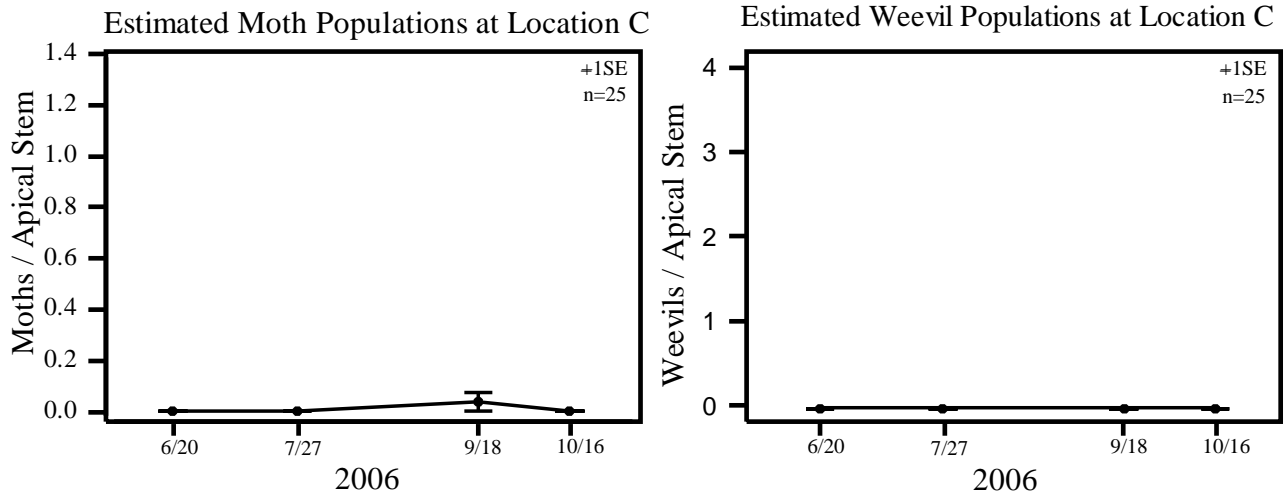


Figure 5a. Mean moth numbers \pm 1 SE (includes only larvae + pupae life stages of the moth) recorded at location C per 25cm length apical stem (n=25 apical stems searched unless noted). Mean Weevil numbers \pm 1 SE (includes all life stages, eggs, larvae and adults) recorded at location C per 25cm length apical stem (n=25 apical stems searched unless noted).

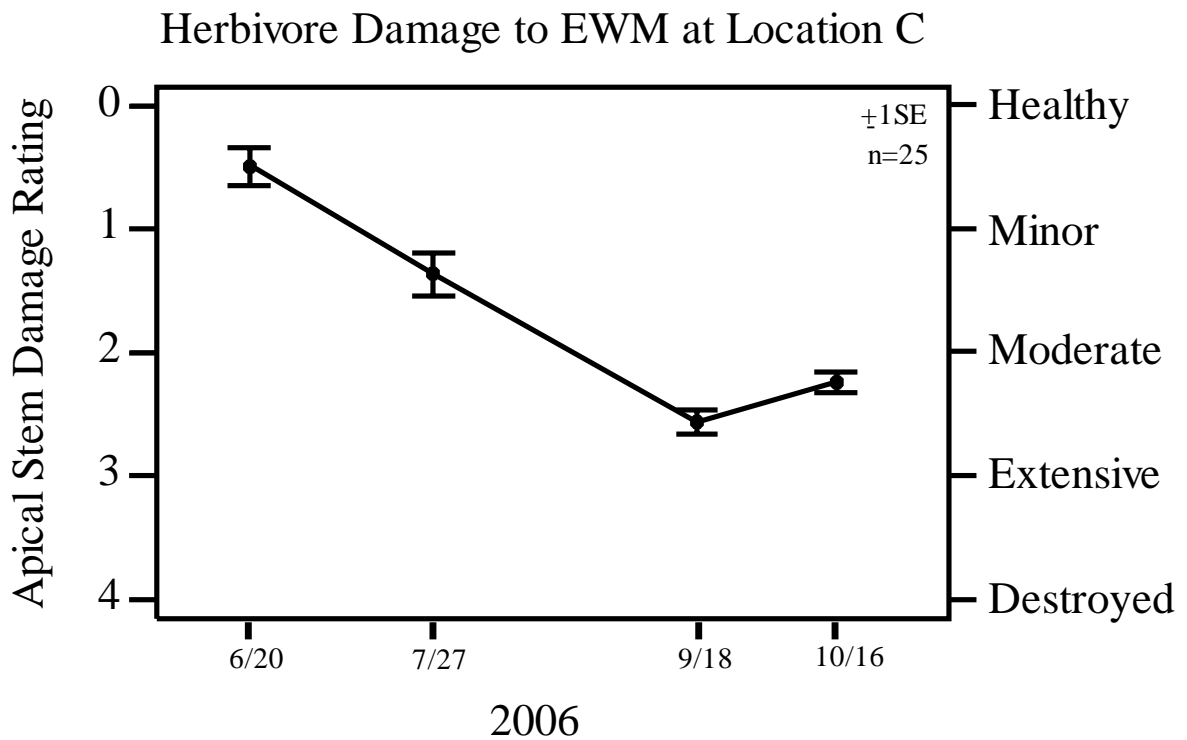


Figure 5b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at location C shown as a mean rating \pm 1 SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.

Cazenovia Lake

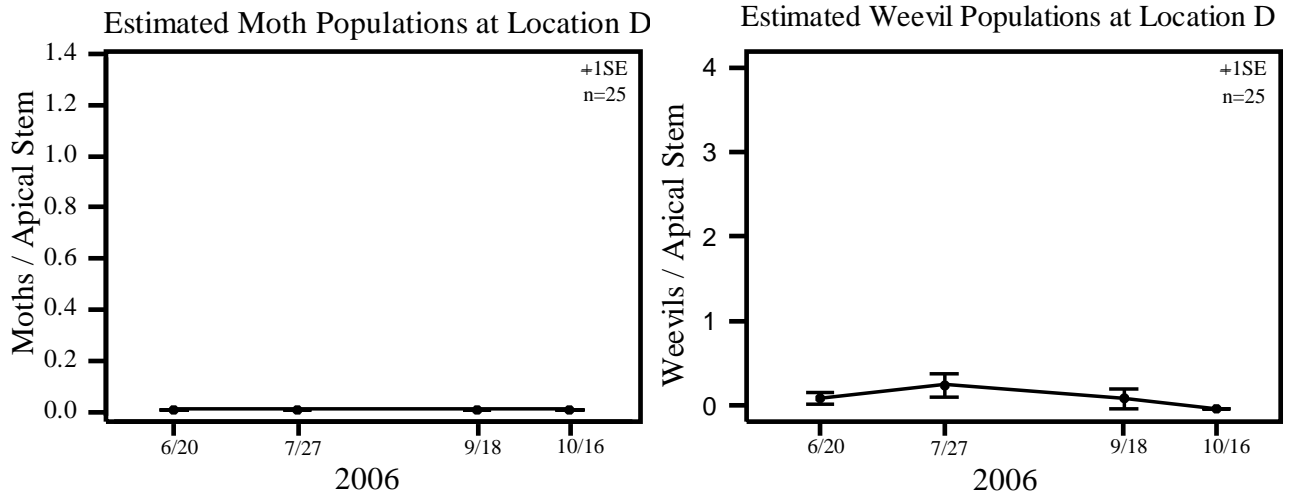


Figure 6a. Mean moth numbers \pm 1 SE (includes only larvae + pupae life stages of the moth) recorded at location D per 25cm length apical stem (n=25 apical stems searched unless noted). Mean Weevil numbers \pm 1 SE (includes all life stages, eggs, larvae and adults) recorded at location D per 25cm length apical stem (n=25 apical stems searched unless noted).

