Aquatic Macrophyte Survey

~Point Intercept Method~

Bone Lake, Polk County Wisconsin

(WBIC: 2688100)

July, 2012

Survey and Analysis Conducted by Ecological Integrity Service, LLC

Sponsored by Spooner Lake Protection and Rehabilitation District and Wisconsin Dept. of Natural Resources.

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Introduction

In June and July 2012, a point intercept method aquatic macrophyte survey was conducted on Bone Lake (WBIC: 2628100), in Polk County Wisconsin. Bone Lake is a 1781-acre drainage lake with a maximum depth of 43 feet. Development around Bone Lake is extensive with much of the lakeshore being developed and/or disturbed from an original native riparian zone.

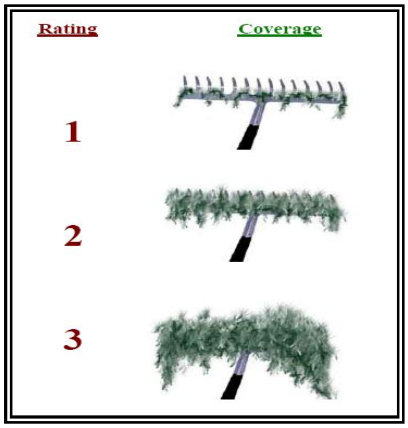
This report presents a summary and analysis of data collected in a point intercept aquatic macrophyte survey. The primary goal of the survey is to compare this PI survey with one conducted in 2007 for the long-term monitoring of aquatic plant populations and allow for the evaluation of any changes that may occur long-term. These changes may be due to human activities such as management of *Potamogeton crispus* (curly leaf pondweed), which has been occurring on Bone Lake. In addition, invasive species presence and location monitoring is important and an integral part of this survey. This survey is acceptable for aquatic plant management planning.

Field Methods

A point intercept method was employed for the aquatic macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grid of 1000 sample points for Bone Lake. Only points shallower than 25 feet were initially sampled on Bone Lake until the maximum depth of plants could be established (of which all points are under 25 feet). If no plants were sampled, one sample point beyond that was sampled for plants. In areas such as bays that appear to be under-sampled, a boat survey was conducted. This involved going to the area and surveying that area for plants, recording the species viewed and/or sampled. The type of habitat is also recorded. These data are not used in the statistical analysis nor is the density recorded. Only plants sampled at predetermined sampled points were used in the statistical analysis. In addition, any plant within six feet of the boat was recorded as "viewed." A handheld Global Positioning System (GPS) located the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy were followed with an 80 ft resolution window and the location arrow touching the point.

At each sample location, a double-sided fourteen-tine rake was used to rake a 1m tow off the bow of the boat. All plants contained on the rake and those that fell off of rake were identified and rated as to rake fullness. The rake fullness value was used based on the criteria contained in the diagram and table below. Those plants that were within six feet were recorded as "viewed," but no rake fullness rating was given. Any under surveyed areas such as bays and/or areas with unique habitats were monitored. These areas are referred to as a "boat survey."

The rake density criteria used:



	Criteria for rake fullness rating
1	Plant present, occupies less than ½ of tine space
2	Plant present, occupies more than ½ tine space
3	Plant present, occupies all or more than tine space
v	Plant not sampled but observed within 6 feet of boat

The depth and predominant bottom type was also recorded for each sample point. Caution must be used in using the sediment type in deeper water as it is difficult to discern between muck and sand with a rope rake. All plants needing verification were bagged and cooled for later examination. Each species was mounted and pressed for a voucher collection and submitted to the Wisconsin DNR for review. On rare occasions a single plant may be needed for verification, not allowing it to be used as a voucher specimen and may be missing from the collection.

