Cisco Chain of Lakes
2012
Invasive Species Assessment

SIGURD OLSON ENVIRONMENTAL INSTITUTE

NORTHLAND® COLLEGE

This project was coordinated and funded by the

Cisco Chain Riparian Owners Association

And Implemented by

The Sigurd Olson Environmental Institute at Northland College

Field Staff:

Carissa Z. Hudson, Tanner Servoss, Alexandra Lee, Emma Broz,

Eric Andrews, Gavin Hayes, Ashley Runge, Madeleine Weibel

Project Coordinators:

Dr. Randy Lehr and Mike Gardner

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Introduction

This report summarizes the status of the aquatic plant communities in the Cisco Chain of Lakes. Understanding the health and long-term changes in the composition of aquatic plant communities is a key element of lake management. The Cisco Chain Riparian Owners Association (CCROA) has been actively involved in the management of the aquatic plant communities in the Cisco Chain of Lakes for the last two decades. Since 2010, the CCROA has been working with the Sigurd Olson Environmental Institute (SOEI) at Northland College, Wisconsin Department of Natural Resources (WDNR) and Michigan Department of Environmental Quality to characterize the health and distribution of aquatic plant communities throughout the Cisco Chain and control the spread of invasive species.

Methodology

Aquatic plant communities were sampled from the major embayments of all 14 lakes (and the respective connecting channels) throughout the Cisco Chain. Surveys were conducted from July to August, 2012. All work was implemented by the SOEI at Northland College on behalf of the CCROA. All field staff were trained in the annual WDNR aquatic plant management workshop.

Sampling Procedure:

Plant communities were sampled following the WDNR Point Intercept Survey Methodology (Hauxwell, et al. 2010). Following this protocol, plant communities were sampled across a grid of points in shallow waters of the lake—the littoral zone. All sampling grids were generated by WDNR staff (e.g., Figure 1).

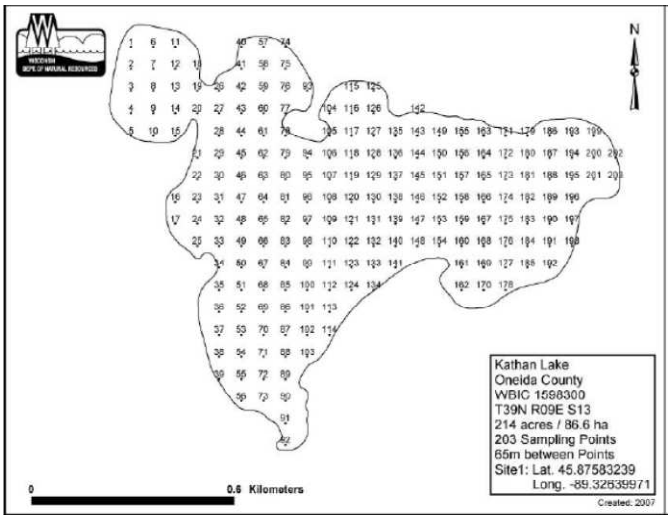


Figure 1 – Model WDNR point intercept grid.

At each sample point, plant communities were sampled using a double-sided rake sampling device (Figure 2). Following the WDNR procedure, the rake is dropped to the bottom, dragged for approximately one-foot and pulled to the surface. Once in the boat, the different species are identified and the relative density of the individual species and total plant density are recorded as rake fullness (Figure 3). Species composition and relative density data are recorded on the WDNR survey form and voucher species are kept for each species at each lake. In addition to species data, water depth and sample site location are measured and recorded at each point using a handheld sonar and GPS units. In lakes with large numbers of points in deep water (e.g., Thousand Island Lake), sampling is concentrated in shallower (depth of less than 20 feet) littoral areas.

Figure 2 – Double-headed rake

Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.

Figure 3 – Criteria used to estimate rake fullness

Following completion of the field survey, all data were entered into the WDNR spreadsheet template and analyzed. Raw data were processed to describe the total number and relative abundance of the different plant species encountered at each lake. Data from each lake was also used to calculate Floristic Quality Index (FQI).

The FQI describes how well the historical aquatic plant community (i.e., the plant community that likely occupied these lakes before human settlement) has been conserved over time. To calculate the FQI, biologists have assigned Coefficients of Conservatism to different species based on their ability to survive across a range of environments. Species that are assigned a value of 0 are species that can survive in most lakes. Species that are assigned a value 10 are those that represent historical plant communities and are often very sensitive to environmental change. The FQI is calculated by combining the species presence data with the appropriate Coefficient of Conservatism to estimate the historical characteristics of the plant community (methods described in detail in Nichols 1999).

Raw species data for each point were combined with GPS data and used to develop a series of maps to describe the aquatic plant communities. Maps depicting the total number of species detected at each point were developed for all lakes. Point data were then analyzed using a Spline Interpolation technique to estimate the likely species distribution between the individual sample points. The resulting data were used to develop a color-coded intensity map in which areas of high species richness are colored red and areas of low species richness are colored green (e.g., Figure 4).

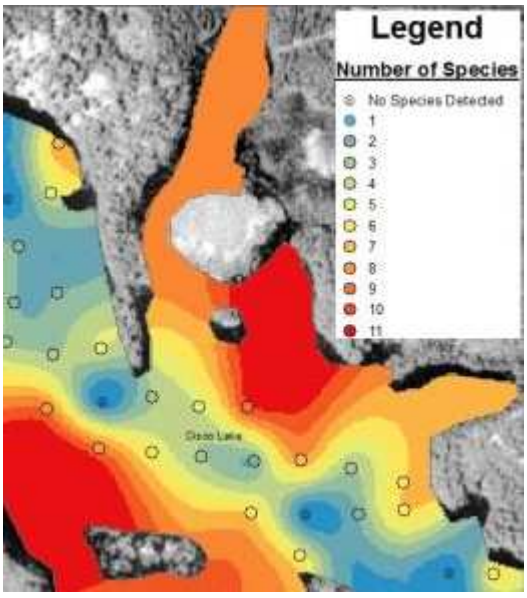


Figure 4 – Example Species Distribution Map

In lakes in which invasive species were detected, additional map layers were generated. All points where invasive species were sampled in a specific sample point were color coded (Eurasian Water-milfoil, EWM – green; Curly-leaf Pondweed, CLP—pink) and scaled, such that the higher the density of the invasive species the larger the sample point appears. In areas where EWM was visually observed, but not directly sampled with the rake, a dotted

green line was used to depict regions of low density (i.e., one plant or a small cluster every 100-200 meters) invasive plant coverage (e.g., Figure 5).

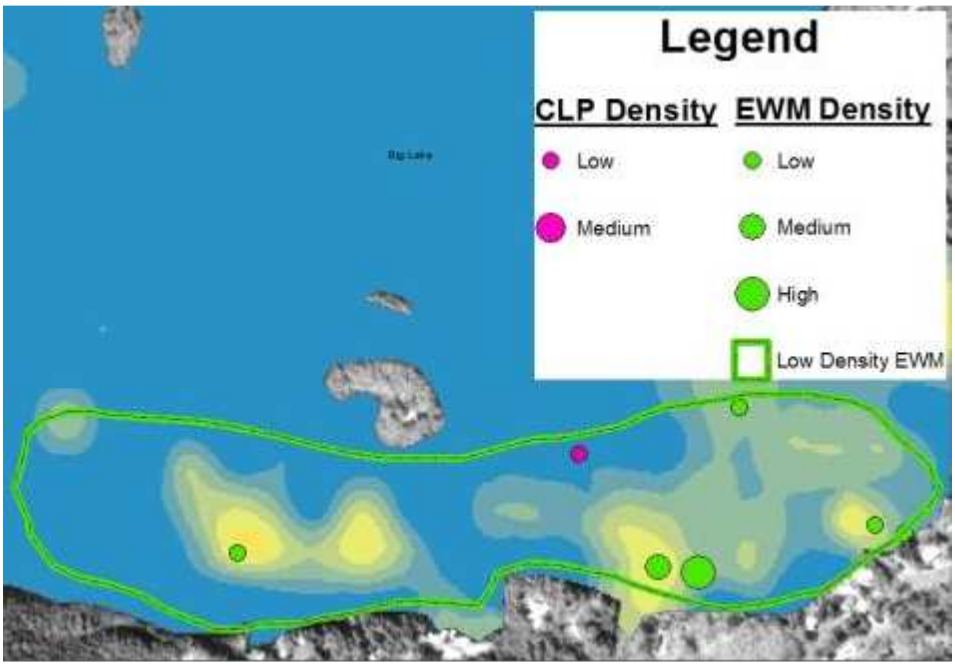


Figure 5 – Example invasive species distribution map

Voucher Specimens:

Voucher specimens were retained for all species in all lakes and identified to species using: "Michigan Flora" Part I, by Edward G. Voss (1972); as well as the "Manual of Aquatic Plants" by Norman C. Fassett (1940). Voucher specimens were then pressed, dried and archived at the Sigurd Olson Environmental Institute (Figure 6).

Figure 6 – Plant pressing and drying system.

Results

The Cisco Chain of Lakes contains a wide diversity of aquatic plant species. Throughout this study, 50 species were identified from all lakes throughout the chain (Table 1). The diversity and richness of species also varied among the lakes, with some individual rake pulls not collecting any plants and other collecting up to eleven species. In general, the areas of highest species richness were in protected bays and connecting channels through the Cisco Chain of Lakes with the areas of highest diversity occurring in Cisco, Indian and Thousand Island Lakes.

Throughout the Cisco Chain, the most common species detected were eloda (*Elodea Canadensis*) and coontail (*Ceratophyllum demersum*). The species that were detected that represent the high level of floristic quality were spiny hornwory (*Ceratophyllum echinatum*), dwarf water-milfoil (*Myriophyllum tenellum*), vasey's pondweed (*Potamogeton vaseyi*), floating-leaf bur-reed (*Sparganium fluctuans*) and small bladderwort (*Utricularia minor*). In general, the FQI scores for lakes throughout the Cisco Chain had scores that were higher than the regional average of 26, with values for Cisco, Thousand Island, Poor and Clearwater Lakes being well above the state averages—indicating the presence of high quality, diverse aquatic plant communities.

Two invasive species were detected throughout the Cisco Chain—Eurasian watermilfoil (EWM; *Myriophyllum spicatum*) and curly-leaf pondweed (CLP; *Potamogeton crispus*). Eurasian water-milfoil was detected at moderate to high densities in Clearwater and Big Lakes and very low densities in Thousand Island Lake. Curly-leaf pondweed was detected at moderate densities in Fishhawk Lake and at one point in Big Lake.

Details of the aquatic plant communities and distribution of aquatic invasive species are described in greater detail in the individual lake sections below. Within each lake-specific section, all of the species detected are listed, species richness is displayed in a detailed distribution map and areas of high, moderate and low densities of invasive species are highlighted.

