Aquatic invasive species survey of lakes with public access in Barron, Chippewa, Dunn, Eau Claire, and Rusk counties

By Anna Mares, Sarah Braun and D. Jo Heuschele
Beaver Creek Reserve Citizen Science Center
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Introduction

Beaver Creek Reserve is a nature reserve and environmental education center located in Eau Claire County. The Beaver Creek Citizen Science Center (BCCSC), established in 2003, has collaborated with scientific professionals on a local, state, and national level while promoting the importance of citizen science with the general public, school groups, and local organizations.

Aquatic invasive species (AIS) are quickly becoming an important issue in waters in west central Wisconsin. Eurasian water milfoil (EWM) and zebra mussels threaten the thousands of lakes and miles of rivers in Wisconsin including the Mississippi and St. Croix Rivers and AIS-infested lakes of the Twin Cities region, which are in close proximity. There are 1,108 lakes, along with thousands of miles of streams and rivers and thousands of acres of wetlands, in the five-county (Barron, Chippewa, Dunn, Eau Claire, and Rusk) region of Wisconsin close to the BCCSC. Of these 1,108 lakes, only nine were documented with infestations of Eurasian water milfoil and zero were documented with infestations of zebra mussels or spiny waterfleas at the start of the project in 2007. Purple loosestrife was documented in all five counties and rusty crayfish populations had been documented at a total of thirteen sites in three of the counties before the survey began. As of spring 2007, curly-leaf pondweed was documented in 25 lakes across all five counties. Although information available through Wisconsin Department of Natural Resources (WDNR), University of Wisconsin-Extension (UWEX), and Wisconsin Association of Lakes indicated this region had low occurrences of AIS, the actual extent of the problem was unknown. Often, the discovery of a new infestation was by accident or documented while conducting research for another purpose. For example, the BCCSC carried out an aquatic plant survey to assess the post-winter drawdown reduction effects on aquatic plant communities in Lake Wissota, Chippewa County. During this scientific survey, Eurasian water milfoil (EWM) was discovered, which was the first confirmed EWM infestation in the lower Chippewa River Basin.

This discovery prompted the WDNR to urge the BCCSC to lead a five-county AIS assessment, education, prevention, and control project, for three years (from 2007 through 2009) on 126 lakes. Six aquatic invasive species were surveyed for, including spiny waterflea (*Bythotrephes longimanus*), zebra mussels (*Dreissena polymorpha*), purple loosestrife (*Lythrum salicaria*), Eurasian water milfoil (*Myriophyllum spicatum*), rusty crayfish (*Orconectes rusticus*), and curly-leaf pondweed (*Potamogeton crispus*). Additional species, Chinese mystery snails (*Bellamya japonica*) and banded mystery snails (*Viviparus georgianus*), were added to the survey scope during the project.

The objective of the project was to assess the five-county region for the presence of AIS and increase awareness of AIS through education. This project had four goals 1) **assess** which lakes in the five-county region were infested with AIS, through monitoring and the involvement of WDNR, county conservationists, university, UW-Extension, school groups, lake associations, organized sportsman's groups, and other citizens; 2) **educate** lakeshore residents and lake users about aquatic invasive species; 3) **prevent** the spread of AIS, as proper assessment and education would help prevent the continued spread of AIS; 4) **monitor and control** AIS infestations by assisting lake associations and districts with AIS suppression or eradication. This report will demonstrate that the BCCSC succeeded in accomplishing the four goals of this project.

Methods

To carry out the goals of the project, an AIS coordinator was hired, as well as an AIS technician to assist with fieldwork and conduct watercraft inspections under the Clean Boats, Clean Waters program. In addition, the BCCSC Director oversaw operations.

Goals 1 & 4: assessment, monitoring, and control

Lakes with public access are more likely to have transient boaters, which are considered the major preventable transmission vector of AIS (UWEX, 2009). The 126 lakes that were surveyed were chosen from the 1,108 lakes in the five-county region based upon the status of their public access points (Table 1). Only those lakes (122 lakes) that were listed as having a BR (Boat Ramp; a defined public boat launching facility which may or may not have parking), BF (Barrier-free Boat Ramp; sites have a boarding dock or means of wheelchair access to boats), or a P (Barrier-free pier; piers were designed to accommodate wheelchairs) according to the publication "*Wisconsin Lakes*" were considered to have public access and therefore included in the study (WDNR, 2005). Four lakes were added to the total after word of mouth confirmed that public boat launches were present. A complete list of the lakes surveyed or attempted to be surveyed are laid out by county in Table 5 (in *Appendix A*). This list of 126 lakes contains fewer lakes than the original proposal of 130 lakes, due to duplication of lakes in the original list that fall within two separate counties (i.e. Holcombe Flowage, Chain Lake and Elk Creek Lake), along with five lakes that were not listed as having public access, and were therefore removed from the survey list.

Table 1. Total number of lakes in five counties in West Central Wisconsin and number of those lakes that have boat launches and lake associations or districts (WDNR, 2005, and UWEX, 2009).

County	Number of Lakes	Lakes with Public Boat Launches	Lakes with Associations or Districts
Eau Claire	20	8 (40%)	4 (20%)
Chippewa	449	40 (9%)	13 (3%)
Dunn	20	4 (20%)	2 (10%)
Barron	369	50 (14%)	18 (5%)
Rusk	250	24 (10%)	8 (3%)
Total	1,108	126	45

Methods used for sampling the six AIS were those that are used by the WDNR (Herman, 2007) for monitoring of these species, unless otherwise noted. This allowed for consistency when entering the survey results into online databases and report forms that were sent to the WDNR. In the initial project proposal, the focus was to be on lakes that had not been monitored since 2005, leaving an estimated 100 lakes to be assessed for EWM and zebra mussels, with additional monitoring to be done for curly-leaf pondweed, purple loosestrife, rusty crayfish and spiny waterfleas on high-risk lakes (i.e. lakes with high recreational use and numerous boat launches). These lakes were to be surveyed once during the duration of the project. Upon further consideration, the BCCSC original lead researcher decided to survey all of the lakes for all of the six species to the best of the survey crew's ability, with the time allotted, to obtain more comprehensive presence/absence results. Each lake was visited three times during one season and one season over the duration of the project. For example, some lakes were sampled three times during 2007, and other lakes were sampled three times during 2008, etc. Sampling occurred during June, July, and August of each year. In June, the researcher and technician conducted a plant survey for EWM and curly-leaf pondweed and tow samples for spiny waterfleas and zebra mussel veligers. In July, the researcher and technician conducted tow samples for spiny waterfleas and zebra mussel veligers and set traps for rusty crayfish if the lake was sampled at the end of the month. In August, the researcher and technician conducted tows for spiny waterfleas, zebra mussel veligers, set traps for rusty crayfish for those lakes sampled at the beginning of the month, and looked for purple loosestrife along the lake edge (Table 2).

Table 2. Frequency at which species were surveyed on each lake over the course of a summer. Each column represents one sampling event.

	June Sampling	July sampling	August Sampling
Surveyed Species	curly-leaf pondweed		
	Eurasian water milfoil		
			purple loosestrife
		rusty crayfish	
	spiny waterflea	spiny waterflea	spiny waterflea
	zebra mussels	zebra mussels	zebra mussels

Order in which lakes were surveyed

The lakes sampled during the first year were chosen based on their geographic proximity to known infested lakes (i.e. Wissota, Holcombe and others). The lakes sampled in the second year of the project were those lakes that were not in Barron County and not already surveyed. The third year of the project the lakes sampled consisted of mainly Barron and half of the Rusk County lakes. Barron County was sampled during the last field season because an intern of the Barron County Soil & Water Conservation Department had surveyed 32 of the lakes in the county in 2006. The intern surveyed for curly-leaf pondweed (present in eight lakes), purple loosestrife (present in nine lakes), Eurasian water milfoil (present in seven lakes), and rusty crayfish (present in three lakes). The intern used snorkeling for a visual inspection at the boat landings and a hand rake for sampling along the rest of the lake shoreline (SWCD, 2006).

Secchi disk readings

Secchi disk readings were taken at zebra mussel veliger and spiny waterflea tow sites (described in the corresponding report sections). Once at each of the sites, the boat anchors were lowered into the water to prevent movement and Global Positioning System (GPS) coordinates were recorded. The Secchi disk, an eight inch circular disk with alternating black and white quarters, attached to a marked rope (in foot increments) was lowered into the water on the shady side of the boat. The depth at which the black and white pattern was no longer visible was marked on the rope and then the disk was further lowered and then brought back up until the pattern was again visible and again the rope was marked. The distance half way between the two marked points was considered the Secchi disk reading. Measurements were rounded to the nearest quarter foot.

Zebra mussel veligers

Three samples for zebra mussel veligers (larvae in the planktonic stage) were taken on three separate dates over the course of one summer for each lake. Samples were taken on an evenly spaced monthly basis after the water reached 54° F, as this is the temperature at which female zebra mussels are able to reproduce. Sample sites were determined by the size and bathymetry of the lake. The preferred method is to sample three sites per lake but that was not always possible or reasonable. Zebra mussel veliger samples and spiny waterflea samples were collected at the same points on each lake. Both samples require that the water depth is at least 15 to 20 ft, and additionally, spiny waterflea samples require a 100 m horizontal tow. If a lake only had one or two sections that allowed for the 100 m tows in areas with 15 to 20 feet of water without overlapping, then only those sites were sampled for zebra mussel veligers.

