Spring 2016

Trophic Interactions And The Efficacy Of Milfoil Weevils For Biocontrol Of Eurasian Watermilfoil In Wisconsin Lakes

Kristopher Andrew Maxson

TROPHIC INTERACTIONS AND THE EFFICACY OF MILFOIL WEEVILS FOR BIOCONTROL OF EURASIAN WATER-MILFOIL IN WISCONSIN LAKES

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Biology

By

Kristopher Andrew Maxson

May 2016

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ABSTRACT

Eurasian water-milfoil (*Myriophyllum spicatum* L., henceforth "EWM") is the most heavily managed nuisance submersed aquatic plant in the United States. EWM's rapid spring growth and formation of dense surface mats inhibits native macrophyte communities, serves as poor-quality habitat for fish and macroinvertebrates, impacts recreation, and can clog water supply infrastructure. The milfoil weevil (*Euhrychiopsis lecontei* Dietz) has been associated with EWM declines in several states, though natural weevil densities are generally too small to effect control. Augmentative biocontrol has had varied success and fish predation may account for high weevil mortality. Weevils were augmented in 4 northern Wisconsin lakes in summer 2013. In summer 2014, I collected invertebrates associated with EWM plus 442 bluegill (*Lepomis macrochirus* Rafinesque) diet samples from the 4 study lakes. Overall, chironomids and oligochaetes were the dominant invertebrates associated with plants, while chironomids and *Daphnia* spp. constituted up to 27.2% and 24.0% of the fish diets, respectively. Milfoil weevils were found in 2.9% of diet samples examined. Weevil larvae were preyed upon more frequently than adults (94.2% of weevils consumed) and sometimes occurred in high numbers within single diet samples. Since the larval stage contributes the most to EWM damage, selective predation on this stage may limit its use as a control agent.

KEYWORDS: Eurasian water-milfoil, *Myriophyllum spicatum*, milfoil weevil, *Euhrychiopsis lecontei*, biological control, bluegill, *Lepomis macrochirus*, diet

This abstract is approved as to form and content

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John E. Havel, Ph. D.
Chairperson, Advisory Committee
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ACKNOWLEDGEMENTS

Work on this project would not have been possible without the help from a great many people. First and foremost, I would like to thank the P.I.s on the project, my research advisor Dr. John Havel and Dr. Susan Knight with UW-Trout Lake. Your aid in experimental design and securing funding for the project has proven invaluable. Your passion and dedication to your fields is truly an inspiration, and I hope one day to be half the naturalist I've seen in you. I would also like to thank my committee, Dr. Day Ligon and Dr. Dan Beckman as well as Dr. John Heywood for advice on experimental design and statistical analysis. The aid of Dr. Greg Sass with Wisconsin DNR was invaluable during early stages of project design and fish sampling, as well as edits to thesis drafts.

I am forever indebted to Adrienne Gemberling, Alex Bauch, Paul Schramm, Willis Perley, Paul Schilke, and the "Weevil Crew" (Erick Fruehling, Jim Miazga, Chris Winter, and Nick Winter). Your aid during late night electrofishing runs, SCUBA diving through dense macrophyte beds, and long days flushing fish stomachs is a testament to your dedication and passion for the field. Credit is also due to the many Trout Lake undergraduates, graduate students, and staff members who provided support in innumerable ways. Because of you, my time spent in the Wisconsin northwoods will forever hold a place in my heart.

I would likely still be picking through invertebrate samples had it not been for Ann Wempe. My gratitude for her aid in process sampling and data entry cannot be fully expressed. Thanks also to Stephanie Sickler. Without her efforts in aging fish scales, the scales collected during my study would likely have remained in their envelopes. The many graduate students of Missouri State University, who shared in the ups and downs of graduate school, will never be forgotten. I can think of no better group with whom to share this journey.

My journey through graduate school would not have been possible without the love and support of my parents, Stephen and Tammy Maxson, twin sister, Courtney Lorenz, and many family and friends from home. Through church collections and food donations, you ensured that I had a car that still ran and filled my pantry with more than Ramen noodles.

Last but not least, I would like to thank my fiancé, Stacey Jackson, for her continued love, support and patience during my tenure in the "wrong Springfield." There is no other person whom I would wish by my side.

Funding for this project was provided by grants from the Wisconsin Department of Natural Resources to S. Knight and J. Havel (ACE-122-12 and AIRD-100-14), a faculty research grant to J. Havel, and thesis funding and summer fellowship from Missouri State University to K. Maxson. Summer housing at Trout Lake Station was provided by the University of Wisconsin-Madison.

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INTRODUCTION

Eurasian water-milfoil (*Myriophyllum spicatum* L., EWM) is a submersed aquatic plant native to Europe, Asia and north Africa (Couch and Nelson 1985). EWM has become one of the most problematic submersed aquatic plants in North America (Smith and Barko 1990). The timing and means of EWM introduction are still being debated, and early reports of EWM are often complicated due to EWM's close physical resemblance to the native northern water-milfoil (*Myriophyllum sibiricum* Komarov) (Smith and Barko 1990). Herbarium collections of EWM exist from the late 1800s (Reed 1977), but Couch and Nelson (1985) argued that these were likely misidentified and the initial invasion did not occur until 1942. EWM was likely introduced to North America as a cultivated plant in Washington, D.C. (Couch and Nelson 1985) or through the aquarium trade (Reed 1977, Couch and Nelson 1985, Johnson and Blossey 2002). Since its initial invasion, EWM has primarily been spread to new waterbodies as a hitchhiker on recreational boats (Reed 1977, Johnstone et al. 1985, Eiswerth et al. 2000). Currently, EWM has spread to 3 Canadian provinces and all states except Hawaii in the United States (Berent et al. 2015).

EWM was first identified as a nuisance species in the 1950s (Nichols 1975, Rawls 1975, Smith and Barko 1990). EWM does not form specialized overwintering structures, but some shoots from the summer survive through the winter, and new shoots may sprout in the fall; these shoots remain dormant, storing carbohydrates in preparation for spring growth (Smith and Barko 1990). These overwintering shoots aid in EWM's characteristic rapid spring growth, allowing it to quickly reach the surface and form a dense surface canopy (Nichols and Shaw 1986, Smith and Barko 1990). These characteristics aid in its

early dominance in the spring and successful displacement of native macrophyte species (Nichols and Shaw 1986, Smith and Barko 1990, Madsen et al. 1991). While EWM is capable of producing seeds, it primarily colonizes through fragmentation and stolon production (Nichols and Shaw 1986, Smith and Barko 1990, Madsen and Smith 1997). Stolon formation allows for expansion within the immediate area, while fragmentation provides a means of distribution over longer distances (Madsen and Smith 1997). Fragmentation can take two forms: autofragmentation, in which internodes form adventitious roots and subsequently break apart, and allofragmentation due to mechanical damage caused by recreational activity, animals or wave action (Aiken et al. 1979, Madsen and Smith 1997). Fragmentation is of special concern, especially in areas of heavy recreational activity. Madsen and Smith (1997) found that 46% of EWM fragments that settled on suitable substrate successfully rooted and established new colonies. Furthermore, field experiments in northern Wisconsin have shown that bundles of EWM characteristic of those found wrapped around boat propellers survived up to 48 hours of air exposure (Bruckerhoff et al. 2015). Because boaters in this region tend to visit multiple lakes within a short period of time, the risk of spread due to fragmentation is increased (Bruckerhoff et al. 2015).

EWM invasions can have significant negative effects on lake ecosystems. As EWM elongates, leaves are continuously lost as they become shaded by higher growth; this, coupled with high levels of decaying biomass at the end of the growing season, can lead to low dissolved oxygen concentrations and fish kills (Newroth 1985, Nichols and Shaw 1986). Dense surface mats of EWM also provide ideal habitat for mosquito larvae

(Batra 1977, Bates et al. 1985, Smith and Barko 1990), increasing the rate and spread of mosquito-borne diseases (Bates et al. 1985).

EWM invasions can also impact sport fisheries. At high densities EWM has been linked to overpopulations of stunted sunfish (*Lepomis* spp.) and decreased density and diversity of littoral invertebrates (Keast 1984, Cheruvelil et al. 2000, Ward and Newman 2006). Macrophyte beds provide a refuge for juvenile fish (e.g. bluegill, *Lepomis macrochirus* Rafinesque) against their predators (e.g. largemouth bass, *Micropterus salmoides* Lacépède) (Savino and Stein 1982, Werner et al. 1983, Olson et al. 1998, Sass et al. 2006). To reduce food limitation at high densities, bluegill often undergo dietary shifts with age. Individuals less than 100 mm are generally restricted to macrophyte beds as a refuge from predators, while larger individuals freed from predation risk can seek out more profitable pelagic zooplanktonic food sources (Mittelbach 1981, Sass et al. 2006). The benefit of these macrophyte beds is best under intermediate stem densities (Crowder and Cooper 1982). Under high stem densities, predators are excluded from the macrophyte beds, removing the check on bluegill populations and allowing them to become overpopulated (Savino and Stein 1982, Engel 1995, Dibble et al. 1997, Sass et al. 2006). Also, foraging efficiency among high density beds is greatly decreased (Dibble et al. 1997, Sloey et al. 1997, Valley and Bremigan 2002). Several studies have also suggested that EWM supports a poorer macroinvertebrate community when compared to native macrophytes (Keast 1984, Cheruvelil et al. 2002, Wilson and Ricciardi 2009, Parsons et al. 2011). In mixed macrophyte beds, macroinvertebrate density depends more upon the quality of epiphyte communities than whether the macrophyte was native or invasive (Strimaitis and Sheldon 2011). However, EWM generally hosted lower

macroinvertebrate diversities, suggesting EWM may influence macroinvertebrate communities by altering epiphytic food sources (Strimaitis and Sheldon 2011). These shifts in macroinvertebrate communities, coupled with the decrease in sunfish foraging efficiency, can cause stunting in the overpopulated sunfish as they compete for the same limited food source (Dibble et al. 1997, Ward and Newman 2006, Parsons et al. 2011) (Figure 1).

EWM invasions can also have significant economic effects on humans. EWM growth can interfere with swimming and boating and reduce the aesthetic appeal of popular waterways (Newroth 1985, Smith and Barko 1990). As such, the presence of EWM in a waterbody can negatively impact property values (Bates et al. 1985, Horsch and Lewis 2009, Zhang and Boyle 2010). In Connecticut, Zhang and Boyle (2010) found that property values decreased up to 16%, depending on the degree of EWM invasion. Horsch and Lewis (2009) found an average decrease of 13% following EWM invasions in Wisconsin. EWM is also known to clog industrial and power plant water intakes, resulting in further economic losses due to lost productivity and costs of removal (Bates et al. 1985). However, difficulty arises in assigning values to damages invaders cause to ecosystem services and the aesthetic value of waterbodies (Bates et al. 1985, Lovell et al. 2006). As such, these studies fail to take into account economic losses due to effects on these properties (Lovell et al. 2006). Eiswerth et al. (2000) estimated that the effects of EWM alone on recreation cost the economy $30-$45 million annually.

Because of the economic effects of nuisance aquatic plants, a lot of effort goes into their control. In 1993, the United States spent $135 million annually on aquatic plant control (OTA 1993, Pimentel et al. 2005). Control methods involve a variety of physical

methods, chemical treatments with herbicides and biological control (Table 1). Because control of EWM can be difficult, the particular method used varied between different waterbodies. The herbicide 2,4-D (2,4-dichlorophenoxy acetic acid) has been a popular control method since the 1950s (Gallagher and Haller 1990, cited in Nault et al. 2014). The popularity of 2,4-D owes to its effective killing of EWM, while having limited effects on native species (Bates et al. 1985). However, such results require careful timing of application and avoiding concentrations that are too high (Nault et al. 2014). Unfortunately, EWM often hybridizes with the native northern water-milfoil (*Myriophyllum sibiricum* Komarov) (Moody and Les 2007), and hybrids are less sensitive to 2,4-D than EWM. EWM hybridization with northern water-milfoil has thus made traditional applications of herbicides less effective (Parsons et al. 2009, LaRue et al. 2013). In whole lake 2,4-D applications, long-term exposure to low doses (≤ 500 µg L^{-1}) resulted in multi-year EWM control (Nault et al. 2014). The herbicide persisted in the water longer than expected and longer exposure to 2,4-D resulted in unanticipated damage to several native species (Nault et al. 2014).

Another popular method for controlling EWM is mechanical harvesting, which involves mowing the aquatic plants a few feet below the water surface. A major drawback of mechanical harvesting is the fact that this method is indiscriminate, removing much of the plant community, greatly influencing fish and invertebrates associated with the macrophytes (Haller et al. 1980, Shireman et al. 1982, Mikol 1985, Dawson et al. 1991). Such harvesting also increases the likelihood of fragmentation and further spread of EWM (Nichols and Shaw 1986). Crowell et al. (1994) reported that

EWM biomass returned to initial levels within 6 weeks post-harvest, implying that harvesting may have to occur multiple times per growing season to effectively control.

Another method for EWM control is manual removal by hand. This method is labor intensive and is thus impractical for large infestations (Kelting and Laxson 2010). Identification of EWM by divers is complicated by the similar appearance of EWM, northern watermilfoil and hybrids of the two species. EWM and northern water-milfoil are typically distinguished by paired leaflet numbers, with EWM having more than 13 pairs and northern water-milfoil less than 12 pairs. Hybrid specimens show considerable overlap of leaflet pairs with the parent species (Moody and Les 2007).

Biological control of EWM has gained increased interest within the last two decades. Grass carp (*Ctenopharyngodon idella* Val.) are an exotic fish species commonly used to control nuisance aquatic plant growth. Unfortunately, EWM is one of the least preferred food sources for the fish, and they will often eat all native macrophytes and leave EWM untouched (Pine and Anderson 1991). In addition, grass carp have become invasive themselves, colonizing many regions of the U.S. Several aquatic insects have been investigated as biological controls for EWM (Newman 2004). The milfoil weevil (*Euhrychiopsis lecontei* Dietz, Coleoptera: Curculionidae) has shown the most promise as a possible biological control agent for EWM (Creed and Sheldon 1993). The milfoil weevil is a native herbivorous insect whose native host is northern water-milfoil. When EWM is present, the weevil seems to prefer and develop better on the exotic when compared to the native (Creed and Sheldon 1993, Sheldon and Creed 1995, Solarz and Newman 1996, 2001, Sutter and Newman 1997, Mazzei et al. 1999, Sheldon and Jones 2001, Roley and Newman 2006).

The milfoil weevil undergoes complete metamorphosis with four life stages: egg, larva, pupa, and adult (Figure 2). In spring, adults emerge from overwintering in shoreline leaf litter to fly to an EWM bed (Newman et al. 2001). Once there, the adult weevil lays 1–2 eggs per day on the apical meristem of the EWM stems (Creed and Sheldon 1991, Sheldon and Jones 2001, Newman 2004). The eggs hatch into first instar larvae that consume and destroy the apical meristems (Jester et al. 2000). Later instars mine the center vascular tissue of each stem (Jester et al. 2000), causing the plant to collapse and reduce its canopy-forming potential (Creed et al. 1992). The larvae mine about 15 cm of the stem (Mazzei et al. 1999) before exiting and crawling down a short distance to reenter the stem and pupate (Newman 2004). Under temperatures typical of the epilimnion of north temperate lakes in summer (25°C), egg development takes about 5 days; larvae and pupae develop in 7–8 days each (Newman 2004). At 25°C, the entire life cycle takes about 21 days, allowing weevils to complete multiple generations, depending on the length of the growing season (Newman 2004). In late August to mid-September, adults develop flight muscles and return to overwintering sites onshore (Newman et al. 2001).

Although EWM declines in several locations have been linked to the milfoil weevil (Creed and Sheldon 1995, Creed 1998), weevil densities in many lakes are not high enough to effectively control EWM (Newman 2004). Some lakes with excessive EWM may benefit from augmented weevil populations. A preliminary study by Jester et al. (2000) showed significant declines in EWM five weeks post-augmentation. However, the generality of this response is unknown. Furthermore, we know little about the prospects for establishing a long-term predator-prey cycle (Batra 1982). A recent project

was designed to test the weevil-control hypothesis using experimental manipulations of weevil densities in four northern Wisconsin lakes over a four-year period (Knight and Havel 2016). Following sampling of background conditions in 2012, weevils were stocked during 2013 in eight beds (two beds in each lake), with eight additional beds serving as controls (two beds in each lake). Stocking involved collecting adult weevils, inoculating weevil eggs onto sprigs of host EWM in the laboratory, and transplanting thousands of eggs and larvae with the host plants, which were tied to resident plants in the EWM beds (C. Marquette, pers. com.). A similar procedure was followed by Parsons et al. (2011) in their augmentation of a weevil population in Washington. Although stocking of the Knight and Havel study beds was discontinued in 2014, weevil population dynamics and correlated patterns of plant diversity and biomass were monitored in the 16 beds during 2013-2015 (Knight and Havel 2016).

One concern with using this method of biocontrol is the fate of weevils following introduction. Weevil larvae and pupae are hidden while living in the EWM stems and thought to be immune to predation (Sutter and Newman 1997, Newman 2004). The black-and-white-striped adults (ca. 3mm), however, are conspicuous to the naked eye and presumably also to sight-feeding predators such as sunfish (e.g., bluegill). Several studies have tested for the effects of fish predation on the milfoil weevil (Table 2). Newbrough (1993) reported that bluegill consumed weevil adults in the laboratory. In field experiments using fish enclosures, the larval stage was the only stage significantly affected by fish predation (Newbrough 1993). In similar enclosure experiments, Ward and Newman (2006) found weevil densities to be negatively correlated with bluegill densities. Milfoil weevils occur in the stomachs of bluegill and pumpkinseed (*Lepomis*

gibbosus Linnaeus) in Minnesota lakes, suggesting that fish predation may be one factor limiting weevil densities (Sutter and Newman 1997). However, not all fishes consume weevils. Yellow perch (*Perca flavescens* Mitchell) did not prey upon milfoil weevils in studies in Vermont and Minnesota (Table 2) (Creed and Sheldon 1992, Creed et al. 1993, Sutter and Newman 1997, Creed 2000).

High sunfish populations are frequently associated with dense macrophyte stands. High density EWM beds could establish a positive feedback cycle in which littoral sunfish density increases following EWM invasion and the fish in turn lower herbivorous insect density (Ward and Newman 2006). Fish predation may therefore have an indirect but positive impact on EWM by suppressing herbivorous insects (Ward and Newman 2006). Moreover, because EWM beds support a lower diversity of aquatic invertebrates (Keast 1984), inordinate pressure may be exerted on weevils by fish foraging in these depauperate invertebrate communities (Sutter and Newman 1997) (Figure 1).

Successful control of EWM by augmented weevil populations in a Washington lake saw a return to a more balanced community of predator and prey fish (Parsons et al. 2011). Can we expect a similar response in Wisconsin lakes? The Knight and Havel (2016) experimental lakes (Figure 3) provide a convenient study system test for the effects of fish predation on weevil populations and other invertebrates in submerged plant communities. Although further weevil stocking in the main study was discontinued, the 16 beds showed a very large range in weevil abundance (0–3.2 weevils/stem) (Knight and Havel 2016) and thus provide a good environmental template for study of the food web.

The primary goal of my study was to test whether bluegill in the four main study lakes consume weevils. If so, do bluegill prefer to consume weevils compared to other

invertebrate taxa and their availability in the environment? Secondary objectives were to quantify the invertebrates associated with submersed macrophytes in the study lakes and to test for their importance and preference in the diets of bluegill.

METHODS

Study Sites

The four lakes included in this study are part of a larger project investigating the use of the native milfoil weevil as a biological control of Eurasian water-milfoil (Knight and Havel 2016). Four lakes in the Northern Highland Lakes District of Wisconsin were chosen for the study: Boot Lake, Little Bearskin Lake, Long Lake, and Manson Lake (Table 3, Figure 3). All four lakes have public boat launches and extensive macrophyte beds. Within each lake, four EWM beds were sampled, with their boundaries mapped using a handheld GPS (Garmin GPSmap78, Olathe, Kansas).

Boot Lake (Figure 4) is located in Vilas County, Wisconsin, about 13 km northwest of Eagle River. The shallow depth of Boot Lake results in frequent resuspension of bottom sediments and nutrients, causing high turbidity in the water column. Previous collections from the EWM beds during 2013–2014 revealed 13 species of submersed plants (Knight and Havel 2016).

Little Bearskin Lake (Figure 5) is located in Oneida County, Wisconsin, about 21 km south of Minocqua. This lake has high submersed plant diversity in the EWM beds, with 24 species collected (Knight and Havel 2016).

Long Lake (Figure 6) is located in Iron County, Wisconsin, about 11 km north of Mercer. Long Lake is stained with tannins, resulting in low clarity (Table 3). Although this lake as a whole has high plant diversity (S. Knight, pers. com.), the study EWM beds have the lowest diversity of submersed plants (12 species) among the study lakes. In Long Lake, I sampled Bed C during the first time period (Table 4), but eliminated this bed from my study due to the very low abundance of macrophytes during the rest of the

summer. In the summers of 2012 and 2013, this site had moderate biomass of EWM and other submerged plants, but most plants were absent in 2014 for unknown reasons (Knight and Havel 2016).

Manson Lake (Figure 7) is located in Oneida County, Wisconsin, about 24 km west of Rhinelander. Manson Lake is the deepest and clearest of the study lakes (Table 3) and has 21 species of submersed plants (Knight and Havel 2016).

Fish Sampling

Fish were collected under Wisconsin Department of Natural Resources Scientific Collectors Permit No. NOR-SCP and University of Wisconsin-Madison Animal Care and Use Protocol L00205-0-11-12.

During three time periods in May–August 2014 (Table 4), I sampled fish from each of the 16 EWM beds using three methods: angling, minnow traps, and electrofishing.

During June and again in August (Table 4), I angled from a boat using ultralight to medium action fishing rods with size 10 bait hooks and a bobber. Hooks were baited with small segments of night crawlers (*Lumbricus terrestris* Linnaeus). At each EWM bed, the boat was anchored at bow and stern on the outer edge of a macrophyte bed, and the line was cast into the bed. Each bed was fished for 1 angler-hour, or until a minimum of fifteen panfish (bluegill, pumpkinseed, or yellow perch) were captured. All fish captured were kept in a live well until processing.

During June and August (Table 4), I set three groups of modified 23 × 44 cm Gee’s minnow traps (Tackle Factory, Fillmore, New York), hung in tiers of three (Figure

8), within each bed. Traps were constructed of 6.4 mm mesh galvanized steel wire and had double entrance openings (38.0 ± 0.4 mm). Traps were hung ca. 0.3 m apart and suspended using a 13 x 28 cm orange bullet-nose float. Each trap was baited with a handful (ca. 21 g) of dry dog food (Old Roy, Doane Pet Food, Brentwood, Tennessee) stuffed in a black nylon sock. Trap tiers were deployed at locations selected by tossing three marker buoys arbitrarily into each bed. Traps were fished for about two hours and then retrieved.

I sampled fish via night pulsed-DC electrofishing during July (Table 4). I began sampling at dusk with a crew of four (two dippers, one live-well monitor, and one driver). I sampled each bed until about fifteen panfish were collected. To target smaller fish, I used a pulse rate of 20 Hz and a duty cycle of 25%.

Fish Processing

All fish were identified to species, measured for total length (mm), and weighed on a digital scale (± 1 g). I permanently clipped the anal fin from all bluegill, pumpkinseed and yellow perch to estimate population density through mark and recapture; however, no marked fish were recaptured during the study period, and no further analysis of population density was attempted. Scales were also collected from each fish from beneath the depressed pectoral fin and made available for a companion study of fish growth rates (Sickler 2015).

Stomach contents were collected using gastric lavage (Figure 9) where possible. The small gape size of bluegill and pumpkinseed limited my use of gastric lavage to individuals ≥ ca. 80 mm (pers. observation). The inner straw of a 500-mL wash bottle

was removed and the tip of the spout snipped to increase water flow. With each fish held upside down, I inserted the spout through the mouth and into the esophagus of the fish. Constant pressure was applied to the bottle as the spout was moved back and forth to allow flushing of the stomach. When the stream of water from the stomach became clear, I assumed that all contents had been flushed. To concentrate the sample, contents were flushed into a plugged funnel with cut "windows" (Figure 9A) lined with 200 μm mesh (Nitex, Sefar AG, Switzerland). After concentration and plug removal, the diet contents in the funnel were flushed with 95% ethanol into a 60-mL bag (Whirl-Pak, Nasco, Fort Atkinson, Wisconsin). Following the measures and collection of diet samples, these larger fish were released back to the lake.

Bluegill and pumpkinseed with total lengths below 80 mm were euthanized using a lethal dose of MS222 (250 mg/L aqueous), placed in ethanol and stored on ice. Stomachs were removed within 8 hours after return to the laboratory.

Environmental Sampling

I collected aquatic plants (Figure 10) during July to compare epiphytic invertebrate taxa available in the environment with taxa present in the fish diet samples. I tossed ten marker buoys into the boundary of each EWM bed. A SCUBA diver equipped with a 2-gallon (7.6 L) bag (Ziploc, SC Johnson, Racine, Wisconsin) swam to each buoy and lowered the bag over the plant closest to the buoy. The diver collected the entire plant by cutting it at the sediment surface and sealing the bag underwater, trapping invertebrates associated with the plant. The diver then brought the sample back to the boat, where I filtered it through a 250-μm sieve. I washed the invertebrate sample into a

125-ml jar and preserved it with 95% ethanol (final concentration > 70%). The plant was placed in a 1-quart (0.9 L) bag (Ziploc, SC Johnson, Racine, Wisconsin) and brought back to the laboratory. There, the plant was visually inspected on a lightbox for any remaining invertebrates. All the plants sampled from each bed were separated into tared drying pans by species, and dried at 60°C for about 48 hours. Dry weights were then measured using a digital scale (± 0.01 g) in a dehumidified room.

Sample Analysis

I analyzed all samples from plants and fish diets under a dissection microscope (Wild-Leitz, Heerbrugg, Switzerland) at 6× magnification. Samples were removed from ethanol by filtering through 200 µm mesh (Nitex, Sefar AG, Switzerland) and washed with water into a graduated cylinder. I identified contents using the keys in Edmondson (1959), Merritt and Cummins (1996), Voshell Jr. (2002), and Thorp and Covich (2009), to a resolution that depended on taxonomic group (Appendix C). Samples with high densities were subsampled after removing and counting larger individuals of less abundant species. Subsamples (2 mL) were taken from the entire sample diluted in a 100 mL graduated cylinder with a Hensen-Stempel pipette, until a minimum of 200 individuals were counted. Due to differences in plant biomass collected in each environmental sample, invertebrate counts from environmental samples were expressed as number per gram dry weight of plant.