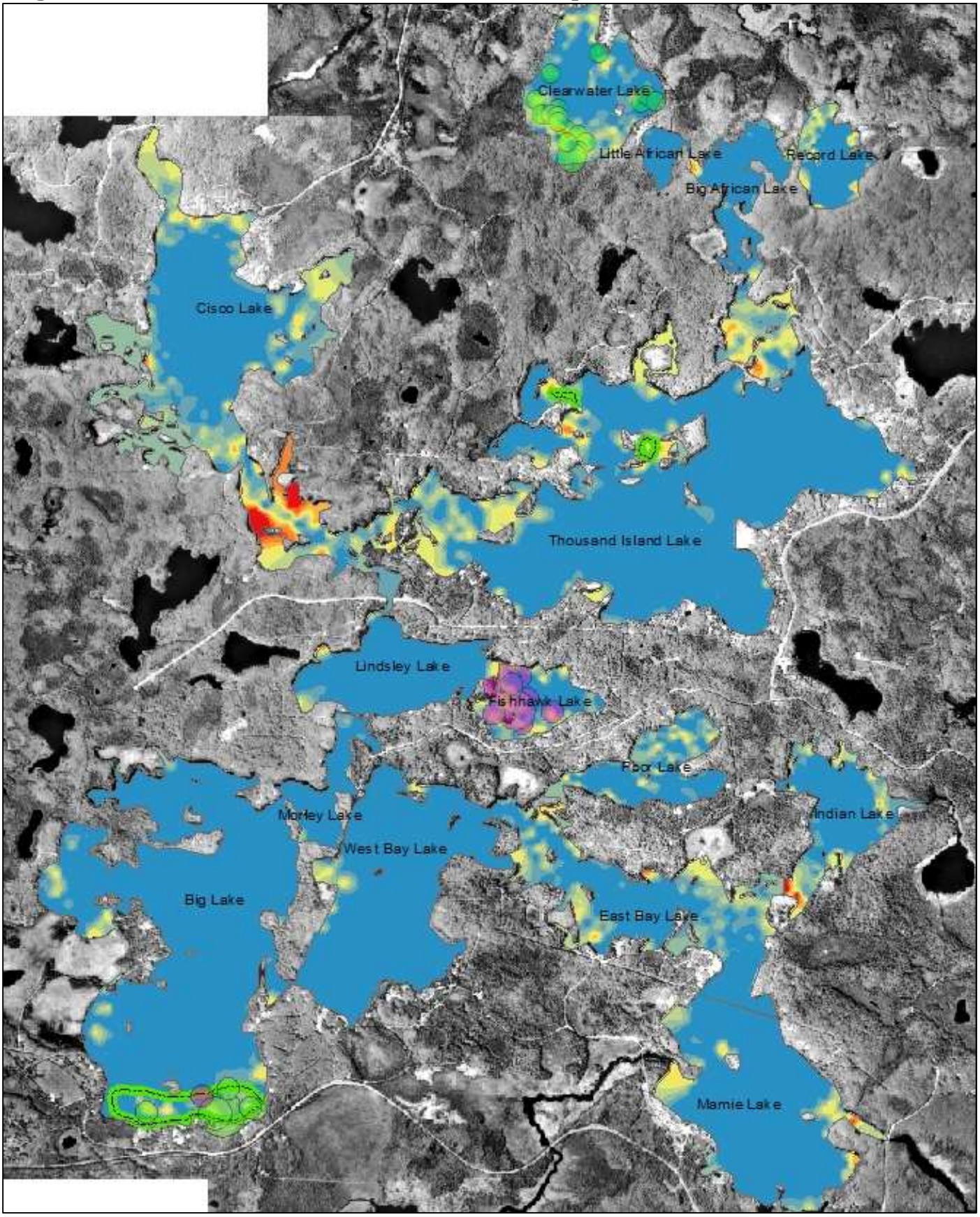
Native Aquatic Plant Species Detected in the Cisco Chain (Table 1)

Species	Common Name	Big	Big Africa	Cisco	Clear-water	East Bay	Fish-hawk	Indian	Little Africa	Lindsley	Mamie	Morley	Poor	Record	Thous. Island	West Bay
Alisma triviale	Northern water-plantain	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Bidens beckii	Water marigold	1	1	1	1	0	1	1	0	0	1	0	1	1	1	1
Bolboschoenus fluviatilis	River bulrush	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Brasenia schreberi	Watershield	0	1	1	0	0	0	0	1	0	0	0	1	1	1	0
Callitriche palustris	Common water-starwort	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ceratophyllum demersum	Coontail	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1
Ceratophyllum echinatum	Spiny hornwort	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1
Chara	Muskgrasses	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0
Elodea canadensis	Common waterweed	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
Elodea nuttallii	Slender waterweed	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Eriocaulon aquaticum	Pipewort	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Heteranthera dubia	Water star-grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lemna trisulca	Forked duckweed	1	1	1	0	0	0	1	0	0	1	0	0	0	0	1
Myriophyllum sibiricum	Northern water-milfoil	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1
Myriophyllum tenellum	Dwarf water-milfoil	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Myriophyllum verticillatum	Whorled water-milfoil	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1
Najas flexilis	Slender naiad	1	1	0	1	0	1	1	0	0	0	0	1	0	1	0
Najas gracillima	Northern naiad	1	0	0	1	0	0	1	0	1	0	0	1	1	0	0
Najas guadalupensis	Southern naiad	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Nitella	Nitella	0	0	1	1	0	0	1	0	0	1	0	1	1	1	0
Nuphar variegata	Spatterdock	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0
Nymphaea odorata	White water lily	0	1	0	0	1	0	1	1	0	0	0	1	1	1	0
Potamogeton alpinus	Alpine pondweed	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Potamogeton amplifolius	Large-leaf pondweed	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1
Potamogeton epihydrus	Ribbon-leaf pondweed	0	0	1	1	0	0	1	0	0	1	0	1	0	1	0
Potamogeton foliosus	Leafy pondweed	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
Potamogeton friesii	Fries' pondweed	1	0	1	0	0	1	1	0	1	1	0	1	1	1	1
Potamogeton gramineus	Variable pondweed	0	1	1	1	0	1	0	0	0	1	0	1	1	0	0
Potamogeton hillii	Hill's pondweed	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0
Potamogeton illinoensis	Illinois pondweed	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0

Native Aquatic Plant Species Detected in the Cisco Chain (Table 1 cont.)

Species	Common Name	Big	Big Africa	Cisco	Clear-water	East Bay	Fish-hawk	Indian	Little Africa	Lindsley	Mamie	Morley	Poor	Record	Thous. Island	West Bay
Potamogeton natans	Floating-leaf pondweed	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0
Potamogeton nodosus	Long-leaf pondweed	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Potamogeton obtusifolius	Blunt-leaf pondweed	1	0	1	1	1	0	0	0	0	0	0	1	1	1	0
Potamogeton praelongus	White-stem pondweed	1	0	1	1	1	1	1	0	1	0	0	1	0	1	1
Potamogeton pusillus	Small pondweed	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Potamogeton richardsonii	Clasping-leaf pondweed	1	0	1	1	1	1	1	0	1	1	0	1	1	1	1
Potamogeton robbinsii	Fern pondweed	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1
Potamogeton strictifolius	Stiff pondweed	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Potamogeton vaseyi	Vasey's pondweed	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potamogeton zosteriformis	Flat-stem pondweed	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1
Ranunculus aquatilis	White water crowfoot	1	0	0	0	1	1	1	0	1	1	0	0	2	1	1
Sparganium eurycarpum	Common bur-reed	0	1	0	1	0	0	1	0	0	0	0	1	0	1	0
Sparganium fluctuans	Floating-leaf bur-reed	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0
Stuckenia filiformis	Fine-leaved pondweed	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Stuckenia vaginata	Sheathed pondweed	0	0	1	0	0	0	1	0	1	1	0	0	0	1	0
Utricularia geminiscapa	Twin-stemmed bladderwort	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Utricularia gibba	Creeping bladderwort	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0
Utricularia minor	Small bladderwort	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Utricularia vulgaris	Common bladderwort	0	1	0	1	0	0	1	1	0	1	0	0	0	0	0
Vallisneria americana	Wild celery	1	0	1	1	1	0	1	0	0	1	0	1	2	1	1
Total Species Detected throughout the Chain = 50																
Species Detected per Lake		**21**	**17**	**27**	**26**	**15**	**16**	**24**	**4**	**12**	**22**	**9**	**24**	**20**	**35**	**17**
Floristic Quality Index		**28.28**	**26.92**	**35.60**	**34.90**	**25.04**	**26.25**	**29.49**	**14.50**	**21.93**	**31.76**	**18.66**	**33.06**	**26.08**	**41.58**	**27.16**

Figure 7 – Distribution of Native and Invasive Species in the Cisco Chain of Lakes



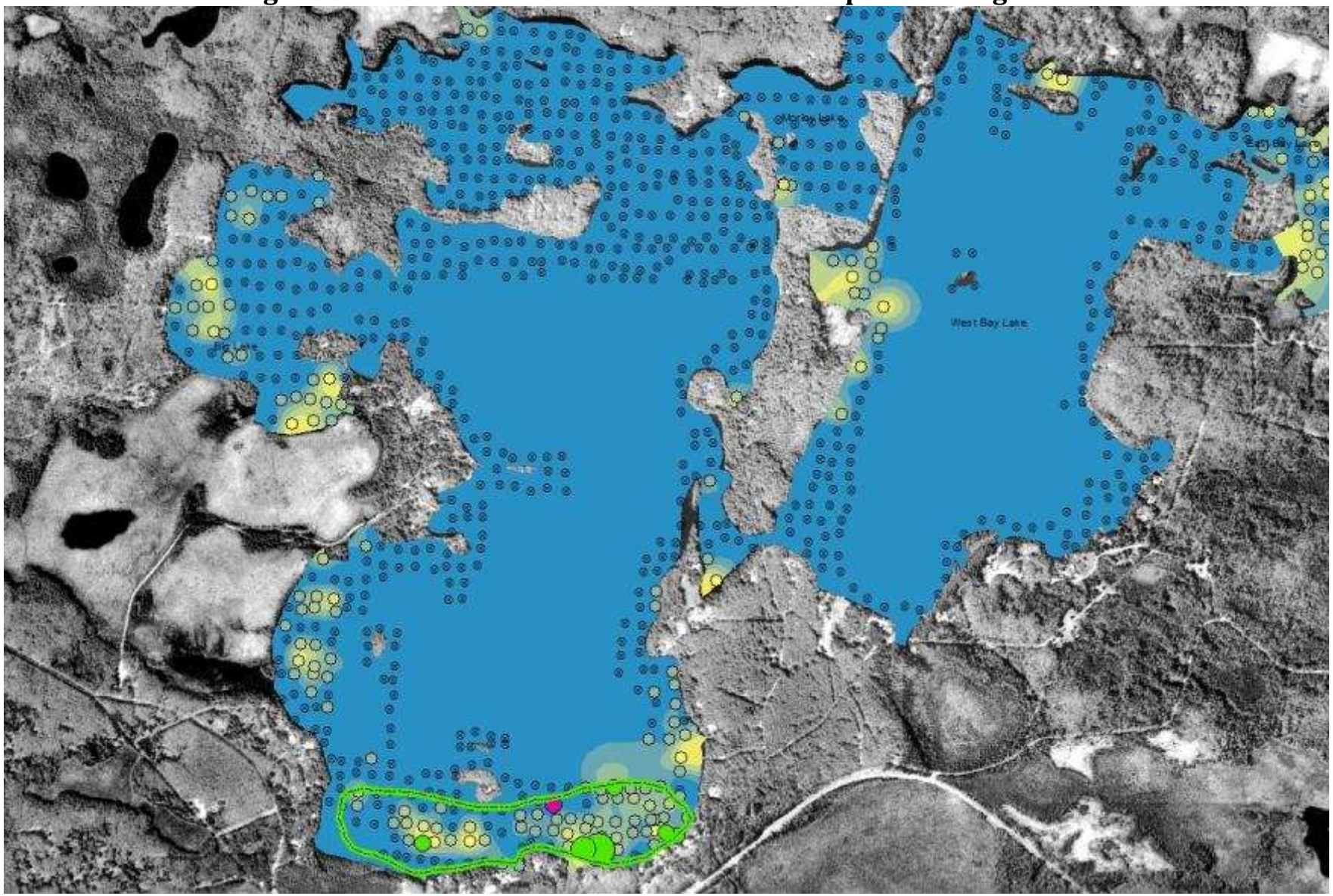
Big Lake

Twenty-one native species and two invasive species (Eurasian Water-milfoil and Curly-leaf Pondweed) were detected throughout Big Lake (Table 2). The majority of species were detected in the main body of Big Lake and Palmer Bay and relatively few species were detected in Michigan Bay (Figure 8). Throughout the entire lake, species diversity and plant community integrity were at moderate levels, with a Floristic Quality Index value of 28.28. The invasive species EWM and CLP were both detected along the southern shore of Big Lake. Throughout the southern end of the lake, CLP was only detected at one discrete point, while EWM was found at a low density throughout much of the littoral area. EWM was also found in one ~1-acre bed at high densities.