After sites had been selected, a standard net with a 0.5 m mouth, a 5:1 length to diameter ratio and with 64-micron mesh, a 0.5 m towing ring with a single point bridle, and a 3.5” PVC 2-piece collecting bucket, was used to collect veliger samples. At each sample point, a Secchi disk reading was taken to determine what the vertical length of the tow would be. An oligotrophic lake with a Secchi disk reading of 10-20 ft would warrant two, 2 m tows. A mesotrophic lake with a Secchi disk reading of 7-10 ft would equal one, 2 m tow and a eutrophic lake with a Secchi disk reading of less than 7 ft would result in one, 1 m tow. These values were determined by combining Tables 3 and 4 and the recommendations of the WDNR (2006), as specific Secchi disk readings were not listed in the protocol used. Vertical samples were taken over the appropriate distance, taking care to not create waves on the surface of the water, which would lower the sample volume. The net was rinsed from the outside by using a hand pump to force debris down to the plankton collection cup. As much water was filtered out as possible to reduce the sample’s volume by swirling the sample. The sample was then transferred to a sample jar and preserved with a 4:1 ratio of 91% isopropyl alcohol or 100% Ethyl Alcohol, depending on availability, to sample. The process was repeated at all of the sample sites on the lake (up to three sites). The samples were placed in a cooler and then put in a refrigerator until processed.

Table 3. Trophic status classification of Wisconsin lakes based on chlorophyll-a, water clarity measurements, and total phosphorus values (Lillie and Mason, 1983).

Trophic Status	Chlorophyll-a (ug/L)	Total Phosphorus (ug/L)	Secchi Disk (ft)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	8
	27	10	6
Eutrophic	30	11	5
	50	15	4

Table 4. Trophic status classification of Wisconsin lakes based on chlorophyll-a, water clarity measurements, and total phosphorus values (Carlson, R.E. and J. Simpson, 1996).

Trophic Status	Trophic Status Index	Chlorophyll-a (ug/L)	Secchi Disk (ft)	Total Phosphorus (ug/L)
Oligotrophic	<30	<0.95	>26	<6
	30-40	0.95-2.6	26-13	6-12
Mesotrophic	40-50	2.6-7.3	13-6.75	12-24
Eutrophic	50-60	7.3-20	6.75-3.25	24-48
	60-70	20-56	1.75-3.25	48-96
Hyper Eutrophic	70-80	56-155	0.75-1.75	96-192
	>80	>155	<0.75	192-384

Once in the lab, a microscope equipped with cross-polarized filters was used to determine the presence or absence of veligers in the sample. The cross-polarization produces an illuminated "cross" on the shells of organisms that contain crystalline calcite material, including zebra mussel veligers. A few zooplankton, such at ostracods, produce the same "cross" but are easily separated from veligers by distinguishing features such as protruding legs and antennae and a dark eye spot. Samples were taken from the refrigerator where suspended material in the sample had time to settle to the bottom of the jar. Samples were left striated so that a 10 ml sample could be pipetted from the bottom, settled material of the sample. The 10 ml was placed in a petri dish and analyzed under the microscope for veligers. The process was repeated five times per sample, totaling 50 ml analyzed. If veligers were suspected, the samples were returned to the sample jar for enumeration. Steve Galarnaue of the WDNR adapted the lab identification procedures used by the survey crew from Wetzel and Likens (1979).

For the 2009 field season, zebra mussel veliger samples were not processed in house. Samples were sent to the WDNR Plymouth office where they were analyzed by the state expert Jim Steinke. Samples were sent in plastic shipping bottles with proper labeling for samples with hazardous liquid (alcohol) in them.

Rusty crayfish

Samples for rusty crayfish were taken in late July and early August, when rusty crayfish were most active. Each lake was sampled once over the duration of the project. Two transects were placed to the right and to the left of the boat launch used by the sampling crew. Minnow traps (16" long x 8.5" wide) with a 2" opening were used to collect the crayfish. Each trap had floats with labels. A ¼ lb of beef liver was used as bait in each of the traps instead of natural fish bait (due to the presence of Viral Hemorrhagic Septicemia (VHS) in Wisconsin). Five traps total were used, with two placed to one side and three to the other side of the boat launch. Traps were placed approximately 10 m apart from each other at water depths of 0.5-1.5 m. Traps were set in a variety of habitat types if available. The substrate composition and depth below the water's surface were noted. Crayfish traps were deployed in the morning and were left in the water for no more than 24 hours. Traps were collected the following day and the crayfish, if any, were counted and then preserved. No more than 30 crayfish were collected from each lake to prevent over trapping. Even if the crayfish trapped appeared to be a species other than rusty crayfish, they were collected anyway to assist The Center for Limnology, located in Madison, Wisconsin, with tracking the species present in Wisconsin. For preservation, crayfish were packed in a Whirl-Pak with a ratio of three parts 91% isopropyl alcohol or 100% Ethyl alcohol to one part crayfish. Crayfish were stored in the freezer until the end of the season and then sent to The Center for Limnology for identification.

Aquatic plants

Plant surveys were conducted in the end of May and the start of June when the water reached 54º F, as this is the temperature at which native plants start new growth for the season. It was important to finish plant sampling before July when curly-leaf pondweed often began to breakdown and die. The plant survey design was based primarily on the rake-sampling method developed by Jessen and Lound (1962), but with a few modifications on the distance between transects and the number of rake samples within each transect for the sake of available sampling time. Transects were used to identify the presence or absence of invasive plants. The number of transects was determined by the size (in acreage) of the lake. For those lakes that were 20 acres or less, transects were sampled every 500 ft around the perimeter of the lake. For lakes over 20 acres, transects were sampled every 1,500 ft. Maps were made using the online Surface Water Data Viewer provided by the WDNR (2009). This web mapping program allowed transects to be delineated on aerial photos provided through the website. The first transect was drawn at the boat landing and the rest were drawn following the 500 or 1,500 ft placement around the perimeter. Transects were drawn radiating out from the shore towards the center of the lake. Along each transect, two rake samples were taken from each depth zone (0-1.5, 1.5-5, 5-10, and 10-20 ft). A True Temper® Thatch Rake was used with a 15" wide head, 54" wood handle, and 19 self-cleaning tines. In waters deeper than five feet, a rake with the same style of head was used, but the handle was detached and a rope was attached in its place. A weight was added to the rake to ensure that it fell to the lake bottom. All native species found using the rake were listed as present. All invasive species found were measured for approximate plant bed size, and three voucher specimens per lake were collected, along with GPS coordinates of the plant bed. Voucher specimens were placed in a plastic bag with water and later pressed onto mounting paper. A sample was collected of all specimens that were unable to be identified in the field and taken back to the lab to key out, according to Crow and Hellquist (2000), or to be identified by a botanist at UWSP Freckmann Herbarium. Purple loosestrife was monitored during the August sampling. Purple loosestrife was not part of the transect monitoring but instead was monitored by surveying the perimeter of the lake with the boat, looking at the shoreland for blooms of the plant. If identified, coordinates were taken and reporting sheets were filled out.

Spiny waterfleas

Sampling methods followed those prescribed by the WDNR (2007). Three samples for spiny waterfleas were taken on three separate dates over the course of one summer for each lake. Samples were taken on an evenly spaced monthly basis after the water reached 54° F. Sample sites were spread over the lake and were the same sites as those used for zebra mussel sampling. The water depth needed to be at least 15-20 ft to allow for the length of the sample net. The sample net was the same style as the zebra mussel veliger net, with a 0.5 m mouth, but had a 250-micron mesh rather than 64-micron mesh. Because the tows required a longer distance than the zebra mussel tows, a larger mesh size of 250-micron was needed to lower the chances of the net becoming clogged from suspended material in the water, while still being selective enough for spiny waterfleas. An electric trolling motor was used to tow the net below the water’s surface for 100 m at approximately 3 mph. Distance was estimated using a handheld GPS unit. A trolling motor allowed for a lower speed than that provided by the gas-powered motor, which often caused the net to pop up out of the water. After the 100 m tow was complete, a hand pump was used to rinse debris and plankton down into the plankton collection cup. The sample was reduced to about 0.5 L by swirling the collection cup, filtering out excess water. The sample was then poured into a white pan. The AIS coordinator visually inspected the sample to determine the presence or absence of spiny waterfleas, as they are large enough to be seen by the naked eye (up to 1 cm) (UWEX, 2007).

Additional monitoring
Although there was no initial intention to monitor for additional aquatic invasive species, samples of species other than the six identified for this survey were collected if found. The WDNR has started to record the presence of invasive snails in the state. Therefore, if any snails were seen that resembled the species that they were looking for (Chinese mystery snails (*Bellamya japonica*), and banded mystery snails (*Viviparus georgianus*)), then a sample snail was taken of each type. If the snail was still alive it was preserved with a ratio of one part snail to three parts alcohol in a labeled bag, and put in the freezer until it was sent to the Center for Limnology for analysis. Empty snail shells were kept in labeled, plastic bags until they were sent in as well. Upon positive identification of Chinese or banded mystery snails, the information was added to the SWIMS database. SWIMS is a new water division data system designed to ensure that staff and management have access to high quality surface water, sediment and aquatic invasives data in an accessible format. Individuals can run quieries to access the statewide data or look at whatever they have entered themselves.