For diet and environmental samples, mean proportion by number ($\overline{P}_i$) was calculated using a slight modification of the formula from Chipps and Garvey (2007):

$$\overline{\mathrm{P}}_{\mathrm{i}} = \frac{1}{k}\sum_{j=1}^{k}\left(\frac{\mathrm{N}_{ij}}{\sum_{i=1}^{L}\mathrm{N}_{ij}}\right) \quad (1)$$

where: N_{ij} = Number of prey type *i* in sample *j*

k = Number of samples that contain at least one prey item

L = Number of prey types possible.

The changes to the Chipps and Garvey (2007) formula included substituting $\overline{\mathrm{P}}_{\mathrm{i}}$ for MN_i, k for P, and L for Q.

Weevil Densities

In the overall weevil project (Knight and Havel 2016), 50 EWM stems were collected to estimate weevil densities within each EWM bed in each lake. A stem was defined as 50 cm long from the apical tip, including all lateral stems that branch off the main stem closer than 50 cm from the apical tip. Stems were viewed under a dissecting microscope and all weevil life stages (eggs, larvae, pupae, adults) were recorded for each stem (Knight and Havel, unpublished data).

In the current study, I identified weevil larvae and adults (results below), but was not able to discriminate eggs or pupae.

Prey Preference

Prey preference was analyzed using Manly-Chesson's alpha (Chesson 1978, 1983, Krebs 1989, Järv et al. 2011):

$$\alpha_i = \frac{r_i}{p_i}\left(\frac{1}{\sum_{i=1}^{m}\frac{r_i}{p_i}}\right) \quad (2)$$

where: α_i = Manly-Chesson's alpha (preference index) for prey type i

r_i = Proportion of prey type i in the diet (i = 1, 2, 3,…, m)

p_i = Proportion of prey type i in the environment

m = Number of prey types possible.

Where $\alpha_i = m^{-1}$, no selection (preference) occurs; where $\alpha_i > m^{-1}$, positive selection occurs; and where $\alpha_i < m^{-1}$, negative selection (avoidance) occurs. The proportion of prey item i in the diet (r_i) and environment (n_i) were calculated as:

$$r_i , n_i = \frac{N_i}{\sum_{i=1}^{m} N_i} \quad (3)$$

where: N_i = Number of prey type i in the sample

m = Number of prey types possible.

Manly-Chesson's α was calculated for each fish, using r_i calculated from each individual diet and the mean n_i ($\bar{P}_i$, eq. 1) from the environmental samples at each site. All α values for each prey taxon were then averaged to obtain mean α values (±1 SE) for each prey taxon in each lake. Efforts were made to avoid confusion between situations in which prey taxa were abundantly available but rare in the diet vs. situations in which prey taxa were rare in the environment and therefore rare in the diet (Chesson 1983). Taxa for which $\bar{P}_i$ (eq. 1) fell below 0.05 were dropped from the Manly-Chesson's alpha analysis. For example, in a situation with 4 prey taxa in which taxa 3 (α_3) was eliminated, new alpha values for the remaining taxa would be calculated as follows (Chesson 1978):

$$\begin{bmatrix}\alpha_1\\ \alpha_2\\ \alpha_4\end{bmatrix} = \begin{bmatrix}\alpha_1\ (\alpha_1 + \alpha_2 + \alpha_4)^{-1}\\ \alpha_2\ (\alpha_1 + \alpha_2 + \alpha_4)^{-1}\\ \alpha_4\ (\alpha_1 + \alpha_2 + \alpha_4)^{-1}\end{bmatrix} \tag{4}$$

Non-parametric Wilcoxon Signed-Rank tests were performed using Minitab release 16 (Minitab Inc., State College, PA) to test whether α values differed significantly from the values of no selection ($\alpha_i = m^{-1}$). My decision to reject the null hypothesis was based on a type-1 error rate of 0.05. Small p-values indicate significant departure from the null hypothesis, and the difference between the median alpha value and H_0 indicates whether a prey group is significantly over-represented (positive selection) or under-represented in the diet.

RESULTS

Fish Collected for Diet Samples

During three sampling periods, 14 fish species were caught from the four study lakes (Table 5). Bluegill made up the majority of fish sampled from Little Bearskin and Manson lakes (70.3 and 85.6%, respectively), while yellow perch were the most abundant fish sampled from Boot and Long lakes (56.1 and 64.3%). Nevertheless, bluegill were abundant in the catch from these lakes as well (22.6 and 27.9%, respectively). Bluegill were the most numerous fish collected in my study and therefore were the focus of my analysis.

Different units were used to report effort for each gear type: angling – 0.5 angler-hours; minnow traps – 2 hour trap sets; electrofishing – minutes. Except in Long Lake, bluegill CPUE varied among the different beds within each lake (Table 6), and each lake differed significantly from one another (Table 7). CPUE for the three methods combined was highest in Little Bearskin Lake and lowest in Long Lake. Mean CPUE for angling was lowest in Boot Lake and highest in Manson Lake. Minnow trap mean CPUE was low in Boot and Long lakes, while higher in Little Bearskin and Manson lakes. Mean CPUE for electrofishing was highest in Little Bearskin Lake, followed by Manson and Boot lakes. Electrofishing mean CPUE for bluegill was lowest in Long Lake, likely a reflection of the higher number of yellow perch captured in this lake (Table 5). To test for the effects of lake, bed, and gear type on bluegill CPUE, effort units were converted to minutes for all three gear types. CPUE was affected by every factor tested, with lake, bed, gear, and their interactions all showing significant effects (Table 7). Although these

interactions cloud our ability to interpret main effects, CPUE was significantly different among the three sampling methods (Table 7, electrofishing highest).

Use of the three sampling methods ensured that bluegill from a broad range of lengths were captured (31–200 mm) (Figure 11). Lake, gear type, and the interactions between the two factors all had significant effects on bluegill length (Table 8). Bluegill captured by angling had significantly longer mean lengths than those captured by electrofishing and minnow traps (Table 8). Bluegill mean lengths from Boot and Long lakes were significantly larger than in Little Bearskin and Manson lakes (Table 8). Bluegill length distributions varied among the study lakes (Figure 12). Bluegill mean length was greatest in Long Lake, followed by Boot, Manson, and Little Bearskin lakes (Table 9).

Taxonomic Composition of Fish Diet Samples

Across all lakes and time periods, 78,415 invertebrates were identified from 468 bluegill diet samples into 40 different taxonomic units (Appendix C). Diet contents were expressed using the mean proportion by number ($\bar{P}_i$, eq. 1). During July, dipterans (primarily chironomids) comprised the major proportion of diet samples from Boot (Figure 13) and Little Bearskin (Figure 14) lakes, with fewer other insects, microcrustaceans, and other groups. *Daphnia* spp. were the main component of July diet samples from Long (Figure 15) and Manson (Figure 16) lakes, with chironomids second most common in Manson Lake. The $\bar{P}_i$ values for taxa in bluegill diet samples from all time periods are shown in Appendix D.

Weevils in Diet Samples

The milfoil weevil occurred infrequently within the bluegill diet samples. Of 442 bluegill diet samples examined, only 13 contained at least one weevil; 2 from Little Bearskin Lake, 5 from Long Lake, and 6 from Manson Lake (Table 10). More weevils were found in diet samples collected from June (120 weevils from 156 sampled diets) than in other months (Table 11). A total of 114 larvae and seven adults were found in all these samples, starkly lower than the many thousands of other invertebrates counted in the fish diet samples (Appendix C). Although weevils most often occurred singly in diet samples, several fish had consumed large numbers of weevil larvae, with up to 52 larvae found in a single fish (Figure 17).

Taxonomic Composition of Environmental Samples

Eurasian water-milfoil was the most frequent macrophyte collected in July environmental samples (n = 150), although nine native species were also collected (Appendix A). These submersed plants vary a great deal in size of individuals. Thus, smaller individuals sometimes contributed only trace amounts to biomass (Appendix B).

A total of 74,475 invertebrates were identified to 38 different taxonomic units (Appendix E). Dipterans (primarily chironomid larvae) and oligochaetes were the primary invertebrates in environmental samples collected from all lakes (Figures 13–16). Little Bearskin Lake also had high proportions of ostracods and gastropods in the samples (Figure 14). Besides chironomids and oligochaetes, ostracods and calanoid and cyclopoid copepods occurred in high proportions in Long Lake (Figure 15). Manson Lake environmental samples had a higher proportion of littoral cladocerans (primarily

chydorids) than did the other lakes (Figure 16). The $\bar{P}_i$ values for taxa in environmental samples are shown in Appendix F.

Milfoil weevil densities were highly variable among lakes and among beds in single lakes (Knight and Havel 2016) **(**Table 12). During 2014, weevil densities were highest in Little Bearskin Lake (0.68 ± 0.16 weevils per stem) and Boot Lake (0.59 ± 0.20), and lowest in Manson Lake (0.05 ± 0.03). Weevil densities showed a general decline over the course of the summer.

Weevils occurred rarely in environmental samples collected during the current study (Table 11). One adult and one larva were detected in samples from Little Bearskin Lake. A single larva was found in a sample from Long Lake. No weevils were found in environmental samples from Boot or Manson lakes.

Prey Preference

Boot Lake bluegill diet (n = 16) and environmental samples (n = 40) suggested a statistically significant preference for amphipods and *Daphnia* spp. and avoidance of littoral cladocerans, ostracods and gastropods (Table 13, Figures 13, 18).

Little Bearskin Lake bluegill diet samples (n = 47) exhibited a significant positive selection for ephemeropterans, while avoiding littoral cladocerans, ostracods, gastropods and oligochaetes (Table 14, Figures 14, 19). Manly-Chesson α values for chironomids and caddisflies did not differ from the null value, suggesting that bluegill showed no preference for or against these taxa.

Although larger samples were collected in other periods, only two bluegill were caught while sampling during July on Long Lake (Table 9). Due to the low sample size, I

did not compare diet samples and environmental samples using Manly-Chesson's alpha. See Figure 15 and Appendices C and D for an account of the composition of bluegill diet samples from Long Lake.

A high degree of variability existed in the bluegill diet samples (n = 129) collected from Manson Lake (Figures 16, 20). Despite this, results of the one-sample Wilcoxon Signed-Rank tests suggested that bluegill from Manson Lake had a significant strong preference for *Daphnia* spp. while significantly avoiding other taxa common in the environmental samples (Table 15).

DISCUSSION

The primary goal of this study was to test whether bluegill in the four study lakes under the main project (Knight and Havel 2016) consumed weevils. My results suggest that, though rare, weevils did occur in bluegill stomachs from 3 of the 4 study lakes. Secondary goals were to quantify the invertebrates associated with submersed macrophytes in the study lakes and relate prey taxa available in the environment to those taxa preferred by bluegill. Below, I consider the potential effects that EWM may have on centrarchid sunfish populations, the effects of various control methods on the aquatic community, factors affecting milfoil weevils in the environment, and subsequent impacts on their uses for biological control of EWM.

Impacts of Dense EWM on Sunfish Populations

The tendency of EWM to form monotypic stands with high stem densities can have significant effects on sports fisheries by excluding large piscivores, such as largemouth bass, while providing refugia for juvenile fish (Werner et al. 1981, Savino and Stein 1982, Olson et al. 1998, Sass et al. 2006). However, this refuge may not be high quality habitat if food resources are poor. EWM has been shown to be a poor host for epiphytic macroinvertebrates when compared to native plant species (Keast 1984, Cheruvelil et al. 2000, Ward and Newman 2006). High bluegill densities and diminished macroinvertebrate communities, coupled with decreased foraging efficiencies at high stem densities, can lead to stunted centrarchid sunfish populations (Engel 1995, Dibble et

al. 1997). Preliminary work is underway to determine if stunting is occurring within these study systems (Sickler 2015).

Multiple Effects from Chemical and Mechanical Control of EWM

Current methods for controlling EWM include herbicides, mechanical harvesting, and manual removal. While effective, herbicides can have an adverse effect on native macrophyte species and are less effective at treating EWM-northern water-milfoil hybrids (Parsons et al. 2009, LaRue et al. 2013). There is also growing concern among members of lake associations, who are wary of adding chemicals to their lakes.

Mechanical harvesting is indiscriminate, removing native macrophytes as well as fish and invertebrate communities associated with the plants (Haller et al. 1980, Shireman et al. 1982, Mikol 1985, Dawson et al. 1991). Furthermore, since the milfoil weevil lays its eggs on the apical meristem and spends much of its life in the upper 1.5 m of the EWM stem, mechanical harvesting can have a significant detrimental effect on weevil populations (Sheldon and O'Bryan 1996). Such harvesting also increases the likelihood of fragmentation and further spread of EWM (Nichols and Shaw 1986).

The Role of Milfoil Weevils in Controlling EWM

The recent field experiment to investigate the use of the native milfoil weevil to control EWM in four northern Wisconsin lakes (Knight and Havel 2016) follows two decades of previous research (Newman 2004). In some lakes, the milfoil weevil appears to be an effective control while in others the weevil is less effective (Newman 2004, Reeves et al. 2008). In Minnesota lakes, Newman and Biesboer (2000) suggested that

weevil densities reaching 1.5 weevils/stem were adequate to control EWM, while lower densities initiated EWM declines in some instances. A study using EWM enclosures in Vermont observed declines in EWM with a weevil density of 1.4 weevils/stem (Creed and Sheldon 1995). Parsons et al. (2011) conducted an augmentation experiment from 2002–2008 in a Washington lake. They reported weevil densities that ranged from zero weevils per stem in 2002 to 0.29 weevils per stem in 2008, though they sampled during different months in the different years which could confound the reported densities (Parsons et al. 2011). Although higher densities were ideal in initiating EWM declines, Newman (2004) summarized reports of EWM declines with a wide range of weevil densities (0.07–2.4 weevils per stem) in field and laboratory studies. Generally, the milfoil weevil occurs naturally in numbers too low to control EWM (Newman 2004), so its population must be augmented to densities that can control EWM. In a Washington lake, weevil augmentations over a 5 year period allowed weevil populations to establish and initiate significant declines in EWM (Parsons et al. 2011). In the current study lakes, milfoil weevils were stocked in just a single year, which had little or no effect on increasing weevil densities or negatively affecting EWM (Knight and Havel 2016).

Fate of Milfoil Weevil Populations

The fate of milfoil weevils and factors affecting their survival at individual life stages is relatively unknown. The adult weevil is about 3 mm long and conspicuously yellow and black in color. They are relatively poor swimmers (Reeves and Lorch 2011) and are fairly active while climbing around the apical meristem of the milfoil (pers. obs.). Their conspicuous color and increased activity may increase their vulnerability to sight

predators such as insectivorous fishes. In diet and enclosure studies in Vermont, yellow perch did not consume or have an effect on the density of milfoil weevils (Creed and Sheldon 1992, Creed et al. 1993). Similarly, Sutter and Newman (1997) found weevils in the stomachs of bluegill and pumpkinseed, but not yellow perch. Therefore, bluegill have the potential to negatively affect weevil populations.

Adults are also dependent on undeveloped shoreline habitat to survive the winter (Newman et al. 2001). Weevil larvae spend most of their time inside the stem mining the central tissue and are generally thought to be protected from fish predation (Sutter and Newman 1997, Newman 2004). However, the larvae will leave the interior and crawl on the exterior of the stem to move around nodes and also to find a location to pupate (Newman 2004). During those periods, the larvae are more vulnerable to fish predators. Such behavior may explain occasionally high densities of larvae in my bluegill diet samples. Pupae are immobile and likely protected from predation within the pupal chambers inside the EWM stem (Newbrough 1993, Sutter and Newman 1997).

Weevil Densities in the Environment

Weevil densities from environmental samples collected in my study were much lower than the densities for the same lakes and study period reported by Knight and Havel (2016) (cf. Tables 11 and 16). For the main project, weevils per stem were lowest in Manson Lake (0.10 weevils/stem) and highest in Little Bearskin Lake (0.73 weevils/stem). Although this trend was also true of environmental samples from my study, the much lower densities I detected (ca. 0.02 weevils/stem) suggests that many weevils were missed in my study. There are two chief sources of this underestimate.

First, because of the large number of invertebrates I counted from environmental samples (Appendix E), it was not practical to filter and identify the eggs. Eggs are often the dominant life stage counted, particularly when the weevils are most abundant early in the summer (Knight and Havel 2016). A second source of underestimation is with larvae (the next most dominant stage). Since larvae typically spend the majority of time burrowed in the stem, Knight and Havel (2016) dissected each EWM stem in order to discover these hidden larvae. Such an approach was not included in the methods of the current study.

Densities reported by Knight and Havel (2016) were highly variable across years and typically declined throughout the summer in all four lakes. In Fish Lake, Wisconsin, Lillie (2000) reported similar annual fluctuations and declines over summer in weevil densities. From 1995–1998, weevil densities averaged 0.065 weevils per stem (Lillie 2000). In a survey of 31 Wisconsin lakes with confirmed weevil populations, Jester et al. (2000) found weevil densities to range from undetectable to 2.5 weevils per stem. Although weevil densities greater than 1.0 weevil per EWM stem seem to be able to control EWM, lower densities (>0.1 weevils per stem) may sometimes effect control (Newman 2004).

Weevils in Bluegill Diet Samples

The low frequency of occurrence of weevils in bluegill diet samples is likely a result of low weevil densities in the lakes. Although weevils occurred infrequently in bluegill diet samples, they sometimes occurred in high numbers in the individual bluegill that had consumed them. Prior studies indicated epiphytic invertebrates exhibit a high degree of spatial variability (Downing and Cyr 1985, Cheruvelil et al. 2000, Alwin et al.

2010). Thus it is not surprising that invertebrate densities observed in my environmental samples and fish diet samples were highly variable. Newbrough (1993) and Knight and Havel (2016) found high variability among individual EWM plants in their weevil densities, revealing the patchy distribution of weevils within the EWM bed. Such patchiness may account for the occasional high number of weevil larvae within individual diet samples if bluegill happen upon a particularly dense aggregation of weevils in the EWM bed.

An alternative explanation involves fish predation behavior. Several studies have shown significant variation in learning and foraging behavior among bluegill (Werner et al. 1981, Gotceitas and Colgan 1988, Ehlinger 1989, Colgan et al. 1991). "Fast-learners" may be more likely to take advantage of weevils as a novel food choice. This behavior would be reinforced on subsequent encounters with the weevil, causing the weevil to form a greater component of the diet in those individuals when compared to the population as a whole.

The presence of weevils in bluegill diet samples from my study reinforces several other studies that have shown that bluegill and other centrarchid sunfish will prey upon weevils. In a study conducted in two Minnesota lakes, Sutter and Newman (1997) found weevils in 27 out of 330 bluegill and pumpkinseed diets. Adult weevils were regularly consumed, but larvae were only rarely consumed (Sutter and Newman 1997). They predicted that the greatest effect of predation would be at high sunfish densities and low weevil densities (Sutter and Newman 1997). Ward and Newman (2006) found weevil densities to be negatively correlated with sunfish densities in the field and were highest within fishless enclosures. A fish enclosure experiment with varying bluegill densities

found a significant decrease in weevil densities in the highest fish density enclosures (Newbrough 1993). Predation was only substantial on weevil larvae (Newbrough 1993), a finding consistent with my results.

Ward and Newman (2006) suggested that centrarchid sunfish densities greater than 25–30 fish per 24-hour trapnet set would inhibit weevil populations (Ward and Newman 2006). Fish survey reports available for Long and Manson lakes suggested bluegill populations at much higher relative abundances than this. A 2011 early summer fyke netting survey in Long Lake yielded a catch of 99 bluegill (> 76 mm) per 24-hour net set (Eslinger et al. 2012). Bluegill length distribution was dominated by smaller fish (101–127 mm), and the high capture rate suggested an overabundant, stunted population (Eslinger et al. 2012). Fyke and mini-fyke nets set in Manson Lake yielded 72.6 and 30.2 bluegill per 24-hour net set, respectively (Kubisiak 2007).

Composition of Bluegill Diet Samples

In the current study, weevils were rarely present in the bluegill diet samples. This result is consistent with studies that indicated bluegill will rarely feed on coleopterans (Flemer 1959, Gerking 1962). Chironomids formed the main component of bluegill diet samples from Boot and Little Bearskin lakes and environmental samples from all lakes. Oligochaetes were common in environmental samples, but absent in diet samples. This result could be due to an avoidance of this group. More likely, the absence of oligochaetes in bluegill diet samples may be due to their soft-bodied nature and short digestion time; oligochaetes would only be observed in the diet if they were consumed shortly before fish capture (Kennedy 1969). Bluegills from the four lakes differed in the

zooplankton they consumed. Fish from all lakes except Little Bearskin consumed more pelagic cladocerans than littoral cladocerans. Although no pelagic zooplankton samples were collected to determine community composition, Little Bearskin Lake is heavily vegetated (pers. obs., Wisconsin DNR unpublished data). The lake-wide prevalence of macrophytes could support a more littoral zooplankton community which would account for the higher composition of littoral Cladocera in the diet samples from Little Bearskin.

Bluegill undergo multiple ontogenetic niche shifts during their life; larval bluegill feed on pelagic zooplankton in the open water before moving to the protection of dense macrophytes as juveniles (<100 mm) (Mittelbach 1981, Mittelbach and Osenberg 1993). Dense macrophyte beds provide a refuge from predators while decreasing foraging efficiency of the sunfish (Savino and Stein 1982, Werner et al. 1983, Olson et al. 1998, Sass et al. 2006). After reaching a size that makes them less vulnerable to predation (>100 mm), bluegill return to the pelagic zone where foraging is more profitable (Mittelbach 1981). Adult bluegill, though opportunistic feeders, tend to have larger numbers of pelagic cladocerans in their diets (Mittelbach 1981, Mittelbach and Osenberg 1993). The higher densities of pelagic cladocerans found in bluegill diet samples from my study lakes suggest bluegill are using EWM beds as a refuge, but foraging in the open water adjacent to the EWM beds. If so, this behavior may limit their effect on weevil populations.

The tendency of epiphytic invertebrates to show high spatial variability (Downing and Cyr 1985, Cheruvelil et al. 2000, Alwin et al. 2010), coupled with variation in individual learning behavior of bluegill (Werner et al. 1981, Gotceitas and Colgan 1988, Ehlinger 1989, Colgan et al. 1991), may jointly account for the variability in diet

composition among bluegills observed in the current study. These factors make it harder to generalize about the potential effects that bluegill may have on weevil populations in the wild. Although a large number of individuals may fail to encounter the weevil or learn to use it as a food source, a few individuals who do may have a significant negative effect on weevil densities. The large numbers of weevil larvae in a few individual bluegill from my study suggest that such an effect could be happening in these Wisconsin lakes.

In many previous studies, weevil larvae were thought to be invulnerable to fish predation as they spend much of their time mining inside the EWM stem (Sutter and Newman 1997, Newman 2004). Results from my study and other previous research (Newbrough 1993) suggest otherwise. Further longer-term studies on weevil population dynamics, coupled with fish population dynamics, are needed to test whether predation on weevil larvae affects future weevil generations throughout the summer. Heavy predation on larvae at the start of the growing season, reducing numbers before they have a chance to mature, should greatly reduce reproductive potential. This process may be responsible for the downward trend in weevil densities throughout the summer found by Knight and Havel (2016).

Success of weevil stocking and EWM control programs will likely depend on an integrated pest management approach. Sunfish populations hiding in EWM beds may be managed by cutting channels through EWM beds, allowing piscivorous fish greater access to the beds (Engel 1987, 1995, Olson et al. 1998). Due to the unique life history of the weevil in which weevils are associated with a specific patch of EWM during the growing season, the weevil population within a lake likely takes on the source-sink characteristics of a metapopulation (Akçakaya et al. 1999). A study of milfoil weevil

genetics suggested a high degree of inbreeding while still maintaining a panmictic population (Roketenetz 2015), suggesting a degree of dispersal from localized patches. Establishing fish exclosure refuges in areas where weevils are stocked could ensure a source population of weevils capable of reestablishing others that have become extirpated. Due to the decision of EnviroScience Inc. to terminate its weevil rearing division (EnviroScience Inc. 2014), weevil stocking efforts will increasingly be dependent on the efforts of local lake associations.

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Table 1. Eurasian water-milfoil control methods. Summarized from Zhang and Boyle (2010).

Class	Method	Costs
Physical	Bottom barriers	$10,000–$20,000 per acre for professional installation.
	Suction harvesting	$20,000–$30,000 for equipment; $1,000–$25,000 per acre for operations/disposal.
	Hand harvesting	$400–$1,000 per acre
	Drawdown	Cost value unavailable.
	Rotovating	$100,000–$200,000 for equipment; $200–$300 per acre for operations; or $1,500 per acre to hire professional service
	Harvesting	$100,000–$200,000 for equipment; $200–$300 per acre for operations
Chemical	Aquatic herbicide	$200–$400 per acre
Biological	Herbivorous insects	Approximately $1,000 per acre for stocking.
	Grass carp	$50–$100 per acre for stocking.

Table 2. Previous studies of fish predation on the milfoil weevil.

Reference	State	Type	Summary
Newbrough (1993)	VT	Field (enclosures)	Weevil larvae densities were reduced under high bluegill density enclosures. Pupae and adults were unaffected.
		Lab	Bluegill consumed adult weevils.
Sutter and Newman (1997)	MN	Field (diets)	Weevils occurred in 7.5% of bluegill diets (23 out of 303) and 14.8% of pumpkinseed diets (4 out of 27) sampled from 2 lakes.
Creed and Sheldon (1992) and Creed et al. (1993), cited in Creed 2000)	VT	Field (enclosures and diets)	Yellow perch did not prey upon weevils.
Ward and Newman (2006)	MN	Field (enclosures)	Sunfish reduced weevil densities in enclosures.
Parsons et al. (2011)	WA	Field (diets)	1 weevil adult was found in a pumpkinseed during the study period.

Table 3. Study lake characteristics (SWIMS 2014). All lakes have a drainage hydrology.

Lake Name	County	Longitude	Latitude	Surface Area (ha)	Secchi depth(m)	Maximum depth (m)
Boot Lake	Vilas	-89.33	45.97	45.97	1.5	4.5
Little Bearskin Lake	Oneida	-89.70	45.71	26.55	1.8	8.1
Long Lake	Iron	-90.03	46.25	60.38	0.9	9.0
Manson Lake	Oneida	-89.63	45.56	38.20	4.8	16.2

Table 4. Sampling periods during summer 2014.

Time Period	Date	Fish*	Environmental samples
1	June 3–25	A, T	No
2	June 26–July 28	N	Yes
3	July 29–Aug 8	A, T	No

*Fish sampling methods: A—angling;
T—minnow traps; N—night electrofishing.