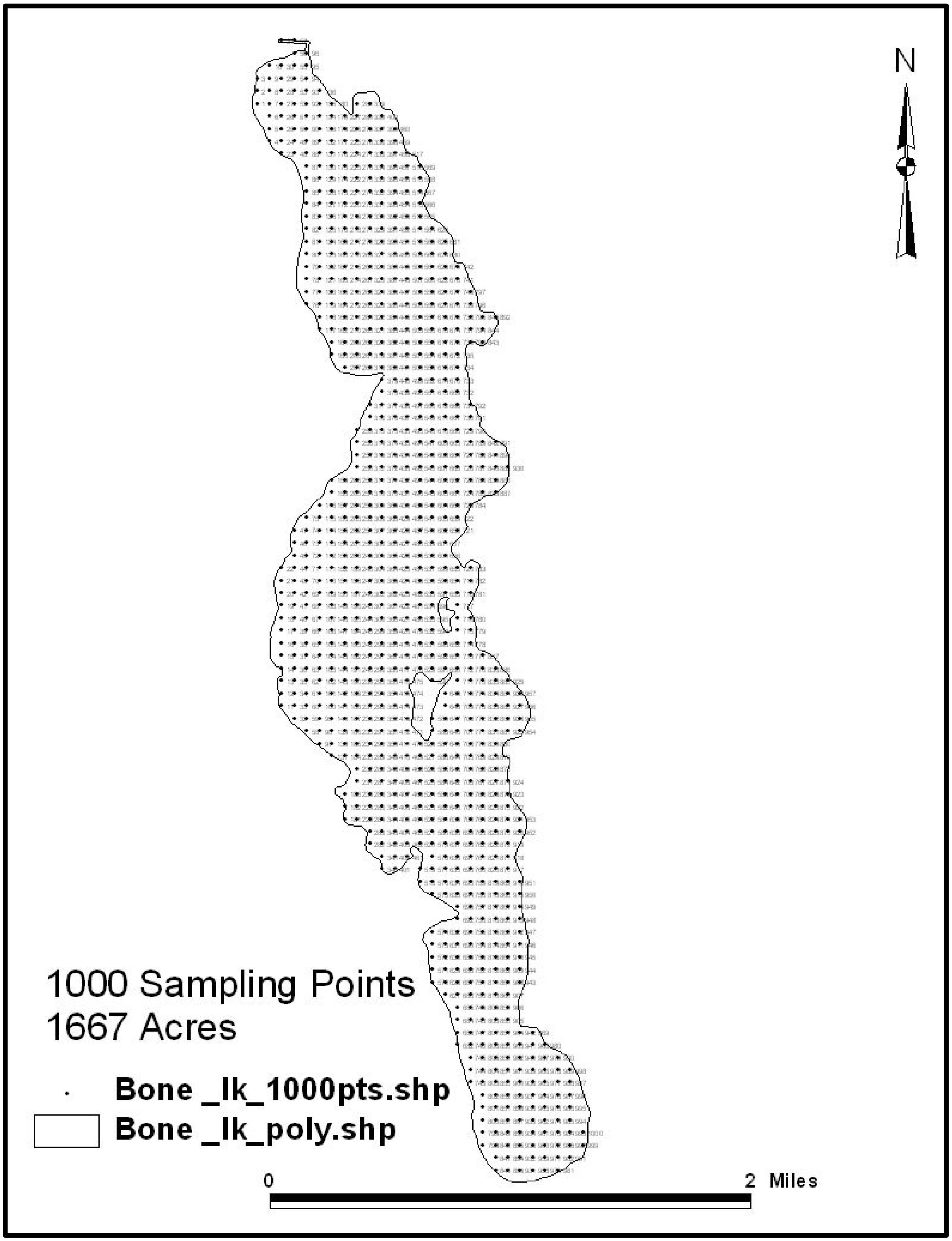


Figure 1: Map of sample points for point intercept survey, generated by Wisconsin DNR.

Data analysis methods

Data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Frequency of occurrence in sample points with vegetation (littoral zone)
- Relative frequency
- Total points in sample grid
- Total points sampled
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

<u>Frequency of occurrence for each species</u>- Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the number of sites. There can be two values calculated for this. The first is the percentage of all sample points that this plant was sampled at depths less then maximum depth plants were found (littoral zone), regardless if vegetation was present. The second is the percentage of sample points that the plant was sampled at only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone (by depth), while the second value shows if considered where points contain plants. In either case, the greater this value, the more frequent the plant is in the lake. If one wants to compare how frequent in the littoral zone, we look at the frequency of all points below maximum depth with plants. This frequency value allows the analysis of how common plants are where they could grow based upon depth. If one wants to focus only where plants are actually present, then one would look at frequency at points in which plants were found. Frequency of occurrence is usually reported using sample points where vegetation was present.

Frequency of occurrence example:

Plant A sampled at 35 of 150 littoral points = 35/150 = 0.23 = 23%

Plant A's frequency of occurrence = 23% considering littoral zone depths.

Plant A sampled at 12 of 40 vegetated points = 12/40 = 0.3 = 30%

Relative frequency-This value shows, as a percentage, the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants will add to 100%. This means that if plant A had a relative frequency of 30%, it occurred 30% of the time compared to all plants sampled or makes up 30% of all plants sampled. This value allows us to see which of the plants the dominant species in the lake are. The higher the relative frequency the more common the plant is compared to the other plants and therefore the more frequent in the plant community.

Relative frequency example:

Suppose we were sampling 10 points in a very small lake and got the following results:

	Frequency sampled
Plant A present at 3 sites	3 of 10 sites
Plant B present at 5 sites	5 of 10 sites
Plant C present at 2 sites	2 of 10 sites
Plant D present at 6 sites	6 of 10 sites

So one can see that Plant D is the most frequent sampled at all points with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If we add all frequencies (3+5+2+6), we get a sum of 16. We can calculate the relative frequency by dividing by the individual frequency.

Total point in sample grid- The Wisconsin DNR establishes a sample point grid that covers the entire lake. Each GPS coordinate is given and used to locate the points.

Number of points sampled- This may not be the same as the total points in the sample grid. When doing a survey, we don't sample at depths outside of the littoral zone (the area where plants can grow). Once the maximum depth of plants is established, many of the points deeper than this are eliminated to save time and effort.

Sample sites with vegetation- The number of sites where plants were actually sampled. This gives a good idea of the plant coverage of the lake. If 10% of all sample points had vegetation, it implies about 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. We also look at the number of sample sites with vegetation in the littoral zone. If 10% of the littoral zone had sample points with vegetation, then the plant coverage in the littoral zone would be estimated at 10%.

Simpson's diversity index-To measure how diverse the plant community is, Simpson's diversity index is calculated. This value can run from 0 to 1.0. The greater the value, the more diverse the plant community is in a particular lake. In theory, the value is the chance that two species sampled are different. An index of "1" means that the two will always be different (very diverse) and a "0" would indicate that they will never be different (only one species found). The higher the diversity in the native plant community, the healthier the lake ecosystem.

Simpson's diversity example:

If one sampled a lake and found just one plant, the Simpson's diversity would be "0." This is because if we randomly sampled two plants, there would be a 0% chance of them being different, since there is only one plant.

If every plant sampled were different, then the Simpson's diversity would be "1." This is because if two plants were randomly sampled, there would be a 100% chance they would be different since every plant is different.

Maximum depth of plants-This depth indicates the deepest that plants were sampled. Generally more clear lakes have a greater depth of plants while lower water clarity limits light penetration and reduces the depth at which plants are found.

Species richness-The number of different individual species found in the lake. There is a number for the species richness of plants sampled, and another number that takes into account plants viewed but not actually sampled during the survey.

Floristic Quality Index-The Floristic Quality Index (FQI) is an index developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index is a measure of the plant community in response to development (and human influence) on the lake. It takes into account the species of aquatic plants sampled and their tolerance for changing water quality and habitat quality. The index uses a conservatism value assigned to various plants ranging from 1 to 10. A high conservatism value indicates that a plant is intolerant while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes, largely due to human influence (Nichols, 1999). The FQI is calculated using the number of species and the average conservatism value of all species used in the index. The formula is:

FQI = Mean C ·√N

Where C is the conservatism value and N is the number of species (only species sampled on rake).

Therefore, a higher FQI indicates a healthier aquatic plant community, which is an indication of better plant habitat. This value can then be compared to the median for other lakes in the assigned eco-region. There are four eco-regions used throughout Wisconsin. These are Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. The 2007 values will also be compared in this analysis.

Summary of Northern Central Hardwood Forests Median Values for Floristic Quality Index:

(Nichols, 1999)

Median species richness = 14

Median conservatism = 5.6

Median Floristic Quality = 20.9

Results

On July 11-16, 2012 the point intercept survey was completed. In June 2012, the *Potamogeton crispus* (curly leaf pondweed) survey was completed and is discussed within the invasive species portion of this analysis (later in this section).