Decontamination
To do their part to stop the spread of aquatic invasive species, the survey crew sanitized everything that came into contact with lake water after sampling each lake, including nets and equipment, boat, trailer, ropes, and anchors. A backpack sprayer was filled with water and chlorine bleach added to obtain a 5% chlorine solution. According to the WDNR (2009), the 5% solution is strong enough to kill zooplankton such as spiny waterfleas and zebra mussel veligers. It also kills VHS. The solution was allowed a contact time of ten minutes. Sampling nets were then rinsed with fresh water from another backpack sprayer to slow the breakdown of the fragile, mesh netting from the acidic chlorine solution. Three nets were purchased over the course of the project as a result of the chlorine deteriorated mesh netting. In addition to sanitization, a visual inspection was conducted on the boat and trailer to look for attached plants and other aquatic hitch-hikers. Trailer rungs and motor props were common places for aquatic plants to become entangled. Also, all water was drained from the live well and the boat plug was removed.

Goals 2 & 3: prevention and education
Trainings and workshops were used as the main tools of prevention and education about AIS. The intention was that when citizens were taught about an invasive species, how they could prevent the spread of invasive species, and how to conduct watercraft inspections, they would be less likely to spread AIS and more likely to tell a friend about what they had learned. Trainings and workshops were advertised through the Beaver Creek Reserve Woodprints Newsletter, by calling lake groups to personally invite them to the events, and through online sites like the UW-Extension Clean Boats, Clean Waters website (http://www.uwsp.edu/cnr/uwexlakes/cbcw/).

AIS trainings
Participants at AIS trainings learned the basic skills of how to identify the common aquatic invasive species in their area, including zebra mussels, spiny waterflea, rusty crayfish, curly-leaf pondweed, Eurasian water milfoil, and purple loosestrife. Participants learned the definition of invasive species, how they are harmful, and how they can prevent their spread to other sites. They were also shown native species that were similar and how they could be distinguished from invasive species. Invasive species Watch Cards were handed out to all participants as well as other resource materials and details about where they could get more information. Trainings lasted an average of three hours.

Clean Boats, Clean Waters training workshops
Clean Boats, Clean Waters (CBCW) training workshops were geared specifically towards training individuals to participate in the Clean Boats, Clean Waters program. The citizen-based CBCW program trains individuals to stand at boat landings and inform boaters about AIS, the current laws in WI, and to conduct interactive watercraft inspections. Participants received an overview of AIS, the common AIS they might see at the landings, and instructions on how to conduct watercraft inspections. Participants also practiced mock-boater encounters. If weather and location permitted, individuals practiced at a real boat landing. They then learned how to enter the data they collected online into the SWIMS database. Each lake group present at the trainings received a Clean Boats, Clean Waters kit with all of the necessary informational material and forms to conduct watercraft inspections. Trainings lasted an average of three hours.

Aquatic plant identification workshops
Aquatic plant identification workshops were geared towards developing the aquatic plant identification skills of volunteers. Many of the common aquatic plants seen in the area were placed in trays with water so that individuals could see live plants versus pressed specimens (which are harder to learn from) and compare them to what is commonly seen in the field. Participants were shown how to group plants to genera to more easily identify them. The training also focused on how to identify which species are invasive and which are considered native by comparing those that most closely resembled each other. Trainings lasted an average of three hours.

AIS lake monitoring workshops
AIS lake monitoring is part of the Citizen Lake Monitoring Network (CLMN). The CLMN is a citizen based program that aims to have volunteers collect data on organisms in the lake and water quality parameters of the lake. At workshops, participants were shown how to monitor for five invasive species on their own lakes. These species included adult zebra mussels, rusty crayfish, purple loosestrife, Eurasian water milfoil, and curly-leaf pondweed. The sampling procedures for each species were explained and demonstrated as best as possible when indoors. Participants learned how to fill out all of the appropriate paper work for each type of monitoring and then how to enter it in the SWIMS online database. Possible forms include: Aquatic Invasives Presence/Absence Report, Aquatic Invasive Animal Incident Report, Plant Bed Density Report, Purple Loosestrife Cultivation Authorization and Biocontrol Insect Applications, Purple Loosestrife Watch, Aquatic Invasive Plant Incident Report, Crayfish Report, Zebra Mussel (Quantitative) Report, or the Water Flea Tow Monitoring Report. Trainings lasted an average of three hours.

Results

The AIS Coordinator worked 800 hours per summer on the project collecting data, entering data, coordinating volunteers, and writing reports. The AIS technician worked 560 hours over a 14 week summer for each of the three years. Twenty hours of the technician's week were devoted to assisting the AIS coordinator with surveying lakes and the other 20 hours per week involved conducting watercraft inspections.

Goals 1 & 4: assessment, monitoring, and control

AIS infestations

Table 6 (2007), Table 7 (2008), and Table 8 (2009) summarize the survey data for six invasive species along with the two species of mystery snail collected over the last three years. No new locations for rusty crayfish, zebra mussels, spiny water flea, or Eurasian water milfoil were documented in the lakes surveyed in 2007 according to comparisons of the survey results and the invasive species distributions lists that the WDNR provides on its website (a compilation of data uploaded onto the SWIMS database). Curly-leaf pondweed was found in 12 lakes where it was not previously documented. The new populations of curly-leaf were well integrated in the native plant population and appear to have been established for a while. In 2008, several new AIS findings were documented. The survey crew found twelve occurrences of AIS, eight of which were new sightings. The greatest numbers of new occurrences were recorded in 2009, with a staggering 92 occurrences of AIS. Fifty five of them were new.

As of September 30, 2009, 114 lakes were sampled for one to eight species. Of the sampled lakes, zero contained zebra mussels, zero contained spiny waterfleas, 17 contained rusty crayfish, 13 contained purple loosestrife, 53 contained curly-leaf pondweed, 15 contained Eurasian water milfoil, 35 contained Chinese mystery snails, and four contained banded mystery snails. Of these, 83 were considered new occurrences. The results displayed in Tables 6, 7, and 8 are also shown in Figures 1, 2, 3, 4, and 5.

The lake maps included in this report vary from 2007-2009 in what information they contain due to availability (or lack thereof) of hard copy data at the time of compilation. GPS points of transects were not recorded for 2007 or 2008 but they were in 2009. Data points/transects visible on 2009 maps correspond to the GPS points taken while conducting the plant surveys. In 2008, maps made using the Surface Water Data Viewer were used as guidelines for plant survey transects but do not necessarily reflect exact transect placement. Therefore, those seen on 2008 maps are approximate transect locations. The 2007 crew did not create Surface Water Data Viewer maps or record GPS points, therefore any transects shown on 2007 maps are those that were hand drawn on maps by the first survey crew and are approximate. Several lakes from 2007 have invasive plants present but locations of these plants were not recorded, and as a result were not placed on the maps. Tables 6, 7, and 8 should be used to verify the presence or absence of AIS in all of the lakes.