Table 5. Number of fish caught by species and sampling method. All EWM beds and sampling periods in summer 2014 pooled. For full species names, see Appendix A. Fish sampling methods: A—angling; T—minnow traps; N—night electrofishing.

Lake	Common Name	Sampling method			Total Fish	Number of diets*
		A	T	N		
Boot Lake	Black Crappie	3	0	7	10	10
	Bluegill	8	3	24	35	34
	Common Shiner	1	0	0	1	1
	Largemouth Bass	0	0	2	2	2
	Pumpkinseed	9	0	7	16	16
	Rock Bass	2	0	1	3	3
	White Sucker	0	0	1	1	0
	Yellow Perch	5	1	81	87	87
Little Bearskin Lake	Black Crappie	1	0	0	1	1
	Bluegill	69	30	57	156	146
	Largemouth Bass	2	1	5	8	8
	Central Mudminnow	0	0	2	2	0
	Northern Pike	0	0	1	1	0
	Pumpkinseed	17	6	18	41	41
	White Sucker	0	0	1	1	0
	Yellow Bullhead	0	0	2	2	0
	Yellow Perch	6	0	4	10	10
Long Lake	Black Crappie	0	0	3	3	3
	Bluegill	64	3	2	39	38
	Common Shiner	1	0	0	1	1
	Largemouth Bass	0	0	2	2	2
	Muskellunge	0	0	1	1	0
	Pumpkinseed	1	1	0	2	2
	Rock Bass	0	0	1	1	1
	Walleye	0	0	1	1	0
	Yellow Perch	50	1	45	90	90
Manson Lake	Bluegill	139	108	56	303	296
	Golden Shiner	1	0	6	7	0
	Largemouth Bass	1	0	12	13	13
	Pumpkinseed	2	2	6	10	9
	Rock Bass	6	3	5	14	14
	Walleye	0	0	1	1	0
	Yellow Perch	2	0	4	6	6

*Only bluegill diets were analyzed for this study.

Table 6. Catch per unit effort (CPUE) for bluegill captured using three sampling methods. Effort is averaged across time periods. For angling and minnow traps, CPUE is averaged from June and August time periods (June, July and August for Manson Lake). Electrofishing was conducted only during July. Effort units: Angling – 0.5 man-hours; Minnow Traps – 2 hour Trap sets; Electrofishing – minutes.

		Angling		Minnow Traps		Electrofishing	
Lake	Bed	CPUE	Mean Effort	CPUE	Mean Effort	CPUE	Mean Effort
Boot	A	0.42	2.6	0.00	8.8	0.67	6.0
	B	0.14	3.5	0.12	8.3	1.17	6.0
	C	0.39	2.3	0.06	9.9	0.43	7.0
	D	0.63	2.7	0.00	9.6	1.43	7.0
	Mean	**0.39**	**2.7**	**0.04**	**9.2**	**0.92**	**6.5**
Little Bearskin	A	4.68	1.7	0.12	10.7	2.78	9.0
	B	3.73	1.8	0.76	10.7	3.20	5.0
	C	5.53	1.8	0.24	9.8	1.83	6.0
	D	10.45	1.4	0.24	10.2	0.33	15.0
	Mean	**6.10**	**1.7**	**0.34**	**10.3**	**2.04**	**8.8**
Long	A	2.00	2.2	0.00	8.1	0.15	13.0
	C	3.86	2.3	0.12	7.2	0.00	5.0
	D	1.61	2.7	0.00	9.0	0.00	14.0
	F	2.81	1.5	0.00	9.4	0.00	6.0
	Mean	**1.86**	**2.3**	**0.03**	**8.8**	**0.04**	**9.5**
Manson	A	4.92	2.3	0.03	11.0	3.00	6.0
	B	8.55	1.7	0.07	11.5	1.57	7.0
	C	9.79	1.8	0.16	10.8	0.80	15.0
	D	5.52*	2.1*	2.44	9.9	1.15	13.0
	Mean	**7.35**	**2.0**	**0.71**	**10.8**	**1.63**	**10.3**

*Values missing for June.

Table 7A. ANOVA results for effects of lake, bed, and gear type on bluegill CPUE (expressed as catch/minute).

Source	DF	Adj SS	Adj MS	F	P
Lake	3	5.2794	1.75981	117.50	<0.0005
Bed(Lake)	12	3.9288	0.32740	21.86	<0.0005
Gear	2	15.5817	7.79085	520.17	<0.0005
Lake*Gear	6	6.7840	1.13067	75.49	<0.0005
Gear*Bed(Lake)	24	7.3255	0.30523	20.38	<0.0005
Error	40	0.5991	0.01498		
Total	87				

Table 7B. Tukey pairwise comparisons showing the effect of lake on mean CPUE. Comparisons based on pairwise 95% confidence intervals; those with different letters denote significantly different means.

Lake	N	Mean	Grouping
Little Bearskin	20	0.7	A
Manson	30	0.6	B
Boot	20	0.3	C
Long	18	0.0	D

Table 7C. Tukey pairwise comparisons showing the effect of gear type on mean CPUE. Comparisons based on pairwise 95% confidence intervals; those with different letters denote significantly different means.

Gear Type	N	Mean	Grouping
Electrofishing	16	1.2	A
Angling	34	0.1	B
Trapping	38	0.0	C

Table 8A. ANOVA results for effects of lake and gear type on mean bluegill length.

Source	DF	Adj SS	Adj MS	F	P
Lake	3	10568	3523	6.63	<0.0005
Gear	2	80969	40484	76.24	<0.0005
Lake*Gear	6	25593	4265	8.03	<0.0005
Error	478	253838	531		
Total	489				

Table 8B. Tukey pairwise comparisons showing the effect of lake on mean bluegill length. Comparisons based on pairwise 95% confidence intervals; those with different letters denote significantly different means.

Gear	N	Mean	Grouping
Angling	242	138.8	A
Electrofishing	138	93.3	B
Minnow traps	110	79.6	B

Table 8C. Tukey pairwise comparisons showing the effect of gear type on mean bluegill length. Comparisons based on pairwise 95% confidence intervals; those with different letters denote significantly different means.

Lake	N	Mean	Grouping
Long	39	118.1	A
Boot	34	111.0	A
Little Bearskin	156	93.8	B
Manson	261	92.7	B

Table 9. Total length of bluegill sunfish collected during 3 time periods in summer 2014. Sampling method targeted smaller-sized fish. Time period: 1—June 3-25, 2—June 26 – July 28, 3—July 29 – August 8. N = number of fish sampled.

Lake	Time Period	N	Total Length (mm)		
			mean	min	max
Boot	1	9	146	54	181
	2	23	92	32	192
	3	2	116	106	125
	Total	**34**	**107**	**32**	**192**
Little Bearskin	1	49	104	54	169
	2	58	88	57	130
	3	49	110	54	168
	Total	**156**	**100**	**54**	**169**
Long	1	18	124	101	154
	2	2	114	111	116
	3	19	135	115	162
	Total	**39**	**129**	**101**	**162**
Manson	1	68	131	43	200
	2	150	85	31	180
	3	43	124	57	176
	Total	**261**	**103**	**31**	**200**

Table 10. Number of bluegill diet samples containing weevils, summer 2014.

Lake	Diets with weevils			Diets
	Larvae	Adults	Total	Analyzed
Boot Lake				
A	0	0	0	6
B	0	0	0	3
C	0	0	0	6
D	0	0	0	12
Total	**0**	**0**	**0**	**27**
Little Bearskin Lake				
A	0	1	1	40
B	0	0	0	37
C	0	1	1	31
D	0	0	0	31
Total	**0**	**2**	**2**	**139**
Long				
A	0	1	1	10
C*	3	2	4	10
D	0	0	0	8
F	0	0	0	9
Total	**3**	**3**	**5**	**37**
Man				
A	0	1	1	47
B	0	0	0	48
C	0	0	0	45
D	4	1	5	99
Total	**4**	**2**	**6**	**239**
PROJECT TOTAL	**7**	**7**	**13**	**442**

*One diet from Long Bed C contained both 9 weevil larvae and 1 adult. 1 diet was subtracted from the total columns to counting it twice.

Table 11. Number of weevils detected in the current study. All beds pooled. Weevil counts are shown, with the number of fish diets sampled in parentheses. Environmental samples collected from 40 plants except in Long Lake (30 plants).

Lake	Diet						Environmental
	June		July		August		July
Boot Lake							
Larvae	0	(8)	0	(17)	0	(2)	0
Adult	0	(8)	0	(17)	0	(2)	0
Little Bearskin Lake							
Larvae	0	(43)	0	(47)	0	(49)	1
Adult	2	(43)	0	(47)	0	(49)	1
Long Lake							
Larvae	77	(43)	0	(2)	0	(19)	1
Adult	2	(43)	0	(2)	1	(19)	0
Manson Lake							
Larvae	37	(62)	0	(133)	0	(44)	0
Adult	2	(62)	0	(133)	0	(44)	0

Table 12. Weevil densities from main weevil study (Knight and Havel 2016). Densities pooled across 4 beds. 2013: n = 20 EWM stems per bed; 2014: n = 50 EWM stems per bed.

Date	Density (%)				Total Density
	Eggs	Larvae	Pupae	Adults	(#/stem)
Boot Lake					
2013					
June	66.0	26.0	5.0	3.0	1.40
July	70.0	15.0	9.0	5.0	0.93
August	16.0	70.0	8.0	7.0	1.44
September	3.0	5.0	5.0	87.0	0.48
2014					
June	72.9	18.3	0.0	8.8	0.92
July	43.7	50.1	0.4	5.9	0.62
August	30.5	53.7	7.4	8.5	0.24
Little Bearskin Lake					
2013					
June	59.0	27.0	9.0	5.0	1.06
July	0.0	100.0	0.0	0.0	0.05
August	46.0	31.0	3.0	0.0	0.16
September	0.0	29.0	29.0	43.0	0.09
2014					
June	53.8	43.5	0.0	2.7	0.93
July	55.9	41.4	1.4	1.4	0.73
August	28.6	45.5	9.1	16.9	0.39
Long Lake					
2013					
June	54.0	36.0	3.0	7.0	1.63
July	60.0	24.0	13.0	2.0	1.13
Aug	40.0	38.0	4.0	18.0	0.98
September	0.0	20.0	10.0	70.0	0.13
2014					
June	69.6	19.6	0.0	10.8	0.51
July	50.2	33.2	12.5	4.2	0.24
Aug	35.3	29.4	14.7	20.6	0.17
Manson Lake					
2013					
June	61.0	35.0	3.0	0.0	0.39
July	33.0	58.0	8.0	0.0	0.15
Aug	0.0	75.0	25.0	0.0	0.05
September	0.0	0.0	0.0	0.0	0.00
2014					
June	40.0	60.0	0.0	0.0	0.03
July	30.0	70.0	0.0	0.0	0.10
Aug	20.0	60.0	20.0	0.0	0.03

Table 13. Wilcoxon Signed-Rank Test statistics from Boot Lake, based on 16 fish. The null hypothesis for Manly-Chesson's α represents neutral selection and depends on the number of prey groups. Boot Lake had 8 common prey groups ($\bar{P}_i \geq 0.05$, Figure 13) and hence $H_0 = 0.125$.

Prey Group	Manly-Chesson's α		Wilcoxon Signed Rank Test	
	H_0	Median	Statistic	p-value
Amphipoda	0.125	0.472	126	0.020
Daphnia sp.	0.125	0.05411	35	0.052
Pelagic Cladocerans	0.125	0	75	0.962
Littoral Cladocerans	0.125	0.001615	0	<0.0005
Ostracoda	0.125	0.000627	17	0.005
Chironomidae	0.125	0.03553	28	0.023
Gastropoda	0.125	0	0	<0.0005
Oligochaeta	0.125	0	0	<0.0005

Table 14. Wilcoxon Signed-Rank Test statistics from Little Bearskin Lake, based on 46 fish. The null hypothesis for Manly-Chesson's α represents neutral selection and depends on the number of prey groups. Little Bearskin Lake had 7 common prey groups ($\bar{P}_i \geq 0.05$, Figure 14) and hence $H_0 = 0.143$.

Prey Group	Manly-Chesson's α		Wilcoxon Signed Rank Test	
	H_0	Median	Statistic	p-value
Littoral Cladocerans	0.143	0.01015	136	<0.0005
Ostracoda	0.143	0.01317	96	<0.0005
Chironomidae	0.143	0.1719	648	0.242
Ephemeroptera	0.143	0.4553	945	<0.0005
Trichoptera	0.143	0.04686	388	0.097
Gastropoda	0.143	0.01114	46	<0.0005
Oligochaeta	0.143	0	0	<0.0005

Table 15. Wilcoxon Signed-Rank Test statistics from Manson Lake, based on 129 fish. The null hypothesis for Manly-Chesson's α represents neutral selection and depends on the number of prey groups. Manson Lake had 8 common prey groups ($\bar{P}_i \geq 0.05$, Figure 15) and hence $H_0 = 0.125$.

	Manly-Chesson's α		Wilcoxon Signed Rank Test	
Prey Group	H_0	Median	Statistic	p-value
Daphnia sp.	0.125	0.4997	7007.0	<0.0005
Pelagic Cladocerans	0.125	0.001259	1131.0	<0.0005
Littoral Cladocerans	0.125	0.0012	1578.0	<0.0005
Cyclopoida	0.125	0	640.0	<0.0005
Ostracoda	0.125	0.00061	2200.0	<0.0005
Chironomidae	0.125	0.01465	2546.0	<0.0005
Gastropoda	0.125	0	1036.0	<0.0005
Oligochaeta	0.125	0	0.0	<0.0005

Table 16. Weevil densities (reported as weevils/stem) from 4 study lakes. Numbers in parentheses represent the number of EWM stems examined.

Lake	(Knight and Havel 2016)		Current study
	2013	2014	2014
Boot	0.93 (80)	0.62 (200)	0.00 ()
Little Bearskin	0.05 (80)	0.73 (200)	0.10 (21)
Long	1.13 (80)	0.24 (200)	0.04 (26)
Manson	0.15 (80)	0.10 (200)	0.00 (40)*

* Represents entire sample, individual stems were not counted.

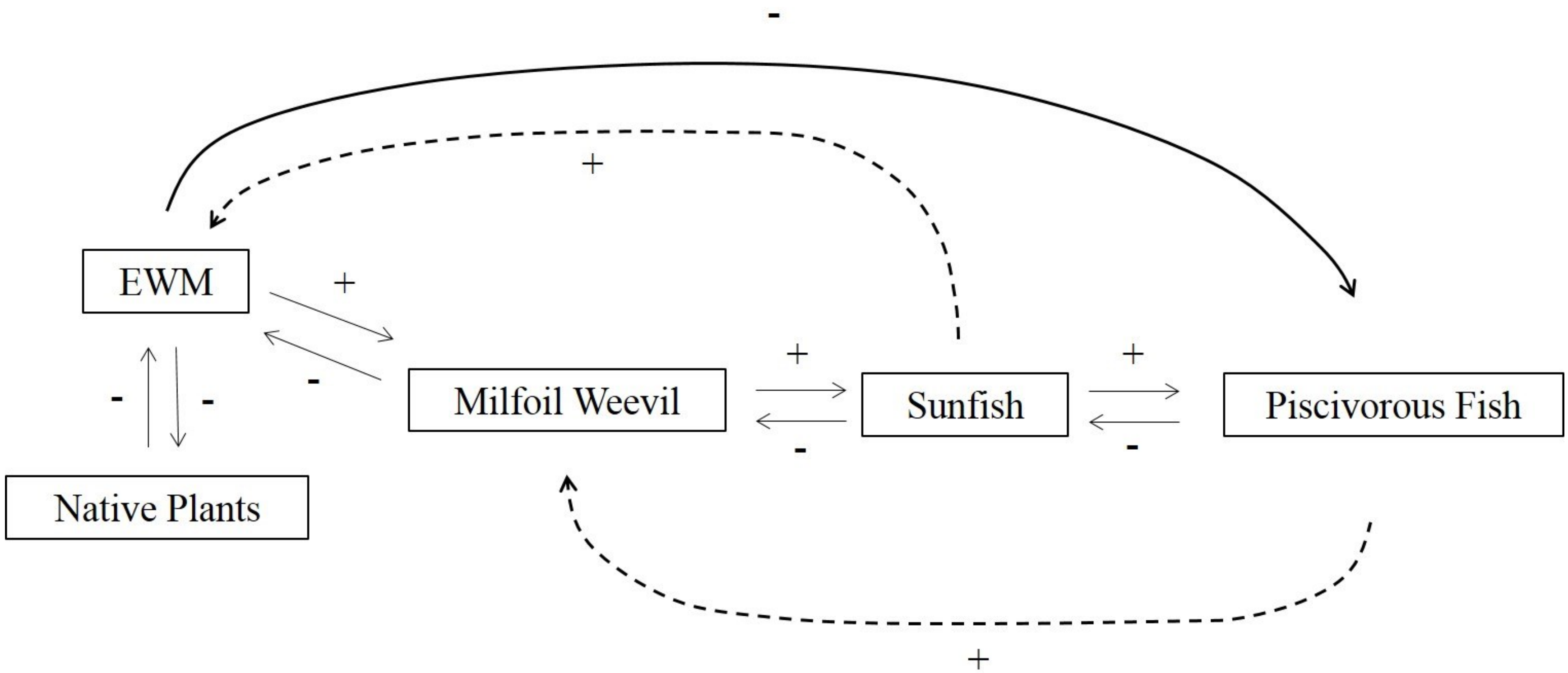

Figure 1. Hypothesized lake food web. Arrows indicate the direction of the interaction, (+) and (-) indicate whether the interaction is positive or negative. Solid lines signify a direct effect while dotted lines signify an indirect effect. Eurasian water-milfoil (EWM) has a direct negative effect on piscivorous fish by limiting their foraging efficiency and access to refuging sunfish. Sunfish have an indirect positive effect on EWM by reducing milfoil weevil populations. Piscivorous fish have an indirect positive effect on the milfoil weevil by controlling sunfish populations. By excluding piscivorous fish, EWM establishes a trophic cascade in which unchecked sunfish populations reduce weevil populations, thereby further facilitating the spread of EWM.

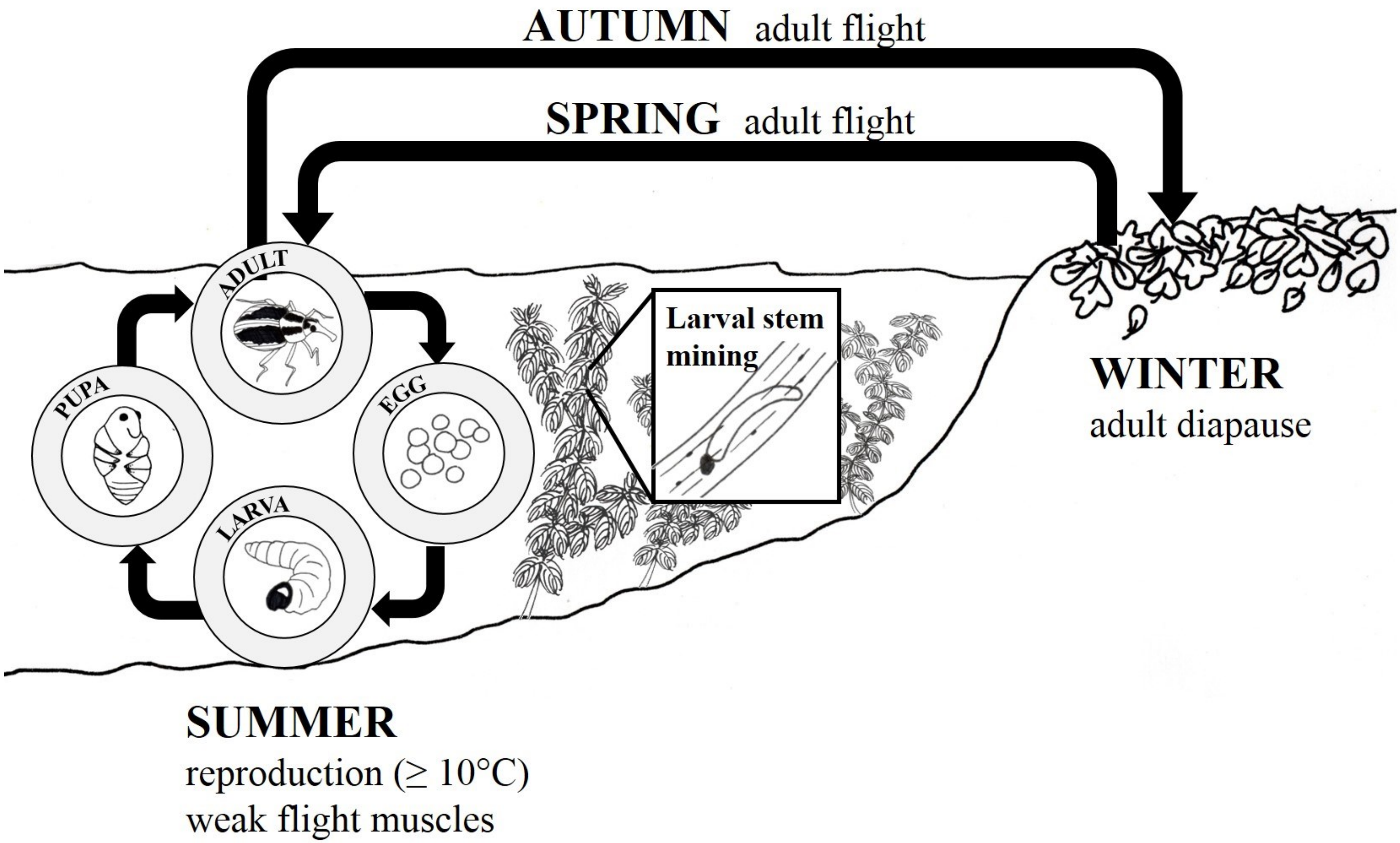

Figure 2. Life cycle of the milfoil weevil, *Euhrychiopsis lecontei*. Diagram created by Ann Wempe.

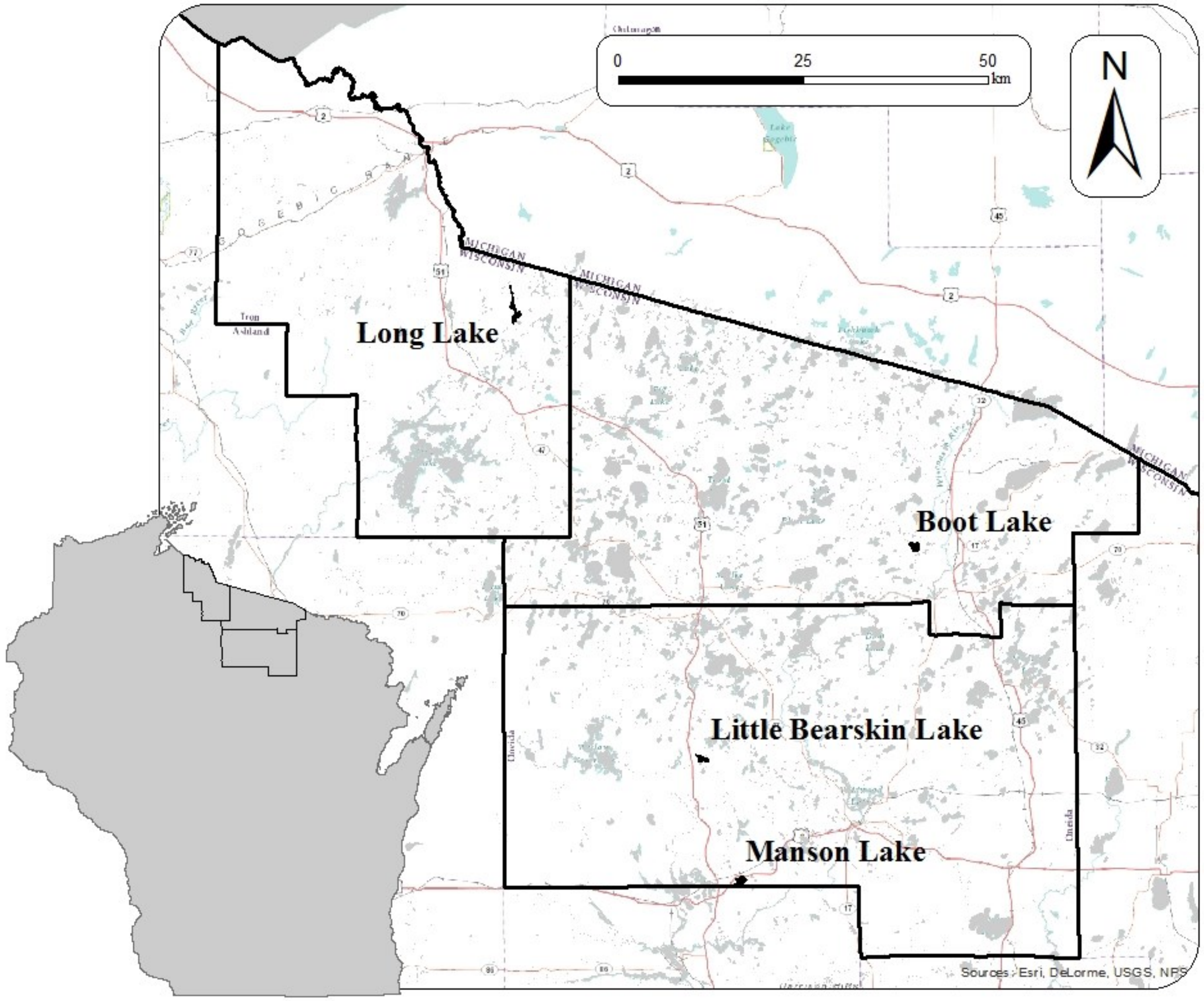

Figure 3. Location of the study lakes.