Native Species	Common Name	Big	Big - Michigan Bay	Big - Palmer Bay
Bidens beckii	Water marigold	1	0	1
Ceratophyllum demersum	Coontail	1	0	1
Ceratophyllum echinatum	Spiny hornwort	1	0	0
Elodea canadensis	Common waterweed	1	1	1
Lemna trisulca	Forked duckweed	1	0	0
Myriophyllum sibiricum	Northern water-milfoil	1	0	1
Najas flexilis	Slender naiad	1	0	0
Najas gracillima	Northern naiad	1	0	1
Potamogeton alpinus	Alpine pondweed	0	1	0
Potamogeton amplifolius	Large-leaf pondweed	1	1	0
Potamogeton foliosus	Leafy pondweed	1	0	1
Potamogeton friesii	Fries' pondweed	1	0	1
Potamogeton nodosus	Long-leaf pondweed	0	0	1
Potamogeton obtusifolius	Blunt-leaf pondweed	1	0	1
Potamogeton praelongus	White-stem pondweed	1	0	0
Potamogeton richardsonii	Clasping-leaf pondweed	1	0	1
Potamogeton robbinsii	Fern pondweed	1	1	1
Potamogeton vaseyi	Vasey's pondweed	0	0	1
Potamogeton zosteriformis	Flat-stem pondweed	1	0	1
Ranunculus aquatilis	White water crowfoot	1	0	0
Vallisneria americana	Wild celery	1	0	0
Invasive Species				
Potamogeton crispus	Curly-leaf Pondweed	1	0	0
Myriophyllum spicatum	Eurasian Water-milfoil	1	0	0
Species Detected		**18**	**4**	**13**
Floristic Quality Index		**28.28**	**13.50**	**23.85**

Table 2 – Aquatic plant abundance and relative quality estimates for Big Lake.

Figure 8 – Distribution of Native and Invasive Species in Big Lake



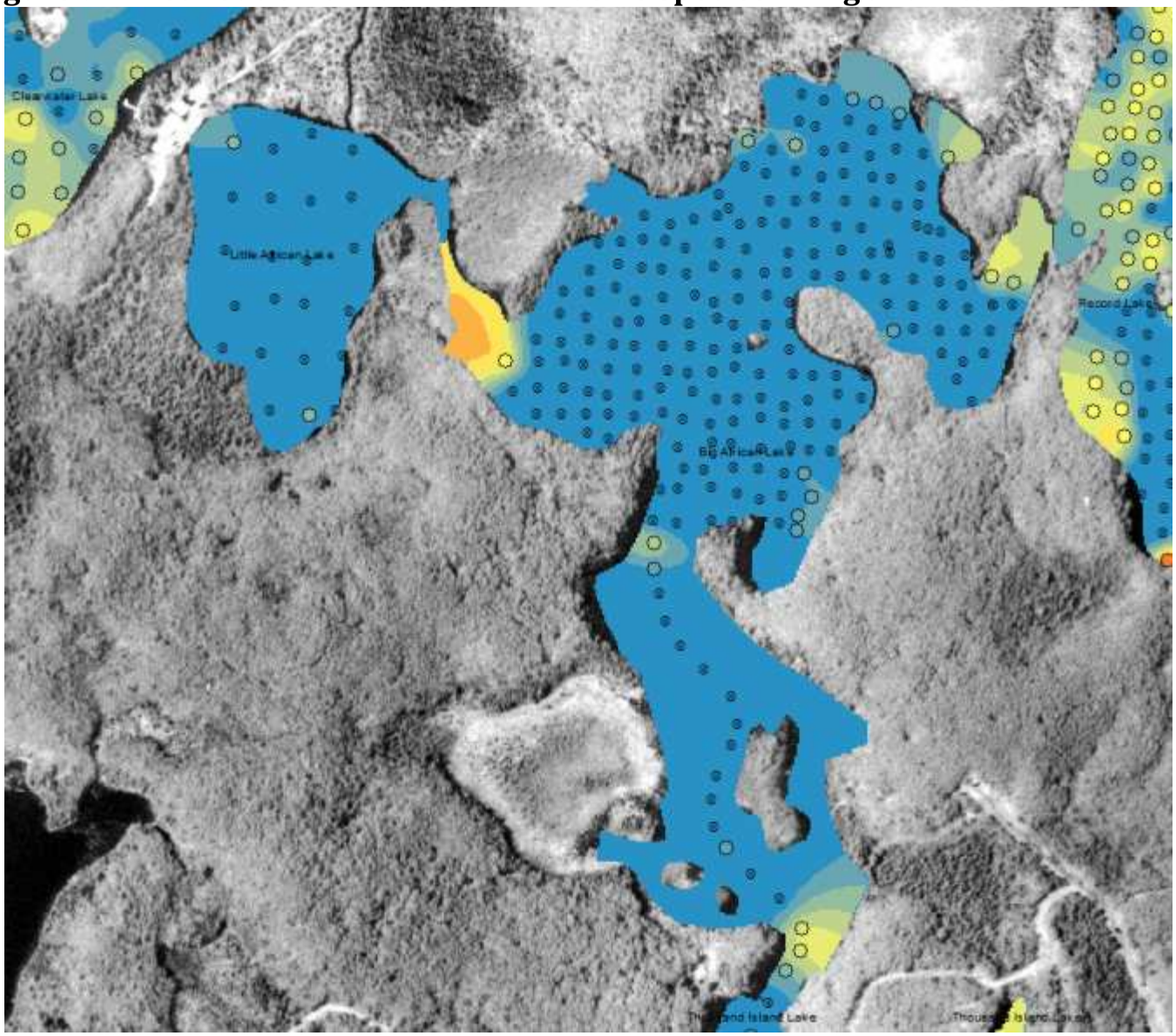
Big and Little Africa

Eighteen native species were detected in Big and Little Africa Lakes (Table 3). Little Africa Lake had the fewest species of all of the lakes throughout the chain and the highest percentage of shallow water points without vegetation. Big Africa Lake had species richness and FQI values that are consistent with regional values. However, most of the vegetation was concentrated in the highly protected bays along the northern, southern and western shorelines (Figure 9).

Species	Common Name	Big Africa	Little Africa
Bidens beckii	Water marigold	1	0
Brasenia schreberi	Watershield	1	1
Ceratophyllum demersum	Coontail	1	0
Elodea canadensis	Common waterweed	1	0
Lemna trisulca	Forked duckweed	1	0
Myriophyllum sibiricum	Northern water-milfoil	1	0
Najas flexilis	Slender naiad	1	0
Nuphar variegata	Spatterdock	1	0
Nymphaea odorata	White water lily	1	1
Potamogeton foliosus	Leafy pondweed	1	0
Potamogeton gramineus	Variable pondweed	1	0
Potamogeton robbinsii	Fern pondweed	1	0
Sparganium eurycarpum	Common bur-reed	1	0
Sparganium fluctuans	Floating-leaf bur-reed	0	1
Utricularia geminiscapa	Twin-stemmed bladderwort	1	0
Utricularia gibba	Creeping bladderwort	1	0
Utricularia minor	Small bladderwort	1	0
Utricularia vulgaris	Common bladderwort	1	1
Species Detected		**17**	**4**
Floristic Quality Index		**26.92**	**14.50**

Table 3 – Aquatic plant abundance and relative quality estimates for Big and Little Africa Lakes.

Figure 9 – Distribution of Native and Invasive Species in Big and Little Africa Lakes



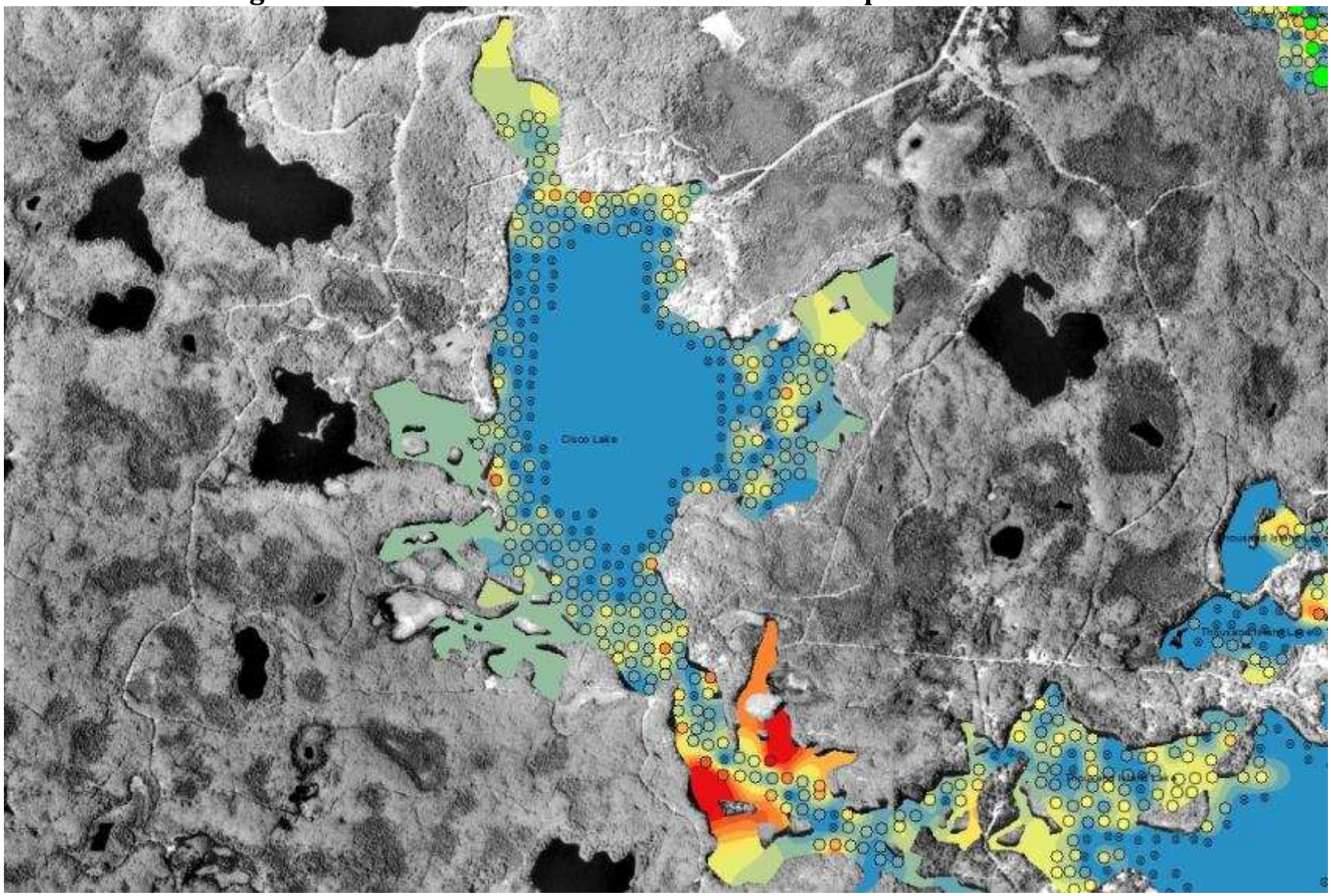
Cisco Lake

Twenty-seven species were identified throughout Cisco Lake (Table 4). Species were widely distributed throughout the shallow waters of the lake with the largest diversity of species occurring in the southern bays and connecting channels (Figure 10). In fact, the connecting channel between Cisco and Thousand Island Lakes represents one of the areas of highest species diversity throughout the entire Cisco Chain. Across all sample points, a wide range of pondweeds and highly conserved species were detected. The resulting FQI value for Cisco Lake (35.60) is among the highest in the Cisco Chain.