Bone Lake has fairly limited plant growth. Of the 1000 sample points in the grid, only 298 of them occur in water less than 20.7 feet, which is the maximum depth plants grew in 2012. This depth defines the littoral zone, or the zone where plants can grow. Due to the bathymetry of Bone Lake, the littoral zone is narrow and limited in area. This limits where plants may grow. The survey statistics support this showing 64.4% of the littoral zone sample points had plants present. The dominant sediment in most areas of Bone Lake is low nutrient sand and rock, also limiting plant growth.

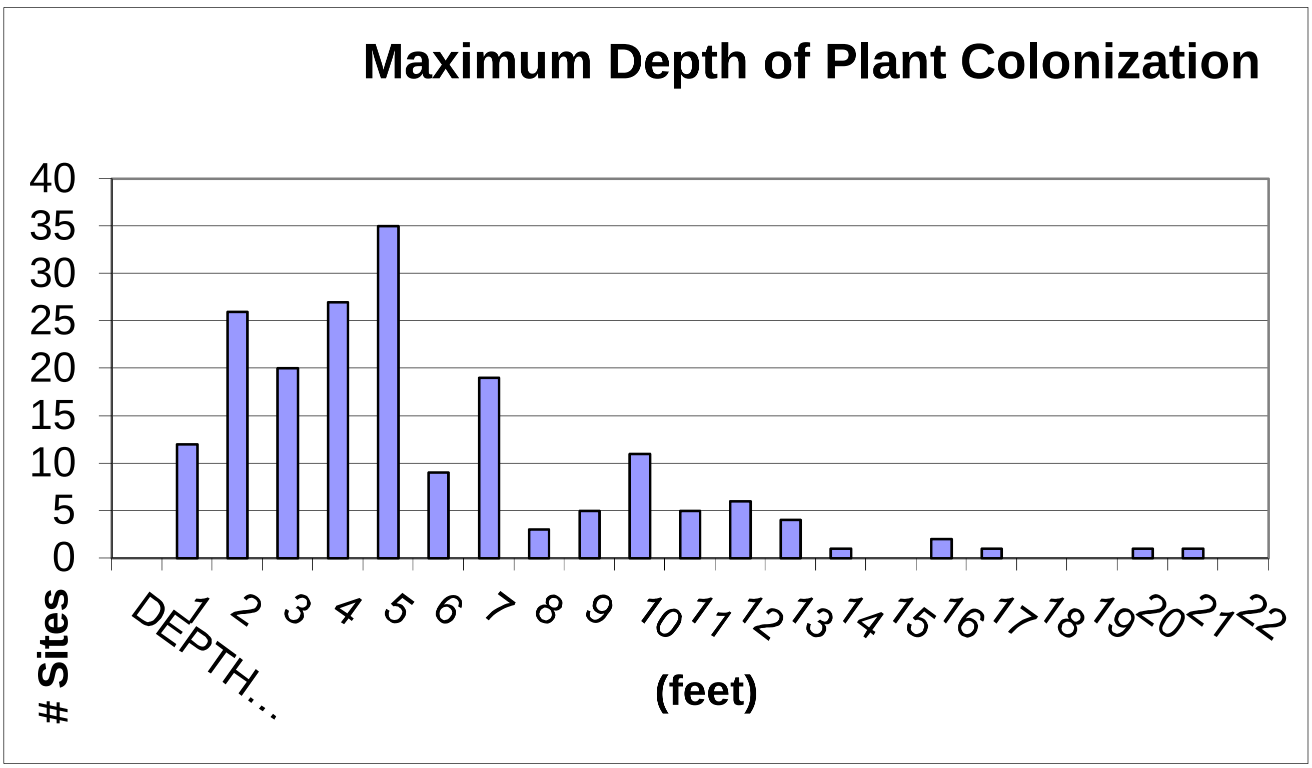


Figure 2: Depth and plant growth analysis graph.

As Figure 2 shows the maximum depth of plants is just below 21 feet (20.7), but the majority of the growth is in 1 to 13 feet of water. Even though the maximum depth of plants was 20.7, most plants growing in the littoral zone were in depths much less, therefore lowering the percentage of growth in the littoral zone.