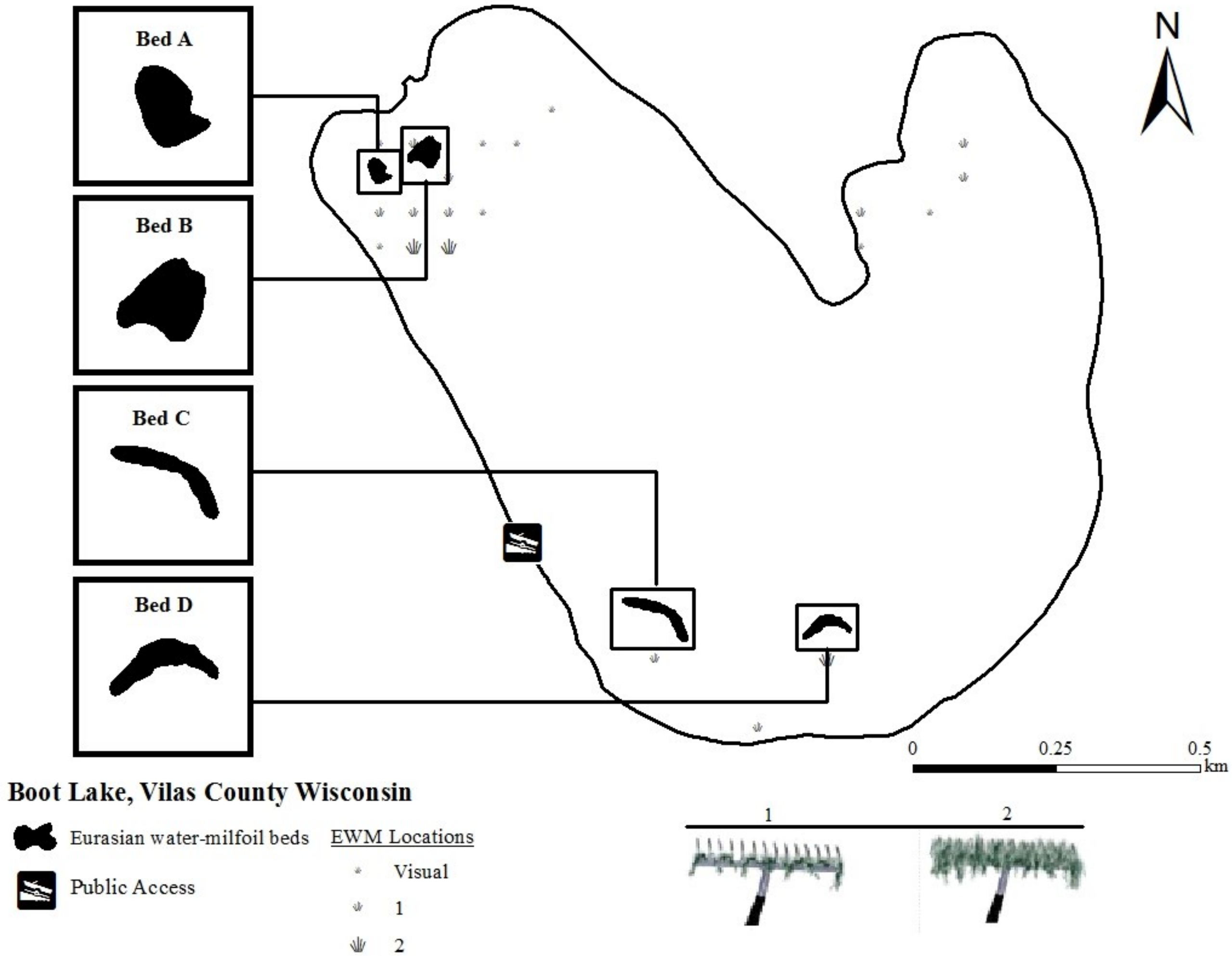

Figure 4. Boot Lake project map. EWM locations show densities as rank data (EWM rake fullness), based on a Point-Intercept (PI) survey conducted by Wisconsin Department of Natural Resources in summer 2013.

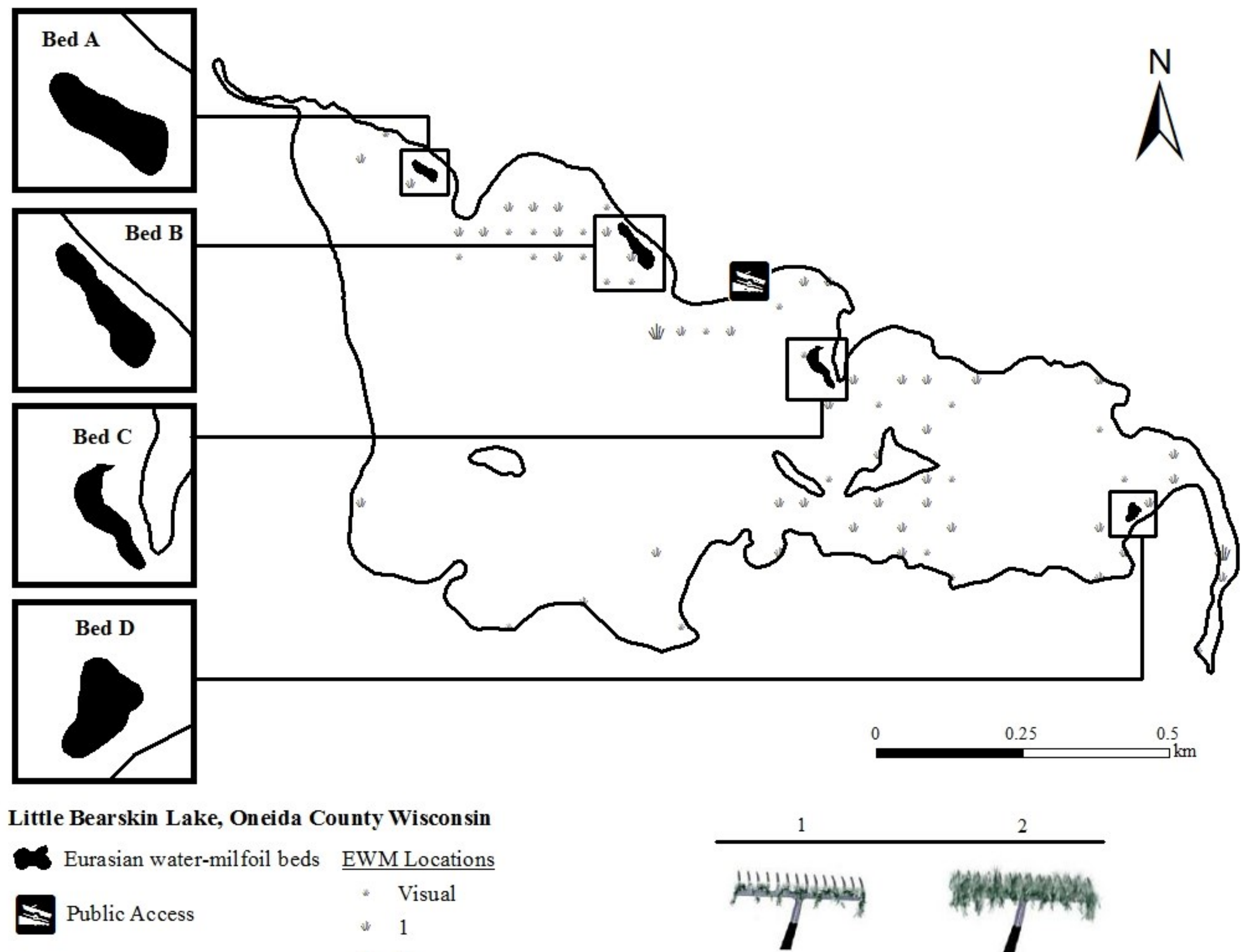

Figure 5. Little Bearskin Lake project map. EWM locations show densities as rank data (EWM rake fullness), based on a Point-Intercept (PI) survey conducted by Wisconsin Department of Natural Resources in summer 2013.

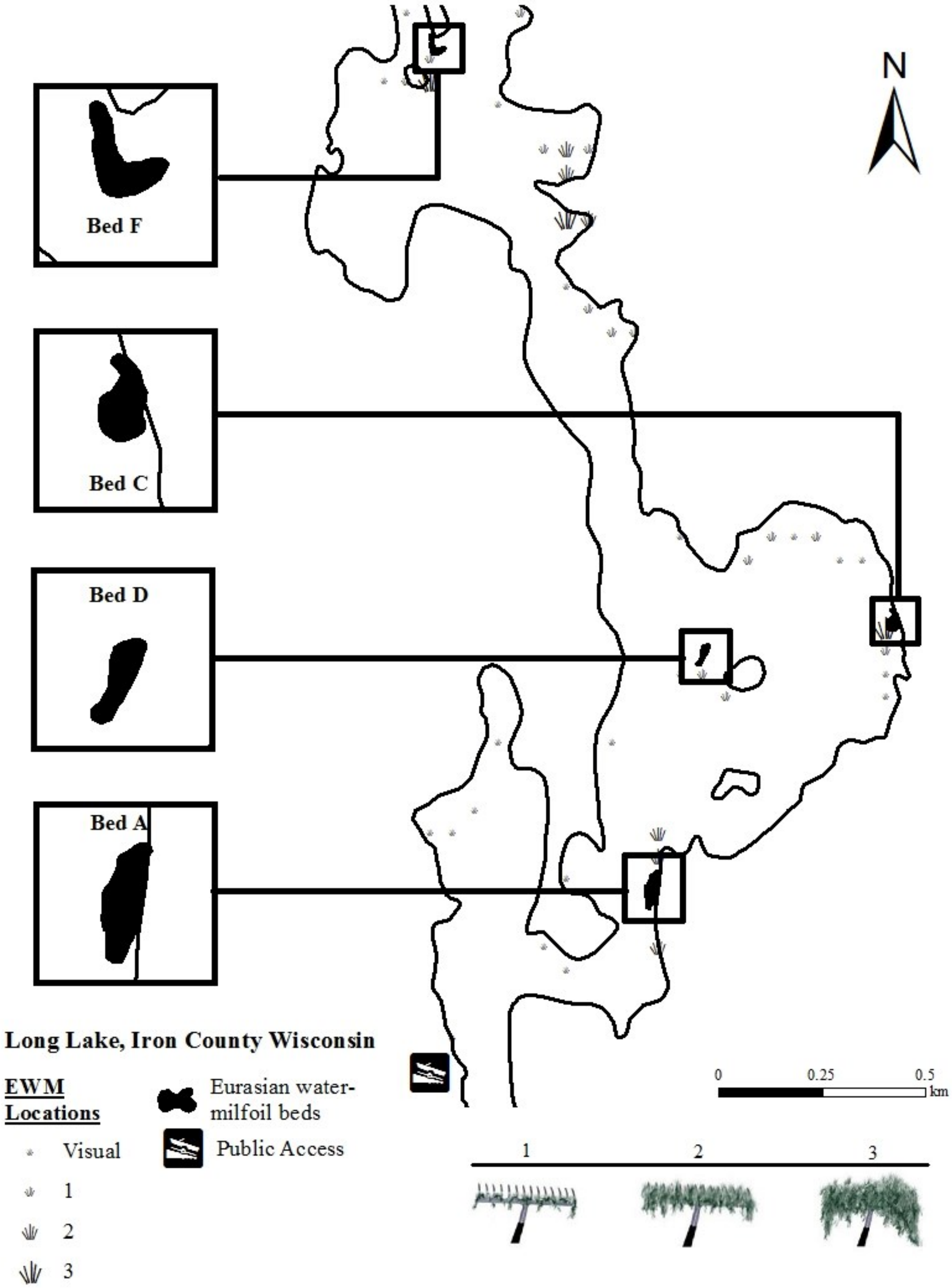

Figure 6. Long Lake project map. EWM locations show densities as rank data (EWM rake fullness), based on a Point-Intercept (PI) survey conducted by Wisconsin Department of Natural Resources in summer 2011.

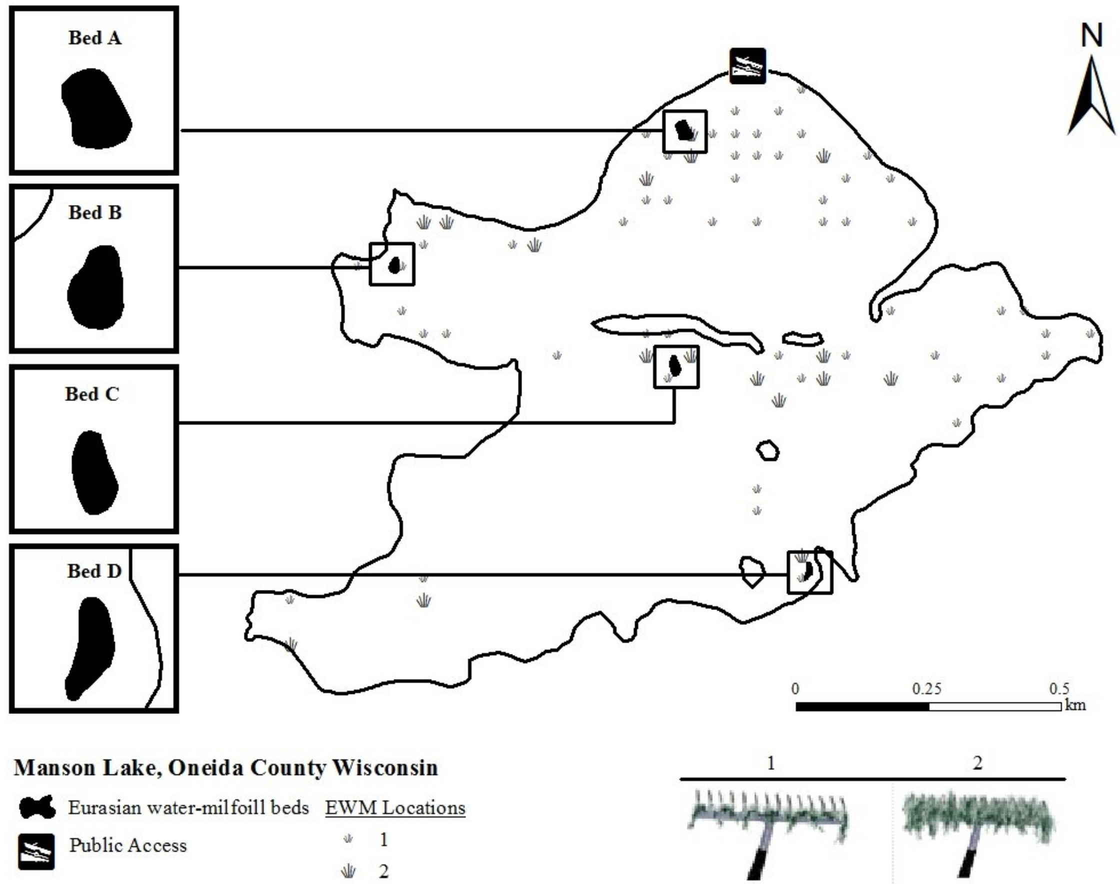

Figure 7. Manson Lake project map. EWM locations show densities as rank data (EWM rake fullness), based on a Point-Intercept (PI) survey conducted by Wisconsin Department of Natural Resources in summer 2014.

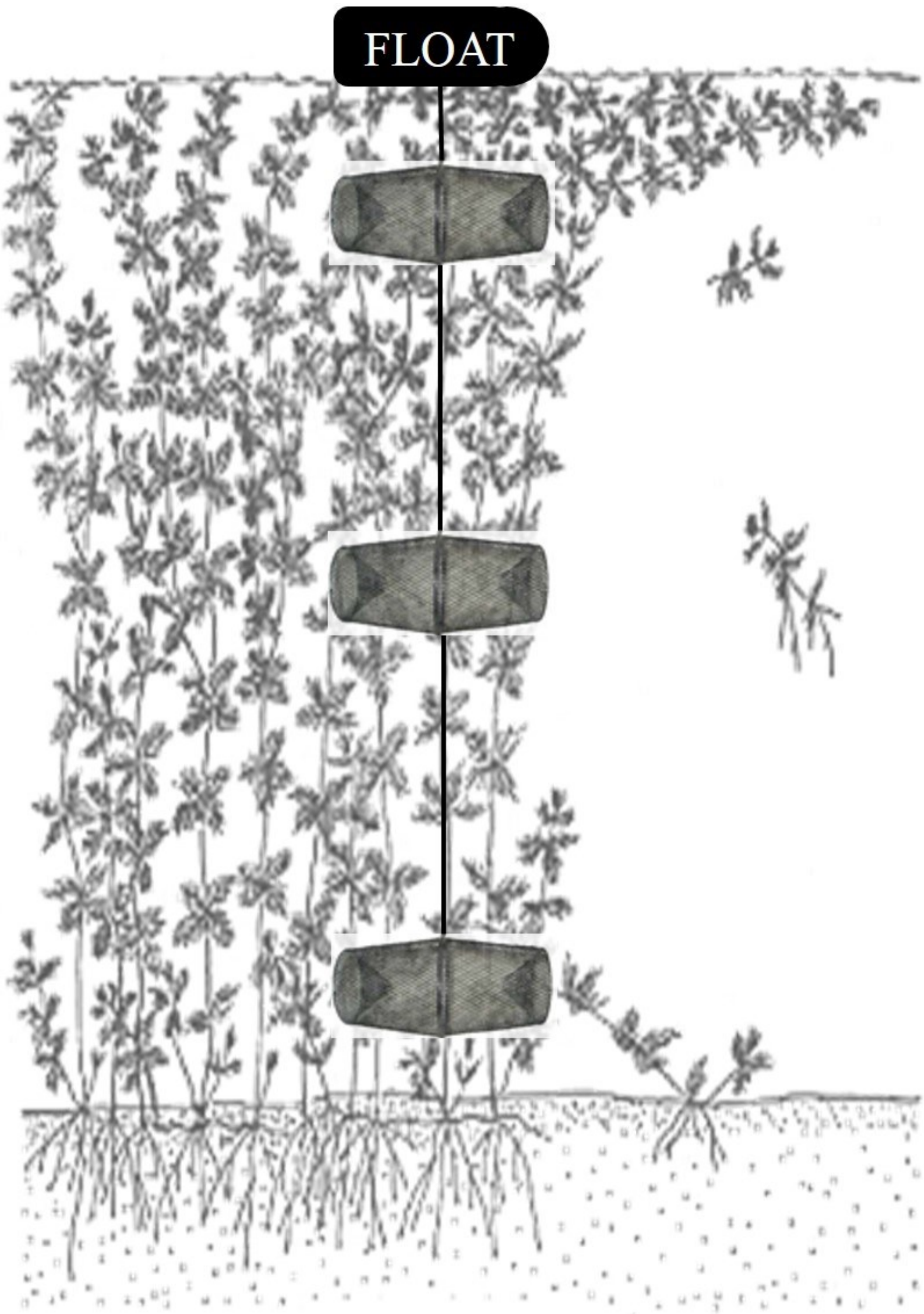

Figure 8. Minnow trap set configuration. Traps were suspended by a bullet float and hung in tiers of 3, ca. 0.3 m apart. Trap aperture was 38.0 mm (± 0.4 mm).

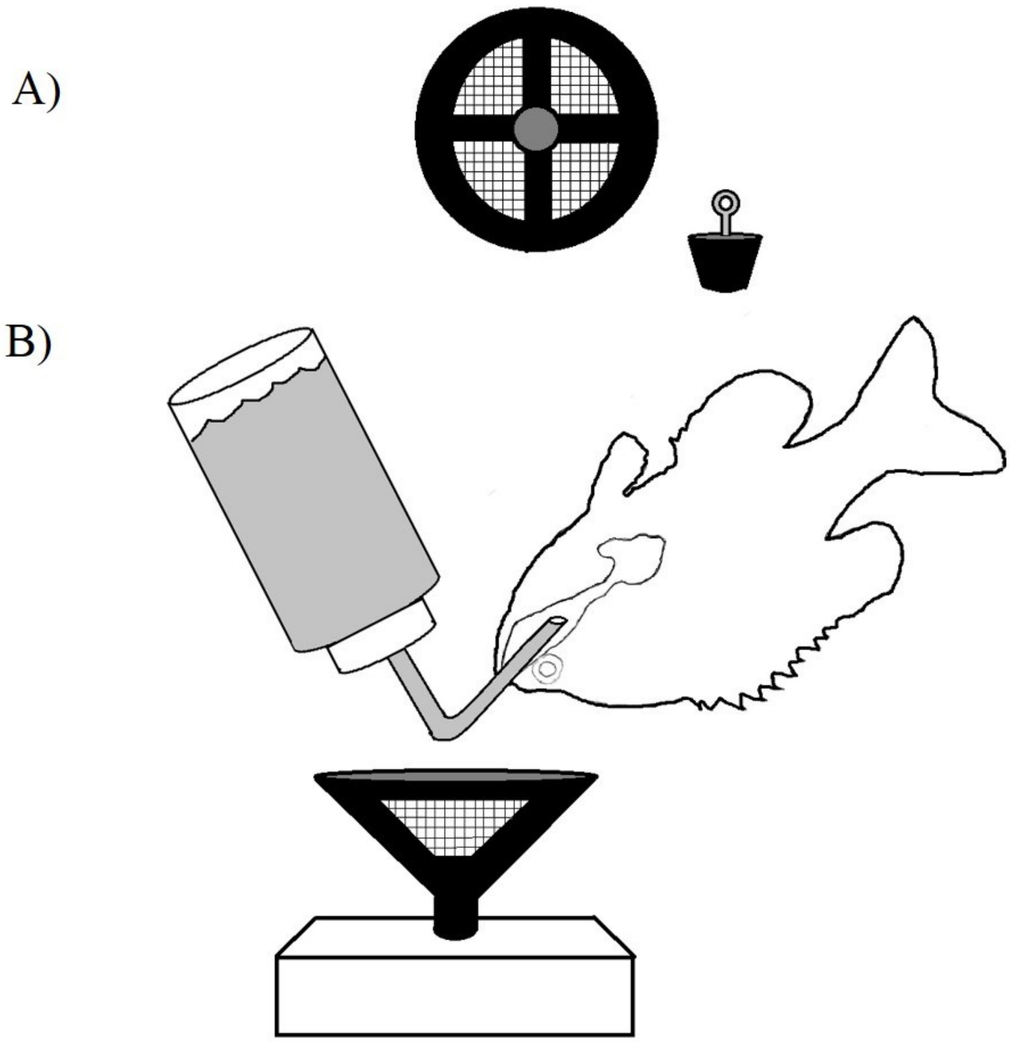

Figure 9. Method for collecting fish diet samples by gastric lavage. A) Top view of modified 20 cm diameter funnel. Four panels were cut out and covered with 200 µm Nitex mesh. A #6 black rubber stopper fitted with an eye hook for easy removal was used to plug the center hole during diet collection. B) A small section of wood block was used to stabilize the funnel during diet collection.

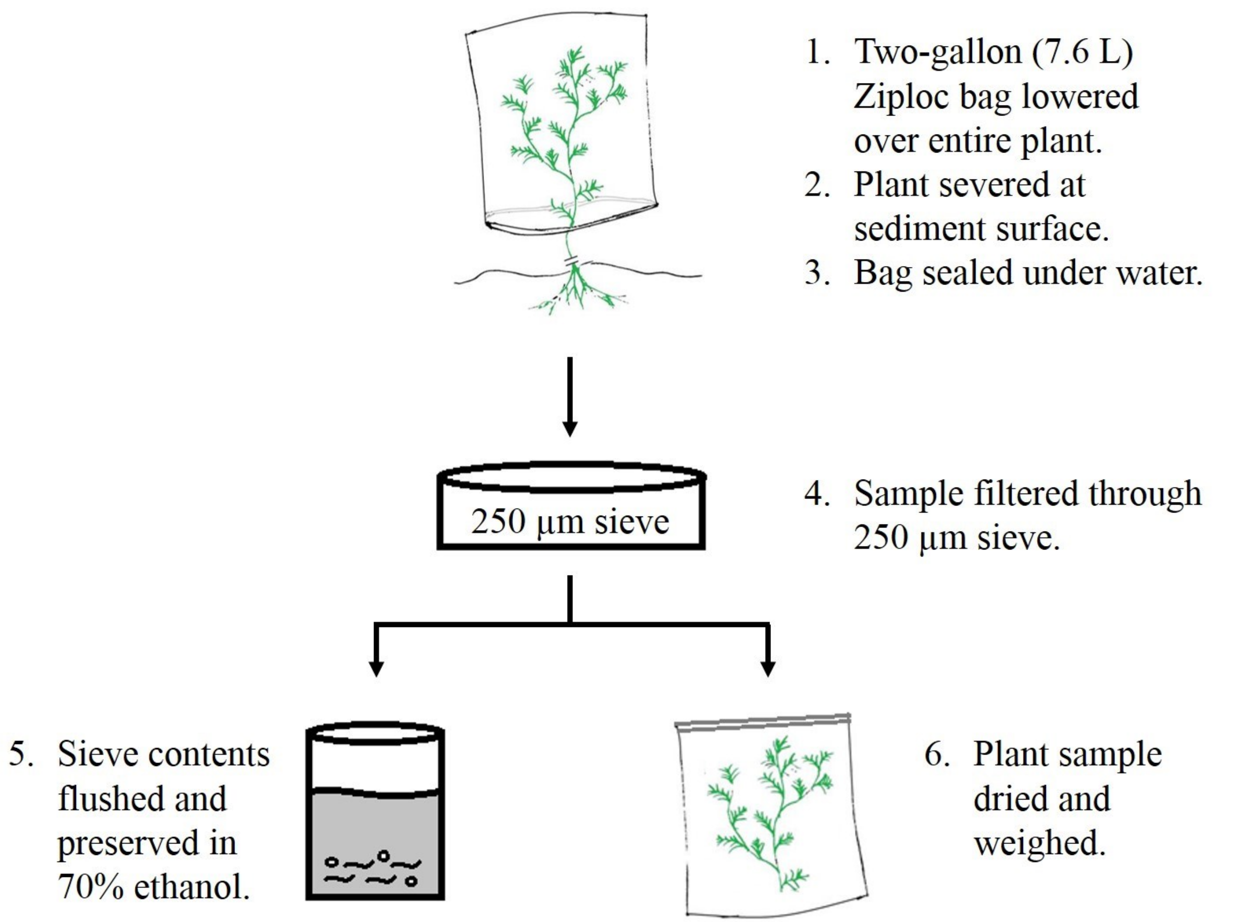

Figure 10. Method for collecting environmental samples.