Species	Common Name
Bidens beckii	Water marigold
Brasenia schreberi	Watershield
Ceratophyllum demersum	Coontail
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Lemna trisulca	Forked duckweed
Myriophyllum sibiricum	Northern water-milfoil
Najas flexilis	Slender naiad
Nitella	Nitella
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton epihydrus	Ribbon-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton gramineus	Variable pondweed
Potamogeton hillii	Hill's pondweed
Potamogeton natans	Floating-leaf pondweed
Potamogeton obtusifolius	Blunt-leaf pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Stuckenia filiformis	Fine-leaved pondweed
Stuckenia vaginata	Sheathed pondweed
Utricularia geminiscapa	Twin-stemmed bladderwort
Utricularia vulgaris	Common bladderwort
Vallisneria americana	Wild celery
Species Detected	**27**
Floristic Quality Index	**35.60**

Table 4 – Aquatic plant abundance and relative quality estimates for Cisco Lake

Figure 10 – Distribution of Native and Invasive Species in Cisco Lake



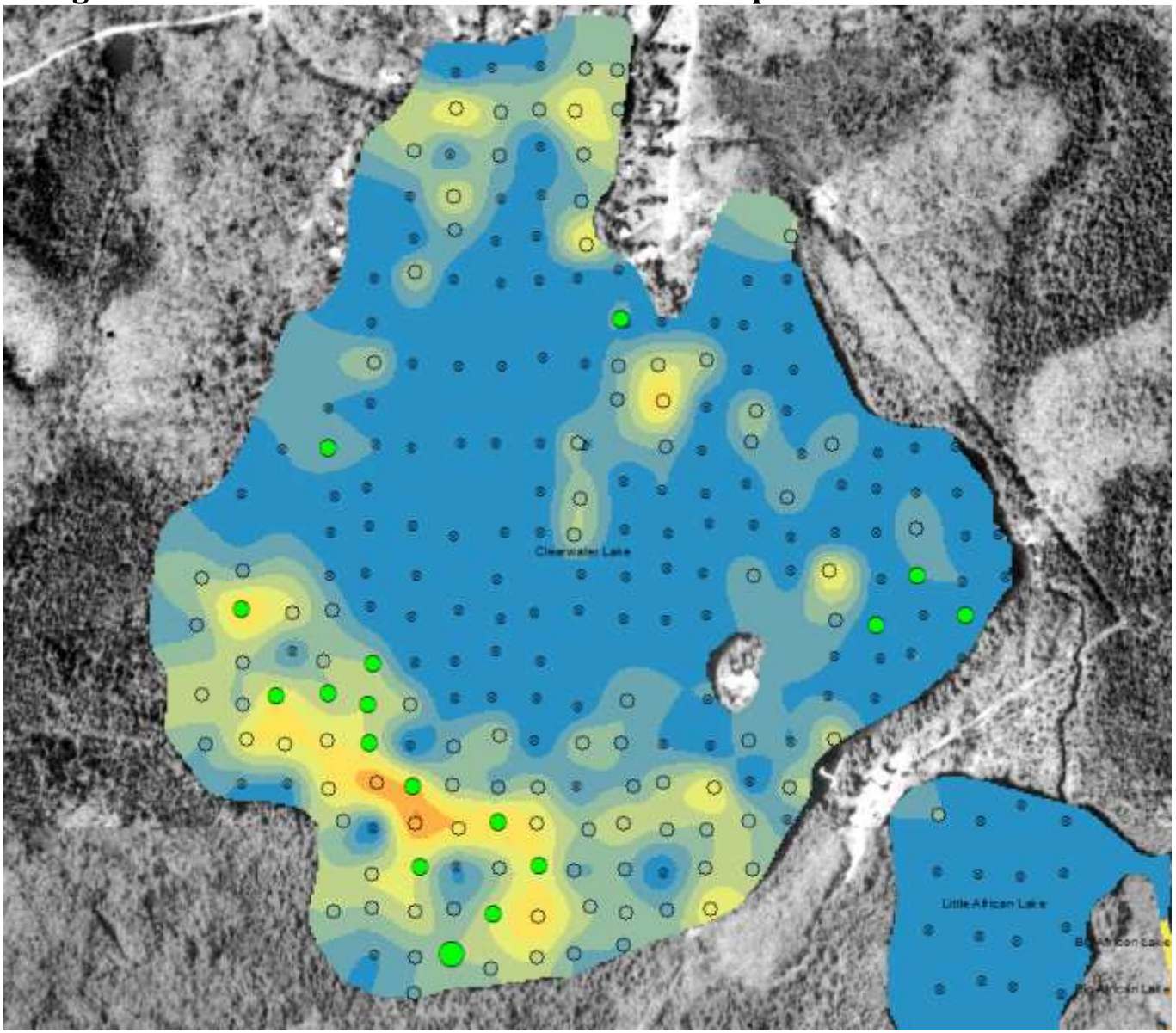
Clearwater Lake

Twenty-six native species and one invasive species (Eurasian water-milfoil) were detected in Clearwater Lake (Table 5). Aquatic plants were detected at most points in the shallow waters of Clearwater Lake, with the areas of highest density and species richness occurring along the northern and southern shorelines (Figure 11). Many of the native species in Clearwater Lake are considered highly conserved and thus, the corresponding FQI is much higher than average (34.91). Eurasian water-milfoil was detected at 17 points at low or moderate densities and was significantly reduced in coverage relative to prior years (likely as a result of the herbicide treatment that occurred in July of 2012).

Native Species	Common Name
Alisma triviale	Northern water-plantain
Bidens beckii	Water marigold
Ceratophyllum demersum	Coontail
Ceratophyllum echinatum	Spiny hornwort
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Eriocaulon aquaticum	Pipewort
Najas flexilis	Slender naiad
Najas gracillima	Northern naiad
Nitella	Nitella
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton epihydrus	Ribbon-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton gramineus	Variable pondweed
Potamogeton illinoensis	Illinois pondweed
Potamogeton nodosus	Long-leaf pondweed
Potamogeton obtusifolius	Blunt-leaf pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Sparganium eurycarpum	Common bur-reed
Sparganium fluctuans	Floating-leaf bur-reed
Utricularia gibba	Creeping bladderwort
Utricularia vulgaris	Common bladderwort
Vallisneria americana	Wild celery
Invasive Species	
Myriophyllum spicatum	Eurasian Water-milfoil
Species Detected	**27**
Floristic Quality Index	**34.90**

Table 5 – Aquatic plant abundance and relative quality estimates for Clearwater Lake

Figure 11 – Distribution of Native and Invasive Species in Clearwater Lake



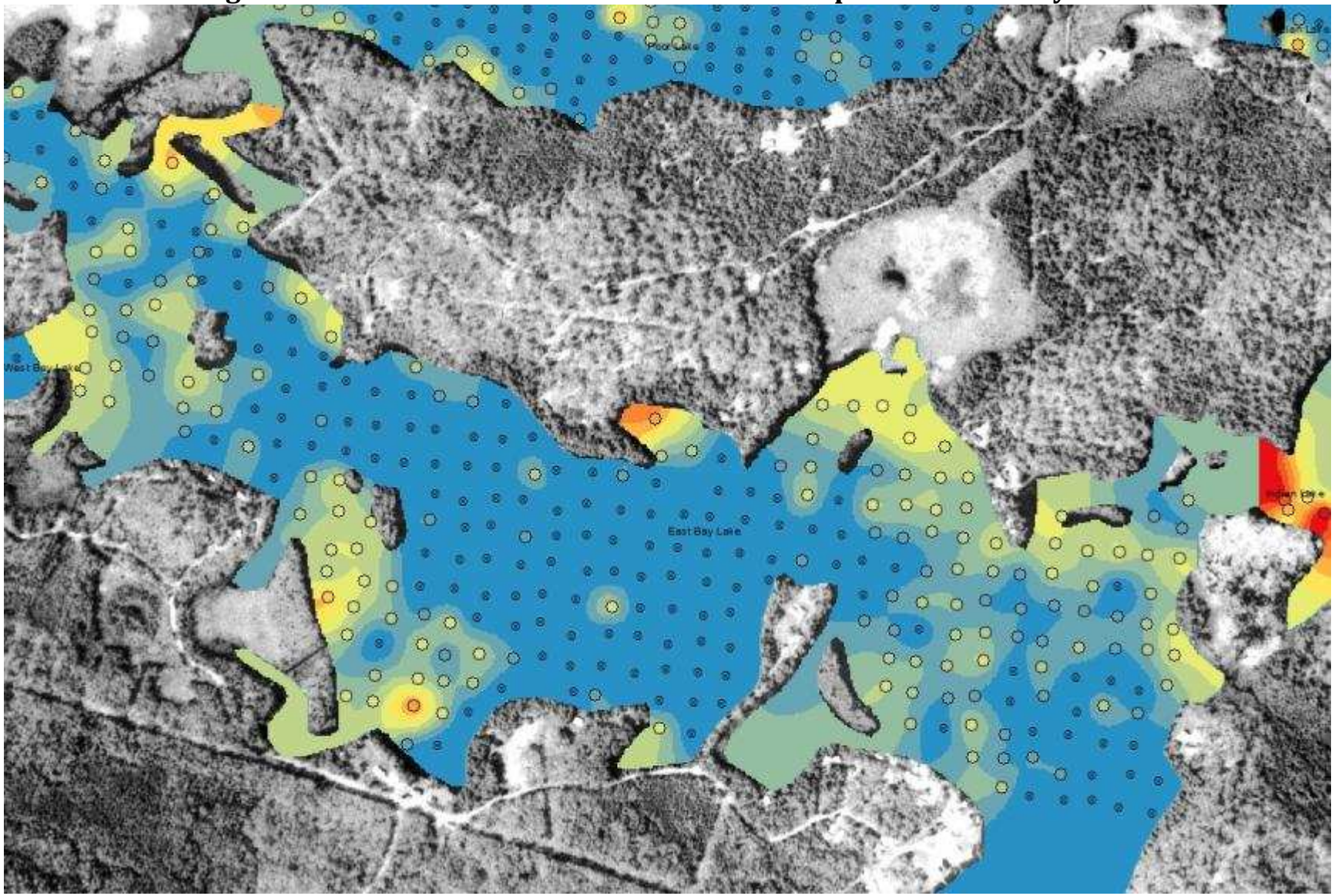
East Bay Lake

Fifteen native species were detected in East Bay Lake (Table 6). Aquatic plants were detected at most of the points within the shallow waters of East Bay Lake, with the areas of greatest density and species richness occurring along the northeastern and southwestern shorelines (Figure 12). Floristic Quality Index values for East Bay Lake are consistent with regional averages.

Species	Common Name
Ceratophyllum demersum	Coontail
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Myriophyllum sibiricum	Northern water-milfoil
Nymphaea odorata	White water lily
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton hillii	Hill's pondweed
Potamogeton obtusifolius	Blunt-leaf pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Vallisneria americana	Wild celery
Species Detected	**15**
Floristic Quality Index	**25.04**

Table 6 – Aquatic plant abundance and relative quality estimates for East Bay Lake.