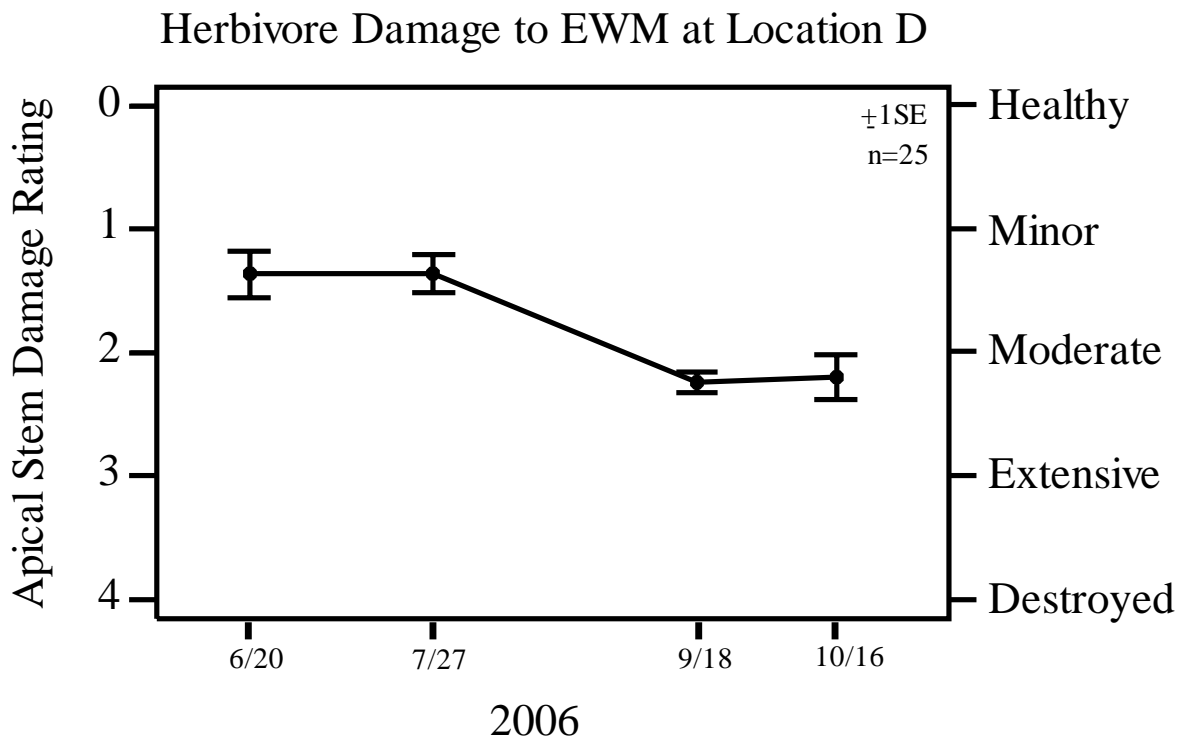


Figure 6b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at location D shown as a mean rating \pm 1 SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.

Cazenovia Lake

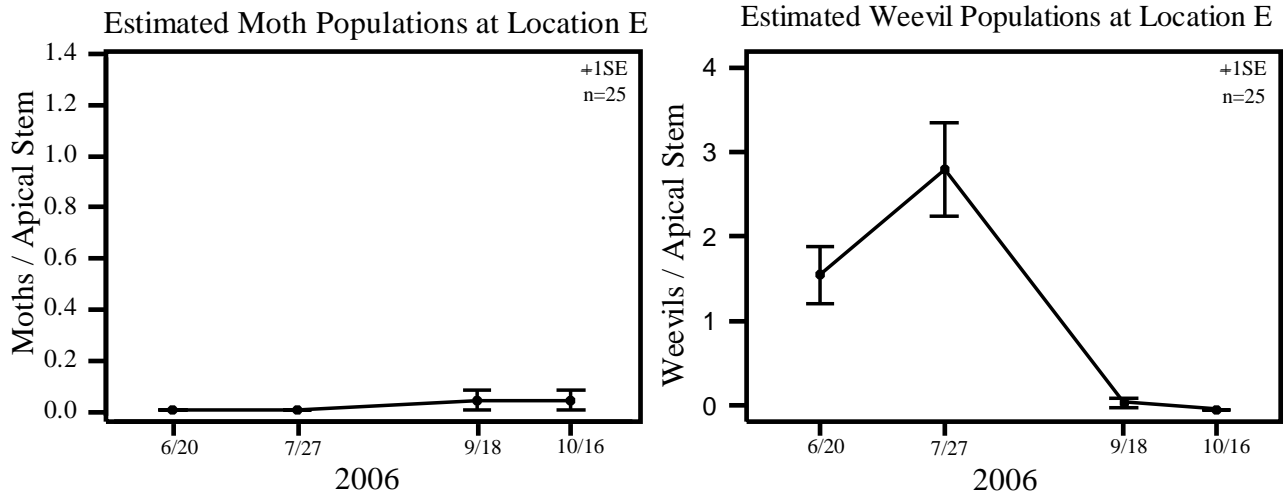


Figure 7a. Mean moth numbers ± 1 SE (includes only larvae + pupae life stages of the moth) recorded at location E per 25cm length apical stem (n=25 apical stems searched unless noted). Mean Weevil numbers ± 1 SE (includes all life stages, eggs, larvae and adults) recorded at location E per 25cm length apical stem (n=25 apical stems searched unless noted).

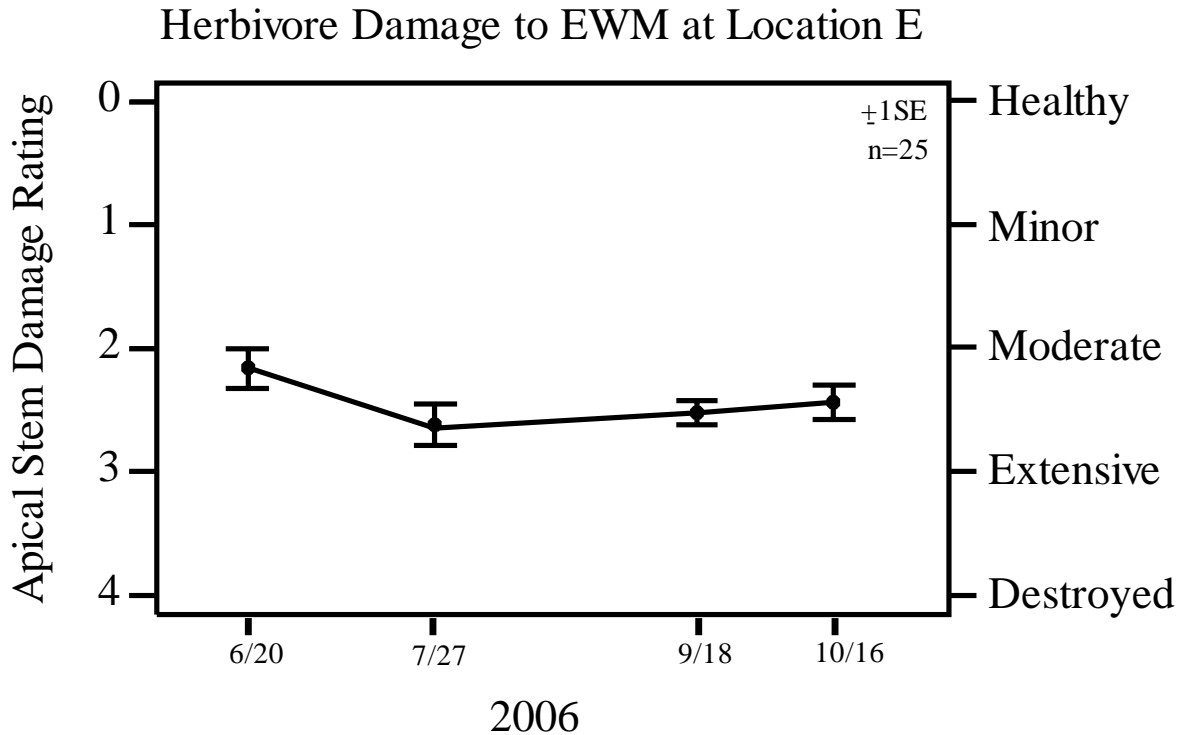


Figure 7b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at location E shown as a mean rating ± 1 SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.