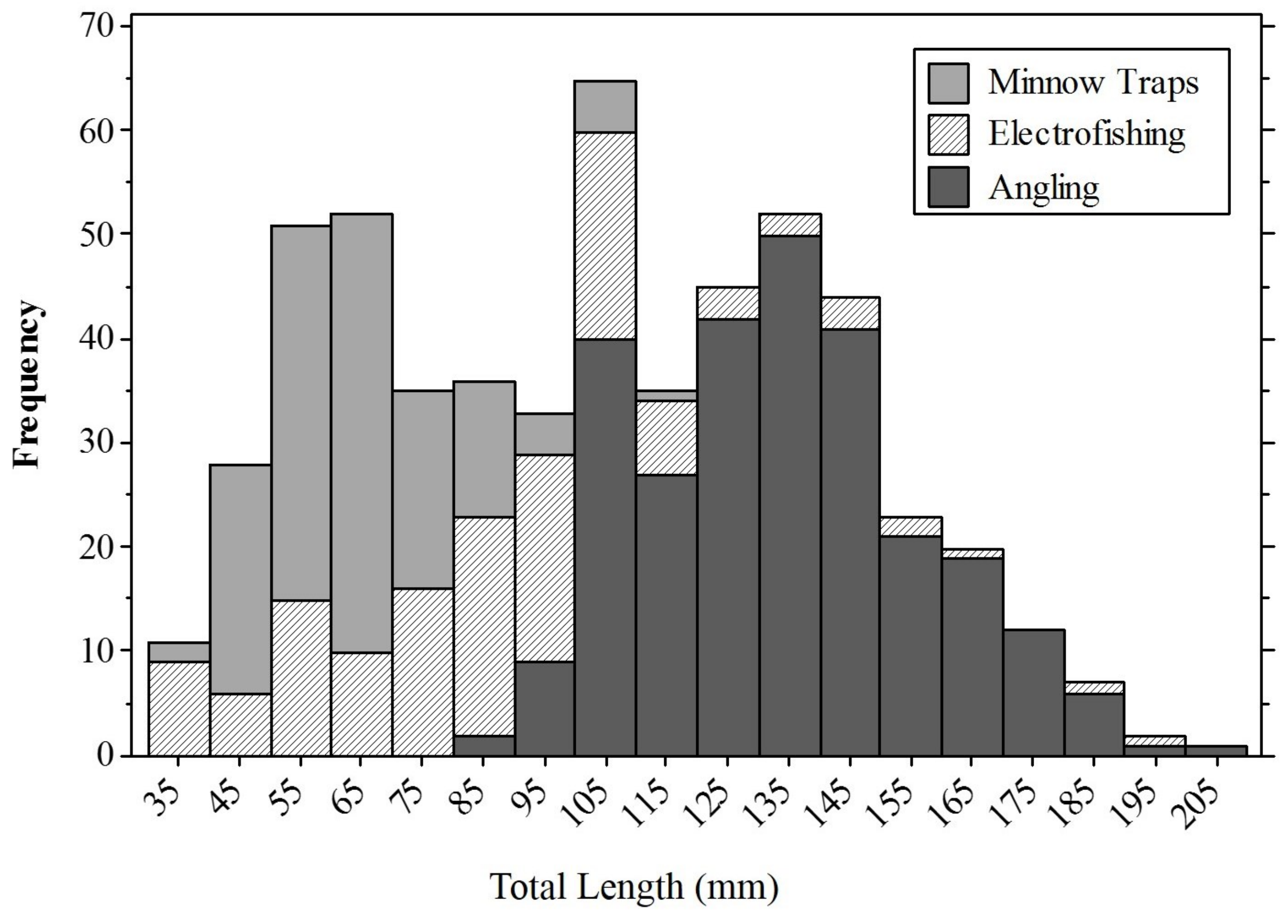

Figure 11. Bluegill length-frequency distribution, pooled from 4 study lakes (Figure 3), sampled June 3 – August 8, 2014. Tick mark represents bin midpoint.

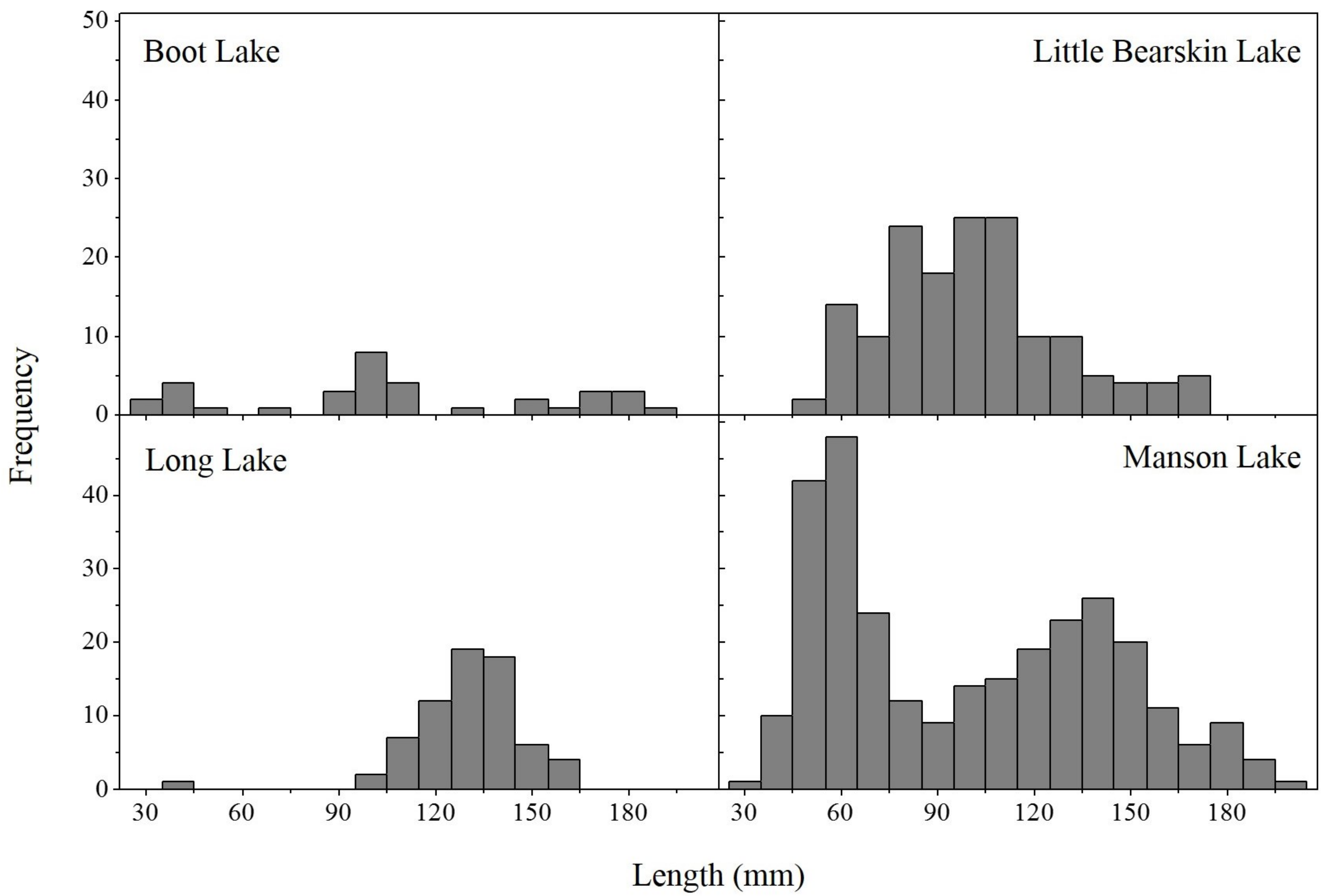

Figure 12. Length distribution of bluegill by lake. All methods pooled.

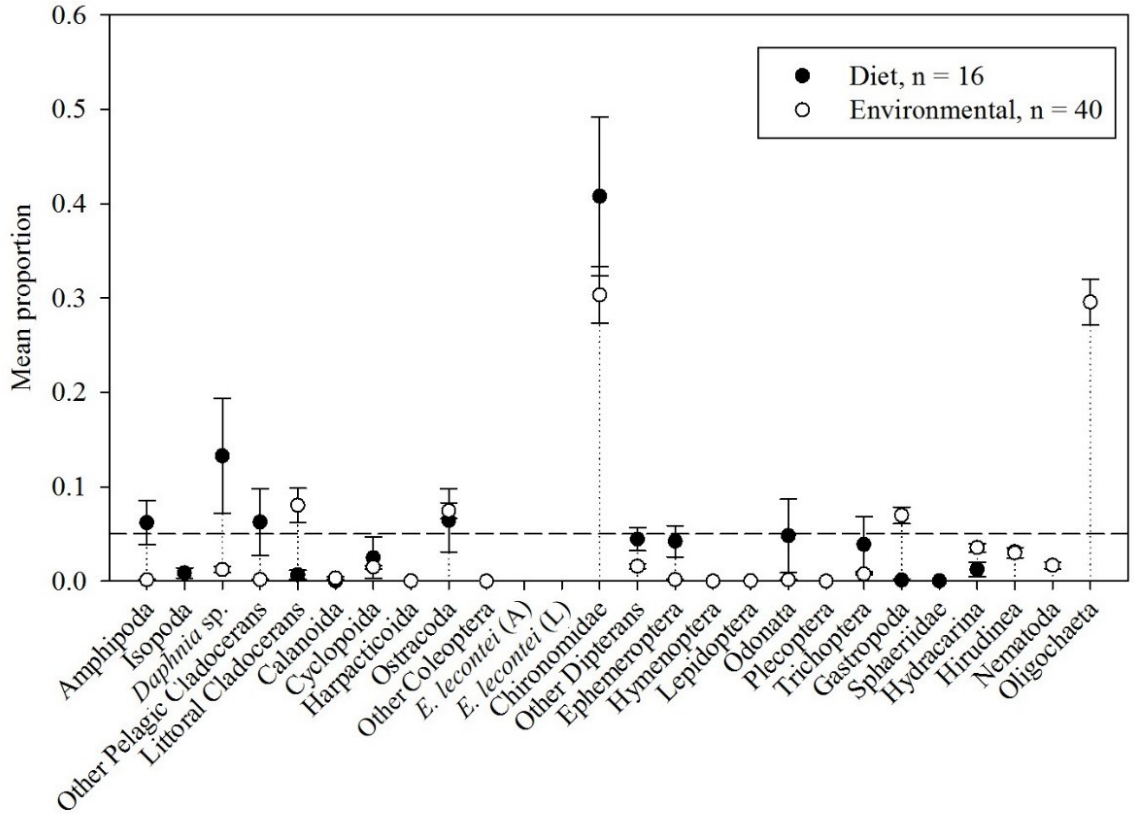

Figure 13. Proportions of each taxonomic group in Boot Lake, based on counts of 16 bluegill diet samples and 40 environmental samples, 4 beds pooled, collected in July 2014. Mean ± SE. Taxa that make up less than 5% (fall below the dotted line) of the counts from both environmental and diet samples are considered to be too rare to provide an accurate estimate of electivity. Sample sizes (n): diets—number of fish, environmental—number of plants. The taxonomic list is from all lakes combined, with some taxa missing from individual lakes. See Appendices D and F for complete lists of $\bar{P}_i$ for diet and environmental samples from each lake.

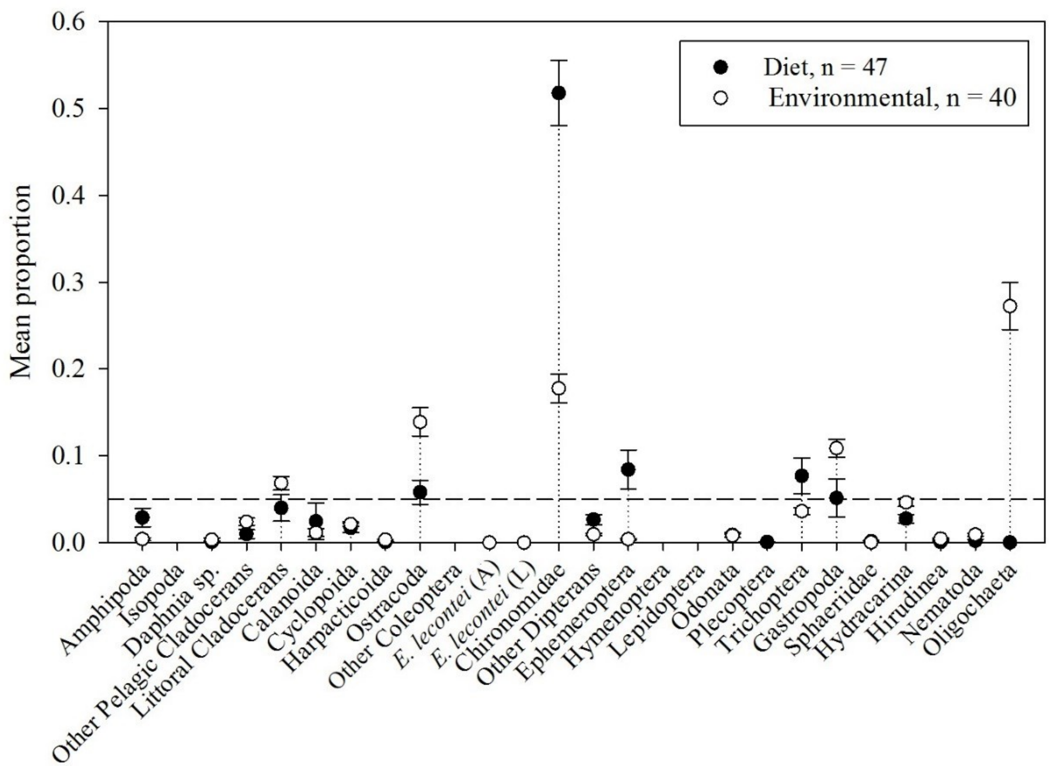

Figure 14. Proportions of each taxonomic group in Little Bearskin Lake, based on counts of 47 bluegill diet samples and 40 environmental samples, 4 beds pooled, collected in July 2014. Mean ± SE. Taxa that make up less than 5% (fall below the dotted line) of the counts from both environmental and diet samples are considered to be too rare to provide an accurate estimate of electivity. Sample sizes (n): diets—number of fish, environmental—number of plants. The taxonomic list is from all lakes combined, with some taxa missing from individual lakes with some taxa missing from individual lakes. **See** Appendices D and F for complete lists of $\bar{P}_i$ for diet and environmental samples from each lake.

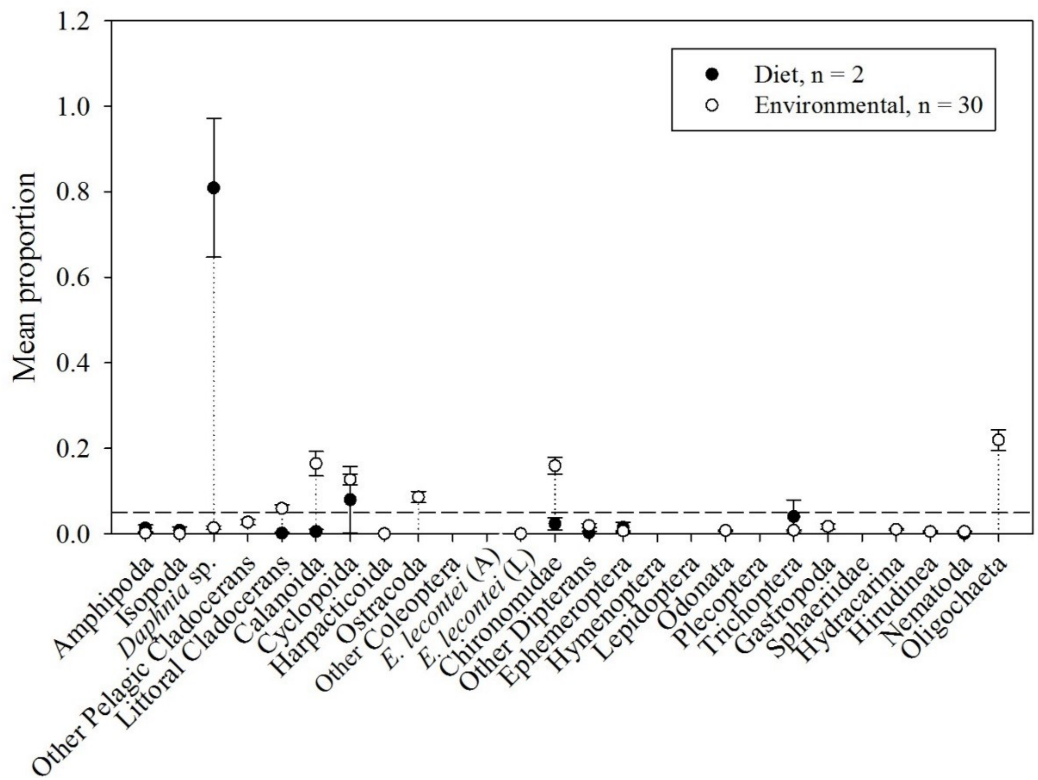

Figure 15. Proportions of each taxonomic group in Long Lake, based on counts of 2 bluegill diet samples and 30 environmental samples, 4 beds pooled, collected in July 2014. Mean ± SE. Taxa that make up less than 5% (fall below the dotted line) of the counts from both environmental and diet samples are considered to be too rare to provide an accurate estimate of electivity. Sample sizes (n): diets—number of fish, environmental—number of plants. The taxonomic list is from all lakes combined, with some taxa missing from individual lakes with some taxa missing from individual lakes. See Appendices D and F for complete lists of $\bar{P}_i$ for diet and environmental samples from each lake.

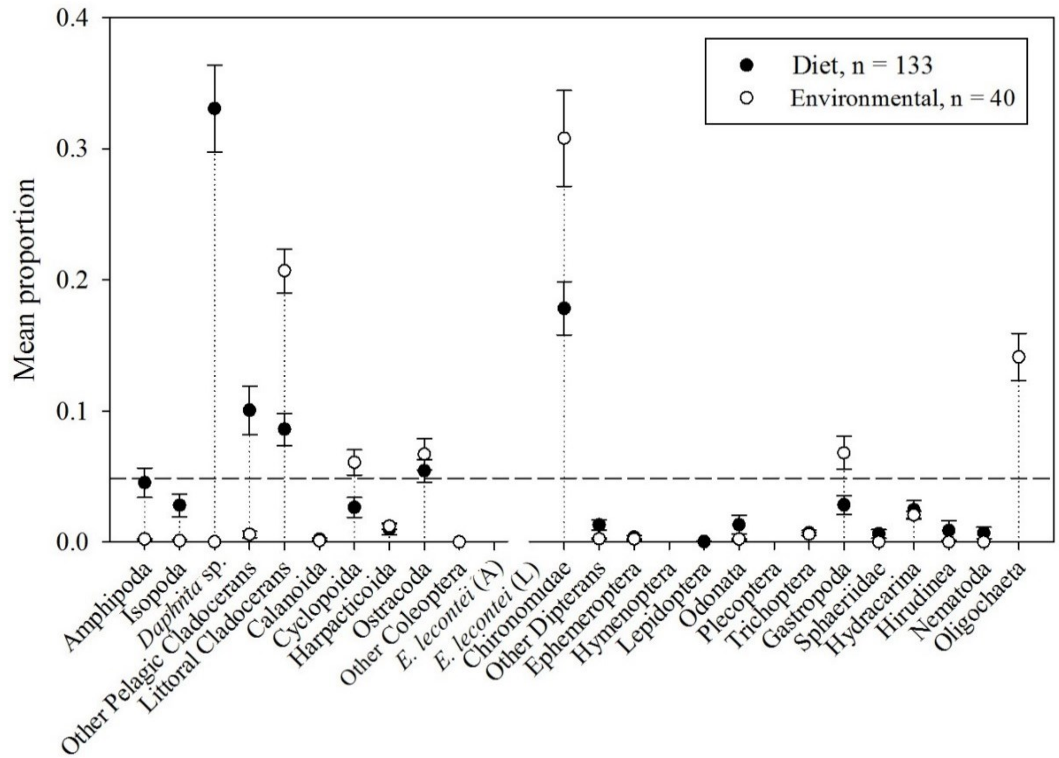

Figure 16. Proportions of each taxonomic group in Manson Lake, based on counts of 133 bluegill diet samples and 40 environmental samples, 4 beds pooled, collected in July 2014. Mean ± SE. Taxa that make up less than 5% (fall below the dotted line) of the counts from both environmental and diet samples are considered to be too rare to provide an accurate estimate of electivity. Sample sizes (n): diets—number of fish, environmental—number of plants. The taxonomic list is from all lakes combined, with some taxa missing from individual lakes with some taxa missing from individual lakes. See Appendices D and F for complete lists of $\bar{P}_i$ for diet and environmental samples from each lake.

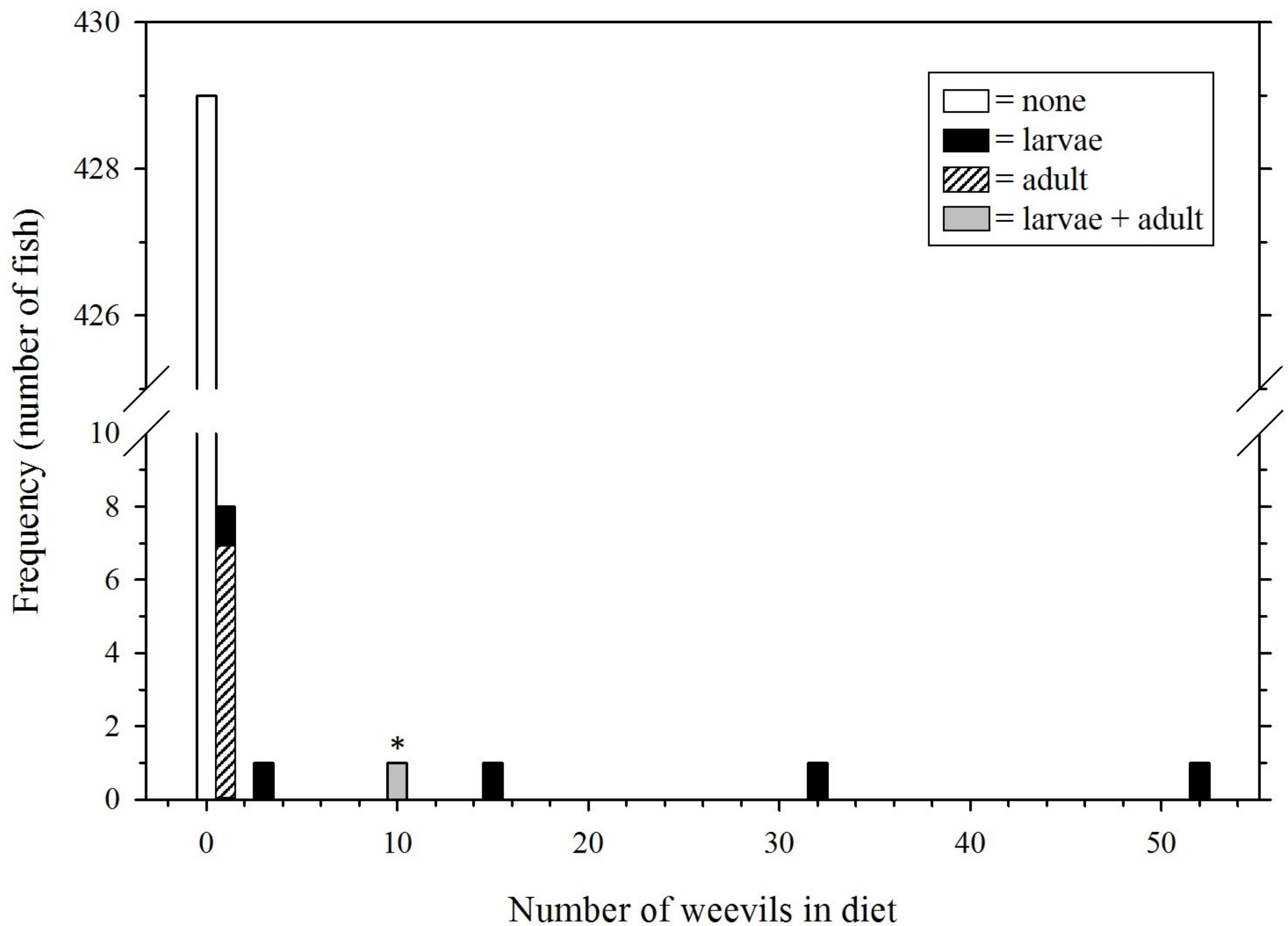

Figure 17. Frequency of occurrence of weevils in bluegill diet samples (n = 442 diet samples). All four lakes pooled, summer 2014. * = 1 adult + 9 larvae

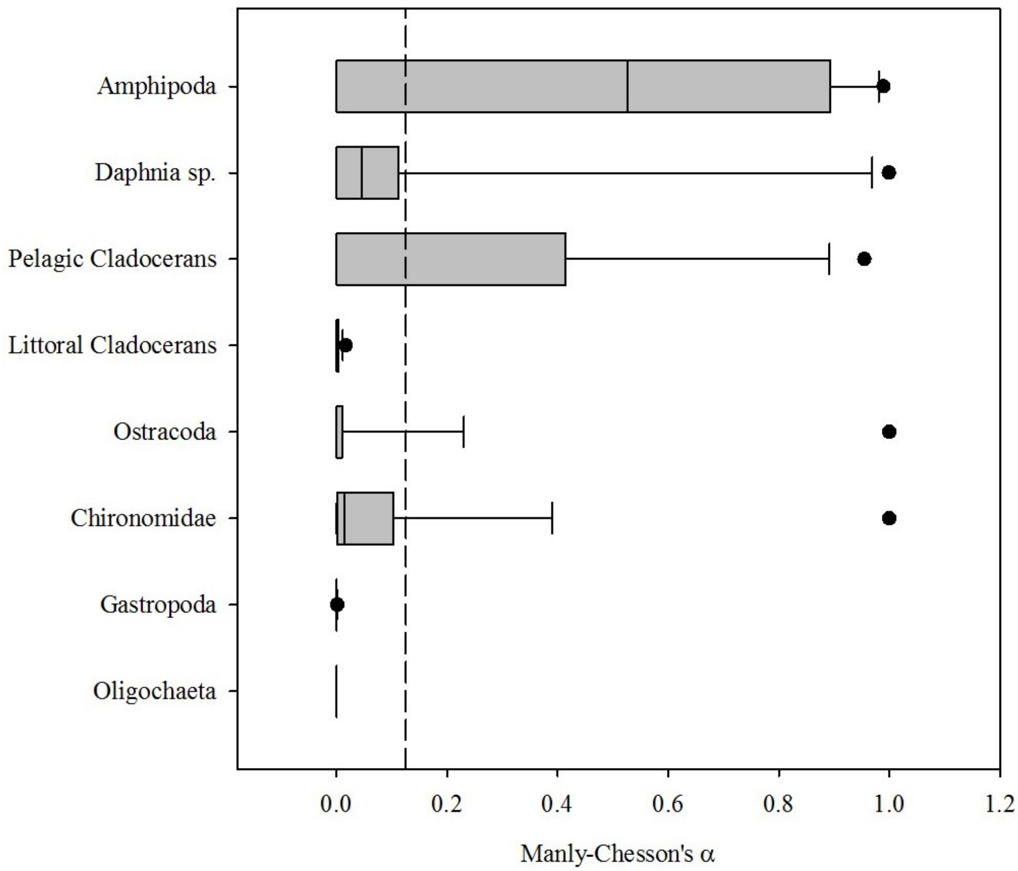

Figure 18. Manly-Chesson's alpha electivity for Boot Lake, based on 40 plant samples and 16 bluegill diet samples from July 2014. Each Box plot indicates the quartiles and median, while whiskers represent the 10^{th} and 90^{th} percentiles. Dots represent outliers. The dotted line represents the value at which no selection occurs. Values higher in value than this line indicate preference, values lower indicate avoidance.