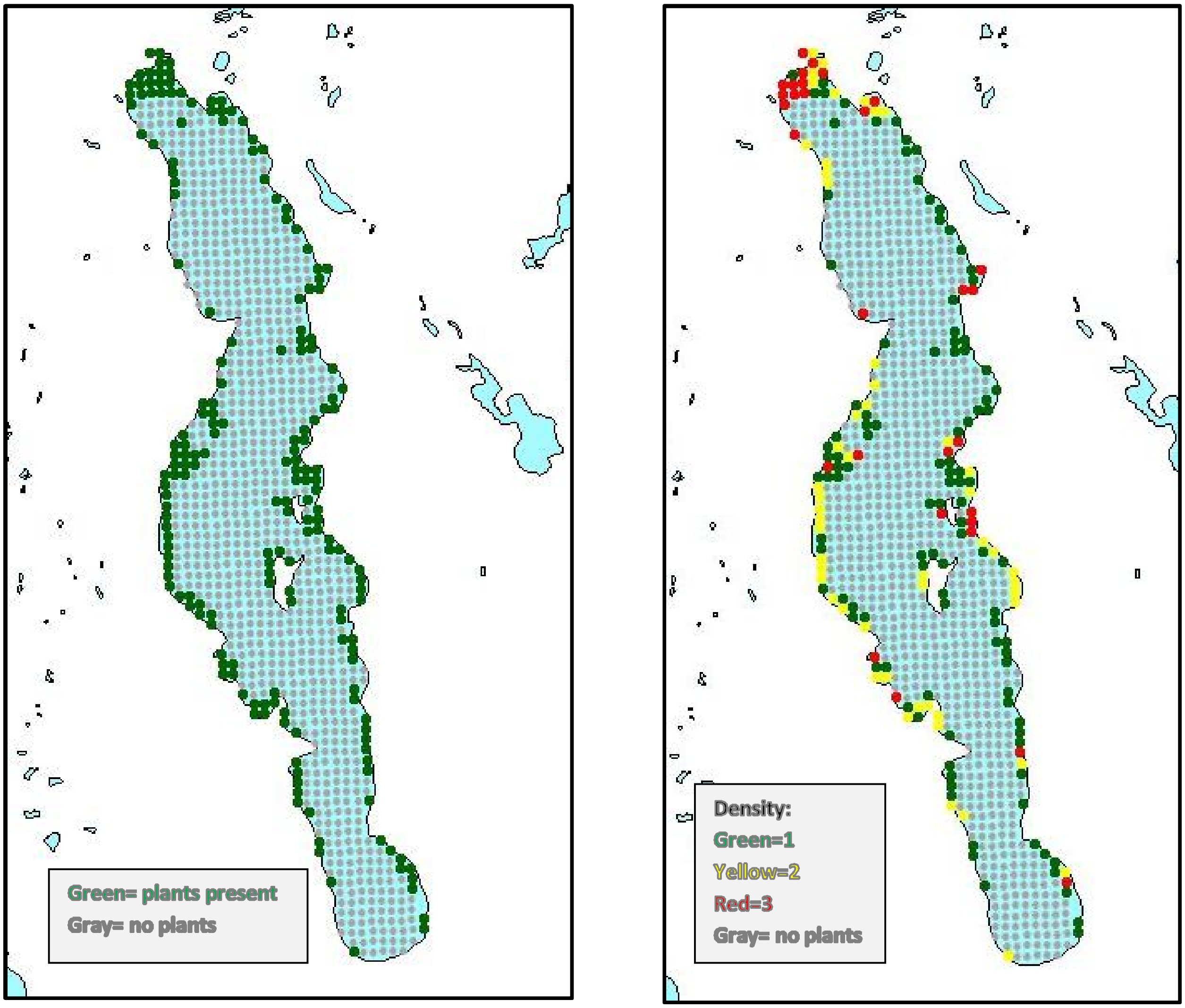


Figure 3: Map of sample points with plant growth and the density rating at each of these sites-2012.

The density of plant growth is also relatively moderate in Bone Lake. The densest growth is in the very north end, and in a bay on the east side, mid-lake running north and south. The remaining portions of the lake had total rake densities that were 1's or 2's, with many 2's associated with *Chara sp*. This plant (actually algae) lies on the bottom, generally not affecting navigation.

2012 PI Survey Stats	
Total number of sample points in grid	**1000**
Total number of sites with vegetation	**192**
Total number of sites shallower than maximum depth of plants	**298**
Frequency of occurrence at sites shallower than maximum depth of plants	**64.43%**
Simpson Diversity Index	**0.92**
Maximum depth of plants (ft)**	**20.70**
Average number of all species per site (veg. sites only)	**2.59**
Average number of native species per site (veg. sites only)	**2.61**
Species Richness (actually sampled on rake)	**36**
Species Richness (including visuals)	**47**
Species Richness (including boat survey)	**54**

Table 1: 2012 point intercept survey summary statistics.

The diversity of the aquatic plant community of Bone Lake is high. This is represented by several data. First, the number of species sampled was 36 (species richness). Of these 36 species, 34 are native species while 2 are non-native (*Potamogeton crispus* and *Phalaris arundinacea*). Of the 34 native species, 32 are vascular plants and 2 are algae (filamentous algae is <u>not</u> included in the species richness). There were 47 species (11 species in addition to the species sampled) if include the visuals (within 6 feet of sample point), with all of them native species. The second indicator is the Simpson's diversity index. This index was 0.92 for Bone Lake in 2012, which is high. This means that if two plants are randomly sampled, there is a 92% probability they are different. Lastly the most dominant species, *Chara sp.* had a relative frequency of 14.4% which shows there are many other plants that are frequent as well. If diversity is low, there is usually a plant or two that dominate the sampling and have very high relative frequencies (such as 25% or more).

The species with the highest relative frequency were *Chara sp*., Wild celery *(Vallisneria Americana)* and coontail *(Ceratophyllum demersum)* with relative frequencies of 14.4%, 13.2% and 11.3% respectively. *Chara* is actually an algae, while wild celery and coontail are vascular plants. All three are desirable, native plants found in many Wisconsin Lakes. No one plant dominates the aquatic plant community with all three of these just over 10% for relative frequency (meaning the % of all plants sampled in the survey). Figures 4 thru 6 show the distribution of these three most common species.

Species	Frequency of occurrence	Relative frequency	Number sampled	Mean density
Chara sp., Muskgrasses	36.46	14.40	70	1.26
Vallisneria americana, Wild celery	33.33	13.17	64	1.00
Ceratophyllum demersum, Coontail	28.65	11.32	55	1.58
Najas flexilis, Slender naiad	21.35	8.44	41	1.07
Potamogeton zosteriformis, Flat-stem pondweed	18.23	7.20	35	1.20
Myriophyllum sibiricum, Northern water-milfoil	16.67	6.58	32	1.09
Potamogeton richardsonii, Clasping-leaf pondweed	9.90	3.91	19	1.00
Potamogeton pusillus, Small pondweed	8.85	3.50	17	1.18
Stuckenia pectinata, Sago pondweed	8.85	3.50	17	1.06
Lemna trisulca, Forked duckweed	8.33	3.29	16	1.06
Potamogeton crispus,Curly-leaf pondweed	7.81	3.09	15	1.00
Lemna minor, Small duckweed	7.81	3.09	15	1.00
Potamogeton illinoensis, Illinois pondweed	6.77	2.67	13	1.00
Wolffia columbiana, Common watermeal	6.77	2.67	13	1.00
Spirodela polyrhiza, Large duckweed	6.25	2.47	12	1.00
Nuphar variegata, Spatterdock	3.65	1.44	7	1.00
Nymphaea odorata, White water lily	3.13	1.23	6	1.00
Potamogeton friesii, Fries' pondweed	2.60	1.03	5	1.20
Schoenoplectus acutus, Hardstem bulrush	2.60	1.03	5	1.00
Potamogeton gramineus, Variable pondweed	2.08	0.82	4	1.00
Potamogeton foliosus, Leafy pondweed	1.56	0.62	3	1.67
Potamogeton praelongus, White-stem pondweed	1.56	0.62	3	1.33
Eleocharis erythropoda, Bald spikerush	1.04	0.41	2	1.00
Heteranthera dubia, Water star-grass	1.04	0.41	2	1.00
Nitella sp., Nitella	1.04	0.41	2	1.00
Potamogeton amplifolius, Large-leaf pondweed	1.04	0.41	2	1.00
Ranunculus aquatilis, White water crowfoot	1.04	0.41	2	1.00
Zizania palustris, Northern wild rice	1.04	0.41	2	1.00
Bidens beckii, Water marigold	0.52	0.21	1	1.00
Elodea canadensis, Common waterweed	0.52	0.21	1	1.00
Equisetum fluviatile, Water horsetail	0.52	0.21	1	1.00
Isoetes lacustris, Lake quillwort	0.52	0.21	1	1.00
Sagittaria cuneata, Arum-leaved arrowhead	0.52	0.21	1	1.00
Sagittaria rigida, Sessile-fruited arrowhead	0.52	0.21	1	1.00
Sparganium eurycarpum, Common bur-reed	0.52	0.21	1	1.00
Phalaris arundinacea, Reed canary grass	0.52	0.21	1	1.00
Filamentous algae	21.35		41	1.15