Cazenovia Lake

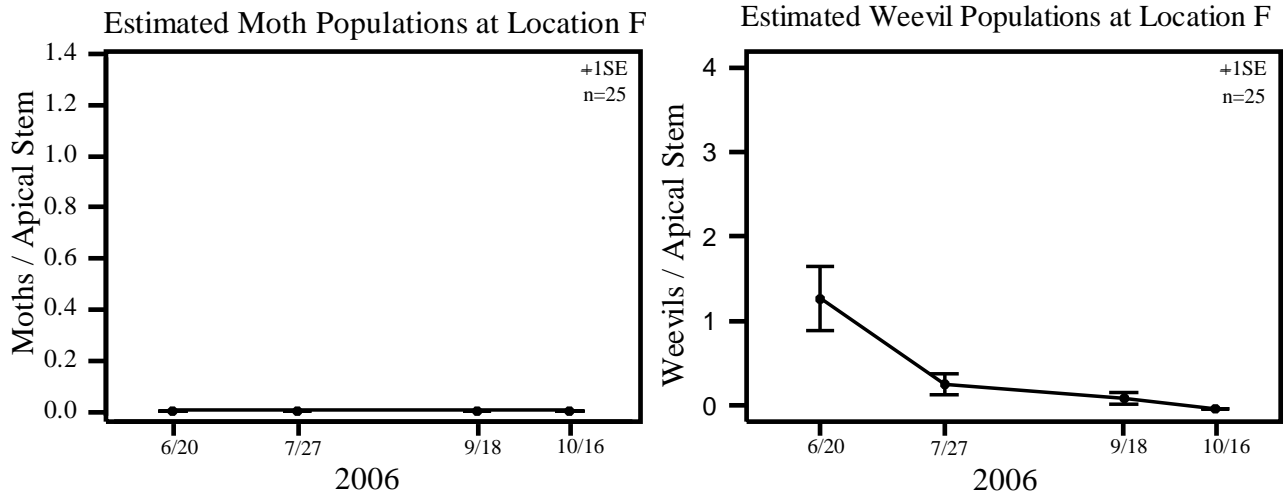


Figure 8a. Mean moth numbers ± 1 SE (includes only larvae + pupae life stages of the moth) recorded at location F per 25cm length apical stem (n=25 apical stems searched unless noted). Mean Weevil numbers ± 1 SE (includes all life stages, eggs, larvae and adults) recorded at location F per 25cm length apical stem (n=25 apical stems searched unless noted).

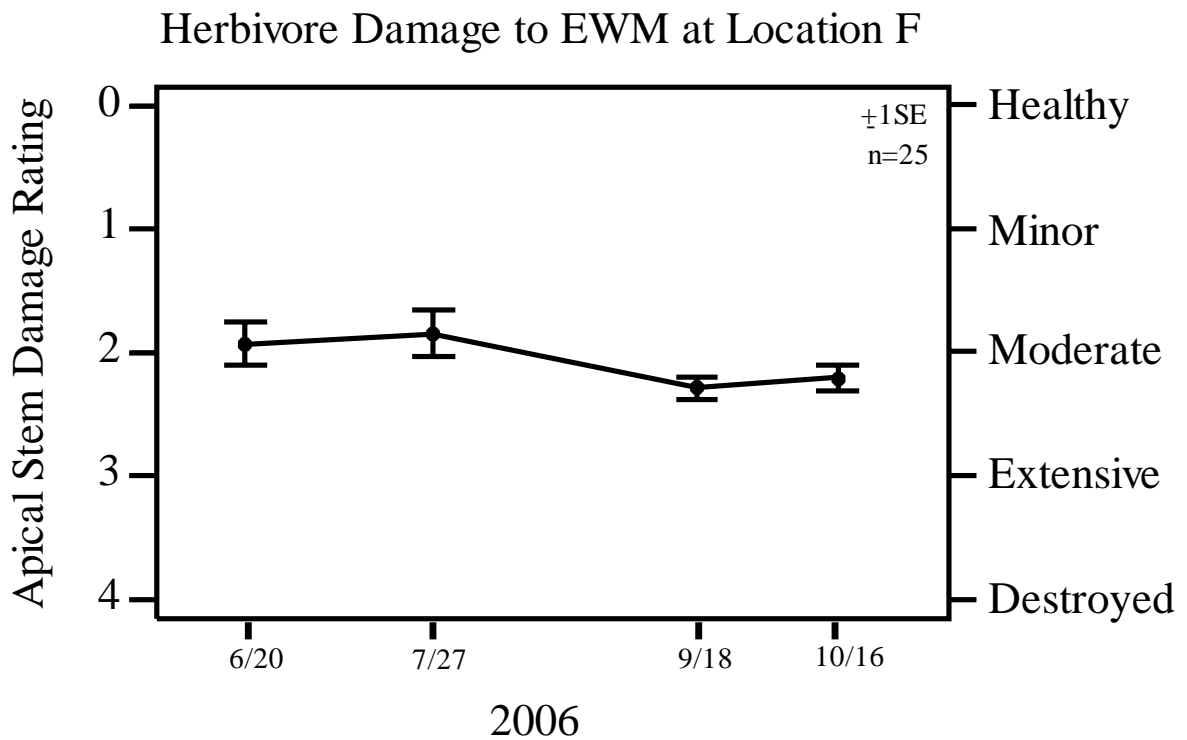


Figure 8b. Herbivore damage to 25cm length apical stems of Eurasian watermilfoil at location F shown as a mean rating ± 1 SE of herbivore damage to 25 apical stems. Herbivore damage ranges from 0 = no damage to 4 = apical tip destroyed.

Relationship of Fish and watermilfoil herbivores

Several studies have suggested that sunfish predation on watermilfoil herbivores may interfere with control of watermilfoil by insect herbivory (Ward and Newman 2006, Lord 2004, Newman 2004, Newman *et al.* 2001, Ward 2002, Newman and Biesboer 2000, Sutter and Newman 1997, Newbrough 1993). While these studies together strongly suggest high sunfish populations limit herbivore populations, the resulting connection to watermilfoil growth control may not be strong. With the notice of our mistake in reporting of electrofishing data for Findley Lake (in the 2003 Chautauqua Lake Report, Lord *et al.* 2004) where the number of bluegills increases from 25 to the correct count of 331 we re-analyzed our data. The following tables and graphs (Tables 2 – 6) display data from five lakes. All the lakes (except for Skaneateles, which has few watermilfoil plants and therefore few herbivores) show a sizeable sunfish population, and all have sizeable herbivore populations. Using our electrofishing and herbivore density results from several lakes in NY, we show fish abundance having little influence to depress populations of moths or weevils over a wide range of fish densities (Fig. 9). This suggests that high sunfish abundance, although a factor is not an impediment for successful biological control of watermilfoil and that we need to explore and understand this complex interaction.

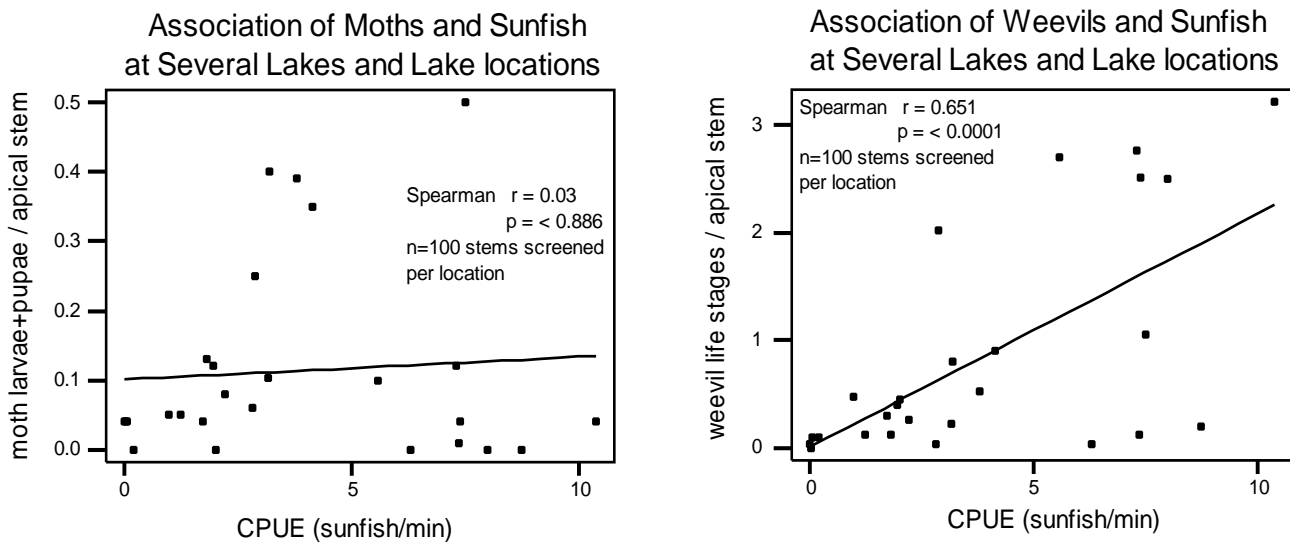


Figure 9. Relationship of *Acentria ephemerella* and *Euhrychiopsis lecontei* densities to sunfish abundance (measured as Catch per Unit Effort) in several lakes in New York.