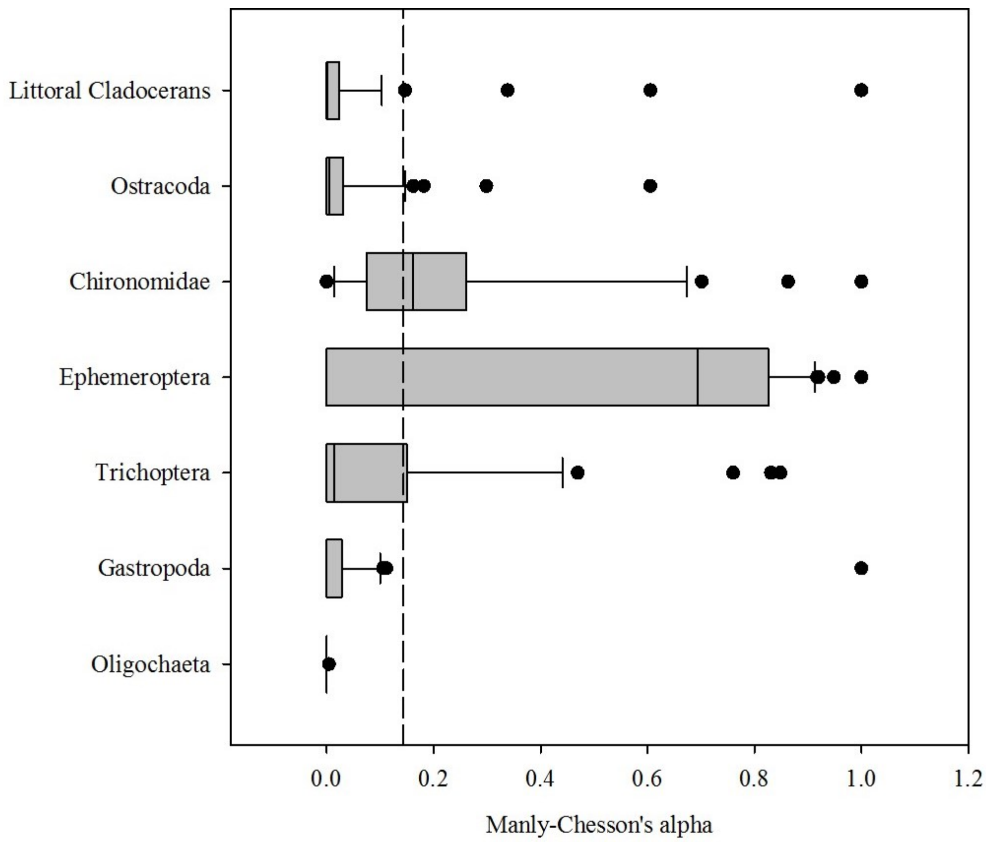

Figure 19. Manly-Chesson's alpha electivity for Little Bearskin Lake, based on 40 plant samples and 47 bluegill diet samples from July 2014. Each Box plot indicates the quartiles and median, while whiskers represent the 10th and 90th percentiles. Dots represent outliers. The dotted line represents the value at which no selection occurs. Values higher in value than this line indicate preference, values lower indicate avoidance.

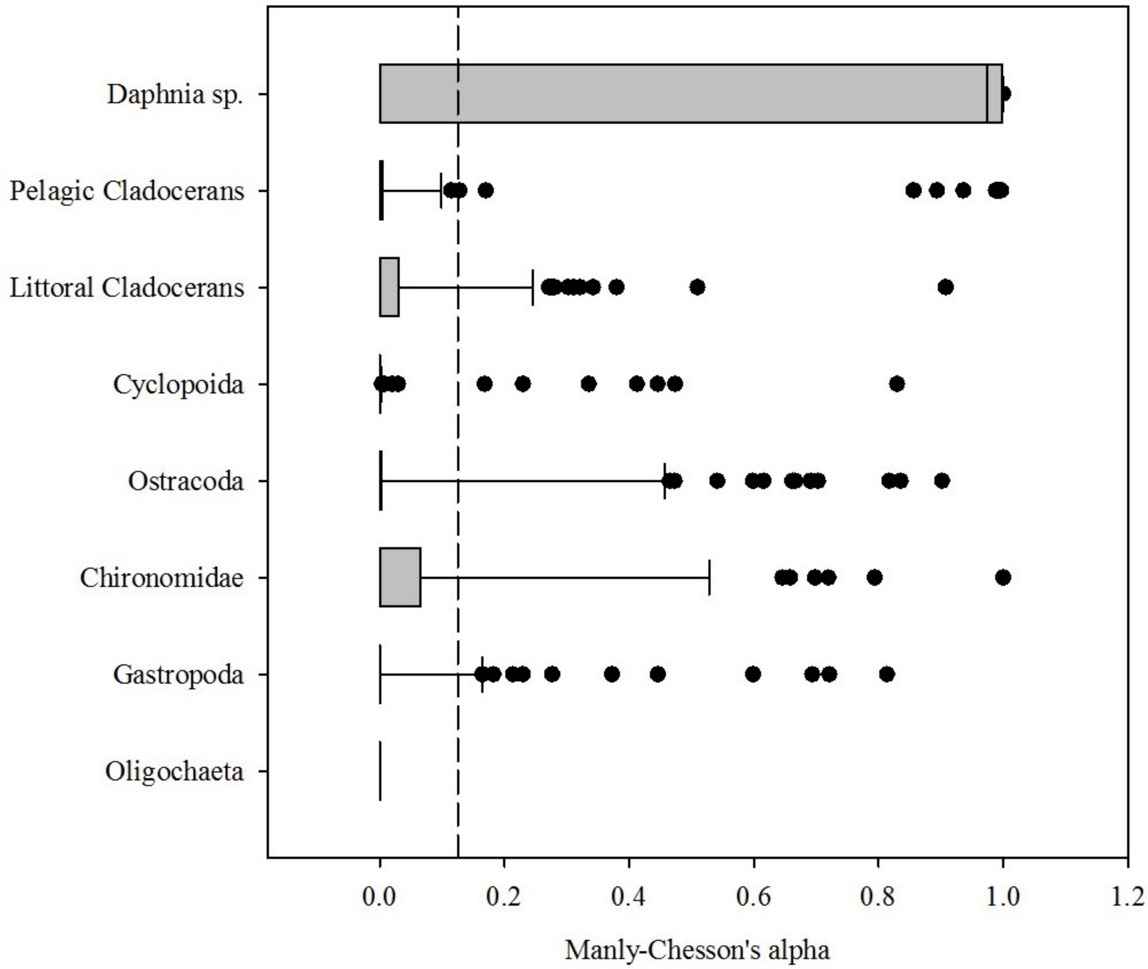

Figure 20. Manly-Chesson's alpha electivity for Manson Lake, based on 40 plant samples and 133 bluegill diet samples from July 2014. Each Box plot indicates the quartiles and median, while whiskers represent the 10^{th} and 90^{th} percentiles. Dots represent outliers. The dotted line represents the value at which no selection occurs. Values higher in value than this line indicate preference, values lower indicate avoidance.

Appendix A. List of common and scientific names, grouped by larger taxonomic group and arranged alphabetically by common name. A complete list of invertebrates identified to broader taxonomic groups can be found in Appendix D.

Common Name	Scientific Name
MACROPHYTES	
Canadian waterweed	*Elodea canadensis* Michx.
Clasping-leaf pondweed	*Potamogeton richardsonii* L.
Coontail	*Ceratophyllum demersum* L.
Eurasian water-milfoil	*Myriophyllum spicatum* L.
Fern-leaf pondweed	*Potamogeton robbinsii* Oakes
Flat-stem pondweed	*Potamogeton zosteriformis* Fernald
Large-leaf pondweed	*Potamogeton amplifolius* Tuck.
Northern water-milfoil	*Myriophyllum sibiricum* Komarov
Southern naiad	*Najas guadalupensis* (Spreng.) Magnus
Water celery	*Vallisneria americana* Michx.
White-stem pondweed	*Potamogeton praelongus* Wulfen
FISH	
Black crappie	*Pomoxis nigromaculatus* Lesueur
Bluegill	*Lepomis macrochirus* Rafinesque
Central mudminnow	*Umbra limi* Kirtland
Common shiner	*Luxilus cornutus* Mitchill
Golden shiner	*Notemigonus crysoleucas* Mitchill
Largemouth bass	*Micropterus salmoides* Lacépède
Muskellunge	*Esox masquinongy* Mitchill
Northern pike	*Esox lucius* Linnaeus
Pumpkinseed	*Lepomis gibbosus* Linnaeus
Rock bass	*Ambloplites rupestris* Rafinesque
Walleye	*Sander vitreus* Mitchill
White sucker	*Catostomus commersonii* Lacépède
Yellow bullhead	*Ameiurus natalis* Lesueur
Yellow perch	*Perca flavescens* Mitchill

Appendix B. Macrophyte Communities.

Macrophyte composition by weight (g) of environmental samples pooled from 10 samples of individual plants from each lake bed. Numbers in parentheses represent frequency of occurrence; i.e., the number plants of that species (out of 10 possible per bed) collected from each plant bed. Three of the plant species were found in only trace amounts (<0.1 g).

Lake	Canadian waterweed	Clasping-leaf pondweed	Coontail	Eurasian water-milfoil	Fern-leaf pondweed	Flat-stem pondweed	Large-leaf pondweed	Southern naiad	Water celery	White-stem pondweed	Total
Boot											
A	0.0 (0)	0.0 (0)	0.0 (0)	0.8 (2)	0.0 (0)	1.6 (1)	0.3 (1)	0.0 (0)	0.0 (0)	7.4 (6)	10.1
B	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (1)	0.0 (0)	0.0 (0)	20.8 (9)	0.0 (0)	0.0 (0)	1.9 (1)	22.7
C	0.0 (0)	0.0 (0)	0.0 (0)	6.3 (9)	0.0 (0)	2.6 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	8.8
D	0.0 (0)	0.0 (0)	3.8 (2)	2.2 (9)	0.0 (0)	0.2 (1)	0.0 (0)	0.0 (0)	0.0 (0)	4.3 (2)	10.5
Total	0.0 (0)	0.0 (0)	3.8 (2)	9.3 (21)	0.0 (0)	4.4 (4)	21.1 (10)	0.0 (0)	0.0 (0)	13.6 (9)	52.2
Little Bearskin											
A	0.0 (0)	0.0 (0)	2.6 (1)	2.5 (3)	2.8 (2)	2.3 (5)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	10.2
B	0.0 (0)	0.6 (1)	8.5 (4)	0.6 (2)	4.6 (5)	0.4 (2)	2.0 (1)	0.0 (0)	0.0 (0)	1.5 (1)	18.1
C	0.0 (0)	0.0 (0)	2.5 (2)	4.7 (9)	0.0 (0)	0.2 (2)	0.0 (0)	0.0 (0)	0.0 (1)	0.0 (0)	7.4
D	<0.1 (1)	2.3 (2)	0.3 (1)	5.7 (7)	2.1 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	10.4
Total	<0.1 (1)	2.9 (3)	13.8 (8)	13.5 (21)	9.5 (8)	2.9 (9)	2.0 (1)	0.0 (0)	0.0 (1)	1.5 (1)	46.1
Long											
A	0.0 (0)	1.3 (1)	0.0 (0)	4.8 (9)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.1 (2)	9.3
D	0.0 (0)	0.0 (0)	0.0 (0)	11.8 (10)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	11.8
F	0.0 (0)	0.0 (0)	0.0 (0)	9.0 (10)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	9.0
Total	0.0 (0)	1.3 (1)	0.0 (0)	25.6 (29)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	3.1 (2)	30.1

Appendix B. Macrophyte Communities (concluded).

Lake	Canadian waterweed	Clasping-leaf pondweed	Coontail	Eurasian water-milfoil	Fern-leaf pondweed	Flat-stem pondweed	Large-leaf pondweed	Southern naiad	Water celery	White-stem pondweed	Total
Manson											
A	0.0 (0)	0.0 (0)	0.3 (1)	12.2 (10)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (2)	0.0 (0)	0.0 (0)	12.5
B	0.1 (2)	0.0 (0)	0.0 (0)	12.8 (10)	0.0 (0)	0.0 (0)	0.1 (1)	0.1 (4)	0.0 (0)	0.0 (0)	13.2
C	0.0 (0)	0.0 (0)	0.0 (0)	11.6 (10)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	11.6
D	0.0 (0)	0.0 (0)	0.0 (0)	7.0 (10)	0.1 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	7.0
Total	0.1 (2)	0.0 (0)	0.3 (1)	43.5 (40)	0.1 (1)	0.0 (0)	0.1 (1)	0.2 (6)	0.0 (0)	0.0 (0)	44.2

Appendix C. Invertebrate Totals in Bluegill Diet Samples.

C-1. Total invertebrate counts in bluegill diet samples from Boot Lake, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

	Sample date												
	June 3				July 15				August 7				Total (27)
Taxa	A (2)	B (1)	C (2)	D (3)	A (4)	B (1)	C (3)	D (9)	A (0)	B (1)	C (1)	D (0)	
ARTHROPODA													
CRUSTACEA													
Amphipoda	35			34	24	22	6	8					129
Isopoda	5			1	5	3		1					15
Cladocera							1						1
Bosminidae													
Bosmina													
Chydoridae	3			23				1					27
Daphniidae													
Daphnia					637	10	3	7			3		660
Ceriodaphnia													
Scapholeberis													
Simocephalus					1	1		1		1			4
Holopedidae													
Holopedium							1	7					8
Leptodoridae													
Leptodora							3	2					5

C-1. Total invertebrate counts in bluegill diet samples from Boot Lake, summer 2014 (continued).

		Sample date												
		June 3				July 15				August 7				Total (27)
Taxa		A (2)	B (1)	C (2)	D (3)	A (4)	B (1)	C (3)	D (9)	A (0)	B (1)	C (1)	D (0)	
Macrothricidae														
Polyphemidae														
Polyphemus														
Sididae														
Diaphanosoma														
Sida		103			6	5	5		7		69			195
Copepoda														
Calanoida						3								3
Cyclopoida		18		10	1	3		3	4		4			43
Harpacticoida														
OSTRACODA		4		8	4	1			12		13	1		43
INSECTA														
Coleoptera											1			1
Curculionidae														
Euhrychiopsis	(L)													
	(A)													
Diptera														
Ceratopogonidae	(L)	9		5	4	4	4	6	12		5			49
	(P)													
Chaoboridae														
Chaoborus			1	356		6		1	4					368

C-1. Total invertebrate counts in bluegill diet samples from Boot Lake, summer 2014 (continued).

		Sample date												
		June 3				July 15				August 7				Total (27)
Taxa		A (2)	B (1)	C (2)	D (3)	A (4)	B (1)	C (3)	D (9)	A (0)	B (1)	C (1)	D (0)	
Chironomidae	(L)	162	6	65	110	375	15	3	217		360	15		1,328
	(P)	11	8	9	13	10			17		5			73
	(A)													
Culicidae	(A)								1					1
Ephemeroptera		6		1	8	24	8		10			2		59
Hymenoptera														
Lepidoptera						1								1
Odonata				4	4	12	1	34	1					56
Plecoptera														
Trichoptera		16	3	24	22		3		4		6			78
CHELICERATA														
Araneae														
Hydracarina		7	3		20	4		1	14		3	2		54
MOLLUSCA														
GASTROPODA		1		1		1					1	6		10
Ancylidae														
Physidae					2									2
Planorbidae														
Viviparidae		1		1								1		3
BIVALVIA														
Sphaeriidae		4			5	1								10

C-1. Total invertebrate counts in bluegill diet samples from Boot Lake, summer 2014 (concluded).

	Sample date												
	June 3				July 15				August 7				Total (27)
Taxa	A (2)	B (1)	C (2)	D (3)	A (4)	B (1)	C (3)	D (9)	A (0)	B (1)	C (1)	D (0)	
ANNELIDA													
Hirudinea					12	1		3		1			17
NEMATODA	1			1						1			3
Total	386	21	484	258	1,129	73	62	333		470	30		3,246

C-2. Total invertebrate counts in bluegill diet samples from <u>Little Bearskin Lake</u>, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

	Sample date												
	June 6				July 8				July 31				Total (139)
Taxa	A (3)	B (12)	C (17)	D (11)	A (24)	B (11)	C (7)	D (5)	A (13)	B (14)	C (7)	D (15)	
ARTHROPODA													
CRUSTACEA													
Amphipoda		6	7	42	6	10	5	16	4	7	147	36	286
Isopoda													
Cladocera			1										1
Bosminidae													
Bosmina		25		163	5	1		1					195
Chydoridae	3	4	12	15	3		1	10	2	4	6	19	79
Daphniidae													
Daphnia	1	1	1	40				3				4	50
Ceriodaphnia		2						1			3		6
Scapholeberis													
Simocephalus	22	31	65	25	4	1	1	1	2	1	2	55	210
Holopedidae													
Holopedium													
Leptodoridae													
Leptodora									37		1	2	40
Macrothricidae	4	16	16	3	13	1	1	2		7	1	1	65

C-2. Total invertebrate counts in bluegill diet samples from Little Bearskin Lake, summer 2014 (continued).

		Sample date												
		June 6				July 8				July 31				Total (139)
Taxa		A (3)	B (12)	C (17)	D (11)	A (24)	B (11)	C (7)	D (5)	A (13)	B (14)	C (7)	D (15)	
Polyphemidae														
Polyphemus														
Sididae														
Diaphanosoma			4	2	7	2			9	1			3	28
Sida		9	7	11	189	19	2	1	11	8	10	17	12	296
Copepoda						1								1
Calanoida						4	1		4					9
Cyclopoida		6	5	39	33	18	2	1	14	11	18	9	66	222
Harpacticoida				1					2				2	5
OSTRACODA		10	9	16	6	89	10	6	5	95	56	14	172	488
INSECTA						3					1			4
Coleoptera		1												1
Curculionidae														
Euhrychiopsis	(L)													
	(A)	1		1										2
Diptera														
Ceratopogonidae	(L)	5	7	447	18	34	3		4	13	5	7	53	596
	(P)													
Chaoboridae														
Chaoborus														
Chironomidae	(L)	39	110	227	72	434	63	11	188	185	141	90	332	1,892

C-2. Total invertebrate counts in bluegill diet samples from Little Bearskin Lake, summer 2014 (continued).

		Sample date												
		June 6				July 8				July 31				Total (139)
Taxa		A (3)	B (12)	C (17)	D (11)	A (24)	B (11)	C (7)	D (5)	A (13)	B (14)	C (7)	D (15)	
Chironomidae	(P)	7	7	9	9	273	20	1	33	8	3	5	15	390
	(A)													
Culicidae	(A)					2	3			3		6	1	15
Ephemeroptera		4	3	9	5	110	5	3	13	4	2	4	4	166
Hymenoptera			3											3
Lepidoptera				2	5									7
Odonata			1		2	11		1	2	5	6	4	17	49
Plecoptera							1			2				3
Trichoptera		37	82	30	51	32	34	10	12	27	35	44	56	450
CHELICERATA														
Araneae														
Hydracarina		1	2	10	3	45	8	1	2	34	8	5	33	152
MOLLUSCA														
GASTROPODA		4	13	32	6	35	12	2	5	109	76	11	123	428
Ancylidae														
Physidae			1			3	3	1	2	4			1	15
Planorbidae														
Viviparidae				1						3	28		6	38
BIVALVIA														
Sphaeriidae						1	1			6		23		31

C-2. Total invertebrate counts in bluegill diet samples from Little Bearskin Lake, summer 2014 (concluded).

	Sample date												
	June 6				July 8				July 31				Total (139)
Taxa	A (3)	B (12)	C (17)	D (11)	A (24)	B (11)	C (7)	D (5)	A (13)	B (14)	C (7)	D (15)	
ANNELIDA													
Hirudinea							1			1	1		3
Oligochaeta	1	2		6				1	1	5			16
NEMATODA		2	1		1			13	1	6			24
Total	155	343	940	700	1,148	181	47	354	565	420	400	1,013	6,266

C-3. Total invertebrate counts in bluegill diet samples from <u>Long Lake</u>, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

	Sample date										
	June 8–9				July 16			August 8			Total (38)
Taxa	A (2)	C (11)	D (4)	F (0)	A (2)	D (0)	F (0)	A (6)	D (4)	F (9)	
ARTHROPODA											
CRUSTACEA											
Amphipoda		1	33		7			5	10	27	83
Isopoda		3	28		3			2	1		37
Cladocera											
Bosminidae											
Bosmina											
Chydoridae		2	1					8		5	16
Daphniidae											
Daphnia					731				1,644	816	3,191
Ceriodaphnia										3	3
Scapholeberis											
Simocephalus					2			1		2	5
Holopedidae											
Holopedium									2	3	5
Leptodoridae											
Leptodora										1	1
Macrothricidae		2						4		1	7

C-3. Total invertebrate counts in bluegill diet samples from Long Lake, summer 2014 (continued).

Taxa		June 8–9 A (2)	June 8–9 C (11)	June 8–9 D (4)	June 8–9 F (0)	July 16 A (2)	July 16 D (0)	July 16 F (0)	August 8 A (6)	August 8 D (4)	August 8 F (9)	Total (64)
Polyphemidae												
Polyphemus												
Sididae												
Diaphanosoma			1								1	2
Sida		2	21	5		2			440	6	9	485
Copepoda												
Calanoida						2					1	3
Cyclopoida		4	16	34		31			95	8	54	242
Harpacticoida												
OSTRACODA			27	4					35		11	77
INSECTA			7									7
Coleoptera			4						7			11
Curculionidae												
Euhrychiopsis	(L)		77									77
	(A)		2						1			3
Diptera												
Ceratopogonidae	(L)		12	4					4	4	31	55
	(P)											
Chaoboridae												
Chaoborus			3			1				4	4	12
Chironomidae	(L)	118	247	149		9			455	50	303	1,331

C-3. Total invertebrate counts in bluegill diet samples from Long Lake, summer 2014 (continued).

Taxa		Sample date: June 8–9 A (2)	June 8–9 C (11)	June 8–9 D (4)	June 8–9 F (0)	July 16 A (2)	July 16 D (0)	July 16 F (0)	August 8 A (6)	August 8 D (4)	August 8 F (9)	Total (64)
Chironomidae	(P)		33	9		4			21	1	2	70
	(A)											
Culicidae	(A)		3									3
Ephemeroptera			16	1		7			4		10	38
Hymenoptera			2									2
Lepidoptera												
Odonata		1	2	2					9		16	30
Plecoptera												
Trichoptera		1	6	2		16			6		7	38
CHELICERATA												
Araneae			4						1			5
Hydracarina			5						11	3	2	21
MOLLUSCA												
GASTROPODA		4	27	12					2		7	52
Ancylidae												
Physidae											1	1
Planorbidae												
Viviparidae				1								1
BIVALVIA												
Sphaeriidae												

C-3. Total invertebrate counts in bluegill diet samples from Long Lake, summer 2014 (concluded).

	Sample date										
	June 8–9				July 16			August 8			Total (64)
Taxa	A (2)	C (11)	D (4)	F (0)	A (2)	D (0)	F (0)	A (6)	D (4)	F (9)	
ANNELIDA											
Hirudinea											
Oligochaeta											
NEMATODA		2	2		1				2	7	14
Total	130	525	287		816			1,111	1,736	1,322	5,927

C-4. Total invertebrate counts in bluegill diet samples from <u>Manson Lake</u>, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

	Sample date												
	June 4–5				June 26, July 10				July 30				Total
Taxa	A (20)	B (16)	C (2)	D (24)	A (23)	B (18)	C (34)	D (58)	A (4)	B (14)	C (9)	D (17)	(239)
ARTHROPODA													
CRUSTACEA													
Amphipoda	23	26		23	86	2	11	23		23	4	66	287
Isopoda	113	81		92	41	2	1	80				24	434
Cladocera					2		100	3					105
Bosminidae													
Bosmina	1			2	4			1,093					1,100
Chydoridae		1		18	5	11	17	359	1	7	69	33	521
Daphniidae													
Daphnia	243	29,066	1,559	861	16	107	14,805	1,640	3	37	2,163	5,762	56,261
Ceriodaphnia													
Scapholeberis								1					1
Simocephalus	1	1								5			7
Holopedidae													
Holopedium	4			7		1	546	70			9	2	639
Leptodoridae													
Leptodora				1	1		1	3		1			7
Macrothricidae					7	11	2	23		9	12	4	68

C-4. Total invertebrate counts in bluegill diet samples from Manson Lake, summer 2014 (continued).

		Sample date												
		June 4–5				June 26, July 10				July 30				Total (239)
Taxa		A (20)	B (16)	C (2)	D (24)	A (23)	B (18)	C (34)	D (58)	A (4)	B (14)	C (9)	D (17)	
Polyphemidae														
Polyphemus						1								1
Sididae														
Diaphanosoma						1								1
Sida		1			1	30	4	1	137	2	114	27	19	336
Copepoda														
Calanoida					6		1		20				426	453
Cyclopoida			1		4	2	10	19	63	1	9	7	14	130
Harpacticoida									29					29
OSTRACODA		8			17	28	16	46	121	5	17	3	7	268
INSECTA			3		3	3	1	5	3			2	25	45
Coleoptera		3	1		1			1						6
Curculionidae														
Euhrychiopsis	(L)				37									37
	(A)	1			1									2
Diptera														
Ceratopogonidae	(L)				5	2	2	13	11		3		2	38
	(P)					2	1	12	1		1			17
Chaoboridae														
Chaoborus		1	22					18	9		1		4	55
Chironomidae	(L)	10	53	4	27	65	92	63	250	20	51	135	61	831

C-4. Total invertebrate counts in bluegill diet samples from Manson Lake, summer 2014 (continued).

Taxa		Sample date: June 4–5 A (20)	June 4–5 B (16)	June 4–5 C (2)	June 4–5 D (24)	June 26, July 10 A (23)	June 26, July 10 B (18)	June 26, July 10 C (34)	June 26, July 10 D (58)	July 30 A (4)	July 30 B (14)	July 30 C (9)	July 30 D (17)	Total (239)
Chironomidae	(P)	13	31			16	103	90	24		32	3	21	333
	(A)	1	2		29	14		12			2		8	68
Culicidae	(A)				2		3		1					6
Ephemeroptera		6	8		12	1	4		11		1		3	46
Hymenoptera					4								1	5
Lepidoptera					3	1			1					5
Odonata		3	6		6	22		3	3	1	6		5	55
Plecoptera														
Trichoptera		11	7		22	7	3	3	28	3	4		6	94
CHELICERATA														
Araneae		2			3						1		1	7
Hydracarina		3	13		4	22	4	14	34	2	6	10	144	255
MOLLUSCA														
GASTROPODA		3	18			36	4	18	16	2	3	8	28	136
Ancylidae			1											1
Physidae					8	2	2	1	1				1	15
Planorbidae		5	2		1	2		15	5		29	2	21	82
Viviparidae		1				5	1	2	1	1			1	12
BIVALVIA														
Sphaeriidae		3	1		1	2		3	9				228	247

C-4. Total invertebrate counts in bluegill diet samples from Manson Lake, summer 2014 (concluded).