Table 2: Species richness with statistics

Species Viewed only	Times viewed
Carex comosa-bottle brush sedge	1
Eleocharis acicularis, Needle spikerush	1
Eleocharis palustris-creeping spikerush	1
Iris versicolor-blue flag iris	1
Juncus pelocarpus f. submerses-brown fruited rush	1
Pontederia cordata, Pickerelweed	1
Sagittaria graminea-grass leaved arrowhead	1
Sagittaria latifolia-common arrowhead	1
Schoenoplectus tabernaemontani-softstem bulrush	1
Typha augustifolia-narrow leaved cattail	1
Typha latifolia-broad leaved cattail	1

Table 3: Species viewed only in 2012 survey

Species viewed only on boat survey
Asclepias incarnate-swamp milkweed
Calla palustris-wild calla
Carex sp.-sedges
Dulichium arundinaceum-three-way sedge
Lythrum salicaria-purple loosestrife
Phragmites australis-giant reed
Rumex orbiculatus-aquatic dock

Table 4: Species viewed from boat survey only

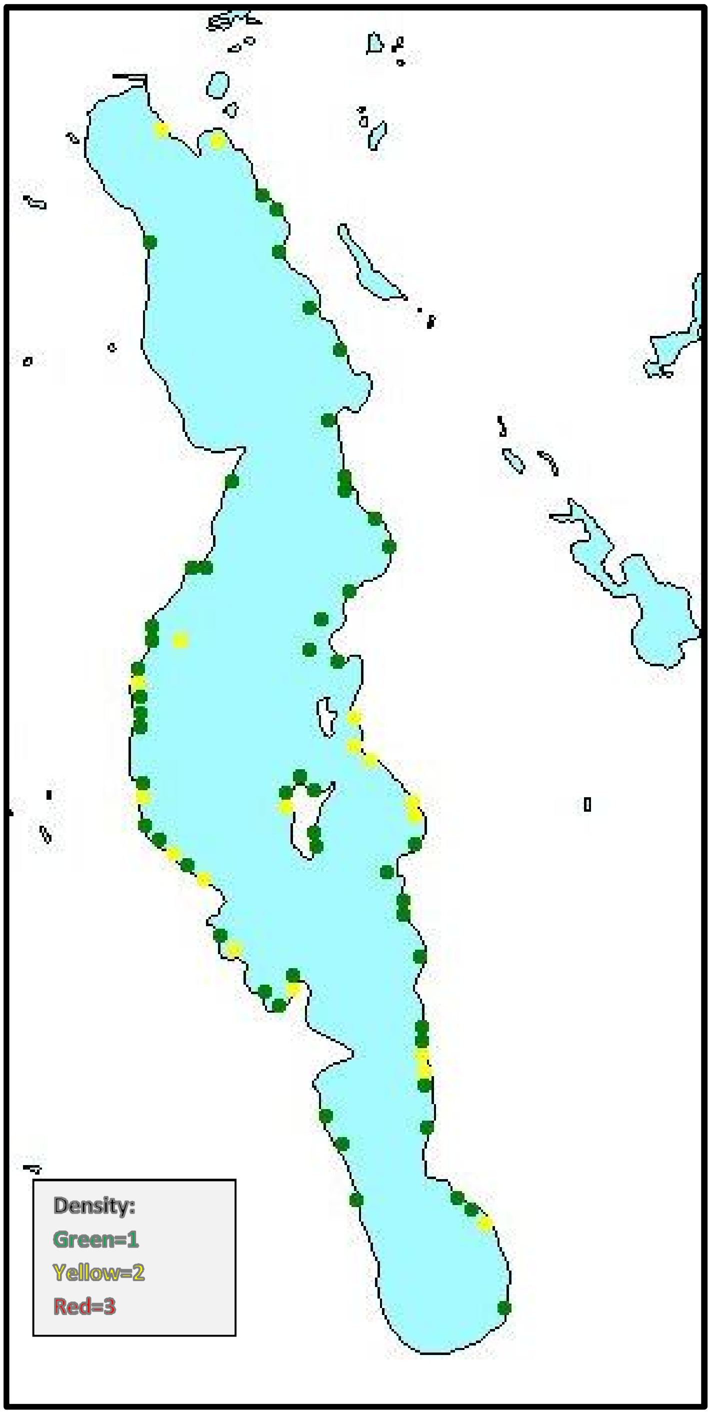


Figure 4: Distribution of *Chara sp.*

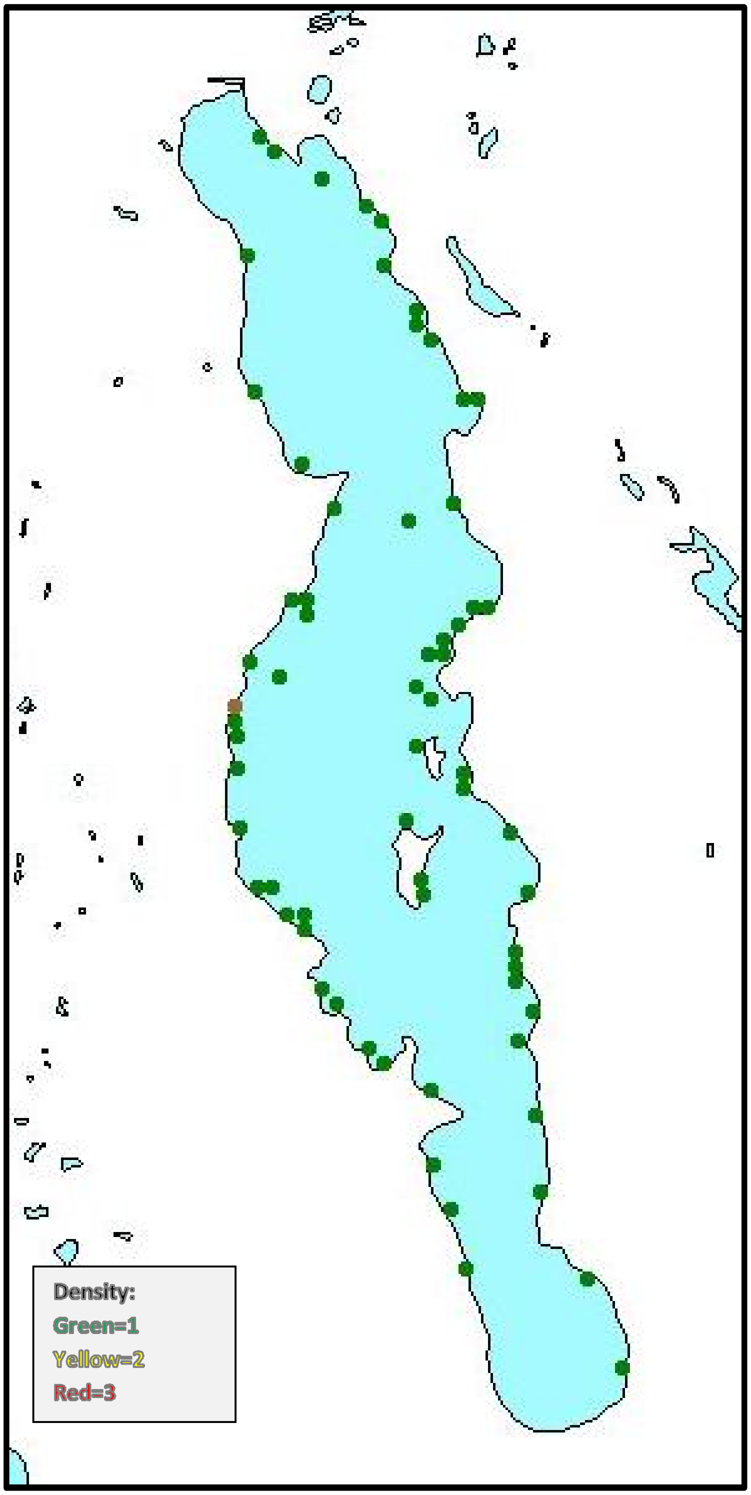


Figure 5: Distribution of *Vallisneria americana*-Wild celery

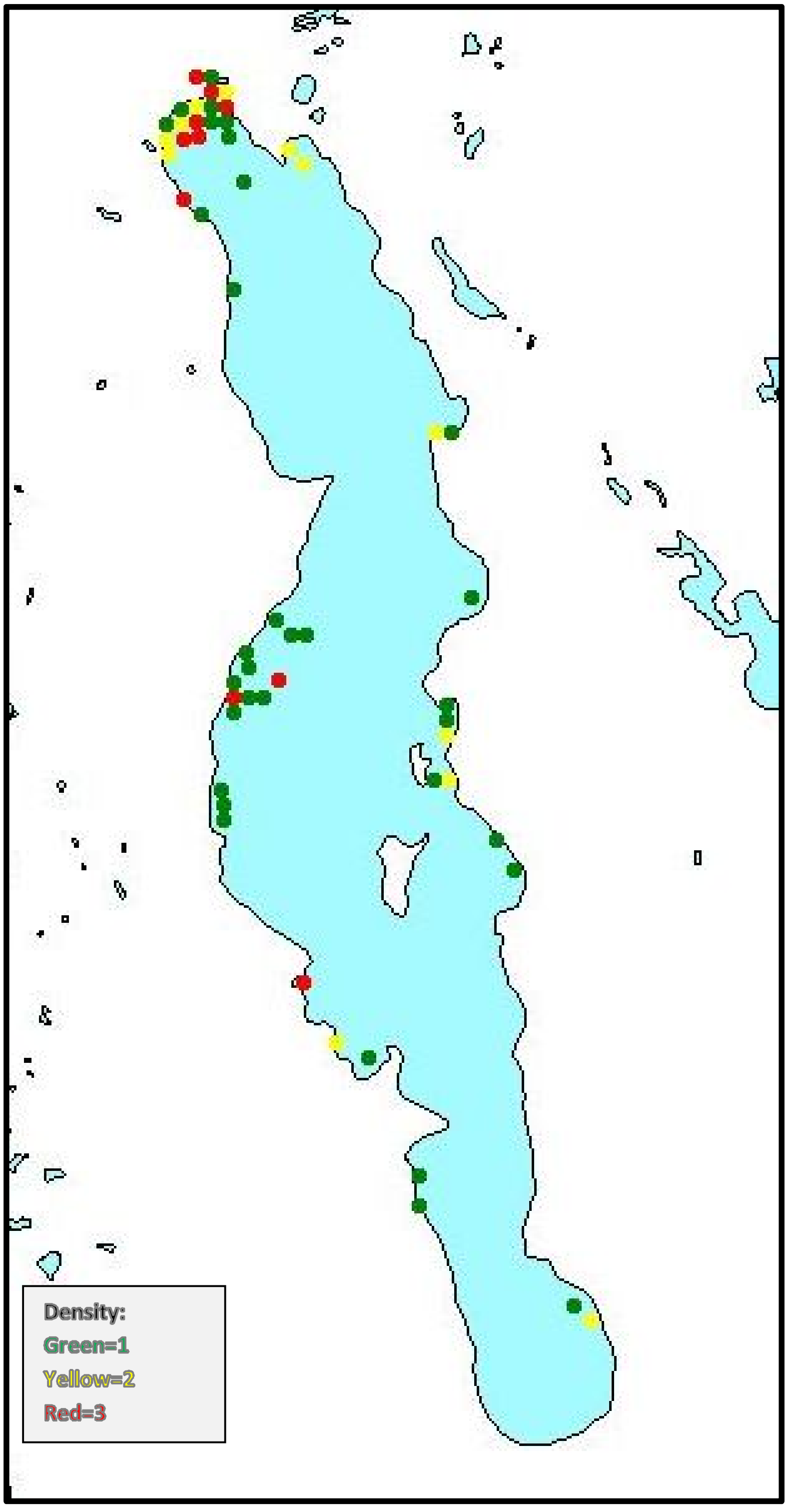


Figure 6: Distribution of *Ceratophyllum demersum*-Coontail

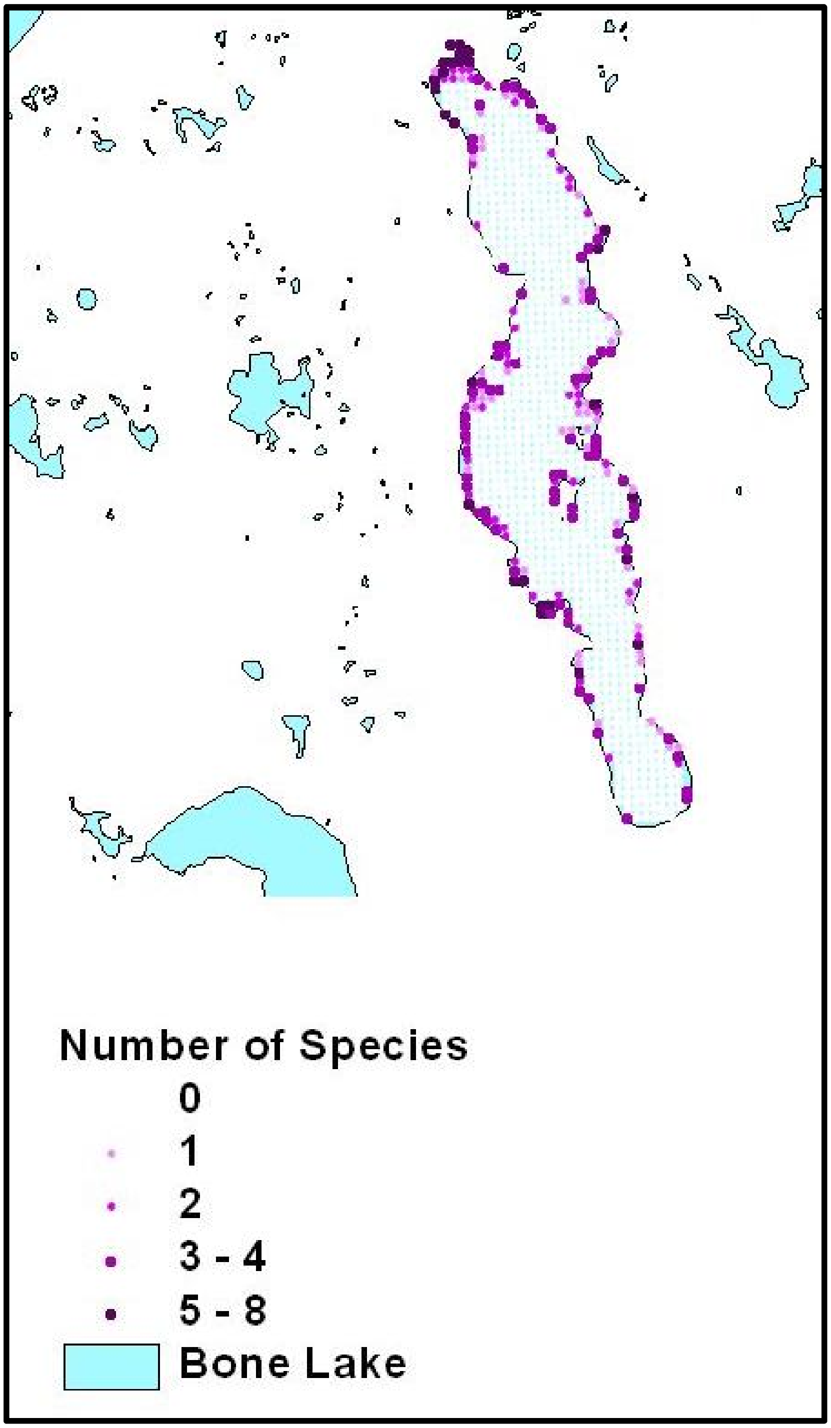


Figure 7: Number of species at each sample point, Bone Lake-2012.

Figure 7 shows that the greatest diversity is located in the north end of Bone Lake and in two bays on the west shoreline. The "lagoon" area on the very north end has the most diversity with large numbers of both emergent and submergent plants.

The littoral zone is limited in Bone Lake. As a result, the amount and location of floating and emergent plants is also limited. The preservation of these plants is important as they serve very important functions in the lake ecosystem. For management purposes, these locations may need to be known. Figure 8 shows areas where emergent and/or floating aquatic vegetation (such as bulrush, white lily and spatterdock to mention a few) was sampled or viewed.