Table 2. Chautauqua Lake estimate of fish community from data collected by electrofishing in 2003 accompanied by a graph of fish species collected per minute (CPUE).

Chautauqua Lake 2003			TOTAL Time (min) = 45	
Scientific Name	Common Name	No. Fish	% Composition	CPUE (fish/min)
<i>Fundulus diaphanus</i>	Banded killifish	1	0.1	0.022
<i>Pomoxis nigromaculatus</i>	Black crappie	1	0.1	0.022
<i>Lepomis spp.</i>	Bluegill/Sunfish	200	20.8	4.444
<i>Ictalurus nebulosus</i>	Brown bullhead	10	1.0	0.222
<i>Cyprinus carpio</i>	Common carp	3	0.3	0.067
<i>Notropis atherinoides</i>	Emerald shiner	1	0.1	0.022
<i>Notemigonus crysoleucas</i>	Golden shiner	24	2.5	0.533
<i>Micropterus salmoides</i>	Largemouth bass	32	3.3	0.711
<i>Percina caprodes</i>	Logperch	6	0.6	0.133
<i>Ambloplites rupestris</i>	Rock bass	46	4.8	1.022
<i>Labidesthes hudsonius</i>	Brook silversides	4	0.4	0.089
<i>Micropterus dolomieu</i>	Smallmouth bass	16	1.7	0.356
	Unknown minnows	35	3.6	0.778
<i>Morone americana</i>	White perch	365	38.0	8.111
<i>Catostomus commersoni</i>	White sucker	12	1.3	0.267
<i>Perca flavescens</i>	Yellow perch	203	21.1	4.511
	ST?	1	0.1	0.022
	TOTAL	960		21.333

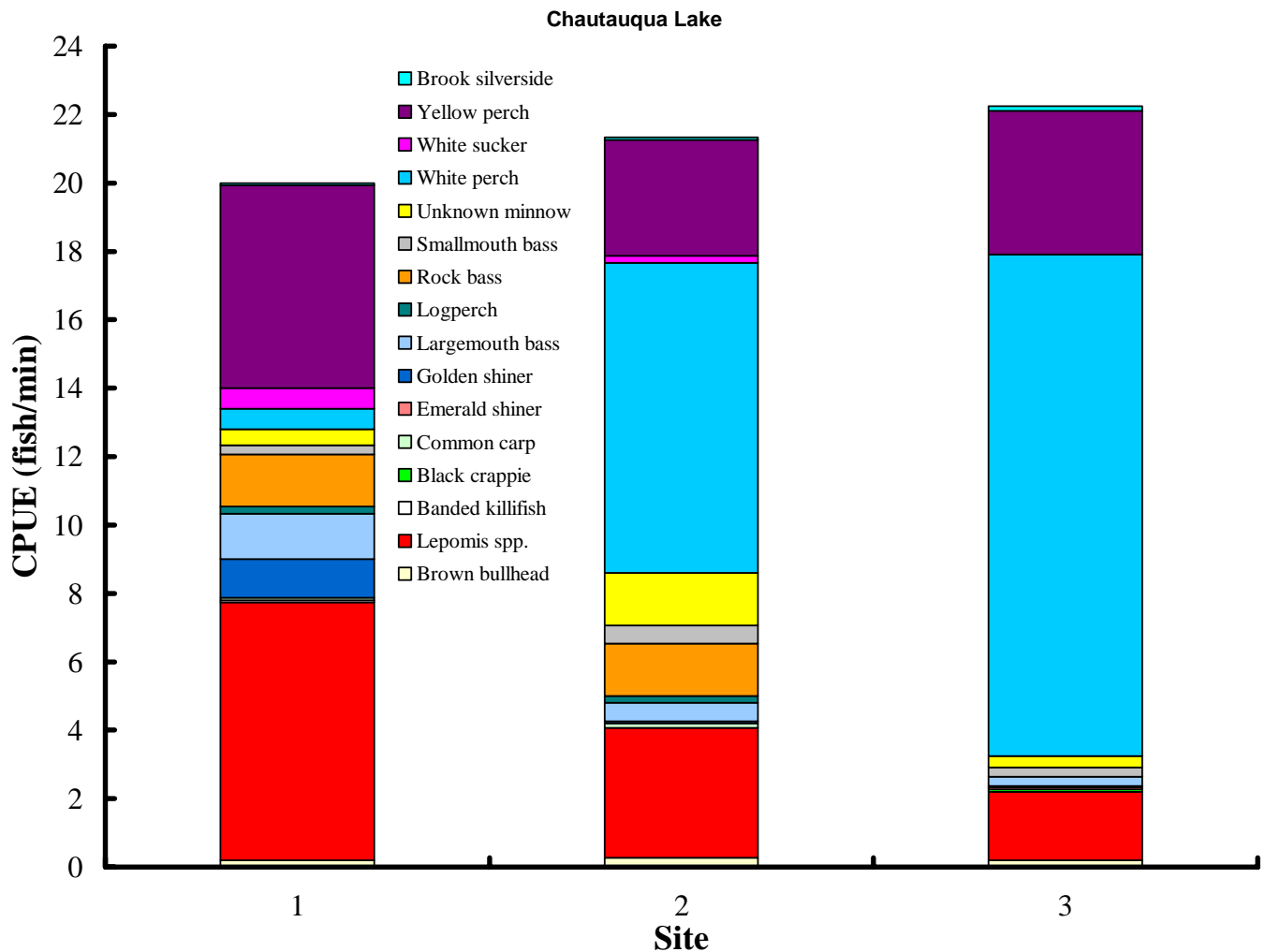


Table 3. Findley Lake estimate of fish community from data collected by electrofishing in 2003, accompanied by a graph of fish species collected per minute (CPUE).

Findley Lake 2003		TOTAL Time (min) = 60		
Scientific Name	Common Name	No. Fish	% Composition	CPUE (fish/min)
<i>Pomoxis nigromaculatus</i>	Black crappie	208	16.0	3.467
<i>Lepomis spp.</i>	Bluegill/Sunfish	461	35.4	7.683
<i>Ictalurus nebulosus</i>	Brown bullhead	27	2.1	0.450
<i>Notropis hudsonius</i>	Spottail shiner	6	0.5	0.100
<i>Pimephales notatus</i>	Bluntnose minnow	19	1.5	0.317
<i>Micropterus salmoides</i>	Largemouth bass	85	6.5	1.417
<i>Percina caprodes</i>	Logperch	25	1.9	0.417
<i>Ambloplites rupestris</i>	Rock bass	15	1.2	0.250
<i>Micropterus dolomieu</i>	Smallmouth bass	55	4.2	0.917
<i>Labidesthes sicculus</i>	Brook silverside	4	0.3	0.067
<i>Stizostedion vitreum</i>	Walleye	21	1.6	0.350
<i>Morone americana</i>	White perch	5	0.4	0.083
<i>Perca flavescens</i>	Yellow perch	373	28.6	6.217
	TOTAL	1304		21.733