Figure 12 – Distribution of Native and Invasive Species in East Bay Lake



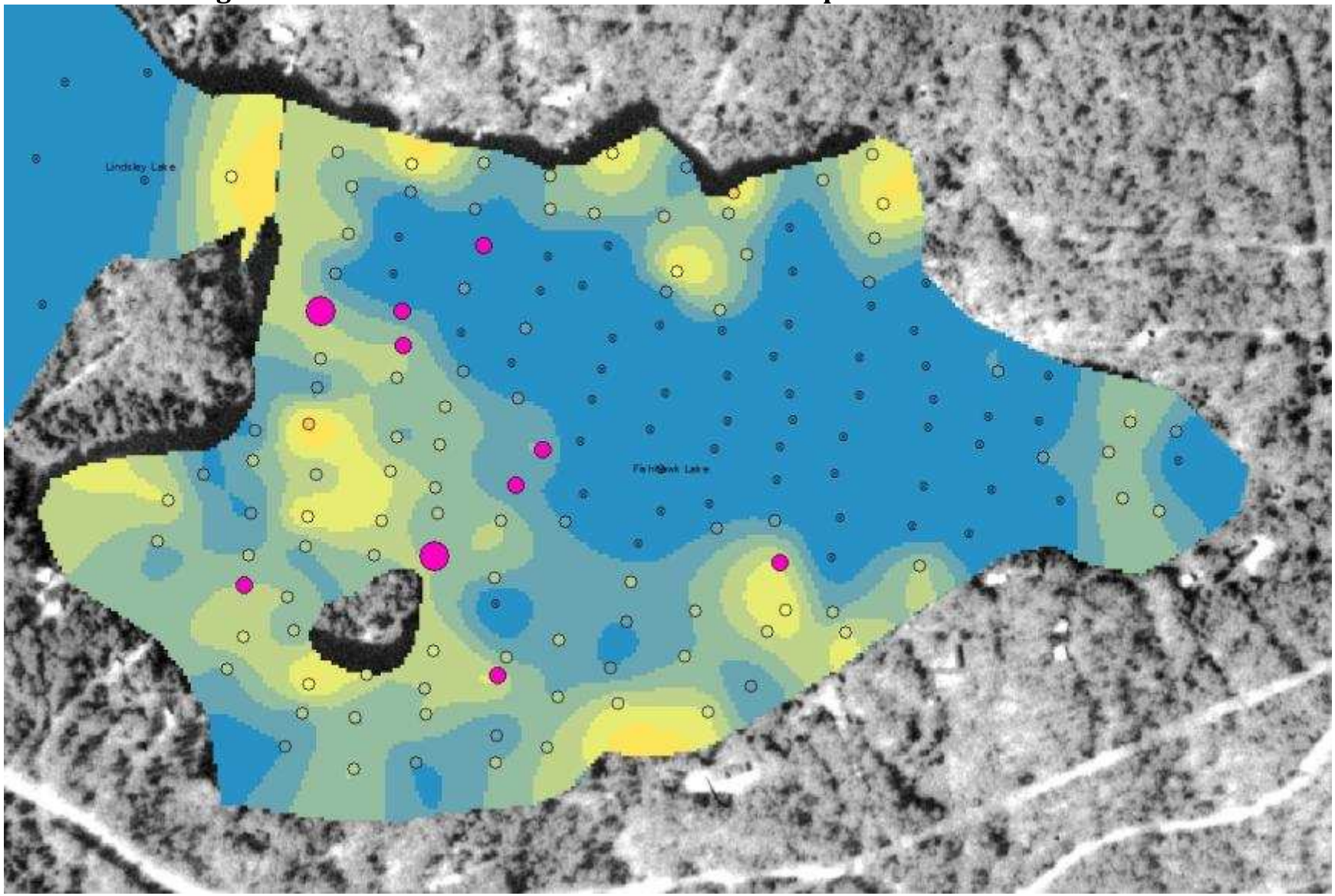
Fishhawk Lake

Sixteen native species and one invasive species (Curly-leaf pondweed) were detected in Fishhawk Lake (Table 7). Aquatic plants were detected at most points that occurred in shallow water throughout the lake, but the areas of greatest diversity and relative species abundance were along the southern and western shorelines (Figure 13). Species richness and FQI values (26.25) are consistent with regional averages. Curly-leaf pondweed was detected at 10 points throughout the lake at low to moderate densities. In previous years, CLP had developed noticeable mats throughout the summer, however no matting was observed during this field assessment.

Native Species	Common Name
Bidens beckii	Water marigold
Bolboschoenus fluviatilis	River bulrush
Ceratophyllum demersum	Coontail
Ceratophyllum echinatum	Spiny hornwort
Elodea canadensis	Common waterweed
Myriophyllum sibiricum	Northern water-milfoil
Najas flexilis	Slender naiad
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton gramineus	Variable pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Invasive Species	
Potamogeton crispus	Curly-leaf Pondweed
Species Detected	**17**
Floristic Quality Index	**26.25**

Table 7 – Aquatic plant abundance and relative quality estimates for Fishhawk Lake.

Figure 13 – Distribution of Native and Invasive Species in Fishhawk Lake



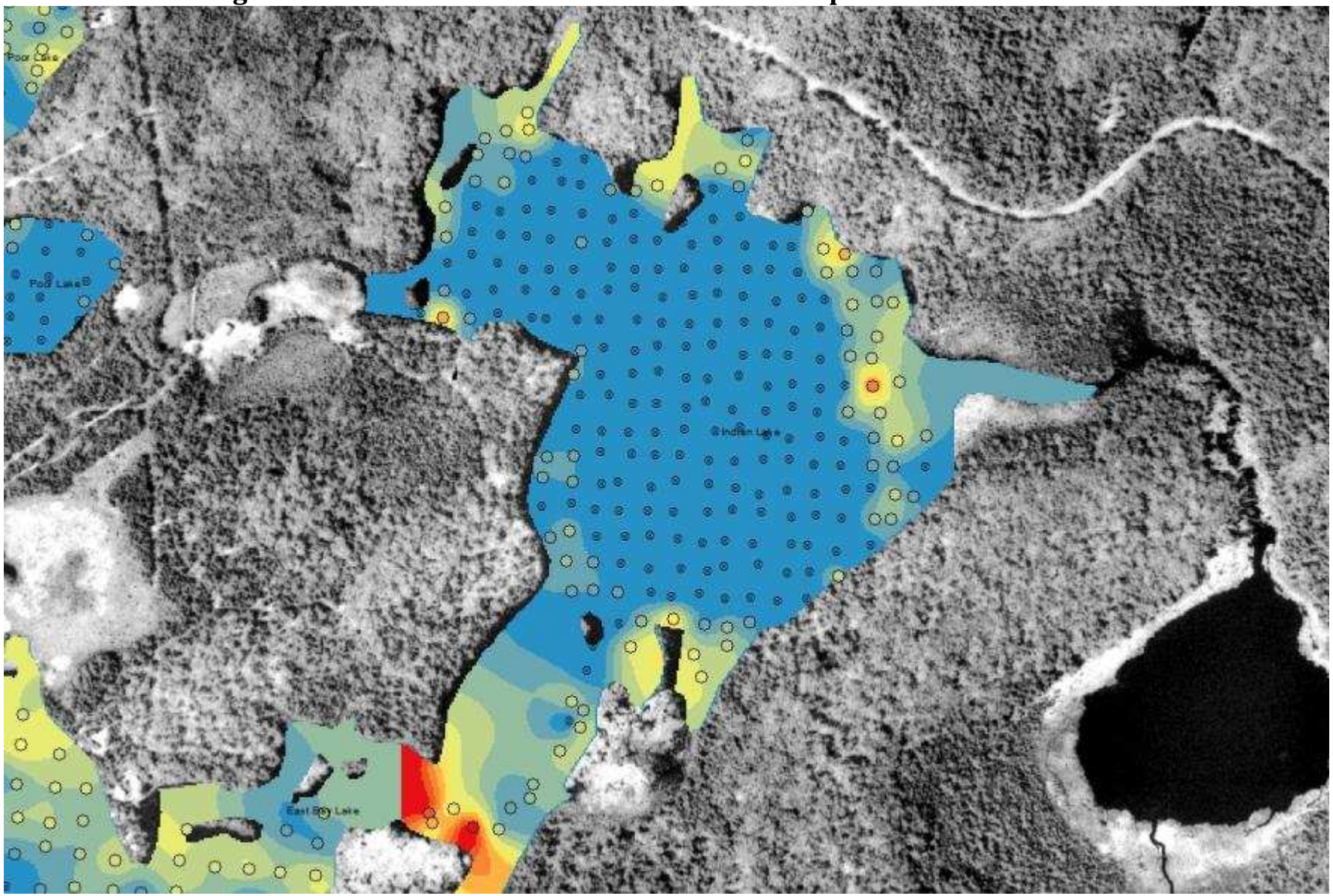
Indian Lake

Twenty-four native species were detected in Indian Lake (Table 9). At many of the points in the shallow waters throughout Indian Lake aquatic plants were not detected. However, the areas of higher plant density along the western and southern shores were relatively diverse (Figure 14). Of the 24 species of aquatic plants detected, many are considered highly conserved. Thus, the plant community of Indian Lake had a higher than average FQI of 29.49.

Species	Common Name
Bidens beckii	Water marigold
Callitriche palustris	Common water-starwort
Ceratophyllum demersum	Coontail
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Lemna trisulca	Forked duckweed
Myriophyllum sibiricum	Northern water-milfoil
Najas flexilis	Slender naiad
Najas gracillima	Northern naiad
Nitella	Nitella
Nymphaea odorata	White water lily
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton epihydrus	Ribbon-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton natans	Floating-leaf pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Sparganium eurycarpum	Common bur-reed
Stuckenia vaginata	Sheathed pondweed
Utricularia vulgaris	Common bladderwort
Vallisneria americana	Wild celery
Species Detected	**24**
Floristic Quality Index	**29.49**

Table 9 – Aquatic plant abundance and relative quality estimates for Indian Lake.