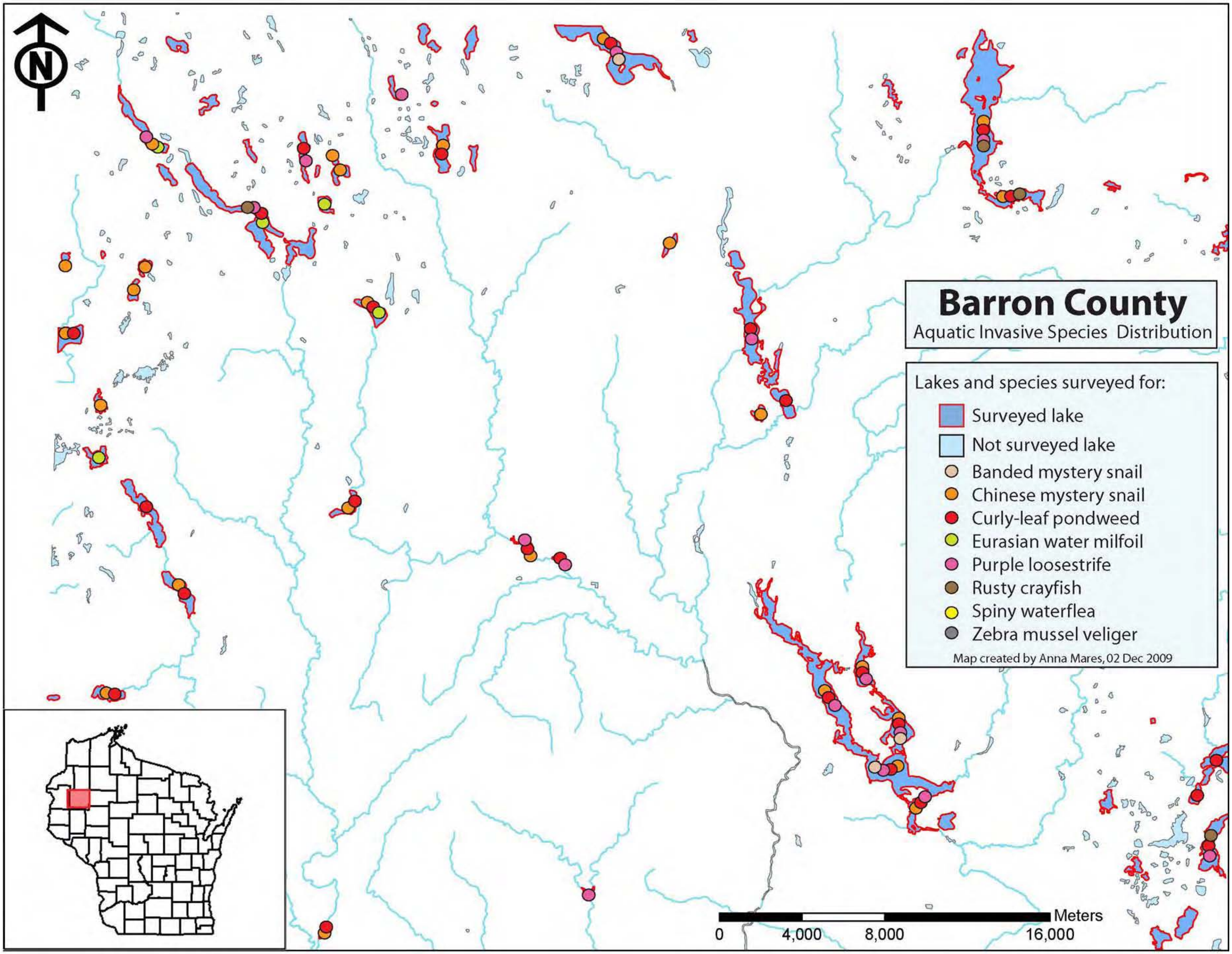

Figure 1. Distribution of eight aquatic invasive species across Barron County in lakes that were part of the five-county survey.

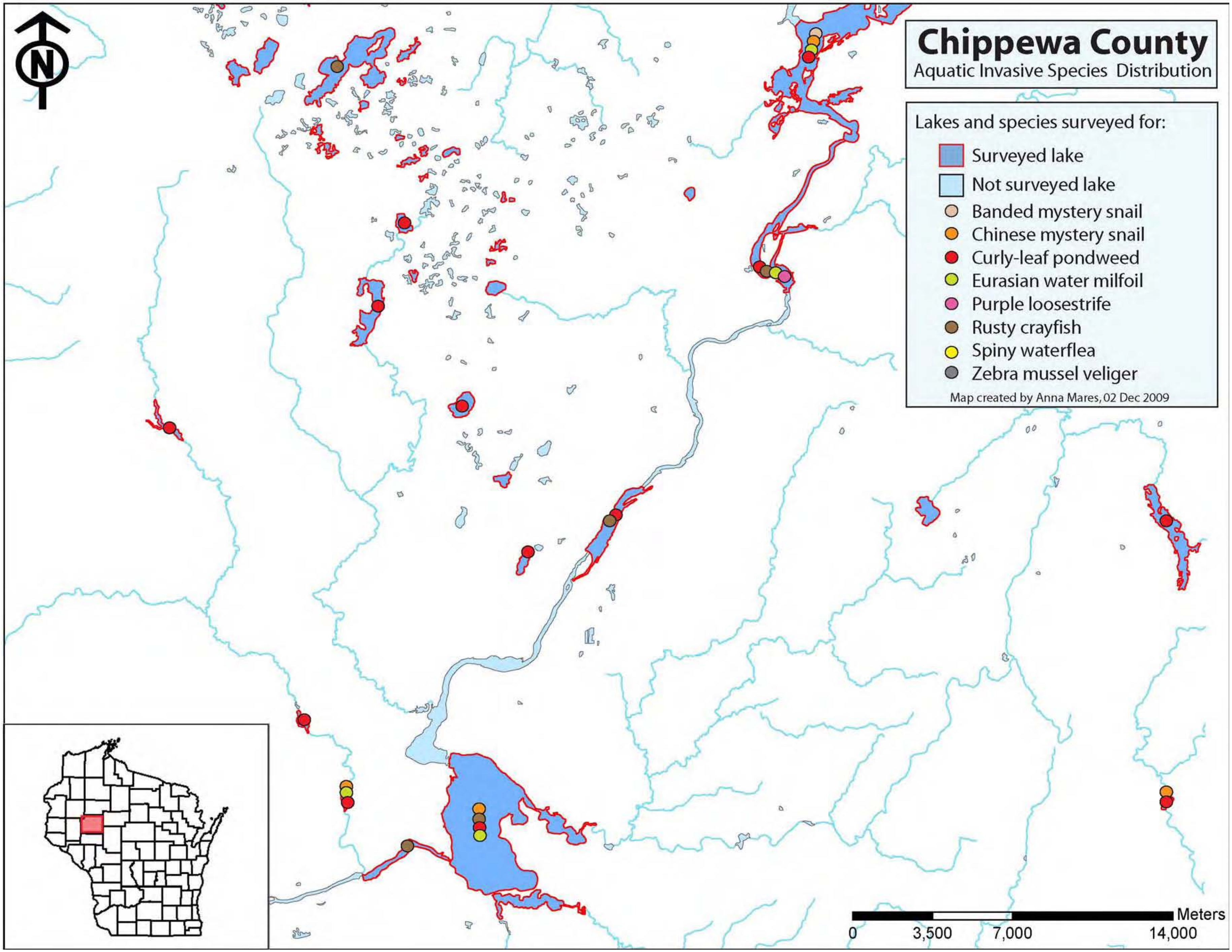

Figure 2. Distribution of eight aquatic invasive species across Chippewa County in lakes that were part of the five-county survey.

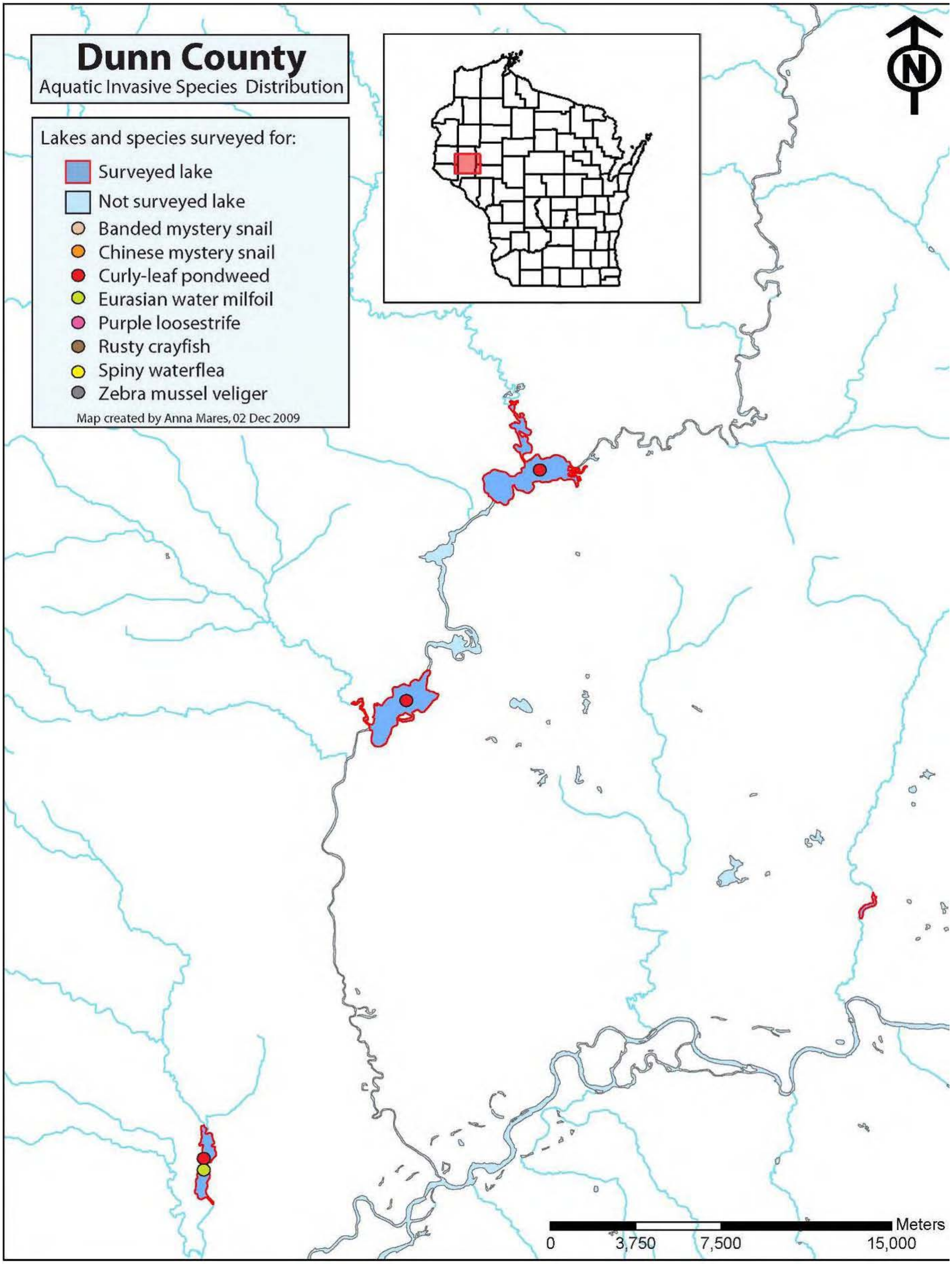

Figure 3. Distribution of eight aquatic invasive species across Dunn County in lakes that were part of the five-county survey.