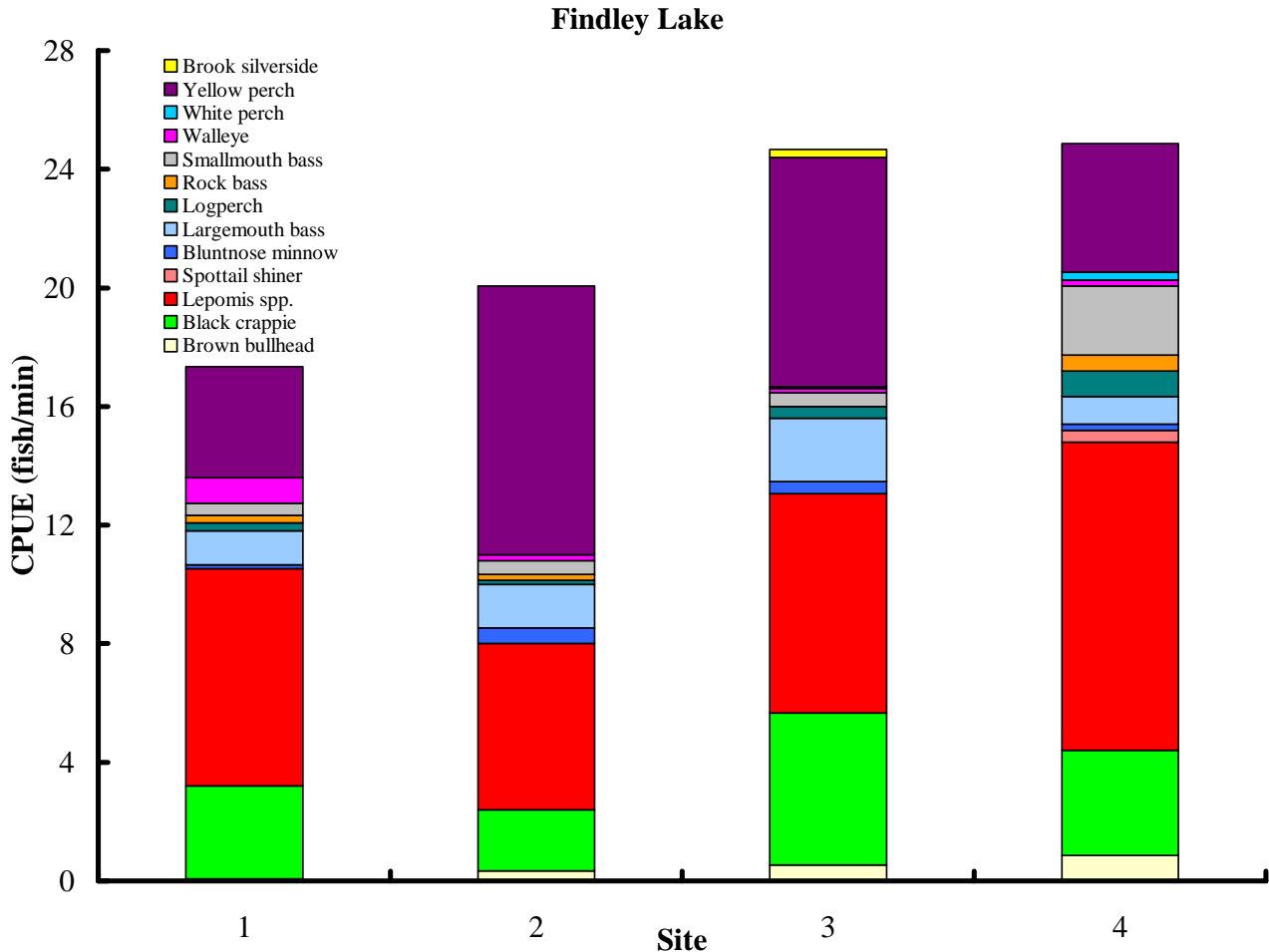


Table 4. Dryden Lake estimate of fish community from data collected by electrofishing in 2003, accompanied by a graph of fish species collected per minute (CPUE).

Dryden Lake 2003			TOTAL Time (min) =	45	
Scientific Name	Common Name	No. Fish	% Composition	CPUE (fish/min)	
<i>Pomoxis nigromaculatus</i>	Black crappie	1	0.2	0.022	
<i>Lepomis spp.</i>	Lepomis spp.	361	58.6	8.022	
<i>Ictalurus nebulosus</i>	Brown bullhead	6	1.0	0.133	
<i>Cyprinus carpio</i>	Common carp	7	1.1	0.156	
<i>Notemigonus crysoleucas</i>	Golden shiner	91	14.8	2.022	
<i>Micropterus salmoides</i>	Largemouth bass	124	20.1	2.756	
<i>Catostomus commersoni</i>	White sucker	6	1.0	0.133	
<i>Perca flavescens</i>	Yellow perch	20	3.2	0.444	
	TOTAL	616		13.689	

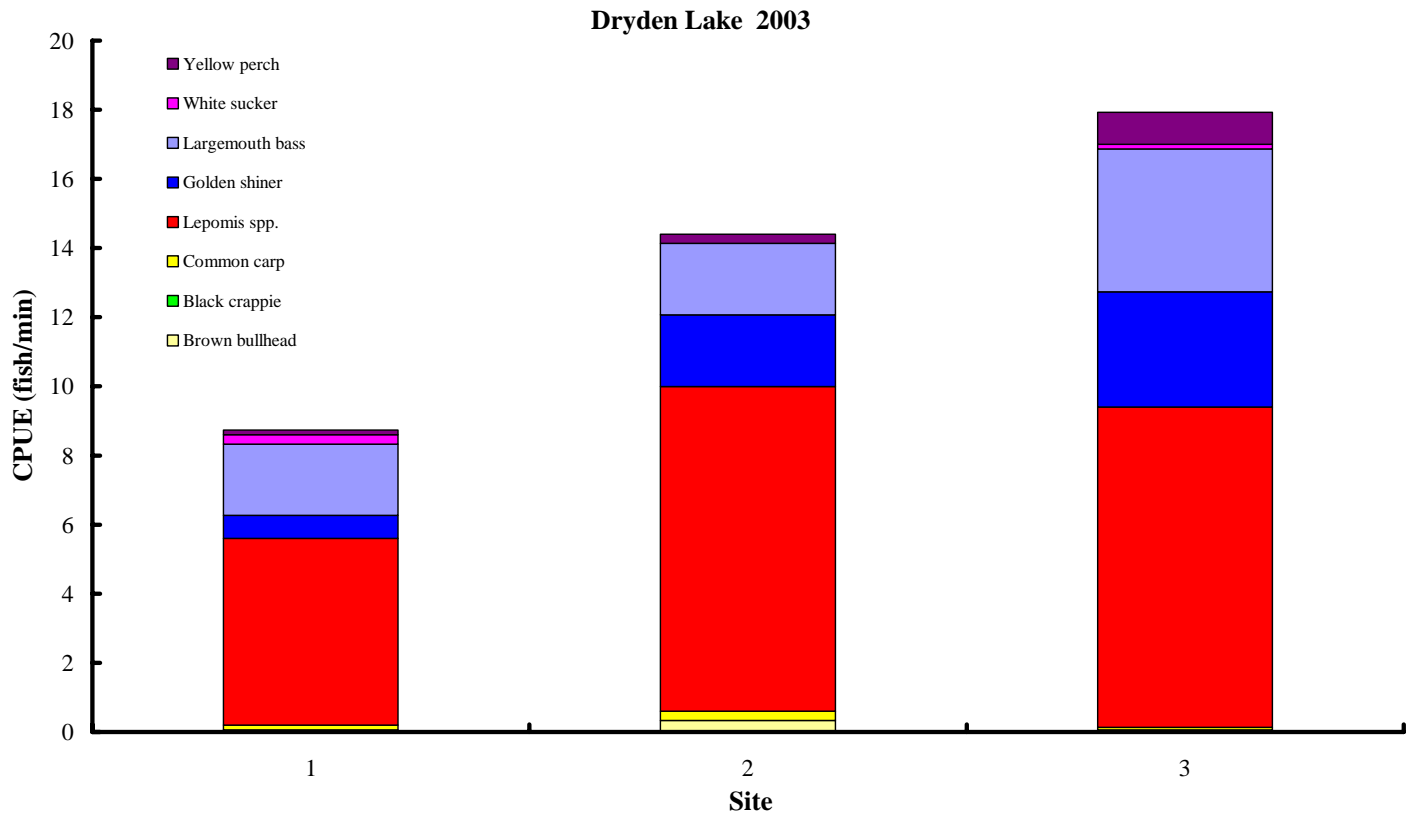


Table 5. Otisco Lake estimate of fish community from data collected by electrofishing in 2004, accompanied by a graph of fish species collected per minute (CPUE).