Figure 14 – Distribution of Native and Invasive Species in Indian Lake



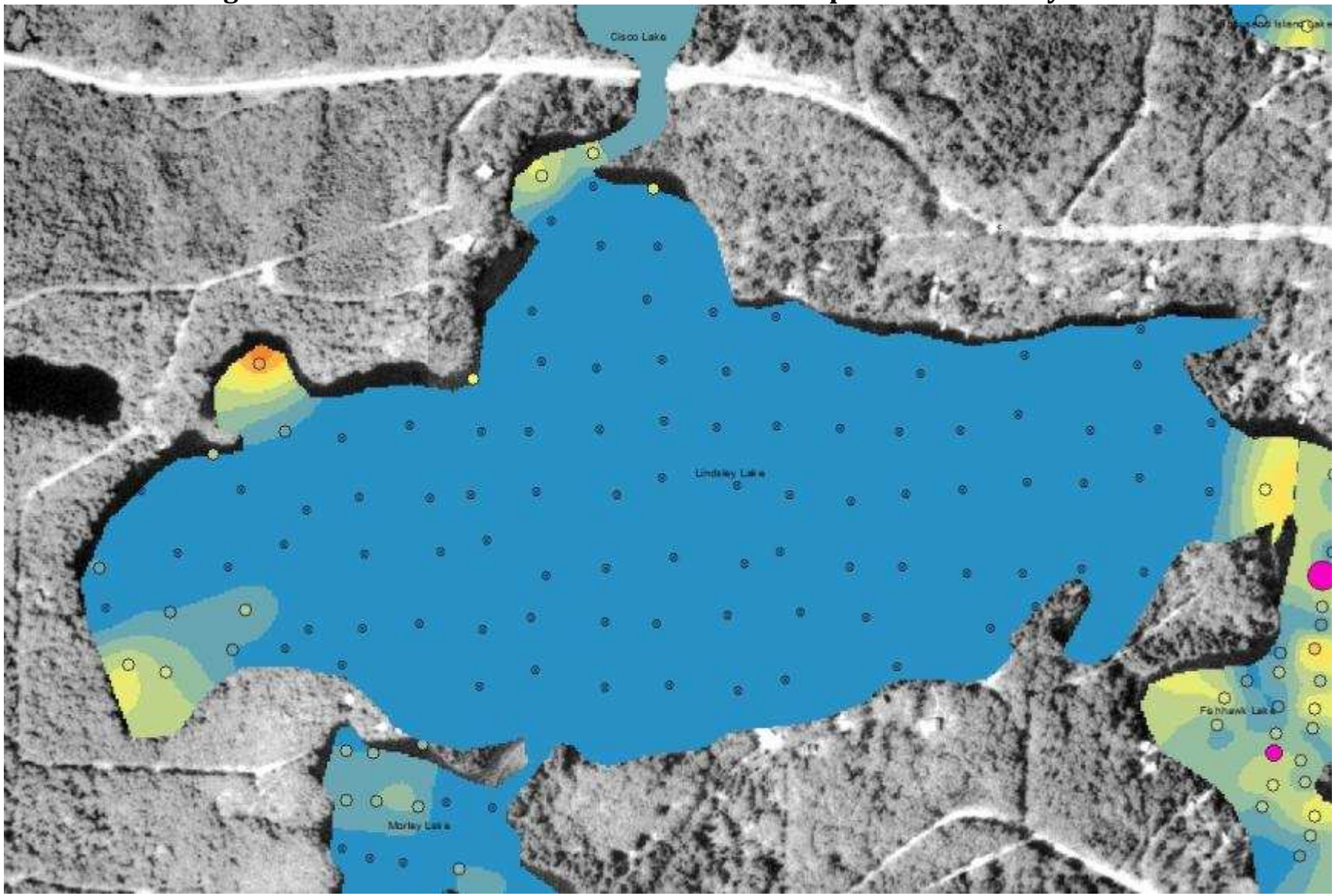
Lindsley Lake

Twelve different native species were detected in Lindsley Lake (Table 10). Given the rapid drop in depth off of most of the shoreline of Lindsley Lake, most of the points sampled did have aquatic plants (Figure 15). Within the points containing aquatic plants, pondweeds were the most dominant species. No invasive species were detected, which is inconsistent with previous observations; CLP was documented in two locations in along the southwest shoreline in 2010. Although this year-to-year change in CLP occurrence stands out, it is not uncommon for invasive species to flourish in some years and be undetectable in other years.

Species	Common Name
Ceratophyllum demersum	Coontail
Elodea canadensis	Common waterweed
Myriophyllum sibiricum	Northern water-milfoil
Najas gracillima	Northern naiad
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Stuckenia vaginata	Sheathed pondweed
Species Detected	**12**
Floristic Quality Index	**21.93**

Table 10 – Aquatic plant abundance and relative quality estimates for Lindsley Lake.

Figure 15 – Distribution of Native and Invasive Species in Linsdley Lake



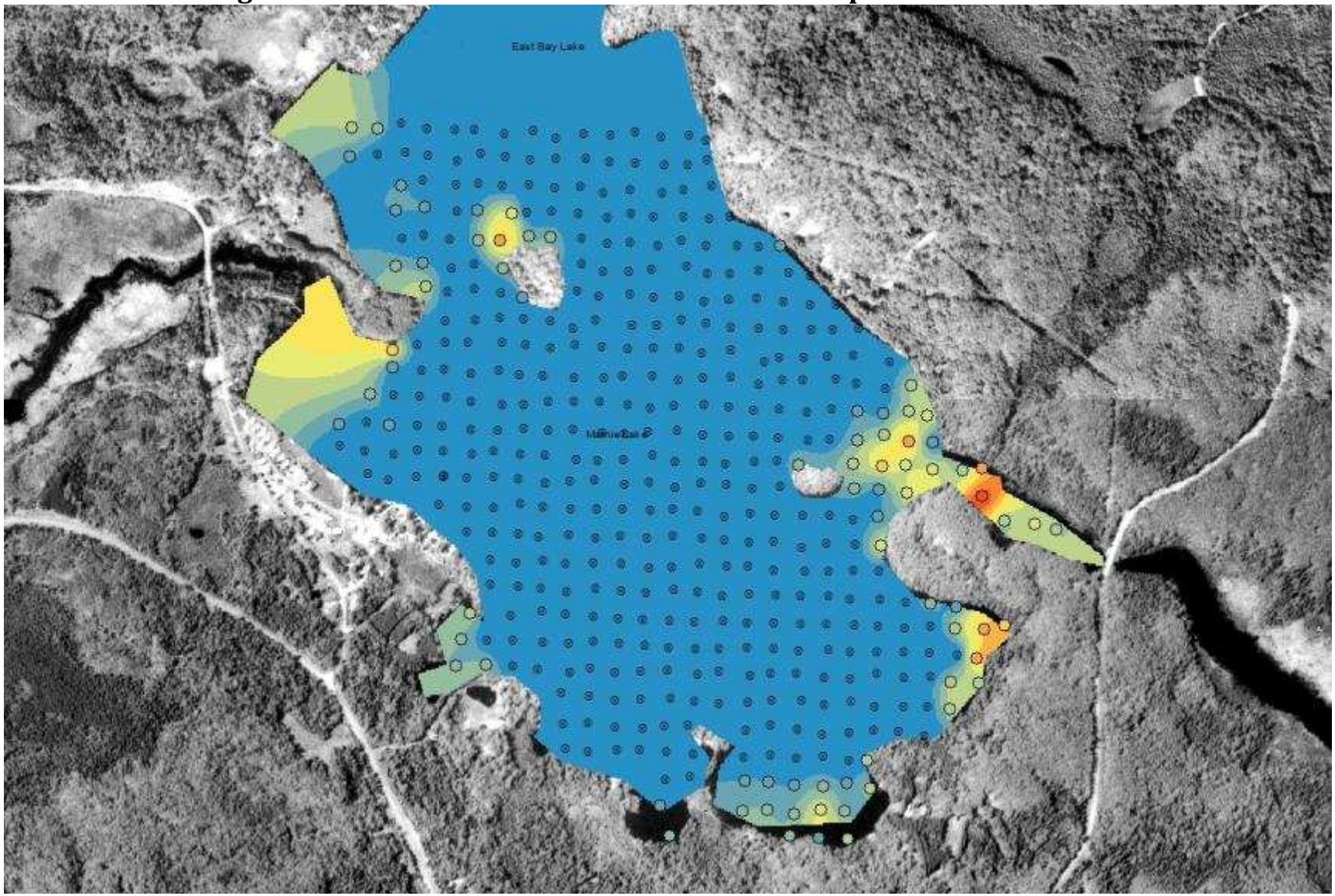
Mamie

Twenty-two native species were detected in Mamie Lake (Table 11). Most of the points sampled in Mamie Lake did not contain aquatic plants, because of the depth of the sampling points. The majority of the plants sampled were located along the southern shoreline and the main island on the north end of the lake (Figure 16). One highly conserved species, the spine hornwort, and many other sensitive species were detected in Mamie Lake. Thus, the FQI for Mamie Lake (31.76) was higher than average.

Species	Common Name
Bidens beckii	Water marigold
Ceratophyllum demersum	Coontail
Ceratophyllum echinatum	Spiny hornwort
Elodea canadensis	Common waterweed
Lemna trisulca	Forked duckweed
Myriophyllum sibiricum	Northern water-milfoil
Myriophyllum verticillatum	Whorled water-milfoil
Nitella	Nitella
Nuphar variegata	Spatterdock
Potamogeton alpinus	Alpine pondweed
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton epihydrus	Ribbon-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton gramineus	Variable pondweed
Potamogeton illinoensis	Illinois pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Stuckenia vaginata	Sheathed pondweed
Utricularia vulgaris	Common bladderwort
Vallisneria americana	Wild celery
Species Detected	**22**
Floristic Quality Index	**31.76**

Table 11 – Aquatic plant abundance and relative quality estimates for Mamie Lake.

Figure 16 – Distribution of Native and Invasive Species in Mamie Lake



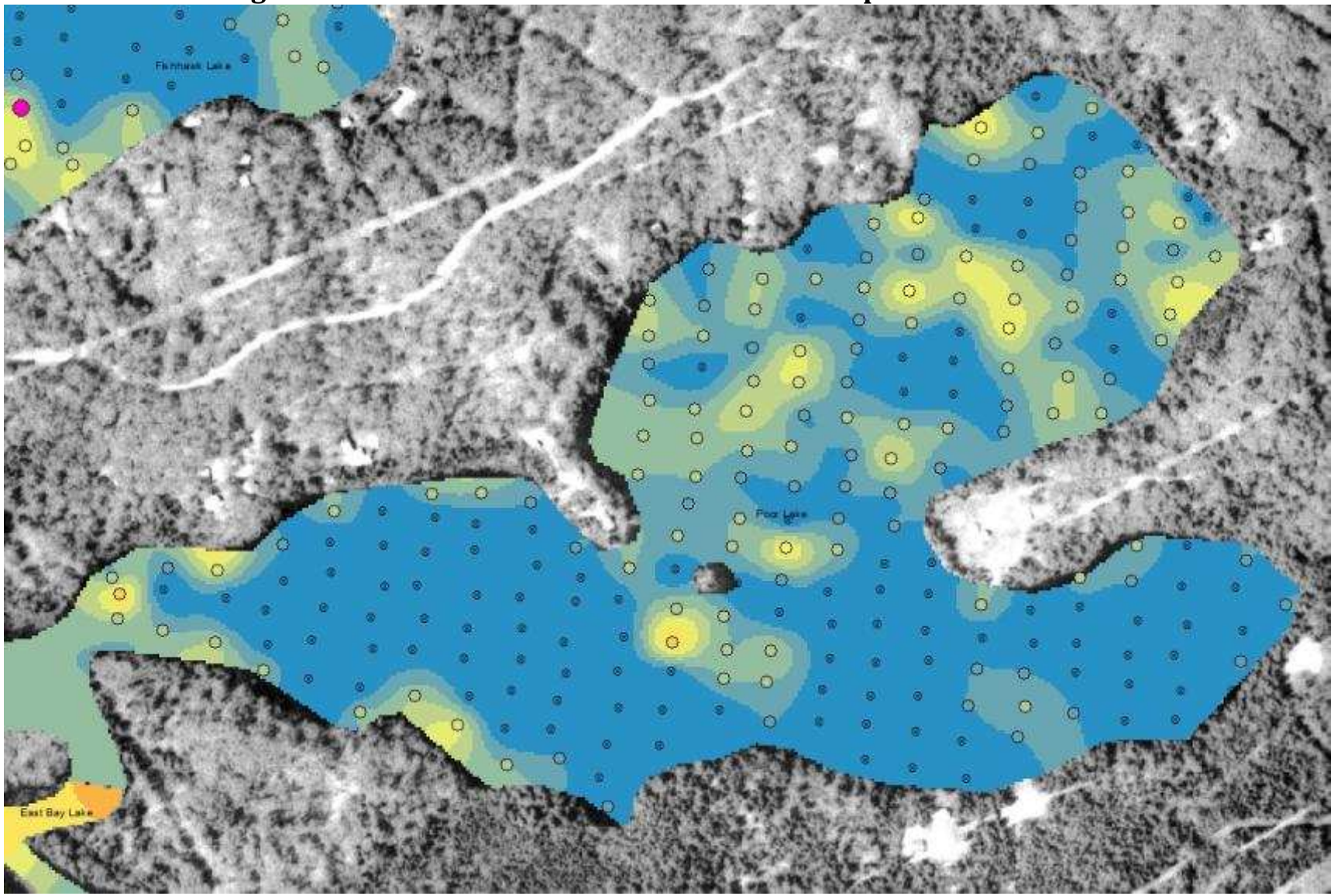
Poor Lake

Twenty-four native species were detected in Poor Lake (Table 12). Throughout Poor Lake, the northern lobe had the highest density of aquatic plants while the areas of greatest species richness were along the southwest shore and in the connecting channel to East Bay Lake (Figure 17). Native milfoils, pondweeds and naiad species accounted for the overwhelming majority of species. Many of the species sampled are considered highly conserved, and as a result the overall FQI value (33.08) for Poor Lake was quite high.