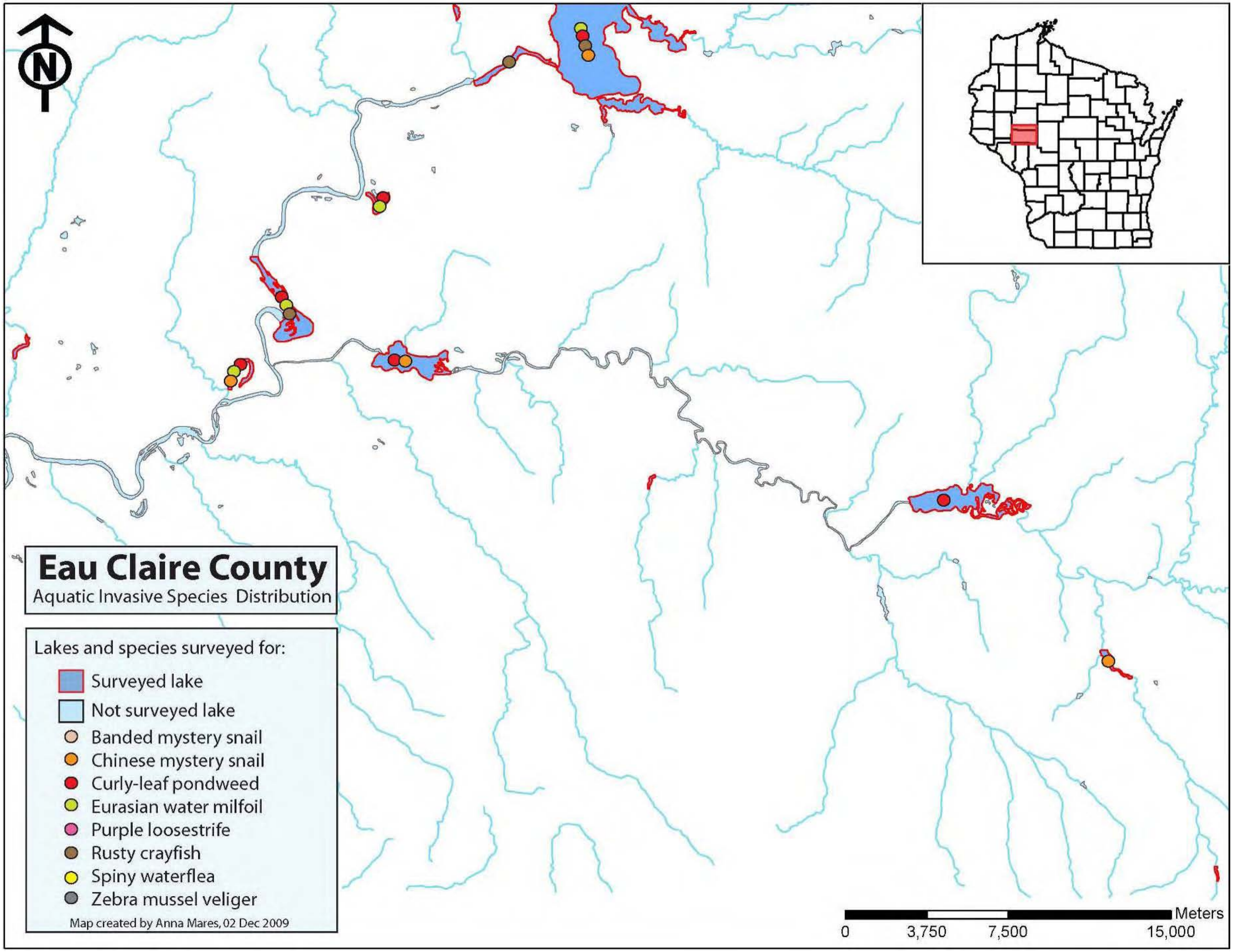

Figure 4. Distribution of eight aquatic invasive species across Eau Claire County in lakes that were part of the five-county survey.

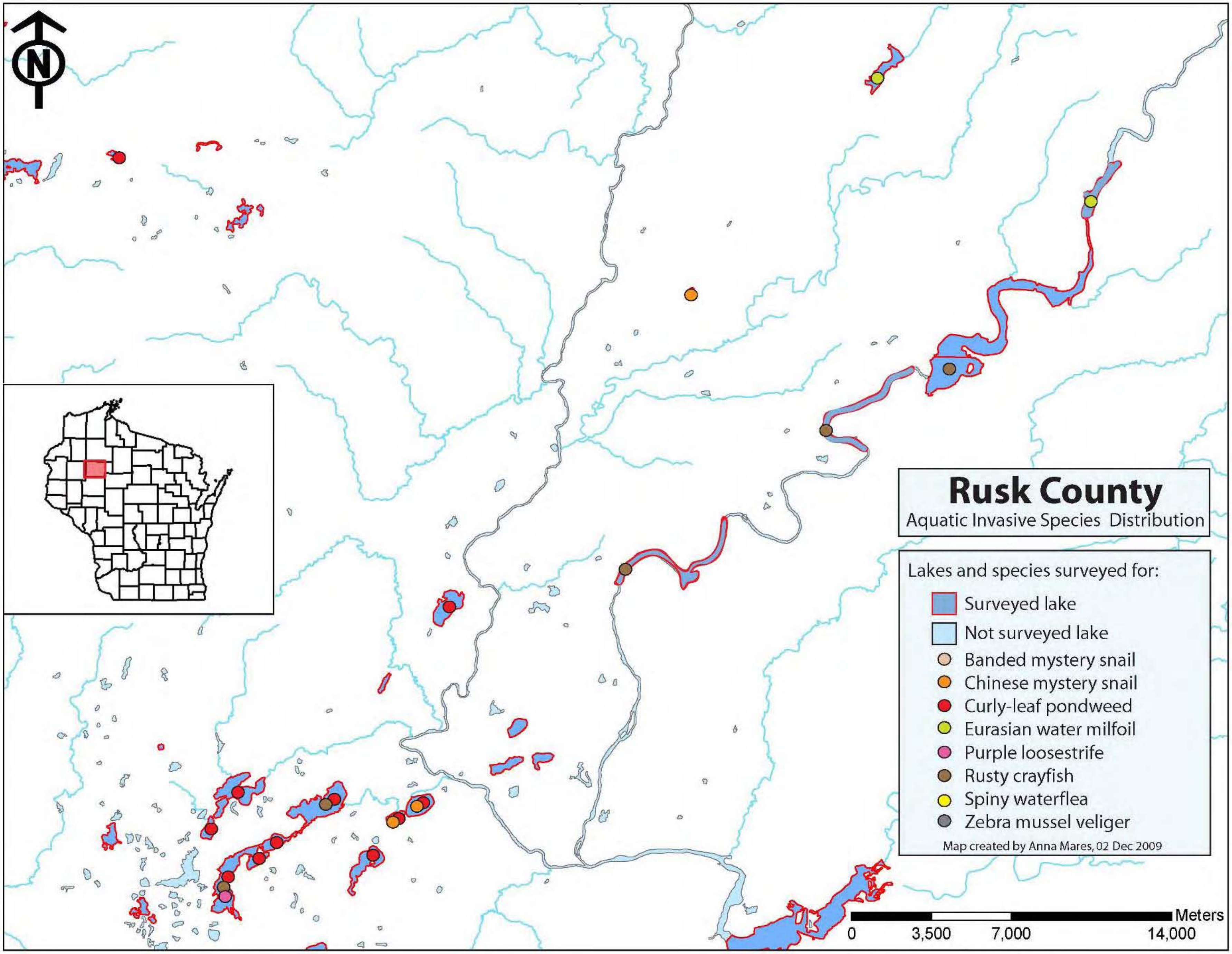

Figure 5. Distribution of eight aquatic invasive species across Rusk County in lakes that were part of the five-county survey.

At the start of the project, the survey crew took pictures of the AIS infestations from the boat. They also took pictures of the boat landings. It became evident that the photos were of no use as they did not clearly show the extent of the infestations and the photos did not hold any identity as to which lake they belonged. All of these photos were scraped and not included in the report.

Personnel changes

In the first year of the project BCCSC staff encountered several setbacks, including the CSC Director at the time leaving the project to attend graduate school and numerous boat, trailer, and vehicle problems, which slowed the progress of the project. The AIS team was able to survey 26 lakes three separate times over the course of the first summer. Sarah Braun was hired as the new CSC Director in August of 2007. In the summer of 2008, the AIS team was able to completely survey 28 lakes. Attempts were made to survey four other lakes, but the quality or lack of boat landings prohibited them from being surveyed. This left 68 lakes to be surveyed in the summer of 2009. There was also a change in personnel in August of 2008. Deborah Jo Heuschele left the AIS Coordinator position to pursue a PhD on August 12, 2008 and Anna Mares replaced her as the lead researcher. The AIS technician changed each of the three years of the project (Shelby Happe in 2007, Kevin Mesiar in 2008, and Zoe Hastings in 2009).