Otisco 2004		67.067 minutes total		
Scientific Name	Common Name	No. Fish	% Composition	CPUE (fish/min)
<i>Fundulus diaphanus</i>	Banded killifish	1	0.3	0.015
<i>Lepomis spp.</i>	Bluegill/Sunfish	204	52.8	3.042
<i>Ictalurus nebulosus</i>	Brown bullhead	3	0.8	0.045
<i>Cyprinus carpio</i>	Common carp	11	2.8	0.164
<i>Notemigonus crysoleucas</i>	Golden shiner	16	4.1	0.239
<i>Micropterus salmoides</i>	Largemouth bass	53	13.7	0.790
<i>Ambloplites rupestris</i>	Rock bass	18	4.7	0.268
<i>Micropterus dolomieu</i>	Smallmouth bass	6	1.6	0.089
<i>Notropis hudsonius</i>	Spottail shiner	9	2.3	0.134
<i>Etheostoma olmstedii</i>	Tessellated darter	1	0.3	0.015
<i>Esox masquinongy x lucius</i>	Tiger muskellunge	1	0.3	0.015
<i>Morone americana</i>	White perch	27	7.0	0.403
<i>Perca flavescens</i>	Yellow perch	36	9.3	0.537
	TOTAL	386		5.755

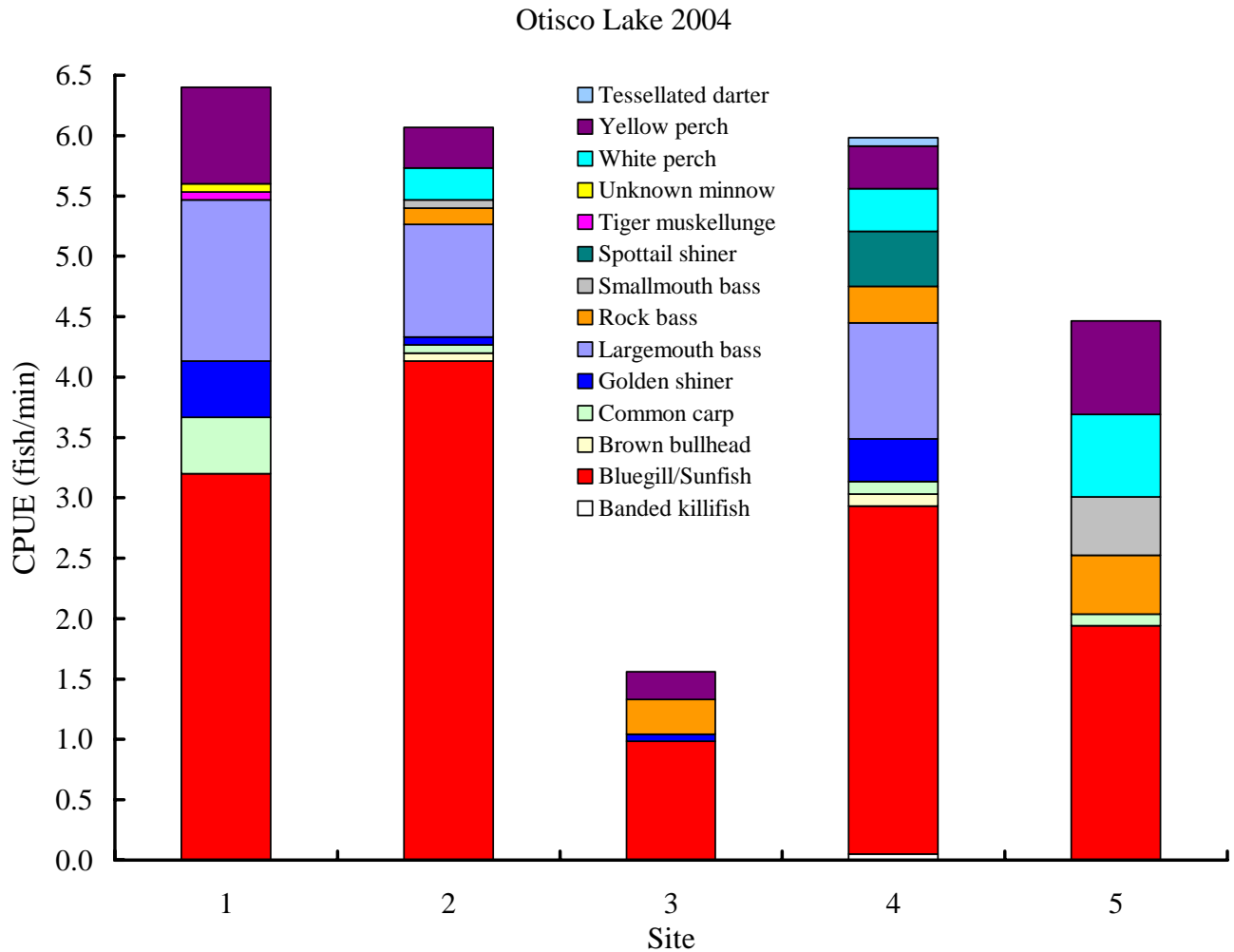
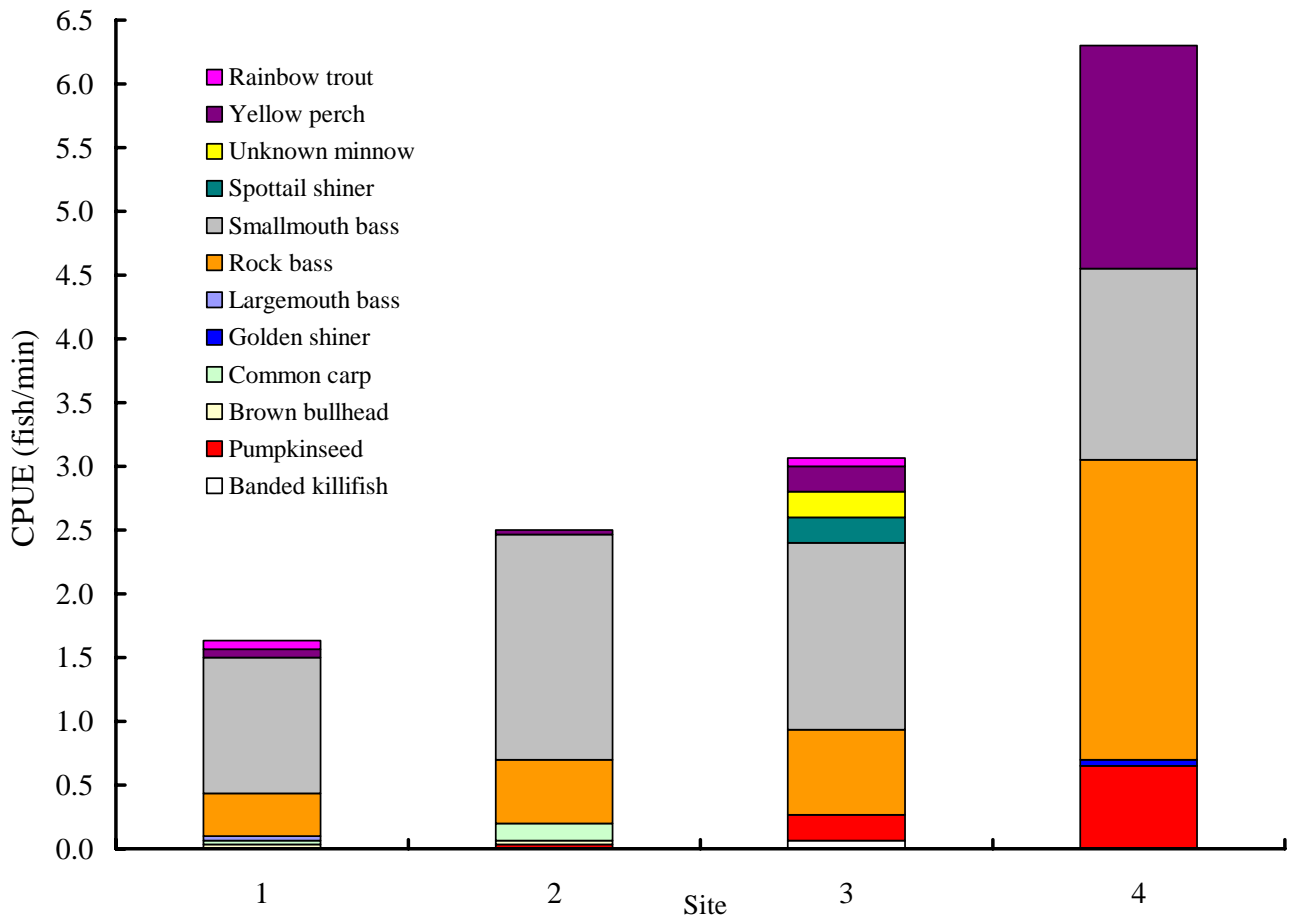


Table 6. Skaneateles Lake estimate of fish community from data collected by electrofishing in 2004, accompanied by a graph of fish species collected per minute (CPUE).