	Sample date												
	June 4–5				June 26, July 10				July 30				Total (239)
Taxa	A (20)	B (16)	C (2)	D (24)	A (23)	B (18)	C (34)	D (58)	A (4)	B (14)	C (9)	D (17)	
ANNELIDA													
Hirudinea				2	2	1		2				1	8
Oligochaeta				1						1			2
NEMATODA	1	5	1	1	8	1				1	1		19
Total	461	29,349	1,564	1,205	436	387	15,822	4,075	41	364	2,455	6,918	63,076

Appendix D. Invertebrate Proportions in Bluegill Diet Samples.

D-1. Mean proportion by number (%) for prey taxa from bluegill diet samples in Boot Lake, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Dashes (-) indicate no individuals of that taxon were present in the bluegill diet samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake. Total columns represent weighted means for each date, with the last column in table body showing the weighted means across all sites and dates.

	Sample date															
	June 3					July 15					August 7					Total (27)
Taxa	A (2)	B (1)	C (2)	D (3)	Total (8)	A (4)	B (1)	C (3)	D (9)	Total (17)	A (0)	B (1)	C (1)	D (0)	Total (2)	
ARTHROPODA																
CRUSTACEA																
Amphipoda	7.5	-	-	14.1	7.2	8.5	30.1	3.9	3.3	6.2	-	-	-	-	-	6.0
Isopoda	1.7	-	-	0.3	0.5	0.5	4.1	-	0.9	0.9	-	-	-	-	-	0.7
Cladocera																
Bosminidae																
Bosmina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chydoridae	0.8	-	-	7.7	3.1	-	-	-	0.9	0.5	-	-	-	-	-	1.2
Daphniidae																
Daphnia	-	-	-	-	-	24.5	13.7	21.5	5.5	13.3	-	-	10.0	-	5.0	8.7
Ceriodaphnia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapholeberis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simocephalus	-	-	-	-	-	0.1	1.4	-	0.1	0.2	-	0.2	-	-	0.1	0.1
Holopedidae																
Holopedium	-	-	-	-	-	-	-	4.2	2.0	1.8	-	-	-	-	-	1.1
Leptodoridae																
Leptodora	-	-	-	-	-	-	-	25.0	0.1	4.5	-	-	-	-	-	2.8

D-1. Mean proportion by number (%) for prey taxa from bluegill diet samples in Boot Lake, summer 2014 (continued).

		Sample date															
		June 3					July 15					August 7					Total (27)
Taxa		A (2)	B (1)	C (2)	D (3)	Total (8)	A (4)	B (1)	C (3)	D (9)	Total (17)	A (0)	B (1)	C (1)	D (0)	Total (2)	
Macrothricidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyphemidae																	
Polyphemus		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sididae																	
Diaphanosoma		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sida		19.2	-	-	2.5	5.7	1.7	6.8	-	0.6	1.1	-	14.7	-	-	7.3	2.9
Copepoda																	
Calanoida		-	-	-	-	-	0.1	-	-	-	0.0	-	-	-	-	-	0.0
Cyclopoida		3.3	-	1.1	0.3	1.2	0.1	-	12.5	0.5	2.5	-	0.9	-	-	0.4	2.0
Harpacticoida		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OSTRACODA		1.2	-	0.9	1.6	1.1	0.5	-	-	12.0	6.5	-	2.8	3.3	-	3.0	4.6
INSECTA																	
Coleoptera		-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	0.1	0.0
Curculionidae																	
Euhrychiopsis	(L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	(A)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																	
Ceratopogonidae	(L)	2.7	-	0.5	1.6	1.4	0.8	5.5	3.9	3.6	3.1	-	1.1	-	-	0.5	2.4
	(P)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaoboridae																	
Chaoborus		-	4.8	49.4	-	12.9	0.2	-	4.2	0.5	1.0	-	-	-	-	-	4.5

D-1. Mean proportion by number (%) for prey taxa from bluegill diet samples in Boot Lake, summer 2014 (continued).

		Sample date															
		June 3					July 15					August 7					Total (27)
Taxa		A (2)	B (1)	C (2)	D (3)	Total (8)	A (4)	B (1)	C (3)	D (9)	Total (17)	A (0)	B (1)	C (1)	D (0)	Total (2)	
Chironomidae	(L)	46.6	28.6	14.1	42.7	34.8	50.9	20.5	2.0	41.3	35.4	-	76.6	50.0	-	63.3	37.3
	(P)	4.1	38.1	2.7	4.8	8.3	1.5	-	-	9.5	5.4	-	1.1	-	-	0.5	5.9
	(A)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae	(A)	-	-	-	-	-	-	-	-	0.6	0.3	-	-	-	-	-	0.2
Ephemeroptera		2.6	-	0.1	2.9	1.8	5.5	11.0	-	4.3	4.2	-	-	6.7	-	3.3	3.4
Hymenoptera		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidoptera		-	-	-	-	-	0.1	-	-	-	0.0	-	-	-	-	-	0.0
Odonata		-	-	3.9	1.8	1.6	1.9	1.4	22.2	0.7	4.8	-	-	-	-	-	3.5
Plecoptera		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera		5.5	14.3	25.3	8.9	12.8	-	4.1	-	6.9	3.9	-	1.3	-	-	0.6	6.3
CHELICERATA																	
Araneae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydracarina		2.3	14.3	-	7.7	5.2	0.2	-	0.7	2.0	1.2	-	0.6	6.7	-	3.7	2.6
MOLLUSCA																	
GASTROPODA		0.2	-	1.9	-	0.5	0.5	-	-	-	0.1	-	0.2	20.0	-	10.1	1.0
Ancylidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physidae		-	-	-	0.7	0.3	-	-	-	-	-	-	-	-	-	-	0.1
Planorbidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viviparidae		0.4	-	0.1	-	0.1	-	-	-	-	-	-	-	3.3	-	1.7	0.2
BIVALVIA																	
Sphaeriidae		1.8	-	-	2.1	1.2	0.1	-	-	-	0.0	-	-	-	-	-	0.4

D-1. Mean proportion by number (%) for prey taxa from bluegill diet samples in Boot Lake, summer 2014 (concluded).

	Sample date															
	June 3					July 15					August 7					Total (27)
Taxa	A (2)	B (1)	C (2)	D (3)	Total (8)	A (4)	B (1)	C (3)	D (9)	Total (17)	A (0)	B (1)	C (1)	D (0)	Total (2)	
ANNELIDA																
Hirudinea	-	-	-	-	-	2.1	1.4	-	4.8	3.1	-	0.2	-	-	0.1	2.0
Oligochaeta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEMATODA	0.2	-	-	0.3	0.2	-	-	-	-	-	-	0.2	-	-	0.1	0.1
SUM	100	100	100	100	100	100	100	100	100	100	0	100	100	0	100	100

D-2. Mean proportion by number (%) for prey taxa from bluegill diet samples in Little Bearskin Lake, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Dashes (-) indicate no individuals of that taxon were present in the bluegill diet samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake. Total columns represent weighted means for each date, with the last column in table body showing the weighted means across all sites and dates.

	Sample date															
	June 6					July 8					July 31					Total (139)
Taxa	A (3)	B (12)	C (17)	D (11)	Total (43)	A (24)	B (11)	C (7)	D (5)	Total (47)	A (13)	B (14)	C (7)	D (15)	Total (49)	
ARTHROPODA																
CRUSTACEA																
Amphipoda	-	1.7	0.5	12.7	3.9	0.6	6.3	3.0	6.4	2.9	0.6	2.5	26.4	4.4	6.0	4.3
Isopoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cladocera																
Bosminidae																
Bosmina	-	6.7	-	12.6	5.1	0.7	0.8	-	0.3	0.6	-	-	-	-	-	1.8
Chydoridae	0.9	0.8	5.4	1.5	2.8	0.2	-	7.1	3.1	1.5	0.2	0.7	1.4	2.7	1.3	1.8
Daphnidae																
Daphnia	0.3	0.3	0.3	3.6	1.1	-	-	-	1.0	0.1	-	-	-	0.2	0.1	0.4
Ceriodaphnia	-	0.5	-	-	0.1	-	-	-	0.4	0.0	-	-	0.8	-	0.1	0.1
Scapholeberis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simocephalus	8.7	10.3	10.6	2.9	8.4	0.6	0.2	2.9	0.4	0.8	1.2	0.1	0.9	4.3	1.8	3.5
Holopedidae																
Holopedium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptodoridae																
Leptodora	-	-	-	-	-	-	-	-	-	-	7.3	-	0.3	0.1	2.0	0.7

D-2. Mean proportion by number (%) for prey taxa from bluegill diet samples in Little Bearskin Lake, summer 2014 (continued).

Taxa		June 6 A (3)	June 6 B (12)	June 6 C (17)	June 6 D (11)	June 6 Total (43)	July 8 A (24)	July 8 B (11)	July 8 C (7)	July 8 D (5)	July 8 Total (47)	July 31 A (13)	July 31 B (14)	July 31 C (7)	July 31 D (15)	July 31 Total (49)	Total (139)
Macrothricidae		1.2	8.0	2.4	0.5	3.4	0.9	0.2	7.1	0.8	1.6	-	1.7	0.1	0.0	0.5	1.8
Polyphemidae																	
Polyphemus		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sididae																	
Diaphanosoma		-	1.0	0.2	0.7	0.6	0.1	-	-	3.0	0.4	0.5	-	-	2.1	0.8	0.6
Sida		6.1	1.4	1.5	8.6	3.6	1.1	0.7	7.1	3.5	2.2	1.0	3.9	4.3	1.0	2.3	2.7
Copepoda																	
Calanoida		-	-	-	-	-	0.3	9.1	-	1.5	2.4	-	-	-	-	-	0.8
Cyclopoida		4.5	1.3	4.3	5.5	3.8	1.3	0.5	2.9	4.5	1.7	1.6	3.4	2.0	6.3	3.6	3.0
Harpacticoida		-	-	0.5	-	0.2	-	-	-	0.8	0.1	-	-	-	0.1	0.0	0.1
OSTRACODA		9.8	2.1	1.7	1.6	2.3	7.2	3.8	7.1	1.7	5.8	15.3	14.9	4.1	12.6	12.8	7.2
INSECTA																	
Coleoptera		3.0	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	0.1
Curculionidae																	
Euhrychiopsis	(L)	1.0	-	0.2	-	0.2	-	-	-	-	-	-	-	-	-	-	0.1
	(A)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																	
Ceratopogonidae	(L)	4.9	1.1	14.8	3.6	7.4	3.1	1.6	-	1.7	2.1	2.1	1.3	2.1	3.8	2.4	3.9
	(P)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaoboridae																	
Chaoborus		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

D-2. Mean proportion by number (%) for prey taxa from bluegill diet samples in Little Bearskin Lake, summer 2014 (continued).

		Sample date															
		June 6					July 8					July 31					Total
Taxa		A (3)	B (12)	C (17)	D (11)	Total (43)	A (24)	B (11)	C (7)	D (5)	Total (47)	A (13)	B (14)	C (7)	D (15)	Total (49)	(139)
Chironomidae	(L)	15.9	34.4	42.8	18.6	32.4	39.4	34.7	20.6	43.7	36.0	35.6	34.8	27.5	28.8	32.2	33.5
	(P)	10.3	1.6	0.8	3.1	2.3	24.4	7.1	2.9	12.1	15.8	1.4	0.5	1.5	11.0	4.1	7.5
	(A)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae	(A)	-	-	-	-	-	0.1	1.9	-	-	0.5	0.3	-	1.5	0.1	0.3	0.3
Ephemeroptera		3.9	0.8	0.7	0.8	1.0	9.7	2.5	15.5	5.3	8.4	1.5	0.7	1.7	0.2	0.9	3.5
Hymenoptera		-	0.7	-	-	0.2	-	-	-	-	-	-	-	-	-	-	0.1
Lepidoptera		-	-	0.2	1.2	0.4	-	-	-	-	-	-	-	-	-	-	0.1
Odonata		-	0.3	-	0.3	0.2	1.5	-	0.6	0.6	0.9	0.7	1.4	1.0	4.8	2.2	1.1
Plecoptera		-	-	-	-	-	-	0.2	-	-	0.1	0.2	-	-	-	0.1	0.0
Trichoptera		24.8	20.0	5.1	19.8	14.4	2.6	21.6	6.0	4.2	7.7	5.2	7.5	13.7	4.2	6.8	9.4
CHELICERATA																	
Araneae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydracarina		0.3	0.5	2.2	0.5	1.1	3.6	2.7	1.2	0.8	2.7	5.4	2.1	1.2	2.2	2.9	2.3
MOLLUSCA																	
GASTROPODA		3.9	5.0	5.6	1.2	4.2	2.2	4.0	14.9	1.7	4.4	16.5	17.5	3.7	10.6	13.2	7.4
Ancylidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physidae		-	0.3	-	-	0.1	0.3	1.6	0.6	0.8	0.7	1.3	-	-	0.0	0.4	0.4
Planorbidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viviparidae		-	-	0.1	-	0.0	-	-	-	-	-	0.4	3.7	-	0.3	1.3	0.5
BIVALVIA																	
Sphaeriidae		-	-	-	-	-	0.1	0.4	-	-	0.1	0.7	-	5.6	-	1.0	0.4

D-2. Mean proportion by number (%) for prey taxa from bluegill diet samples in Little Bearskin Lake, summer 2014 (concluded).

	Sample date															
	June 6					July 8					July 31					Total (139)
Taxa	A (3)	B (12)	C (17)	D (11)	Total (43)	A (24)	B (11)	C (7)	D (5)	Total (47)	A (13)	B (14)	C (7)	D (15)	Total (49)	
ANNELIDA																
Hirudinea	-	-	-	-	-	-	-	0.6	-	0.1	-	0.1	0.1	-	0.1	0.1
Oligochaeta	0.3	0.2	-	0.8	0.3	-	-	-	0.1	0.0	0.2	1.6	-	-	0.5	0.3
NEMATODA	-	1.0	0.2	-	0.3	0.0	-	-	1.7	0.2	0.6	1.5	-	-	0.6	0.4
SUM	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

D-3. Mean proportion by number (%) for prey taxa from bluegill diet samples in Long Lake, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Dashes (-) indicate no individuals of that taxon were present in the bluegill diet samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake. Total columns represent weighted means for each date, with the last column in table body showing the weighted means across all sites and dates.

	Sample date													
	June 8–9					July 16				August 8				Total (38)
Taxa	A (2)	C (11)	D (4)	F (0)	Total (17)	A (2)	D (0)	F (0)	Total (2)	A (6)	D (4)	F (9)	Total (19)	
ARTHROPODA														
CRUSTACEA														
Amphipoda	-	0.8	11.2	-	3.1	1.3	-	-	1.3	0.9	1.4	1.3	1.2	2.1
Isopoda	-	0.7	15.1	-	4.0	0.8	-	-	0.8	0.2	0.1	-	0.1	1.9
Cladocera														
Bosminidae														
Bosmina	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chydoridae	-	0.2	0.2	-	0.2	-	-	-	-	0.5	-	0.5	0.4	0.3
Daphnidae														
Daphnia	-	-	-	-	-	80.9	-	-	80.9	-	91.1	43.6	39.8	24.2
Ceriodaphnia	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
Scapholeberis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simocephalus	-	-	-	-	-	0.2	-	-	0.2	0.1	-	0.2	0.1	0.1
Holopedidae														
Holopedium	-	-	-	-	-	-	-	-	-	-	0.1	0.0	0.0	0.0
Leptodoridae														
Leptodora	-	-	-	-	-	-	-	-	-	-	-	0.1	0.0	0.0

D-3. Mean proportion by number (%) for prey taxa from bluegill diet samples in Long Lake, summer 2014 (continued).

		Sample date													
		June 8–9					July 16				August 8				Total (38)
Taxa		A (2)	C (11)	D (4)	F (0)	Total (17)	A (2)	D (0)	F (0)	Total (2)	A (6)	D (4)	F (9)	Total (19)	
Macrothricidae		-	0.2	-	-	0.2	-	-	-	-	0.3	-	0.1	0.1	0.1
Polyphemidae															
Polyphemus		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sididae															
Diaphanosoma		-	0.1	-	-	0.1	-	-	-	-	-	-	0.1	0.0	0.0
Sida		0.8	2.7	2.1	-	2.3	0.2	-	-	0.2	30.4	0.2	0.5	9.9	6.0
Copepoda															
Calanoida		-	-	-	-	-	0.5	-	-	0.5	-	-	0.3	0.1	0.1
Cyclopoida		1.6	4.7	8.3	-	5.2	8.0	-	-	8.0	8.1	0.5	5.2	5.1	5.3
Harpacticoida		-	-	-	-	-	-	-	-	-	-	-	-	-	-
OSTRACODA		-	3.7	0.9	-	2.6	-	-	-	-	3.8	-	1.1	1.8	2.0
INSECTA															
Coleoptera		-	0.8	-	-	0.5	-	-	-	-	1.2	-	-	0.4	0.4
Curculionidae															
Euhrychiopsis	(L)	-	0.2	-	-	0.1	-	-	-	-	0.1	-	-	0.0	0.1
	(A)	-	9.4	-	-	6.1	-	-	-	-	-	-	-	-	2.7
Diptera															
Ceratopogonidae	(L)	-	2.0	1.2	-	1.6	-	-	-	-	0.3	0.4	2.6	1.4	1.4
	(P)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaoboridae															
Chaoborus		-	0.3	-	-	0.2	0.3	-	-	0.3	-	0.2	0.1	0.1	0.2

D-3. Mean proportion by number (%) for prey taxa from bluegill diet samples in Long Lake, summer 2014 (continued).

Taxa		June 8–9 A (2)	June 8–9 C (11)	June 8–9 D (4)	June 8–9 F (0)	June 8–9 Total (17)	July 16 A (2)	July 16 D (0)	July 16 F (0)	July 16 Total (2)	August 8 A (6)	August 8 D (4)	August 8 F (9)	August 8 Total (19)	Total (38)
Chironomidae	(L)	95.3	54.1	51.3	-	58.3	1.5	-	-	1.5	48.6	5.2	35.8	33.4	42.9
	(P)	-	5.3	3.9	-	4.3	0.9	-	-	0.9	1.9	0.1	0.1	0.7	2.3
	(A)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae	(A)	-	0.5	-	-	0.3	-	-	-	-	-	-	-	-	0.1
Ephemeroptera		-	3.0	0.3	-	2.0	1.5	-	-	1.5	0.3	-	1.9	1.0	1.5
Hymenoptera		-	0.4	-	-	0.2	-	-	-	-	-	-	-	-	0.1
Lepidoptera		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata		0.4	0.4	0.5	-	0.4	-	-	-	-	0.7	-	2.4	1.3	0.9
Plecoptera		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera		0.4	0.8	0.6	-	0.7	4.0	-	-	4.0	1.0	-	0.6	0.6	0.8
CHELICERATA															
Araneae		-	1.0	-	-	0.6	-	-	-	-	0.1	-	-	0.0	0.3
Hydracarina		-	1.7	-	-	1.1	-	-	-	-	1.4	0.4	0.4	0.7	0.8
MOLLUSCA															
GASTROPODA		1.6	6.6	3.4	-	5.2	-	-	-	-	0.1	-	1.3	0.6	2.7
Ancylidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physidae		-	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0.0
Planorbidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viviparidae		-	-	0.3	-	0.1	-	-	-	-	-	-	-	-	0.0
BIVALVIA															
Sphaeriidae		-	-	-	-	-	-	-	-	-	-	-	-	-	-

D-3. Mean proportion by number (%) for prey taxa from bluegill diet samples in Long Lake, summer 2014 (concluded).

		Sample date													
		June 8–9					July 16				August 8				Total (38)
Taxa		A (2)	C (11)	D (4)	F (0)	Total (17)	A (2)	D (0)	F (0)	Total (2)	A (6)	D (4)	F (9)	Total (19)	
ANNELIDA															
Hirudinea		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligochaeta		-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEMATODA		-	0.2	0.8	-	0.3	0.1	-	-	0.1	-	0.1	1.9	0.9	0.6
SUM	0	100	100	100	0	100	100	0	0	100	100	100	100	100	100

D-4. Mean proportion by number (%) for prey taxa from bluegill diet samples in Manson Lake, summer 2014. On each date, 4 sites (EWM beds) were sampled. Numbers in parentheses indicate total number of bluegill with contents in their stomach. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Dashes (-) indicate no individuals of that taxon were present in the bluegill diet samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake. Total columns represent weighted means for each date, with the last column in table body showing the weighted means across all sites and dates.

	Sample date															
	June 4–5					June 26, July 10					July 30					Total (239)
Taxa	A (20)	B (16)	C (2)	D (24)	Total (62)	A (23)	B (18)	C (34)	D (58)	Total (133)	A (4)	B (14)	C (9)	D (17)	Total (44)	
ARTHROPODA																
CRUSTACEA																
Amphipoda	2.1	2.0	-	2.9	2.3	22.4	0.7	0.4	1.1	4.5	-	5.2	1.1	3.8	3.3	3.7
Isopoda	16.4	3.4	-	13.2	11.3	9.8	1.8	0.2	1.9	2.8	-	-	-	1.4	0.5	4.6
Cladocera																
Bosminidae																
Bosmina	0.6	-	-	1.4	0.7	1.2	-	-	11.7	5.3	-	-	-	-	-	3.1
Chydoridae	-	0.1	-	6.0	2.4	1.3	4.3	3.9	12.4	7.2	1.9	3.5	4.6	2.2	3.1	5.2
Daphnidae																
Daphnia	54.5	87.5	99.7	43.9	60.4	7.3	25.4	59.1	30.4	33.1	5.8	19.8	43.5	57.3	37.9	41.0
Ceriodaphnia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scapholeberis	-	-	-	-	-	-	-	-	0.1	0.0	-	-	-	-	-	0.0
Simocephalus	0.6	0.1	-	-	0.2	-	-	-	-	-	-	1.0	-	-	0.3	0.1
Holopedidae																
Holopedium	4.6	-	-	0.5	1.7	-	0.1	14.1	2.2	4.6	-	-	1.0	0.1	0.2	3.0
Leptodoridae																
Leptodora	-	-	-	0.5	0.2	0.4	-	0.0	0.1	0.1	-	1.8	-	-	0.6	0.2

D-4. Mean proportion by number (%) for prey taxa from bluegill diet samples in Manson Lake, summer 2014 (continued).

Taxa		June 4–5 A (20)	June 4–5 B (16)	June 4–5 C (2)	June 4–5 D (24)	June 4–5 Total (62)	June 26, July 10 A (23)	June 26, July 10 B (18)	June 26, July 10 C (34)	June 26, July 10 D (58)	June 26, July 10 Total (133)	July 30 A (4)	July 30 B (14)	July 30 C (9)	July 30 D (17)	July 30 Total (44)	Total (239)
Macrothricidae		-	-	-	-	-	1.6	2.4	0.0	1.5	1.3	-	1.5	13.1	0.9	3.5	1.4
Polyphemidae																	
Polyphemus		-	-	-	-	-	0.4	-	-	-	0.1	-	-	-	-	-	0.0
Sididae																	
Diaphanosoma		-	-	-	-	-	0.4	-	-	-	0.1	-	-	-	-	-	0.0
Sida		0.5	-	-	0.0	0.2	8.9	2.7	0.1	1.7	2.7	18.8	24.4	6.4	0.6	11.0	3.6
Copepoda																	
Calanoida		-	-	-	0.1	0.0	-	0.3	-	0.4	0.2	-	-	-	5.9	2.3	0.5
Cyclopoida		-	0.5	-	0.5	0.3	1.0	4.1	1.7	3.4	2.6	6.3	1.4	6.7	0.6	2.6	2.0
Harpacticoida		-	-	-	-	-	-	-	-	2.2	1.0	-	-	-	-	-	0.5
OSTRACODA		1.3	-	-	3.7	1.8	6.8	5.1	2.6	6.6	5.4	6.5	2.2	1.0	1.3	2.0	3.9
INSECTA																	
Coleoptera		1.1	0.0	-	0.1	0.4	-	-	0.0	-	0.0	-	-	-	-	-	0.1
Curculionidae																	
Euhrychiopsis	(L)	0.4	-	-	0.2	0.2	-	-	-	-	-	-	-	-	-	-	0.0
	(A)	-	-	-	2.7	1.1	-	-	-	-	-	-	-	-	-	-	0.3
Diptera																	
Ceratopogonidae	(L)	-	-	-	2.2	0.8	0.8	2.1	1.0	0.7	1.0	-	0.5	-	0.4	0.3	0.8
	(P)	-	-	-	-	-	0.2	0.2	0.4	0.0	0.2	-	0.2	-	-	0.1	0.1
Chaoboridae																	
Chaoborus		0.6	0.1	-	-	0.2	-	-	0.4	0.1	0.1	-	0.3	-	0.0	0.1	0.1

D-4. Mean proportion by number (%) for prey taxa from bluegill diet samples in Manson Lake, summer 2014 (continued).