2009 sampling strategies

Several strategies were employed to make sampling more efficient and less time consuming in the third year of the project so that all 68 remaining lakes could be sampled. The survey crew camped out during the summer near the lakes that were to be surveyed each week. This saved over 72 hours on travel time (about 4344 miles) and increased the amount of available sampling time, as 40 hours per week was the maximum work week. Still, approximately 212 hours were spent driving (about 4134 miles) to and from lakes or sanitizing equipment while approximately 321.5 hours were spent surveying for AIS. Crayfish traps were placed only near the boat landings to allow for easy pick up the day following deployment. That way the boat was not needed to retrieve the traps. Another time saver was the off site processing of the zebra mussel veliger tow samples. By not processing the samples at Beaver Creek Reserve, the survey team was able to save 80 hours of lab time (157 samples x 0.5 hr per sample = 80 hours).

Exceptions as to why some portions or whole lakes were not surveyed

A number of lakes in the region have very active lake associations or districts that received grants through the DNR to fund AIS management and full aquatic plant surveys. The survey team wanted to be as efficient with their time as possible and did not want to duplicate work that had been done recently by lake associations and other groups on lakes in the study area. As a result, not all of the 126 lakes were surveyed for all six species.

BCCSC staff did not conduct plant surveys on the following lakes: Beaver Dam Lake, Echo Lake, Half Moon Lake, Lake Holcombe, Lake Wissota, Long Lake, and Rice Lake. Beaver Dam Lake is a 1,112-acre lake that was not surveyed for aquatic plants by BCCSC in the summer of 2009 because the lake is currently managing Eurasian water milfoil (EWM). Each year a private contractor is hired to conduct a 1,100-point survey on the lake's entire littoral zone before the chemical treatment commences on the approximate 200 acres of EWM. From these surveys they have also become aware of approximately 10 acres of scattered curly-leaf pondweed. This management is scheduled to continue into the future. The WDNR conducted a full point intercept plant survey on Echo Lake in the summer of 2007. From 2008-2012 the Echo Lake Association will be conducting spring pre- and post-treatment surveys for Eurasian water milfoil management. The association also conducts a fall survey to identify where management will take place in the following spring. Half Moon Lake did not have an aquatic plant survey completed by the BCCSC due to the discovery of Eurasian water milfoil in 2008. The lake now contains both curly-leaf pondweed and Eurasian water milfoil. As a result of these discoveries, the lake was being heavily monitored before and after the early spring chemical treatment in 2009. Rice Lake had a full point intercept survey by a private contractor in the summer of 2008 as part of Rice Lake Protection and Rehabilitation District's Lake Management Plan. Rice Lake is currently managing for large populations of curly-leaf pondweed. Sand Lake Association had a full point intercept survey conducted in the summer of 2005 and is scheduled to have another in 2010. In the mean time, 408 locations are surveyed yearly for the presence of aquatic invasive plants. Although plant surveys were not conducted on the above lakes, rusty crayfish, purple loosestrife, zebra mussel veligers and spiny water-flea were sampled by the BCCSC.

The following lakes, Blueberry Lake, Bog Lake, Dallas Flowage, Fairchild Pond, Fish Lake, Half Moon Lake, Hay Meadow Flowage #2, Knickerbocker Lake, Little Dummy Lake, Lowland Lake, Pickerel Lake, and Upper Devil's Lake were not surveyed for any of the six invasive species during the project. Blueberry Lake did not have an access road leading to the lake. Bog Lake did not have an accessible boat launch either. Dallas Flowage's unmaintained boat launch was over grown with 15 ft of vegetation out from the shore. Fairchild Pond does not have a maintained boat landing. The dock is present in front of the Rod and Gun Club but the boat would need to be launched over a grassy berm into thickly vegetated muck. Fish Lake's water level was at least five feet lower than normal and it also did not have a boat landing that was visible. Half Moon Lake was not surveyed for spiny waterflea or zebra mussel veligers because of its shallow depth and because it is already being intensely monitored for EWM and curly-leaf pondweed, as it has both. Hay Meadow Flowage #2 did not have a visible boat ramp from the trail. Knickerbocker Lake had a poorly constructed landing that was unsafe to launch a boat into. Little Dummy Lake had a public boat landing but the water level was so low that it was impossible to launch a boat. Lowland Lake did not have a boat landing. Stones had been placed as a barrier where there once had been a landing, and now only a canoe or kayak could be launched from the spot. There was also no turn around space at the end of the very winding and narrow access road. Pickerel Lake's access road was blockaded by a large wooden debris pile, purposefully placed. Lastly, Upper Devil´s water level was too low, leaving the boat launch over 100 m from the waters edge.

Loon Lake, Chapman Lake, Barron Flowage #3, Barron Flowage #1, Lea Lake Flowage, Tenmile Lake, Spring Lake, Prairie Farm Flowage, and Moon Lake were not surveyed for spiny waterfleas or zebra mussel veligers because the water was not deep enough in the lake/flowage and or the aquatic plants were hindering the collection of a good sample. Loon Lake´s boat launch was not deep enough for our boat to be launched. Spring Lake had a boat launch that was in disrepair, so the boat could not be launched onto the lake.

Additional monitoring
In addition to surveying for AIS using the transect method, BCCSC also conducted pre- and post- treatment surveys on Lake Wissota and Lake Holcombe from 2007 to 2009 for the management of Eurasian water milfoil as part of public outreach. Maps were made from the survey data using Geographic Information Systems to assist the lake associations in best assessing which areas should be considered for chemical treatment and plant management. Maps of curly-leaf pondweed beds were made for Marsh Miller Lake and Amacoy Lake. See *Appendix E* for maps.

Goals 2 & 3: education and prevention
A large portion of this grant project dealt with education of the public through talks, trainings and volunteers assisting with monitoring and office work. Beaver Creek Reserve was able to provide a total of 27 educational programs to lake associations and lake districts to encourage citizen monitoring of invasive species. Presentations included basic background information about the six aquatic invasive species in the area, and hands on education with the invasive species. Beaver Creek Reserve's Aquatic Invasive Species Coordinator was asked to speak at, and accepted, seven engagements, including a presentation at the August 2007 Northwest Lakes Conference on Invasive Species in Cable, WI. A project board was exhibited at seven events across Wisconsin. A poster was also presented at the Wisconsin Association of Lakes annual conference in April of 2009 on the most current findings of the survey. Through the generous support of the WDNR, Xcel Energy, and Wisconsin Environmental Education Board grants, the Citizen Science Center staff was able to conduct 14 formal workshops to train volunteers to monitor for aquatic invasive species and to conduct Clean Boats, Clean Waters watercraft inspections at area boat landings. It was difficult to properly devote enough time to lake groups to host as many workshops as previously hoped due to the amount of time required for thorough sampling of the lakes. Individual trainings were also given to volunteers who assisted staff with AIS monitoring and watercraft inspections. One after-school biology club from Hudson was trained to conduct Eurasian water milfoil surveys. Another group of youth from Eau Claire surveyed the Lake Wissota Beach for AIS, identifying and pressing whatever aquatic plants they found. A summer girl's camp (ages 9-12) conducted aquatic plant surveys from a pontoon on Lake Wissota in July of 2009.

A total of 187 volunteers were trained and contributed 1,820 hours of monitoring and inspections to date. These volunteers and staff also talked to a documented 2,136 people (data available from WDNR SWIMS database) while conducting watercraft inspections. In addition, educational exhibits were displayed at five local and state wide events, the Chippewa Valley Outdoor Games, which reached several hundred people and the first ever Lake Fair at Lake Wissota State Park, which reached an estimated 1,000 adults and kids from around WI and other states. The booth was also displayed at the 2008 NW Wisconsin Lakes Conference (200 people), the 2009 WAL Conference (400 people), and the Community Action Fair at UWEC in fall 2008, spring 2009 and fall 2009 (300 people). The number of people reached about aquatic invasive species thus far, 5,730 (through speaking engagements, events, and CBCW), and the number of volunteers we now work with, 187, is a measure of the success of this program. Many of our volunteers recruit new volunteers for Beaver Creek Reserve, expanding the program and the message exponentially. Two service learning volunteers from the University of Wisconsin-Eau Claire provided 30 hours each of volunteer service and three additional service learning volunteers committed 40 hours each.