Skaneateles Lake 2004			Total time (min) =	95
Scientific Name	Common Name	No. Fish	% Composition	CPUE (fish/min)
<i>Fundulus diaphanus</i>	Banded killifish	1	0.3	0.011
<i>Lepomis gibbosus</i>	Pumpkinseed	17	5.8	0.179
<i>Ictalurus nebulosus</i>	Brown bullhead	2	0.7	0.021
<i>Cyprinus carpio</i>	Common carp	5	1.7	0.053
<i>Notemigonus crysoleucas</i>	Golden shiner	1	0.3	0.011
<i>Micropterus salmoides</i>	Largemouth bass	1	0.3	0.011
<i>Ambloplites rupestris</i>	Rock bass	82	28.0	0.863
<i>Micropterus dolomieu</i>	Smallmouth bass	137	46.8	1.442
<i>Notropis hudsonius</i>	Spottail shiner	3	1.0	0.032
<i>Salmo gairdneri</i>	Rainbow trout	3	1.0	0.032
<i>Perca flavescens</i>	Yellow perch	41	14.0	0.432
	TOTAL	293		3.084

Skaneateles Lake 2004



Importance of Rooted Aquatic Plants to Cazenovia Lake's Ecosystem

Rooted submersed plants are essential to the health of Chautauqua Lake's ecosystem. They provide more than the obvious benefits such as food and cover for invertebrates, small fish, birds, nutrient cycling, etc. The dense plant beds stabilize the local ecosystem by protecting the sediments on the lake bottom from re-suspension by wave action, and therefore limiting nutrient release to the water column to aid algae growth. They provide a refuge for zooplankton from fish predation allowing increased zooplankton populations to decrease high phytoplankton density and in turn reduce algal bloom turbidity. Vascular plants, Cazenovia Lake's "weeds" remove nutrients from the water column that are required to increase phytoplankton and filamentous algae growth. These processes buffer the impacts of increased nutrient loading and the resulting turbidity seen in non-vegetated lakes (Downing 2005, van de Bund *et al.* 2004, Stephen *et al.* 2004, Takamura *et al.* 2003, Scheffer *et al.* 2000, Basu *et al.* 2000, Stephen *et al.* 1998).

In shallow lakes like Cazenovia, any management activity within the watershed that increases nutrient loading to the lake's water column from the landscape, bottom sediments, and rooted vascular plants should be limited. Changes in land use practices can lower nutrient levels within the lake that will help reduce phytoplankton populations and in turn, decrease turbidity. Aquatic plant control practices that preserve coverage of the lake bottom by rooted submersed plants should be encouraged (Genkai-Kato and Carpenter 2005, van Nes *et al.* 2002, Engelhardt and Ritchie 2002).

In lakes without a healthy rooted plant community the use of biomanipulation, in this case (top down control of the food web), to reduce planktonic algae and the turbidity they cause is popular. This method manipulates the fishery to increasing predation on small fish that eat zooplankton. This can allow an expansion of the large bodied species of the zooplankton population, which would more effectively consume phytoplankton. However, the method appears to work best in small lakes and ponds that are primarily closed systems. (Albright *et al.* 2004, Morris, *et al.* 2003, Bachmann *et al.* 2002, Scheffer *et al.* 1992, Scheffer *et al.* 2001, Harman, *et al.* 2002, Scheffer *et al.* 1993, Irvine *et al.* 1989).

We have included an example of possible outcomes that depends on the presence or absence of rooted submersed aquatic plants and should be considered in any aquatic plant control program.

Aquatic plant-dominated clear state vs. phytoplankton-dominated turbid state

The following illustration (Figure 10) depicts the alternative stable states theory that predicts shallow lakes with high nutrient concentrations have a high probability of switching from a state dominated by rooted aquatic plants to one dominated by phytoplankton and/or filamentous algae (Didham *et al.* 2005, Scheffer 2001, Scheffer and Carpenter 2003, Scheffer *et al.* 2001, Carpenter *et al.* 1999, Ludwig *et al.* 1997, Scheffer *et al.* 1997, Scheffer *et al.* 1993).

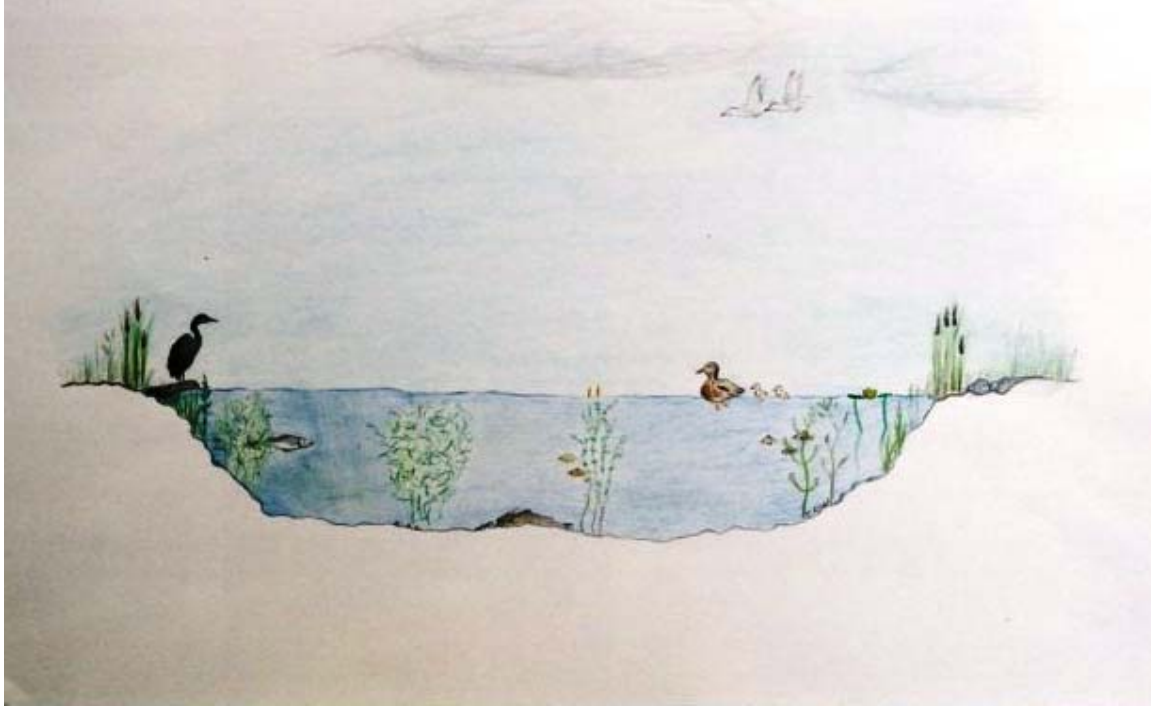


Figure 10. This illustration shows a shallow lake with two possible outcomes determined by the presence or absence of submersed plants. In the upper drawing, we see an aquatic plant - dominated clear state and at the bottom a phytoplankton - dominated turbid state.

Drawings by J. M. Riggs, adapted from Scheffer, M. 2001 *TheScientificWorld* 1: 254-263.

Watershed and Land Use Recommendations

The Cazenovia Lake Association <http://www.cazlake.org>, Cazenovia, and landowners can do much to ameliorate the situation regarding eroding of soils into the lake and the excessive growth of aquatic plants in Cazenovia Lake. They can encourage and insist on the use of silt fencing, either fabric and/or straw/hay bales around construction sites within 1000' of the lake or within 500' from lake tributaries. The unintended products of roadside ditching efforts, undertaken by the municipalities and individuals without erosion control measures (e.g., cobble over landscape cloth linings or hydroseeding), can be corrected by properly constructing ditches. The purchase and installation of sediment traps should be a goal wherever culverts dump road runoff into the Lake. Many lake associations purchase these sediment traps for their municipalities, which, typically, install and maintain the traps. Local soil and water conservation districts will work with farmers to conserve agricultural soils.

Local residents need to report actions by individuals that cause soil to erode toward the lake. Local NYS DEC environmental conservation officers (ECOs) are obliged to issue a summons to anyone found to be causing soil to wash into NYS lakes or streams (NYSDEC, 2005) without proper permits. These measures will help to limit the downhill flow of sediments into Cazenovia Lake.

Lakeside landowners can also lessen the impacts of their presence on the lake. Buffer strips of deep-rooted terrestrial and emergent vegetation should separate lawns from shorelines to stop the downhill flow of fertilizers, animal waste, and atmospheric deposition. An excellent new reference "[Landscaping for Water Quality](#)" (pdf, 3.5 MB) is now available. This booklet provides ideas for property owners who want to create landscapes that protect and enhance nearby waterbodies and is found on the Onondaga County Cornell Cooperative Extension's web site http://counties.cce.cornell.edu/onondaga/002_environment/001_water_quality/000063.php with other valuable water quality information. Another is [Landscaping for Wildlife and Water Quality](#) (Henderson *et al.*, undated) and is available for purchase from the State of Minnesota, with information about purchase at http://mnlakes.org/main_dev/news/pdf/lakescaping.pdf. Written for Minnesota, Wisconsin and Michigan, Henderson *et al.*'s concepts and techniques are appropriate for New York State, you should however use its plant lists with care.