		Sample date															
		June 4–5					June 26, July 10					July 30					Total (239)
Taxa		A (20)	B (16)	C (2)	D (24)	Total (62)	A (23)	B (18)	C (34)	D (58)	Total (133)	A (4)	B (14)	C (9)	D (17)	Total (44)	
Chironomidae	(L)	2.4	4.1	0.2	5.6	4.0	10.0	27.1	8.6	13.5	13.5	24.3	9.8	17.9	6.8	11.6	10.7
	(P)	6.1	0.7	-	-	2.2	4.5	15.2	1.7	1.7	4.0	-	9.4	0.1	1.5	3.6	3.5
	(A)	0.0	0.0	-	1.8	0.7	1.2	-	0.5	-	0.3	-	3.9	-	1.3	1.7	0.7
Culicidae	(A)	-	-	-	0.3	0.1	-	0.2	-	0.0	0.0	-	-	-	-	-	0.0
Ephemeroptera		2.6	0.3	-	2.0	1.7	0.2	1.2	-	0.4	0.4	-	1.0	-	0.5	0.5	0.7
Hymenoptera		-	-	-	0.2	0.1	-	-	-	-	-	-	-	-	0.0	0.0	0.0
Lepidoptera		-	-	-	0.2	0.1	0.0	-	-	0.1	0.0	-	-	-	-	-	0.0
Odonata		0.6	0.2	-	0.3	0.4	6.1	-	0.2	0.5	1.3	1.9	0.7	-	0.2	0.5	0.9
Plecoptera		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera		1.3	0.1	-	7.5	3.4	0.8	0.9	0.1	0.9	0.7	5.8	0.6	-	0.7	1.0	1.4
CHELICERATA																	
Araneae		0.8	-	-	0.1	0.3	-	-	-	-	-	-	1.0	-	0.0	0.3	0.1
Hydracarina		1.8	0.0	-	0.6	0.8	4.7	1.4	0.6	2.9	2.4	14.4	0.9	3.5	2.2	3.2	2.2
MOLLUSCA																	
GASTROPODA		0.2	0.7	-	-	0.2	2.8	1.0	1.3	1.0	1.4	8.2	0.6	0.7	1.9	1.8	1.2
Ancylidae		-	0.1	-	-	0.0	-	-	-	-	-	-	-	-	-	-	0.0
Physidae		-	-	-	0.8	0.3	0.5	2.0	0.0	0.0	0.4	-	-	-	0.0	0.0	0.3
Planorbidae		0.4	0.2	-	0.0	0.2	1.0	-	2.3	0.1	0.8	-	4.8	0.1	1.6	2.1	0.9
Viviparidae		0.1	-	-	-	0.0	0.2	1.4	0.2	0.0	0.3	6.3	-	-	0.0	0.6	0.3
BIVALVIA																	
Sphaeriidae		0.3	0.0	-	0.1	0.1	1.1	-	0.4	0.7	0.6	-	-	-	8.8	3.4	1.0

D-4. Mean proportion by number (%) for prey taxa from bluegill diet samples in Manson Lake, summer 2014 (concluded).

	Sample date															
	June 4–5					June 26, July 10					July 30					
Taxa	A (20)	B (16)	C (2)	D (24)	Total (62)	A (23)	B (18)	C (34)	D (58)	Total (133)	A (4)	B (14)	C (9)	D (17)	Total (44)	Total (239)
ANNELIDA																
Hirudinea	-	-	-	1.7	0.6	0.5	0.3	-	1.7	0.9	-	-	-	0.2	0.1	0.7
Oligochaeta	-	-	-	0.4	0.2	-	-	-	-	-	-	1.8	-	-	0.6	0.1
NEMATODA	0.8	0.0	0.2	0.5	0.5	3.8	0.3	-	-	0.7	-	3.6	0.1	-	1.2	0.7
SUM	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix E. Invertebrate Totals in Environmental Samples.

E-1. Total invertebrate counts in environmental samples from Boot Lake, July 18, 2014. Ten samples (individual plants) were collected from each bed. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae.

Taxa		A	B	C	D	Total
ARTHROPODA						
CRUSTACEA						
Amphipoda		3	10	18	23	54
Isopoda						
Cladocera			2			2
Bosminidae						
Bosmina			1	6	27	34
Chydoridae		200	98	2,551	210	3,060
Daphniidae						
Daphnia		5		178	729	912
Ceriodaphnia		12	5	133	1,036	1,187
Scapholeberis						
Simocephalus		2	1			3
Holopedidae		1	1	10	3	16
Holopedium						
Leptodoridae						
Leptodora						
Macrothricidae						
Polyphemidae						
Polyphemus						
Sididae						
Diaphanosoma		7	5	5	1	17
Sida		225	378	6	62	671
Copepoda						
Calanoida		12	1	42	182	237
Cyclopoida		92	66	127	337	622
Harpacticoida			2		4	5
OSTRACODA		520	147	1,092	867	2,626
INSECTA						
Coleoptera			1	1		3
Curculionidae						
Euhrychiopsis	(L)					
	(A)					
Diptera						
Ceratopogonidae	(L)	78	39	258	174	549

E-1. Total invertebrate counts in environmental samples from Boot Lake, July 18, 2014 (concluded).

Taxa		A	B	C	D	Total
Ceratopogonidae	(P)				6	6
Chaoboridae						
Chaoborus				37		37
Chironomidae	(L)	1,032	2,618	1,592	2,515	7,756
	(P)	12	5	20	56	93
	(A)				1	1
Culicidae	(A)					
Ephemeroptera		14	3	24	13	54
Hymenoptera				1		1
Lepidoptera		5	0		2	7
Odonata		17	4	28	7	56
Plecoptera			1			1
Trichoptera		59	67	25	72	222
CHELICERATA						
Araneae						
Hydracarina		163	96	478	399	1,136
MOLLUSCA						
GASTROPODA		280	109	346	377	1,113
Ancylidae		11	2	5	3	21
Physidae				2		2
Planorbidae		50	71	225	278	625
Viviparidae		40	9	206	366	621
BIVALVIA						
Sphaeriidae						
ANNELIDA						
Hirudinea*		322	68	181	575	1,146
Oligochaeta		2,064	1,606	3,168	5,981	12,818
NEMATODA		102	54	191	63	409
Total		5,326	5,469	10,955	14,370	36,120

*Likely a combination of Hirudinea and Planaria.

E-2. Total invertebrate counts in environmental samples from Little Bearskin Lake, July 11, 2014. Ten samples (individual plants) were collected from each bed. Stage: (A) – adult; (P) – pupae; (L) – larvae. For insects, stage is assumed to be larvae unless otherwise specified.

Taxa		A	B	C	D	Total
ARTHROPODA						
CRUSTACEA						
Amphipoda		10	8	20	25	63
Isopoda						
Cladocera			7	7		14
Bosminidae						
Bosmina		112	219	96	18	445
Chydoridae		34	278	175	410	897
Daphniidae						
Daphnia		6	6		172	184
Ceriodaphnia		143	270	712	148	1,272
Scapholeberis			1			1
Simocephalus		2	3	109	60	175
Holopedidae						
Holopedium						
Leptodoridae			1		1	2
Leptodora						
Macrothricidae			29	10	72	111
Polyphemidae						
Polyphemus						
Sididae						
Diaphanosoma		33	30	187	140	389
Sida		126	353	389	804	1,673
Copepoda						
Calanoida		58	14	64	434	571
Cyclopoida		87	95	295	257	735
Harpacticoida		4	16	22	64	105
OSTRACODA		597	1,162	1,015	1,442	4,217
INSECTA						
Coleoptera						
Curculionidae						
Euhrychiopsis	(L)			1		1
	(A)				1	1
Diptera						
Ceratopogonidae	(L)	36	20	78	196	330

E-2. Total invertebrate counts in environmental samples from Little Bearskin Lake, July 11, 2014 (concluded).

Taxa		A	B	C	D	Total
Ceratopogonidae	(P)					
Chaoboridae						
Chaoborus					9	9
Chironomidae	(L)	1,015	873	620	2,315	4,822
	(P)	8	2	10	9	29
	(A)					
Culicidae	(A)	3	4			7
Ephemeroptera		12	35	24	45	117
Hymenoptera						
Lepidoptera						
Odonata		3	17	61	333	414
Plecoptera						
Trichoptera		123	198	223	408	951
CHELICERATA						
Araneae						
Hydracarina		222	356	422	242	1,242
MOLLUSCA						
GASTROPODA		483	588	854	498	2,423
Ancylidae					1	1
Physidae		9	19	9		36
Planorbidae						
Viviparidae		13	114	11	3	141
BIVALVIA						
Sphaeriidae		1	0		2	3
ANNELIDA						
Hirudinea		24	42	35	9	109
Oligochaeta		1,886	1,368	3,929	1,866	9,049
NEMATODA		83	30	22	85	220
Total		5,132	6,158	9,401	10,069	30,760

E-3. Total invertebrate counts in environmental samples from Long Lake, July 23, 2014. Ten samples (individual plants) were collected from each bed. Stage: (A) – adult; (P) – pupae; (L) – larvae. For insects, stage is assumed to be larvae unless otherwise specified.

Taxa		A	D	F	Total
ARTHROPODA					
CRUSTACEA					
Amphipoda		7		20	27
Isopoda		1	0	1	2
Cladocera			2	1	3
Bosminidae					
Bosmina		0	44	8	52
Chydoridae		119	412	194	726
Daphniidae		2	29		31
Daphnia		39	337	51	428
Ceriodaphnia		15	227	28	270
Scapholeberis					
Simocephalus		2		4	5
Holopedidae		1		3	4
Holopedium					
Leptodoridae			1		1
Leptodora					
Macrothricidae		9		12	21
Polyphemidae					
Polyphemus					
Sididae					
Diaphanosoma		25	402	214	641
Sida		101	720	135	956
Copepoda					
Calanoida		1,212	244	2,070	3,526
Cyclopoida		600	1,106	1,060	2,765
Harpacticoida			1	3	3
OSTRACODA		522	311	640	1,473
INSECTA					
Coleoptera					
Curculionidae					
Euhrychiopsis	(L)	2			2
	(A)				
Diptera					
Ceratopogonidae	(L)	94	62	74	230

E-3. Total invertebrate counts in environmental samples from Long Lake, July 23, 2014 (concluded).

Taxa		A	D	F	Total
Ceratopogonidae	(P)	7		1	8
Chaoboridae					
Chaoborus				70	70
Chironomidae	(L)	538	539	1,075	2,151
	(P)	9	15	16	40
	(A)				
Culicidae	(A)	1			1
Ephemeroptera		42	7	62	111
Hymenoptera					
Lepidoptera					
Odonata		42	97	47	186
Plecoptera					
Trichoptera		52	37	30	120
CHELICERATA					
Araneae					
Hydracarina		68	13	47	129
MOLLUSCA					
GASTROPODA		18	36	5	59
Ancylidae					
Physidae					
Planorbidae		7	23		30
Viviparidae		81	133	5	219
BIVALVIA					
Sphaeriidae					
ANNELIDA					
Hirudinea		10	91	21	122
Oligochaeta		1,294	1,318	871	3,483
NEMATODA		33	21	31	85
Total		4,952	6,229	6,798	17,979

E-4. Total invertebrate counts in environmental samples from Manson Lake, July 3, 2014. Ten samples (individual plants) were collected from each bed. Stage: (A) – adult; (P) – pupae; (L) – larvae. For insects, stage is assumed to be larvae unless otherwise specified.

Taxa		A	B	C	D	Total
ARTHROPODA						
CRUSTACEA						
Amphipoda		7	10	2	9	28
Isopoda		11	1		1	13
Cladocera		1	5	9	2	17
Bosminidae						
Bosmina		6	3	3	49	61
Chydoridae		829	710	669	899	3,107
Daphniidae		2	5	1	4	12
Daphnia				0	3	3
Ceriodaphnia		9	2	3		14
Scapholeberis						
Simocephalus		6				6
Holopedidae		1			4	5
Holopedium						
Leptodoridae						
Leptodora						
Macrothricidae		88	71	12	8	179
Polyphemidae						
Polyphemus						
Sididae						
Diaphanosoma						
Sida		604	336	132	364	1,436
Copepoda						
Calanoida		1	1	5	15	22
Cyclopoida		223	113	120	548	1,003
Harpacticoida		46	46	9	113	215
OSTRACODA		205	125	506	89	925
INSECTA						
Coleoptera			1			1
Curculionidae						
Euhrychiopsis	(L)					
	(A)					
Diptera						
Ceratopogonidae	(L)		29	5	4	39

E-4. Total invertebrate counts in environmental samples from Manson Lake, July 3, 2014 (concluded).

Taxa		A	B	C	D	Total
Ceratopogonidae	(P)					
Chaoboridae						
Chaoborus						
Chironomidae	(L)	2,254	2,327	140	660	5,382
	(P)	1	9	2		12
	(A)					
Culicidae	(A)					
Ephemeroptera		11	9	0	17	38
Hymenoptera						
Lepidoptera						
Odonata		3	19	1	17	40
Plecoptera						
Trichoptera		25	56	4	18	103
CHELICERATA						
Araneae						
Hydracarina		64	94	49	112	320
MOLLUSCA						
GASTROPODA		37	43	199	13	292
Ancylidae		1	1			2
Physidae		11	5	0		16
Planorbidae		115	109	178	84	486
Viviparidae		14	3	17	3	37
BIVALVIA						
Sphaeriidae					1	1
ANNELIDA						
Hirudinea			1			1
Oligochaeta		180	412	696	1,009	2,296
NEMATODA		1	1			1
Total		4,758	4,545	2,763	4,048	16,114

Appendix F. Invertebrate Proportions in Environmental Samples.

F-1. Mean proportion by number (%) for prey taxa from environmental samples in Boot Lake, July 18, 2014. On each date, 4 sites (EWM beds) were sampled. Ten samples (individual plants) were collected from each bed. For insects, stage is assumed to be larvae unless otherwise specified. Stage: (A) – adult; (P) – pupae; (L) – larvae. Dashes (-) indicate no individuals of that taxon were present in the environmental samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

Taxa	A	B	C	D	Total
ARTHROPODA					
CRUSTACEA					
Amphipoda	0.0	0.2	0.2	0.2	0.1
Isopoda	-	-	-	-	-
Cladocera					
Bosminidae					
Bosmina	-	0.0	0.0	0.1	0.0
Chydoridae	3.7	1.8	18.6	1.3	6.5
Daphnidae	-	-	-	-	-
Daphnia	0.1	-	1.3	3.8	1.2
Ceriodaphnia	0.2	0.1	1.0	5.2	1.5
Scapholeberis	-	-	-	-	-
Simocephalus	0.0	0.0	-	-	0.0
Holopedidae					
Holopedium	0.0	0.0	0.1	0.0	0.0
Leptodoridae					
Leptodora	-	-	-	-	-
Macrothricidae	-	-	-	-	-
Polyphemidae					
Polyphemus	-	-	-	-	-
Sididae					
Diaphanosoma	0.2	0.1	0.0	0.0	0.1
Sida	4.9	7.0	0.1	0.8	3.3
Copepoda					
Calanoida	0.1	0.0	0.3	1.0	0.3
Cyclopoida	1.7	1.1	1.2	2.0	1.5
Harpacticoida	-	0.0	-	0.0	0.0
OSTRACODA	10.2	2.8	11.0	5.7	7.5
INSECTA					
Coleoptera	-	0.0	0.0	-	0.0

F-1. Mean proportion by number (%) for prey taxa from environmental samples in Boot Lake, July 18, 2014 (concluded).

Taxa		A	B	C	D	Total
Curculionidae						
Euhrychiopsis	(L)	-	-	-	-	-
	(A)	-	-	-	-	-
Diptera						
Ceratopogonidae	(L)	1.2	0.7	2.7	1.1	1.4
Ceratopogonidae	(P)	-	-	-	0.1	0.0
Chaoboridae						
Chaoborus		-	-	0.5	-	0.1
Chironomidae	(L)	26.4	50.0	16.9	26.8	30.1
	(P)	0.2	0.1	0.3	0.3	0.2
	(A)	-	-	-	0.0	0.0
Culicidae	(A)	-	-	-	-	-
Ephemeroptera		0.2	0.1	0.2	0.2	0.2
Hymenoptera		-	-	0.0	-	0.0
Lepidoptera		0.1	0.0	-	0.1	0.0
Odonata		0.2	0.1	0.2	0.0	0.1
Plecoptera		-	0.0	-	-	0.0
Trichoptera		1.0	1.1	0.2	0.6	0.8
CHELICERATA						
Araneae		-	-	-	-	-
Hydracarina		3.1	1.6	4.8	5.0	3.6
MOLLUSCA						
GASTROPODA		4.4	1.7	3.5	4.0	3.4
Ancylidae		0.2	0.0	0.0	0.0	0.1
Physidae		-	-	0.0	-	0.0
Planorbidae		1.2	1.4	2.4	2.5	1.8
Viviparidae		0.9	0.2	2.3	3.6	1.7
BIVALVIA						
Sphaeriidae		-	-	-	-	-
ANNELIDA						
Hirudinea*		6.3	1.2	1.6	2.9	3.0
Oligochaeta		31.0	27.7	27.8	32.2	29.6
NEMATODA		2.4	0.9	2.7	0.6	1.7
TOTAL		100.0	100.0	100.0	100.0	100.0

*Likely a combination of Hirudinea and Planaria.

F-2. Mean proportion by number (%) for prey taxa from environmental samples in Little Bearskin Lake. July 11, 2014. On each date, 4 sites were sampled. Ten samples (individual plants) were collected from each bed. Stage: (A) – adult; (P) – pupae; (L) – larvae. For insects, stage is assumed to be larvae unless otherwise specified. Dashes (-) indicate no individuals of that taxon were present in the environmental samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

Taxa	A	B	C	D	Total
ARTHROPODA					
CRUSTACEA					
Amphipoda	0.3	0.2	0.5	0.6	0.4
Isopoda	-	-	-	-	-
Cladocera					
Bosminidae					
Bosmina	1.8	1.8	1.4	0.1	1.3
Chydoridae	0.7	5.5	2.2	4.3	3.2
Daphnidae	-	-	-	-	-
Daphnia	0.1	0.1	-	1.1	0.3
Ceriodaphnia	2.5	2.9	5.7	1.2	3.1
Scapholeberis	-	0.0	-	-	0.0
Simocephalus	0.0	0.1	0.8	0.5	0.4
Holopedidae					
Holopedium	-	-	-	-	-
Leptodoridae					
Leptodora	-	0.0	-	0.0	0.0
Macrothricidae	-	0.2	0.1	0.7	0.3
Polyphemidae					
Polyphemus	-	-	-	-	-
Sididae					
Diaphanosoma	0.5	0.8	1.6	1.6	1.1
Sida	2.2	5.1	3.4	8.1	4.7
Copepoda					
Calanoida	1.0	0.1	0.6	2.9	1.2
Cyclopoida	1.7	1.8	2.7	2.3	2.1
Harpacticoida	0.1	0.4	0.2	0.6	0.3
OSTRACODA	11.1	18.6	10.2	15.7	13.9
INSECTA					
Coleoptera	-	-	-	-	-

F-2. Mean proportion by number (%) for prey taxa from environmental samples in Little Bearskin Lake. July 11, 2014 (concluded).

Taxa		A	B	C	D	Total
Curculionidae						
Euhrychiopsis	(L)	-	-	-	0.0	0.0
	(A)	-	-	0.0	-	0.0
Diptera						
Ceratopogonidae	(L)	0.6	0.6	0.8	1.6	0.9
Ceratopogonidae	(P)	-	-	-	-	-
Chaoboridae						
Chaoborus		-	-	-	0.0	0.0
Chironomidae	(L)	24.2	18.5	7.3	20.6	17.7
	(P)	0.1	0.1	0.1	0.1	0.1
	(A)	-	-	-	-	-
Culicidae	(A)	0.1	0.1	-	-	0.0
Ephemeroptera		0.2	0.4	0.4	0.5	0.4
Hymenoptera		-	-	-	-	-
Lepidoptera		-	-	-	-	-
Odonata		0.1	0.2	0.7	2.3	0.8
Plecoptera		-	-	-	-	-
Trichoptera		3.0	4.2	2.9	4.4	3.6
CHELICERATA						
Araneae		-	-	-	-	-
Hydracarina		4.5	6.8	4.7	2.6	4.6
MOLLUSCA						
GASTROPODA		11.2	12.6	11.4	5.3	10.1
Ancylidae		-	-	-	0.0	0.0
Physidae		0.3	0.4	0.2	-	0.2
Planorbidae		-	-	-	-	-
Viviparidae		0.4	1.5	0.3	0.0	0.6
BIVALVIA						
Sphaeriidae		0.0	0.0	-	0.1	0.0
ANNELIDA						
Hirudinea		0.4	0.7	0.5	0.2	0.4
Oligochaeta		31.1	15.6	41.2	21.2	27.3
NEMATODA		1.8	0.6	0.2	1.1	0.9
TOTAL		100.0	100.0	100.0	100.0	100.0

F-3. Mean proportion by number (%) for prey taxa from environmental samples in Long Lake. July 23, 2014. On each date, 4 sites were sampled. Ten samples (individual plants) were collected from each bed. Stage: (A) – adult; (P) – pupae; (L) – larvae. For insects, stage is assumed to be larvae unless otherwise specified. Dashes (-) indicate no individuals of that taxon were present in the environmental samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

Taxa	A	D	F	Total
ARTHROPODA				
CRUSTACEA				
Amphipoda	0.2	-	0.3	0.2
Isopoda	0.0	0.0	0.0	0.0
Cladocera				
Bosminidae				
Bosmina	0.0	0.3	0.2	0.2
Chydoridae	2.7	8.5	3.4	4.9
Daphnidae	0.1	0.1	-	0.1
Daphnia	0.8	3.0	0.5	1.4
Ceriodaphnia	0.4	1.8	0.3	0.8
Scapholeberis	-	-	-	-
Simocephalus	0.0	-	0.0	0.0
Holopedidae				
Holopedium	0.1	-	0.0	0.0
Leptodoridae				
Leptodora	-	0.0	-	0.0
Macrothricidae	0.2	-	0.2	0.1
Polyphemidae				
Polyphemus	-	-	-	-
Sididae				
Diaphanosoma	0.9	3.9	2.7	2.5
Sida	2.3	13.7	2.4	6.2
Copepoda				
Calanoida	25.2	2.8	21.3	16.4
Cyclopoida	10.9	13.5	13.7	12.7
Harpacticoida	-	0.0	0.1	0.0
OSTRACODA	9.7	4.0	12.1	8.6
INSECTA				
Coleoptera	-	-	-	-

F-3. Mean proportion by number (%) for prey taxa from environmental samples in Long Lake. July 23, 2014 (concluded).

Taxa		A	D	F	Total
Curculionidae					
Euhrychiopsis	(L)	-	-	-	-
	(A)	0.0	-	-	0.0
Diptera					
Ceratopogonidae	(L)	1.7	1.2	1.4	1.4
Ceratopogonidae	(P)	0.1	-	0.0	0.0
Chaoboridae					
Chaoborus		-	-	1.4	0.5
Chironomidae	(L)	12.1	14.6	20.4	15.7
	(P)	0.2	0.5	0.2	0.3
	(A)	-	-	-	-
Culicidae	(A)	0.0	-	-	0.0
Ephemeroptera		0.8	0.1	1.0	0.7
Hymenoptera		-	-	-	-
Lepidoptera		-	-	-	-
Odonata		0.7	0.9	0.7	0.8
Plecoptera		-	-	-	-
Trichoptera		1.3	0.6	0.5	0.8
CHELICERATA					
Araneae		-	-	-	-
Hydracarina		1.5	0.7	0.8	1.0
MOLLUSCA					
GASTROPODA		1.0	0.4	0.1	0.5
Ancylidae		-	-	-	-
Physidae		-	-	-	-
Planorbidae		0.2	0.3	-	0.2
Viviparidae		2.1	0.9	0.0	1.0
BIVALVIA					
Sphaeriidae		-	-	-	-
ANNELIDA					
Hirudinea		0.3	0.8	0.4	0.5
Oligochaeta		23.7	26.9	15.2	22.0
NEMATODA		0.6	0.4	0.6	0.6
TOTAL		100.0	100.0	100.0	100.0

F-4. Mean proportion by number (%) for prey taxa from environmental samples in Manson Lake. July 3, 2014. On each date, 4 sites were sampled. Ten samples (individual plants) were collected from each bed. Stage: (A) – adult; (P) – pupae; (L) – larvae. For insects, stage is assumed to be larvae unless otherwise specified. Dashes (-) indicate no individuals of that taxon were present in the environmental samples. Taxa are listed if they were found in any of the 4 study lakes and so may not be present in every lake.

Taxa	A	B	C	D	Total
ARTHROPODA					
CRUSTACEA					
Amphipoda	0.2	0.2	0.1	0.3	0.2
Isopoda	0.3	0.0	-	0.0	0.1
Cladocera					
Bosminidae					
Bosmina	0.2	0.1	0.1	1.8	0.5
Chydoridae	16.7	14.8	21.2	26.1	19.7
Daphnidae	0.0	0.1	0.0	0.2	0.1
Daphnia	-	-	0.0	0.1	0.0
Ceriodaphnia	0.1	0.1	0.2	-	0.1
Scapholeberis	-	-	-	-	-
Simocephalus	0.1	-	-	-	0.0
Holopedidae					
Holopedium	0.0	-	-	0.2	0.0
Leptodoridae					
Leptodora	-	-	-	-	-
Macrothricidae	1.5	1.2	0.3	0.2	0.8
Polyphemidae					
Polyphemus	-	-	-	-	-
Sididae					
Diaphanosoma	-	-	-	-	-
Sida	11.1	9.1	5.4	10.2	8.9
Copepoda					
Calanoida	0.0	0.0	0.1	0.3	0.1
Cyclopoida	4.0	1.8	4.6	13.9	6.1
Harpacticoida	0.9	0.7	0.3	2.9	1.2
OSTRACODA	4.4	2.6	17.9	2.1	6.7
INSECTA					
Coleoptera	-	0.0	-	-	0.0

F-4. Mean proportion by number (%) for prey taxa from environmental samples in Manson Lake. July 3, 2014 (concluded).

Taxa		A	B	C	D	Total
Curculionidae						
Euhrychiopsis	(L)	-	-	-	-	-
	(A)	-	-	-	-	-
Diptera						
Ceratopogonidae	(L)	-	0.6	0.3	0.1	0.2
Ceratopogonidae	(P)	-	-	-	-	-
Chaoboridae						
Chaoborus		-	-	-	-	-
Chironomidae	(L)	49.0	52.8	5.8	15.4	30.8
	(P)	0.0	0.1	0.1	-	0.1
	(A)	-	-	-	-	-
Culicidae	(A)	-	-	-	-	-
Ephemeroptera		0.3	0.2	0.0	0.4	0.2
Hymenoptera		-	-	-	-	-
Lepidoptera		-	-	-	-	-
Odonata		0.1	0.3	0.0	0.4	0.2
Plecoptera		-	-	-	-	-
Trichoptera		0.5	1.1	0.2	0.6	0.6
CHELICERATA						
Araneae		-	-	-	-	-
Hydracarina		1.6	2.1	1.7	3.0	2.1
MOLLUSCA						
GASTROPODA		1.0	0.6	9.1	0.3	2.8
Ancylidae		0.0	0.0	-	-	0.0
Physidae		0.3	0.1	0.0	-	0.1
Planorbidae		3.3	2.8	6.7	2.0	3.7
Viviparidae		0.3	0.1	0.6	0.1	0.3
BIVALVIA						
Sphaeriidae		-	-	-	0.0	0.0
ANNELIDA						
Hirudinea		-	0.1	-	-	0.0
Oligochaeta		3.9	8.2	25.3	19.3	14.2
NEMATODA		0.0	0.0	-	-	0.0
TOTAL		100.0	100.0	100.0	100.0	100.0