Dissemination of survey results

It was important that the information collected during this project was shared with as many interested individuals and groups as possible. Individual lake reports and maps were sent to the respective lake organizations upon completion of the project. All of the invasive species presence data collected was entered into the online database called SWIMS (Surface Water Integrated Monitoring System), where individuals can view the data and set queries for specific interests. In SWIMS, the dates of the surveys were recorded, along with surveyor's names, hours spent on the lake, presence of invasive species, sampling strategies employed, infestation location, and approximate distribution within the lake, whether or not samples were vouchered and where the specimen samples are located for permanent storage. All of the aquatic plant voucher specimens collected for this project are located at the Stevens Point Herbarium and the University of Wisconsin Madison Museum (if they were an animal specimen). Over the 2009 summer, a monthly newsletter was created to update lake users and groups about the progress of the AIS Five-County Survey Project (see *Appendix F*). Tables 6, 7, and 8 were sent to the email list-serv of AIS coordinators across the state so that they were up to date on the findings in this region. A spreadsheet of all of the lakes, along with a list of the native plants found in each of them, was sent to the Natural Heritage Foundation and the WDNR for a permanent record, as some of the plants documented were considered to be species of special concern. A spreadsheet of all Secchi disk readings (Tables 9, 10, and 11 in *Appendix C*) for each of the lakes was entered into the SWIMS database. The full final report for this project will be added to the Beaver Creek Reserve website, as well as given to the WDNR, Xcel Energy, Barron County Soil and Water Conservation Department and the Rusk County AIS Coordinator. An article about this AIS project was written by the survey crew and published on The Citizen Scientist website (http://www.sas.org/tcs/weeklyIssues_2009/2009-09-04/feature2/index.html), operated by the Society for Amateur Scientists. Three press releases were issued to update citizens about the new findings of AIS in the region. Another way that survey information reached people was through personal contact. Many lake users and homeowners were curious as to what the survey crew was doing on their lake when they would see them in the boat or at the boat launches. This resulted in encounters with 50+ individuals that asked questions about the project and invasive species in general, giving the survey crew the opportunity to discuss the project goals of assessment and stopping the spread of AIS. A large majority of the volunteers that came out onto the lakes with the survey crew were members of lake associations or districts. They would go back to their lake organizations and tell them about the work that they had done out on the boat with staff and some of the new facts that they had learned.

Project deliverables

BCCSC was able to create as complete of a list as possible (Tables 6, 7, and 8 in *Appendix B*) of the presence/absence of AIS in the five-county region. These tables also double as a list of lakes with true (easily accessible) public boat launches. *Appendix G* contains individual lake reports, including: descriptions of the boat launch(es), maps of each of the lakes surveyed, aquatic plant transect locations (where available), and locations of spiny waterflea tows/zebra mussel veliger tows/Secchi disk readings. The maps and reports were sent to corresponding lake groups at the end of the project. *Appendix E* contains maps of pre/post surveys of Holcombe Flowage and Lake Wissota used for assistance with managing EWM, and maps of Amacoy Lake and Marsh Miller curly-leaf pondweed beds. Tables 9, 10, and 11 (in *Appendix C*) contain Secchi disk readings taken while surveying the lakes for zebra mussel veligers. The BCCSC was also able to create a network of professionals and citizens by working with University of Wisconsin-Extension, University of Wisconsin-Eau Claire, WDNR, Xcel Energy, Beaver Creek Reserve, Lake Holcombe Marina, Wisconsin Environmental Education Board, Barron County Parks and Forestry Department, Barron County Soil & Water Conservation Department, UW-Extension Basin Educators, 38 lake associations or individuals that live on the lake, non-lake dwelling citizens, school groups, and day camps. There were 29 lake groups that were involved with the Clean Boats, Clean Waters volunteer watercraft inspection program before the start of the project and now there are 30 lake groups involved. Sixty two groups are participating in CLMN and will hopefully continue to do so after the end of this project.

Discussion

Invasive species distributions

Although the number of newly discovered (83) and total number of AIS (137) discovered during the course of this project is disconcerting, it cannot be used as an indicator of the speed of the spread of AIS. Many of these populations of AIS may have been in the lakes for years, if not decades. Citizens and groups like BCCSC have just begun to formally document and voucher AIS specimens. Monitoring for invasive species must continue in order to ascertain whether or not populations are changing within these lakes and spreading to other lakes. This survey provides a baseline of AIS in the five-county region.

When looking at the distributions of the invasive species across the five-county region (Figures 1-5), it is evident that rivers are providing a conduit for AIS to move across the region effectively. If a lake in the upper reaches of a river system has an AIS, the lakes further down the system also have that AIS. For example in Barron County Lower Lake Vermillion has curly-leaf pondweed present. This lake is upstream of Poskin Lake, Barron Flowage #1, Barron Flowage #3, Tainter Lake, and Lake Menomin (in that order) and all have curly-leaf pondweed present. Similarly, Lake Holcombe in Chippewa County has curly-leaf pondweed, Eurasian water milfoil, Chinese mystery snails, and banded mystery snails. Curly-leaf pondweed is present in the lower reaches of the Cornell Flowage, Old Abe Flowage, Lake Wissota, and Dells Pond. Eurasian water milfoil is present in Cornell Flowage, Lake Wissota, and Dells Pond. It can be considered inevitable that the impoundments further downstream from the aforementioned lakes will soon harbor curly-leaf pondweed and Eurasian water milfoil, if they don't already.

Impoundments

Forty five of the lakes in this survey that are part of river systems are considered impoundments (man-made lakes). Johnson and Vander Zanden (2008) conducted a study to answer questions such as: are impoundments more frequently invaded compared to natural lakes…what combination of factors account for observed differences…and has the widespread creation of impoundments facilitated species invasions in freshwater ecosystems? They found that impoundments are significantly more likely to be invaded than natural lakes possibly due to combining factors of lower water clarity, higher conductivity, higher numbers of boat landings, more surface area, larger watersheds, and higher accessibility by humans, and/or more hydrologic connections (Johnson, 2008). They also found that "these results also suggest that impoundments increase the risk of invasion into natural lakes by both decreasing inter-lake distance and by increasing the total number of invaded water bodies on the landscape" (Johnson, 2008). These results are significant when 45 (36%) out of 126 lakes in the five-county survey are impoundments and 39 of those impoundments have at least one invasive species present. These invaded impoundments should be considered the largest threat for the spread of AIS in the five-county region.

"Super spreaders"

"Super spreaders" are lakes that pose the greatest risk of causing AIS invasions to neighboring lakes, due to the large number of AIS present in the lake and the large number of boaters that use the lake (Rothlisberger, 2008). Researchers at the University of Notre Dame (UND) coined the phrase "super spreaders" while looking at the number of AIS, the number of boats, and lakes across the whole state of Wisconsin. According to their research, three of the lakes in the five-county region are "super spreaders". These are Holcombe Flowage of Chippewa County, Island Lake of Rusk County and Lake Wissota of Chippewa County (Rothlisberger, 2008).

All of the counties have multiple invasive species present and those that are present are widely dispersed across the counties. Both highly frequented and less frequented lakes have AIS present. This is most likely due to having several high traffic lakes that are scattered across the county that are popular locally with recreational users, who in turn also use the smaller, lower traffic lakes. Regionally, the AIS are probably entering the heavy use lakes first and then spreading to the smaller, close-proximity lakes. Based upon casual observations (number of vehicles at boat landings and number of boats on the lake) from being at the lakes over the last three years, some lakes are more heavily used than others. For Barron County more heavily used lakes include: Bear Lake, Beaver Dam Lake, Chetek Chain of Lakes, Red Cedar Lake, Rice Lake, Sand Lake and Staples Lake. The busiest lakes in Chippewa County appear to be: Lake Holcombe Flowage, Lake Wissota, Long Lake, and Marsh Miller Lake. Dunn County has three lakes, Eau Galle, Menomin, and Tainter Lake, which are used frequently. In Eau Claire County there are substantially fewer lakes than in Barron or Chippewa, and of these, Dells Pond, Half Moon Lake, Lake Altoona and Lake Eau Claire could be considered equally popular lakes. Lastly, Dairyland Reservoir, Fireside Lakes, Island Chain of Lakes, Potato Lake, and Sand Lake seem to be the heaviest used lakes in Rusk County. All of the above lakes could be considered “super spreaders”.

Part of the reason that more lakes from the five-county region were not considered “super spreaders” in the UND study could be that the study did not have the most current data of the five-county region. The UND study was published in 2008 when the survey data from this project had not been entered into the statewide database, resulting in extremely low AIS numbers compared to the actual AIS numbers for this region. More of the lakes, especially the heavy use lakes, that were studied in the five-county AIS project could be considered “super spreaders” based upon the criteria set forth in the UND study. Those listed as heavy use lakes in this study all contain at least one, and upwards of four, AIS. These lakes provide many possibilities for the spread of AIS across the region and the state.

Smart prevention

In the same breath, it is important to note that just because an AIS is introduced to a new environment, does not mean that the AIS will become successful. Vander Zanden states that in order for a species to become invasive, it must be able to get to a new location, survive and proliferate, and then have adverse impacts on the new location or species that are native to it (2008). Different habitat characteristics make some lakes more desirable to AIS than others. Using the criteria set forth by Vander Zanden (2008), certain lakes may be designated as highly vulnerable to zebra mussel, or spiny waterflea, etc. and therefore should be monitored more frequently for AIS than other lakes in the region. This idea is known as smart prevention. The idea of “super spreaders” has helped change the CBCW focus from a stance of protecting pristine lakes to that of keeping the AIS already present in lakes contained to those lakes. In the near future, state agencies, lake organizations, and programs such as Clean Boats, Clean Waters may be switching the focus of AIS monitoring efforts with this idea of smart prevention in mind to make the best use of money and time.