A good, free complement to Henderson *et al.* is Slattery *et al.* [Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed](#). It is an 82-page booklet filled with pictures and notes about plant species and where you can plant them. (A web address, <http://www.nps.gov/plants/pubs/chesapeake/>, provides the USFWS booklet as a PDF file.

The previous references emphasize practices such as buffer strips to discourage goose nesting around Cazenovia Lake, minimizing that source of lake nutrient introduction. They show how to reduce impervious surfaces in new construction by using materials and techniques that slow water and permit it to percolate through upland and shoreline soils. They describe how to use dry wells to collect flows from persistent impervious surfaces. We recommend these references and web sites to provide information on lake friendly practices for homeowners and anyone concerned with the health of Cazenovia Lake.

References

- Albright, M. F., W. N. Harman, W. T. Tibbits, M. S. Gray, D. M. Warner and R. J. Hamway. 2004. Biomanipulation: A classic example in a shallow eutrophic pond. *Lake and Reserv. Manage.* Vol. 20. No.3. pp.181-187.
- Bachmann, R. W., C. A. Horsburgh, M. V. Hoyer, L. K. Mataraza, and D. E. Danfield, Jr. 2002. Relations between trophic state indicators and plant biomass in Florida lakes. *Hydrobiologia* 470: 219-234.
- Basu, B. K., J. Kalff, and B. Pinel-Alloul. 2000. The influence of macrophyte beds on plankton communities and their export from fluvial lakes in the St. Lawrence River. *Freshwater Biology* 45: 373-382.
- Carpenter, S. R., D. Ludwig, and W. A. Brock. 1999. Management of eutrophication for lakes subject to potentially irreversible change. *Ecological Applications* 9: 751-771.
- Didham, R. K., and C. H. Watts. 2005. Are systems with strong underlying abiotic regimes more likely to exhibit alternative stable states? *Oikos* 110: 2.
- Downing, A. L. 2005. Relative effects of species composition and richness on ecosystem properties in ponds. *Ecology* 86: 701-715.
- Engelhardt, K.A. M., and M. E. Ritchie. 2002. The effect of aquatic plant species richness on wetland ecosystem processes. *Ecology* 83: 2911-2924.
- Genkai-Kato, M., and S. R. Carpenter. 2005. Eutrophication due to phosphorus recycling in relation to lake morphometry, temperature, and macrophytes. *Ecology* 86: 210-219.
- Henderson, C.J., C.J. Dindorf, and R. J. Rozumalski. Undated. Lakescaping for wildlife and water quality. Nongame Wildlife Program Section of Wildlife, Minnesota Department of Wildlife. ISBN 0-9647451-2-7.
- Harman, W. N., M. F. Albright, and D. M. Warner. 2002. Trophic changes in Otsego Lake, NY following introduction of the alewife, *Alosa pseudoharangus*. *Lake & Res Mgt.* Vol. 18. No. 3. pp. 215-226.
- Irvine, K., B. Moss, and H. Balls. 1989. The loss of submerged plants with eutrophication II. Relationships between fish and zooplankton in a set of experimental ponds, and conclusions. *Freshwater Biology* 22: 89-107.
- Johnson, R. L. and B. Blossey 2002. Eurasian Watermilfoil, in: Van Driesche, R., *et al.*, 2002, *Biological Control of Invasive Plants in the Eastern United States*, USDA Forest Service Publication FHTET-2002-04, 413 p.
<http://www.invasive.org/eastern/biocontrol/6EurasianMilfoil.html>
- Lord, P. H., A. D. Miroiu, C. E. Schraeder, and R. L. Johnson. 2004. Chautauqua Lake Eurasian watermilfoil (*Myriophyllum spicatum*) research 2003. Cornell University Research Ponds, Dept of Ecology & Evolutionary Biology, Corson Hall, Cornell University, Ithaca, NY.

- Ludwig, D., B. Walker, and C.S. Holling. 1997. Sustainability, stability and resilience. *Conservation Ecology* 1: 7.
- Morris, K., P. C. Bailey, P. I. Boon and L. Hughes. 2003. Alternative stable states in the aquatic vegetation of shallow urban lakes. II. Catastrophic loss of aquatic plants consequent to nutrient enrichment. *Marine & Freshwater Res.* 54: 201-215.
- Newbrough, K. L. 1993. The effect of bluegills (*Lepomis macrochirus*) on the density and survival of an aquatic weevil. M.Sc. thesis, University of Vermont, Burlington, VT.
- Newman, R. M., 2004. Invited review – Biological control of Eurasian watermilfoil by aquatic insects: basic insights from an applied problem. *Arch. Hydrobiol.* 159: 145-184.
- Newman, R. M., and Biesboer, D. D. 2000. A decline of Eurasian watermilfoil in Minnesota associated with the milfoil weevil, *Euhrychiopsis lecontei*. *J. Aquat. Plant Manag.* 38:105-111.
- Newman, R. M., Ragsdale, D. W., Milles, A., and Oien, C. 2001. Overwinter habitat and the relationship of overwinter to in-lake densities of the milfoil weevil, *Euhrychiopsis lecontei*, a Eurasian watermilfoil biological control agent. *J. Aquat. Plant Manag.* 39: 63-67.
- Sutter, T. J., and Newman, R. M. 1997. Is predation by sunfish (*Lepomis spp.*) an important source of mortality for the Eurasian watermilfoil biocontrol agent *Euhrychiopsis lecontei*? *J. Freshwater Ecology* 12: 225-234.
- Ward, D. M. 2002. The impact of fish predation on Eurasian watermilfoil herbivores and indirect effects on the macrophyte community. M.Sc. thesis, University of Minnesota, St. Paul, Minn.
- Ward, D. M., and Newman, R. M. 2006. Fish predation on Eurasian watermilfoil (*Myriophyllum spicatum*) herbivores and indirect effects on macrophytes. *Can. J. Fish. Aquat. Sci.* 63:1049-1057.
- Scheffer, M. 2001. Alternative Attractors of Shallow Lakes. *TheScientificWorld* 1: 254-263.
- Scheffer, M. and S. R. Carpenter. 2003. Catastrophic regime shifts in ecosystems: linking theory to observation. / *Trends in Ecology & Evolution* 18: 648-656.
- Scheffer, M., S. Carpenter, J. A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems. *Nature* 413: 591-596.
- Scheffer, M., M. R. De Redelijkheid, and F. Noppert. 1992. Distribution and dynamics of submerged vegetation in a chain of shallow eutrophic lakes. *Aquatic Botany* 42:199-216.
- Scheffer, M., H. Hosper, M-L. Meijer, B. Moss, and E. Jeppesen. 1993. Alternative equilibria in shallow lakes. *Trends in Ecology & Evolution* 8: 275-279.
- Scheffer, M., S. Rinaldi, A. Gragnani, L. R. Mur, and E. H. van Nes. 1997. On the dominance of filamentous cyanobacteria in shallow, turbid lakes. *Ecology* 78: 272-282.
- Scheffer, M., S. Rinaldi, and Y. A. Kuznetsov. 2000. Effects of fish on plankton dynamics: a theoretical analysis. *Can. J. Fish. Aquat. Sci.* 57: 1208-1219.
- Stephen, D., D. M. Balayla, S. E. Collings, and B. Moss. 2004. Two mesocosm experiments investigating the control of summer phytoplankton growth in a small shallow lake. *Freshwater Biology* 49: 1551-1564.

- Stephen, D., B. Moss, and G. Phillips. 1998. The relative importance of top-down and bottom-up control of phytoplankton in a shallow macrophyte-dominated lake. *Freshwater Biology* 39: 699-713.
- Takamura, N., Y. Kadono, M. Fukushima, M. Nakagawa, and B.O. Kim. 2003. Effects of aquatic macrophytes on water quality and phytoplankton communities in shallow lakes. *Ecological Research* 18: 381-395.
- van de Bund, W. J., and E. van Donk. 2004. Effects of fish and nutrient additions on food-web stability in a charophyte-dominated lake. *Freshwater Biology* 49: 1565-1573.
- van Nes, E. H., M. Scheffer, M. S. van den Berg, H. Coops. 2002. Aquatic macrophytes: restore, eradicate or is there a compromise? *Aquatic Botany* 72: 387-403.
- Cazenovia Lake Association <http://www.cazlake.org/> Life on the lake.
- Onondaga County Cornell Cooperative Extension.
http://counties.cce.cornell.edu/onondaga/002_environment/001_water_quality/000063.php