Species	Common Name
Bidens beckii	Water marigold
Brasenia schreberi	Watershield
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Myriophyllum sibiricum	Northern water-milfoil
Myriophyllum verticillatum	Whorled water-milfoil
Najas flexilis	Slender naiad
Najas gracillima	Northern naiad
Nitella	Nitella
Nymphaea odorata	White water lily
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton epihydrus	Ribbon-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton gramineus	Variable pondweed
Potamogeton illinoensis	Illinois pondweed
Potamogeton obtusifolius	Blunt-leaf pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Sparganium eurycarpum	Common bur-reed
Utricularia gibba	Creeping bladderwort
Vallisneria americana	Wild celery
Species Detected	**24**
Floristic Quality Index	**33.06**

Table 12 – Aquatic plant abundance and relative quality estimates for Poor Lake.

Figure 17 – Distribution of Native and Invasive Species in Poor Lake



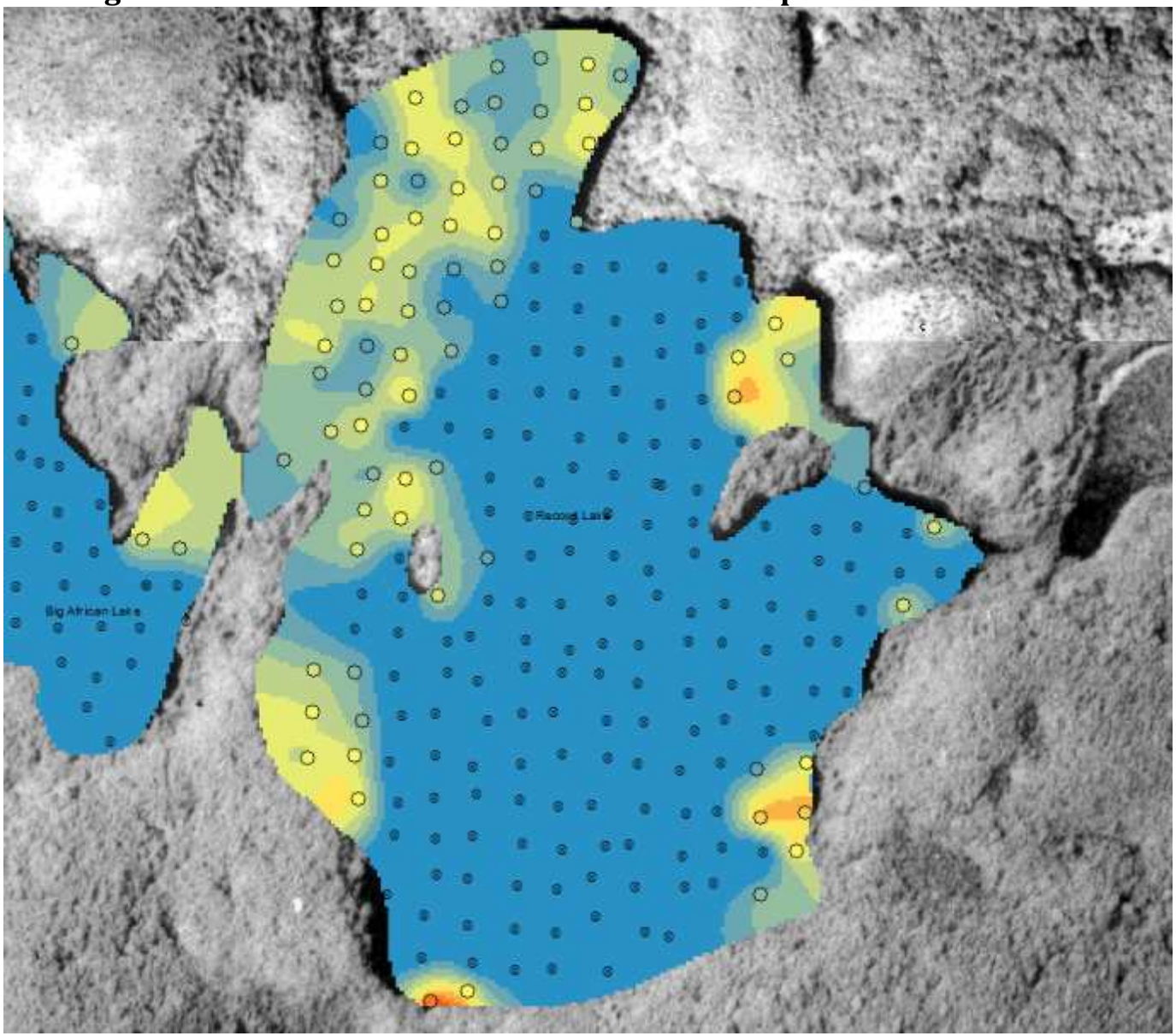
Record Lake

Twenty native species were detected in Record Lake (Table 13). Aquatic plants were widely distributed around the shallow waters of the lake, with the areas of highest species richness occurring in the protected bays along the southern and western shorelines (Figure 18). Floristic Quality Index values for Record Lake were consistent with regional averages.

Species	Common Name
Bidens beckii	Water marigold
Brasenia schreberi	Watershield
Ceratophyllum demersum	Coontail
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Myriophyllum sibiricum	Northern water-milfoil
Najas gracillima	Northern naiad
Nitella	Nitella
Nuphar variegata	Spatterdock
Nymphaea odorata	White water lily
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton gramineus	Variable pondweed
Potamogeton obtusifolius	Blunt-leaf pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Vallisneria americana	Wild celery
Species Detected	**20**
Floristic Quality Index	**26.08**

Table 13 – Aquatic plant abundance and relative quality estimates for Record Lake.

Figure 18 – Distribution of Native and Invasive Species in Record Lake



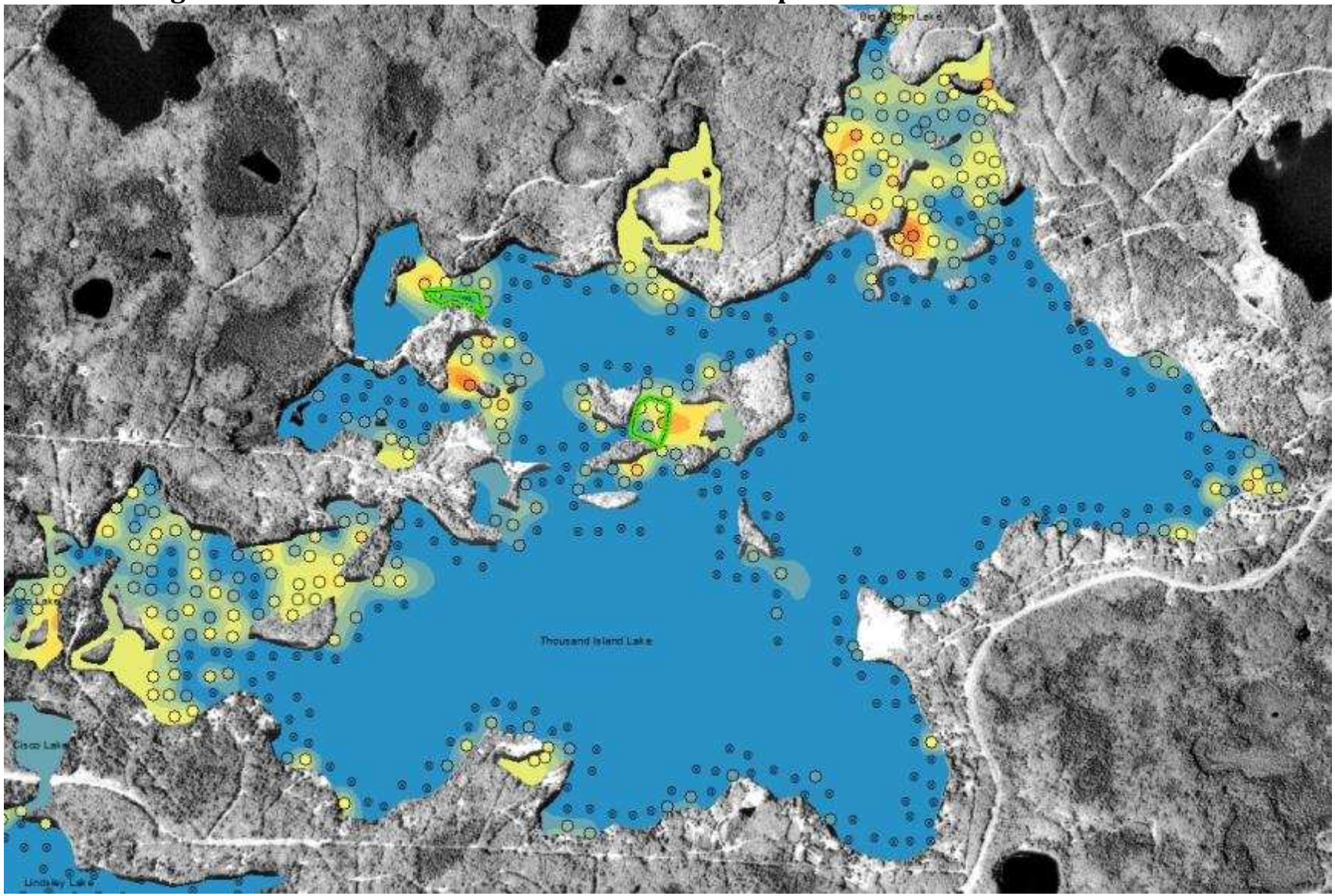
Thousand Island Lake

Thirty-six native and one invasive species (Eurasian Water-milfoil) were detected in Thousand Island Lake (Table 14). Across all lakes in the Cisco Chain, Thousand Island had the greatest number of species and highest floristic quality score (41.58). The areas of highest diversity were in the northern and western bays (Figure 19). Eurasian water-milfoil was observed at low densities (clusters of 1-3 plants) in areas surrounding the islands on the northern shore of the lake. However, given this low density, no EWM plants were collected using the rake sampler (all identification was based on visual confirmation).

Species	Common Name
Bidens beckii	Water marigold
Brasenia schreberi	Watershield
Ceratophyllum demersum	Coontail
Chara	Muskgrasses
Elodea canadensis	Common waterweed
Elodea nuttallii	Slender waterweed
Myriophyllum sibiricum	Northern water-milfoil
Najas flexilis	Slender naiad
Najas guadalupensis	Southern naiad
Nitella	Nitella
Nuphar variegata	Spatterdock
Nymphaea odorata	White water lily
Potamogeton alpinus	Alpine pondweed
Potamogeton amplifolius	Large-leaf pondweed
Potamogeton epihydrus	Ribbon-leaf pondweed
Potamogeton foliosus	Leafy pondweed
Potamogeton friesii	Fries' pondweed
Potamogeton hillii	Hill's pondweed
Potamogeton illinoensis	Illinois pondweed
Potamogeton natans	Floating-leaf pondweed
Potamogeton obtusifolius	Blunt-leaf pondweed
Potamogeton praelongus	White-stem pondweed
Potamogeton pusillus	Small pondweed
Potamogeton richardsonii	Clasping-leaf pondweed
Potamogeton robbinsii	Fern pondweed
Potamogeton strictifolius	Stiff pondweed
Potamogeton zosteriformis	Flat-stem pondweed
Ranunculus aquatilis	White water crowfoot
Sparganium eurycarpum	Common bur-reed
Sparganium fluctuans	Floating-leaf bur-reed
Stuckenia filiformis	Fine-leaved pondweed
Stuckenia vaginata	Sheathed pondweed
Utricularia geminiscapa	Twin-stemmed bladderwort
Utricularia gibba	Creeping bladderwort
Vallisneria americana	Wild celery
Invasive Species	
Myriophyllum spicatum	Eurasian Water-milfoil
Species Detected	**36**
Floristic Quality Index	**41.58**

Table 14 – Plant abundance and relative quality estimates for Thousand Island Lake.