Programs such as Clean Boats, Clean Waters are important because they are the first line of defense against the spread of AIS. Scientists at UND have shown that “preventing transport of AIS away from these ‘super-spreader’ lakes can make the greatest difference in slowing the [lake to lake] spread of AIS” by recreational boaters (Rothlisberger, 2008). Numerous accounts have been given of watercraft inspectors finding an AIS on a boat trailer coming from another lake as it was about to be backed into a different, uninfested lake. These lakes could have easily been invaded without the efforts of watercraft inspectors. On the questionnaire used at the boat landings by the watercraft inspectors, 39% of people say that they heard about AIS through a watercraft inspector, the largest percentage (UWEX, 2009). Looking at the statistics available from SWIMS, it is possible to see that the watercraft inspectors are playing a crucial role in presenting the AIS message to lake recreationists.

Interlake variations
The 126 lakes sampled for this report appeared to be different from one another in several ways. Some lakes in the study had high plant species diversity (see *Appendix D*), like Hemlock Lake of Barron County that contained 34 species of native plants and one invasive species while other lakes such as Dells Pond only had four native species and two invasive species. Prairie Farm Flowage in Barron County had few plant species and extremely low densities of those species even though it has a shallow mucky (the sediment type that most plants prefer) bottom. Similar to plants, the lakes had varying numbers of genera, species and abundance of zooplankton. Lake Desair of Barron County had only one observed species from the genus *Leptodora*, in very low quantities, during each of the three sample dates in 2009. This could possibly be due to algaecide applications for nuisance algae in 2006 in Lake Desair or natural variations. On the other end of the spectrum, Lake Altoona of Eau Claire County had multiple genera, multiple species of each genera and the individuals of a species were also very large in size compared to some other lakes where the same species would have been about ¼- ½ the size. These could be yearly variations or a sign that some lakes are better able to support healthy and diverse life forms.

Boat landings
The list of lakes with boat landings should be updated to reflect which type of boat landings are at each lake, which boat landings actually exist, and where the boat landings are located. Some were not easy to find. Barron County provided the best signage among the counties, indicating which roads led to boat landings, although improvements could still be made in that county. Some of the boat landings should be improved to make it easier to enter and leave the landing without getting stuck. Horseshoe Lake (Chippewa County) has a muck landing that should be improved with crushed rock. Two Island Lake's landing should be improved as well. Deep gullies have formed on the access road leading to the landing. The gullied and unkempt landing on Spring Lake, in Barron County, needs to drastically be improved so that the public can use it. The "Wisconsin Lakes" booklet should also be updated to reflect true public access points.

Management
Of the 50 lakes that have curly-leaf pondweed, not all of them require management activity at this time. A large percentage of the populations of curly-leaf seem to have integrated themselves into the native plant communities and do not appear to be creating a monoculture. There are a small number of lakes that should be considered for management or intensive monitoring. Marsh Miller Lake has a large stand of curly-leaf in the center of the lake. There are also small pockets of it scattered around the lakes edge. It is recommended that Marsh Miller Lake Association considers managing for this invasive species. Amacoy Lake also has a dense population of curly-leaf in the northeast bay of the lake, but it was not found anywhere else in the lake, indicating that it is containing itself to the bay area or that it is a relatively recent addition to the community and has not had time to spread. Amacoy Lake Association should heavily monitor this area for the spread of the species, and should it spread, consider managing for it. Otter Lake has multiple beds of curly-leaf on each side of the lake with the largest being in a

shallow bay in the center portion of the lake on the east side. The plant density in this particular curly-leaf bed obstructed boat maneuverability. It is highly recommend that curly-leaf be managed on Otter Lake to improve habitat and recreation. The Chetek Chain of Lakes has hundreds of acres of curly-leaf pondweed that impedes navigation. Potato Lake contains curly-leaf pondweed at nearly every transect. All of the transects in Staples Lake had curly-leaf pondweed in them. In Marsh Miller, Otter Lake, Potato Lake, Staples Lake and the Chetek Chain of Lakes, the very poor water quality could possibly be improved with less curly-leaf pondweed in the plant community, which contributes to algal blooms when it dies off in early summer. Curly-leaf pondweed was also found in all four Island Chain of Lakes. The plant has currently integrated itself into the native plant community. In Island Lake, during 2007, the population of curly-leaf pondweed was large possibly due to the lack of snow on the ice in 2006. It is recommended that the curly-leaf pondweed beds be monitoried for any growth in size and that management options are re-evaluated if there is a population explosion. Granite Lake's curly-leaf population could be eradicated with diligent harvesting as soon as it appears in spring, as only three plants were seen and pulled during the study. The aquatic plants of Hemlock Lake (Barron County) should be monitored as there is high species diversity but also an invasive species, curly-leaf pondweed. It is important that curly-leaf pondweed does not displace some of the native species.

All lakes with *Myriophyllum spicatum* present should be monitored to establish growth rates and then assess what type of management is appropriate. CBCW should be employed at the landings of lakes with *M. spicatum* so that boaters are not leaving the water with *M. spicatum* attached.

Fortunately spiny waterfleas and zebra mussel veligers were not found in any of the lakes within the project scope. That does not mean that the five-county region is immune to them. Future monitoring could be focused on lakes that are considered more vulnerable or more likely to be invaded by each of the species according to Vander Zanden (2008). That way the region is still being monitored for spiny waterfleas and zebra mussel veligers but not in all 126 lakes, saving time and resources.

Purple loosestrife was not detected as often as was anticipated by the survey crew around the shores of lakes. Only thirteen lakes contained purple loosestrife. Bear Lake, Beaver Dam Lake, and Sand Lake had the largest populations present and will require significant efforts to reduce and/or eliminate the populations. Lakes such as Sylvan and Granite had fewer than ten plants present and could be removed manually or with chemical treatment with little effort.

Once present in a water body, rusty crayfish are nearly impossible to eradicate. Long Lake of Chippewa County has had rusty crayfish present since at least 1980 when the lake district began to monitor them. Although there has been intense trapping over the last three decades, rusty crayfish are still present but in diminished numbers. Seventeen water bodies contain rusty crayfish. They appear to prefer river systems as that is where they are most frequently found, possibly due to the rocky nature of flowages. Rusty crayfish were collected on Chain Lake and Island Lake of Island Chain of Lakes, and because McCann and Clear are connected it is safe to assume that they are present in all four lakes. Monitoring is recommended. On lakes where the populations have become too large or where native species are being crowded out, rusty crayfish should be trapped to lower numbers.

Some lakes needed additional surveys for invasive species as part of their management plans. In order to properly assess these lakes, a whole day was needed to conduct the surveys for the locations of the AIS and another day for data analysis. The best days for AIS surveying for these purposes, were in early summer (sometime in May, depending upon water temperatures) and these prime days fell during the hectic preseason prep time and orientation days of new summer employees. Free days were infrequent during the summer of 2009, making it difficult to give adequate attention to lake groups needing additional survey work for their management plans.

Volunteers
Although the pace of work can be slightly slowed with the addition of volunteers, the volunteers assisting the crews proved to be a valuable asset to this project. Volunteers contributed 1,820 hours to assisting with this project, the equivalent of 4 full time summer staff (12 weeks, 40 hrs/week). Sometimes surveying could not have been completed without the volunteers assistance, as the field technician was only paid for 20 hours per week of survey work and surveying was conducted by the lead researcher (who needed an assistant) 40 hours per week. Fortunately, a few dedicated individuals were available to help fill the 20 hour voids on a consistent basis. Five service learning volunteers helped immensely over the 2009 summer. Working with volunteers also provided a great opportunity to connect with younger citizens that might share what they learned out on the boat with classmates or pursue professions in biological sciences related to invasive species. Volunteers from the lakes that were surveyed also seemed to enjoy the research crew's visits to their lake. The volunteers had a sense that they got to help with something vital to the health of their lake and that their lake was important, because it was included in the survey. Not once did the volunteers walk away from the boat without saying "Thank you for letting us come along, it was very interesting and fun", or something to that effect. It was a mutually positive experience for the crew and the volunteers. In the future, however, it is recommended that a field technician be paid to work 30 of the 40 hours per week versus 20 hours per week as this will increase the efficiency of the crew. Volunteers would still be a valuable asset to the team even with the increased hours of a paid field technician.

Conclusion

The BCCSC was able to accomplish all four goals set forth for this project, including assessment, education, prevention, and monitoring and control. Through the efforts of the survey crew, 126 lakes were surveyed, resulting in 83 newly discovered and 137 total aquatic invasive species that were formally documented to provide a baseline set of data for the five-county region. Approximately 1,453 volunteer hours were contributed to make that possible. Twenty eight educational meetings, events, and trainings were attended to help educate the general public as well as lake organizations about AIS. Through these trainings and continued efforts on behalf of the lake organizations, 30 lake groups contributed an additional 367 hours towards the Clean Boats, Clean Waters program to help slow the spread of AIS in the region. The BCCSC was also able to assist lake groups from Marsh Miller Lake, Lake Amacoy, Holcombe Flowage, and Lake Wissota with monitoring for AIS on their lakes for the management of established AIS. Continued monitoring for invasive species is essential in order to ascertain whether or not populations are changing within lakes and/or spreading to other lakes. It is unclear whether or not funding will be available to continue monitoring efforts such as this and that is why it is crucial that citizens continue to be trained to conduct monitoring on their lakes.

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