Figure 19 – Distribution of Native and Invasive Species in Thousand Island Lake



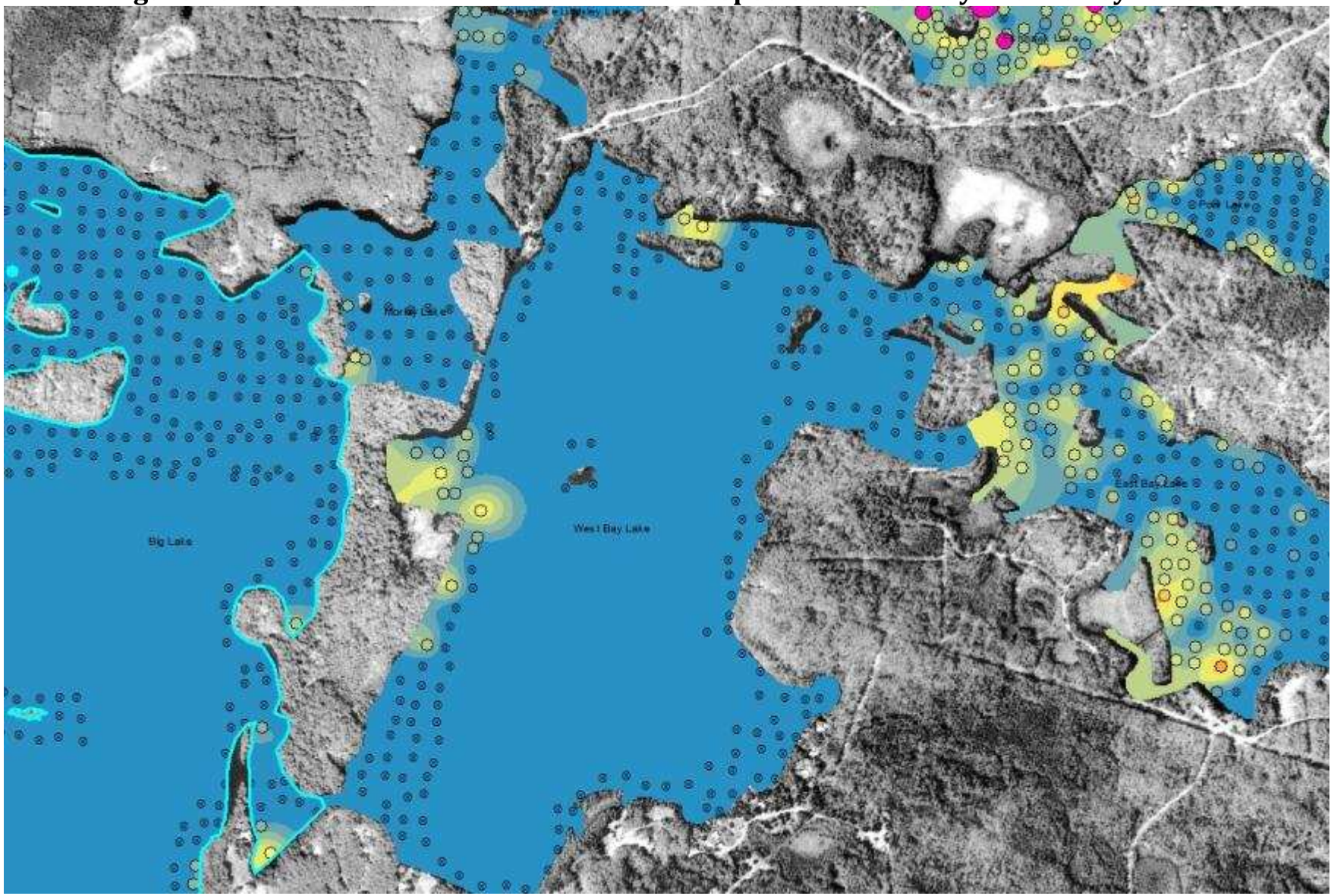
West Bay and Morley Lakes

Nineteen native species were detected in Morley and West Bay Lakes (Table 15). The majority of points sampled throughout West Bay and Morley Lakes did not contain vegetation. Most of the aquatic plants were detect in a few locations in the shallow bays along the northwestern shoreline (Figure 20). Throughout these two lakes the most commonly detected species were elodea and coontail. In general, the FQI scores were consistent with state averages for the region in West Bay Lake, but significantly lower in Morley Lake.

Species	Common Name	Morley	West Bay
Bidens beckii	Water marigold	0	1
Ceratophyllum demersum	Coontail	1	1
Ceratophyllum echinatum	Spiny hornwort	0	1
Chara	Muskgrasses	1	0
Elodea canadensis	Common waterweed	1	1
Heteranthera dubia	Water star-grass	0	1
Lemna trisulca	Forked duckweed	0	1
Myriophyllum sibiricum	Northern water-milfoil	1	1
Myriophyllum tenellum	Dwarf water-milfoil	1	0
Myriophyllum verticillatum	Whorled water-milfoil	0	1
Potamogeton amplifolius	Large-leaf pondweed	1	1
Potamogeton epihydrus	Ribbon-leaf pondweed	0	0
Potamogeton foliosus	Leafy pondweed	1	1
Potamogeton friesii	Fries' pondweed	0	1
Potamogeton praelongus	White-stem pondweed	0	1
Potamogeton richardsonii	Clasping-leaf pondweed	0	1
Potamogeton robbinsii	Fern pondweed	1	1
Potamogeton zosteriformis	Flat-stem pondweed	1	1
Ranunculus aquatilis	White water crowfoot	0	1
Vallisneria americana	Wild celery	0	1
Species Detected		**9**	**17**
Floristic Quality Index		**18.6667**	**27.16**

Table 15 – Aquatic plant abundance and relative quality estimates for West Bay and Morley Lakes.

Figure 20 – Distribution of Native and Invasive Species in West Bay and Morley Lakes



Management Recommendations

Across the Cisco Chain of Lakes, management efforts should build on the ongoing work of the CCROA to continue to address three primary goals: 1) monitoring and maintaining the diversity of native aquatic plants across all lakes; 2) control and management of existing invasive species beds; and 3) prevention of the spread and introduction of new invasive species. These goals are described in greater detail below, along with potential strategies for their implementation.

Monitoring and Maintaining the Diversity of Native Aquatic Communities

Diverse native aquatic communities are a key component of healthy lake ecosystems. Native plant communities: 1) support healthy fisheries by providing spawning and rearing habitat for juvenile fish; 2) promote water quality by providing habitat for zooplankton (which control algal blooms) and preventing sediments (and the associated nutrients) from being re-suspended throughout the lake; and 3) prevent the establishment and spread of invasive species by occupying habitat that invasive species could potentially utilize.

The first step in maintaining diverse native plant communities is to establish a recurring monitoring program to document any changes in community composition or structure over time. A recurring aquatic plant monitoring program like this would be implemented by conducting a point-intercept survey (the same protocol described above) to characterize the extent and composition of aquatic plant communities in all shallow waters (depth of < 20 feet) on all lakes every three to five years. Given the number of lakes throughout the Cisco Chain and potential for year to year variability, if a recurring monitoring program was developed, a staggered sampling design would likely be most appropriate. Following a staggered design, all of the lakes would be visited every three to five years, but in any given year only two to three lakes would be sampled. This work would build on the aquatic plant surveys that the CCROA has commissioned over the last several years.

Management of Existing Invasive Species

Proactive control of existing invasive species is necessary to prevent their further establishment and spread and future efforts should build on the ongoing work by the CCROA. Invasive species were detected in three lakes in this past survey (Clearwater Lake, Big Lake and Fishhawk Lake) and have been documented in a fourth lake (Lindsley Lake) in previous surveys. Management of existing invasive species should continue to be implemented based on lake-by-lake needs, but follow a general structure of preliminary delineation, treatment (potentially using a range of methods; described below) and follow-up monitoring. In general, treatments for Curly-leaf pondweed and Eurasian Water-milfoil should be conducted in the early season (likely in May-June depending on water temperatures) to maximize their efficacy and minimize any impacts on native plant communities.

Methods and/or chemicals that are implemented to control invasive species should be determined on a lake-by-lake basis. In lakes with well-established beds (i.e., areas of dense plant growth that are dominated by invasive species) herbicide application is likely the best option for control of invasive species. The type of herbicide that is applied will vary depending the species of plant, cost of the chemical and potential for secondary or non-target effects of the herbicide.

In lakes with low density invasive species coverage (i.e., noticeable beds do not exist), herbicide application is often less effective and/or has a higher potential for secondary effects. The efficacy of herbicide application is dependent on the concentration and "contact time" (i.e., duration of exposure at a particular concentration) of the chemical. In situations where plants are at a low density, the area that must be treated to maintain an effective herbicide concentration is much larger than the area covered by the invasive plants. As a result, treatments that focus on one plant or a small cluster of plants are often either not effective or have a large area of secondary herbicide exposure. In areas of low density, control methods should consider hand pulling or the use of a containment curtain to maintain effective concentrations in proportionally smaller areas.

Prevent the Spread and further Introduction of Invasive Species

Given the range of potential sources (primarily boat launches and existing beds) of invasive species for the Cisco Chain of Lakes and the high percentage of lakes that are not affected by invasive species, continuing efforts that build on the CCROA's ongoing work to minimize the spread and/or new introduction of invasive species are critical. To this end, one approach that is increasingly utilized is the development and implementation of an early detection, rapid response plan.

An early detection, rapid response plan combines targeted invasive species monitoring activities with a document that articulates the action steps and decision criteria that will be used to prevent the establishment of new invasive species in a particular lake. Annual monitoring activities are generally comprised of high intensity monitoring efforts in the areas of highest probability for invasive species spread or introduction (e.g., adjacent to boat launches and areas of high traffic—connecting channels). The rapid response planning document is developed collaboratively with the respective state agency (in this case either or both the Michigan Department of Environmental Quality or Wisconsin Department of Natural Resources) and articulates how (i.e., by what means?), when (i.e., in response to what change?) and by what process (i.e., who needs to be involved when, and in what order) new or expanding invasive species will be managed. Rapid response plans are then implemented in tandem with outreach efforts to increase awareness among lake users of the potential risks of invasive species and the options to prevent future spread or introduction.

Summary

The Cisco Chain of Lakes has a range of highly diverse, healthy aquatic plant communities which are critical to sustain many of the desired uses for the lakes (e.g., fishing, aesthetics and recreation). While most of the lakes within the chain are not currently affected by invasive species, the established populations of Eurasian water-milfoil and Curly-leaf Pondweed present a potential risk to all of the lakes throughout the connected chain. Going forward, management of aquatic plants throughout the Cisco Chain should build on the ongoing efforts of the CCROA to develop and implement a comprehensive aquatic plant management plan. To this end, the resulting aquatic plant management activities would include recurring monitoring of aquatic plant communities across all lakes, lake-specific efforts to control existing invasive species and efforts to proactively prevent the expansion or introduction of new invasive species throughout the chain.