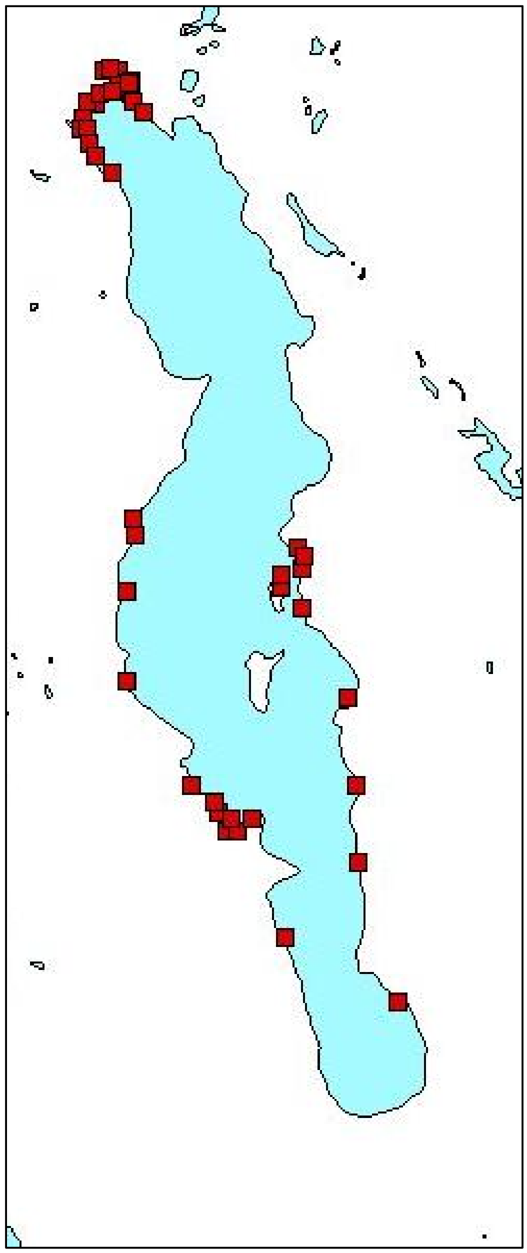


Figure 8: Map showing locations of emergent and/or floating aquatic vegetation.

Invasive species

There were four non-native species observed. The most prevalent invasive species present being *Potamogeton crispus* or curly leaf pondweed (CLP). This plant has been managed over the past several years on Bone Lake through herbicide application of CLP beds and navigation channel creation. As a result, this plant has been mapped annually the last few years. In June 2012, during peak growth, the CLP was mapped. Any areas that had high density (generally greater than “2”) and had growth at or near the surface were delineated as beds. CLP was also sampled at numerous locations during the July survey. Figure 9 shows the mapped beds as well as the locations of the CLP sampled in the July survey. There was 68 acres of CLP beds delineated in June 2012. The frequency of occurrence of CLP in the July 2012 survey was 7.81%.

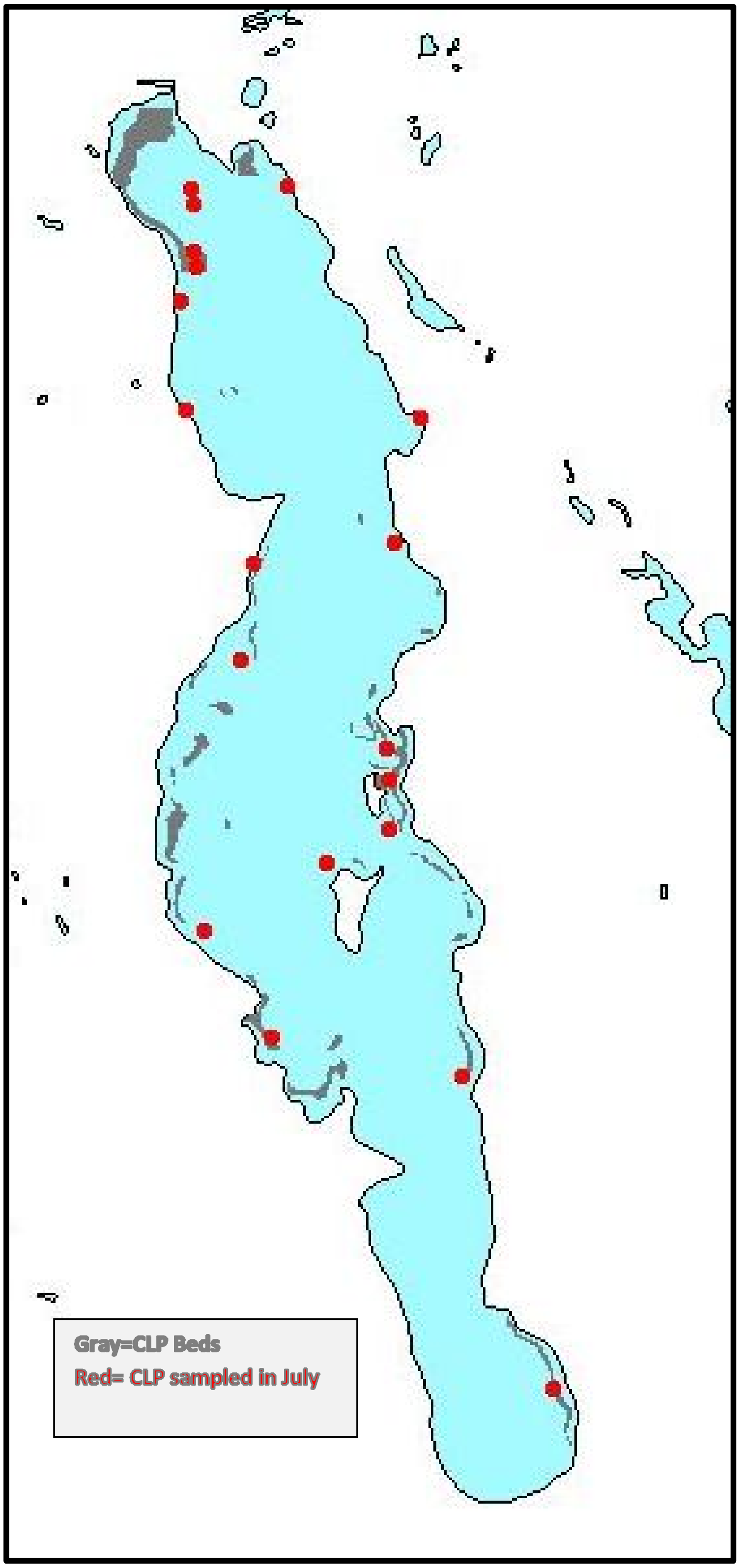


Figure 9: Map of CLP beds and sample locations of CLP-2012.

In addition to CLP, there were three other non-native species located in Bone Lake. These were purple loosestrife, reed canary grass and giant reed. In the case of purple loosestrife, only a few plants were observed (in one location) in the July survey and were removed. Giant reed was also seen in two locations, with limited growth. Reed canary grass was actually sampled in one location and viewed in one other location. Purple loosestrife and giant reed can both become very invasive and these locations should be monitored closely. Reed canary grass is very common and may be growing in many areas around Bone Lake. Therefore control of this plant may not be a high priority. Figure 10 shows the locations of these exotic species.

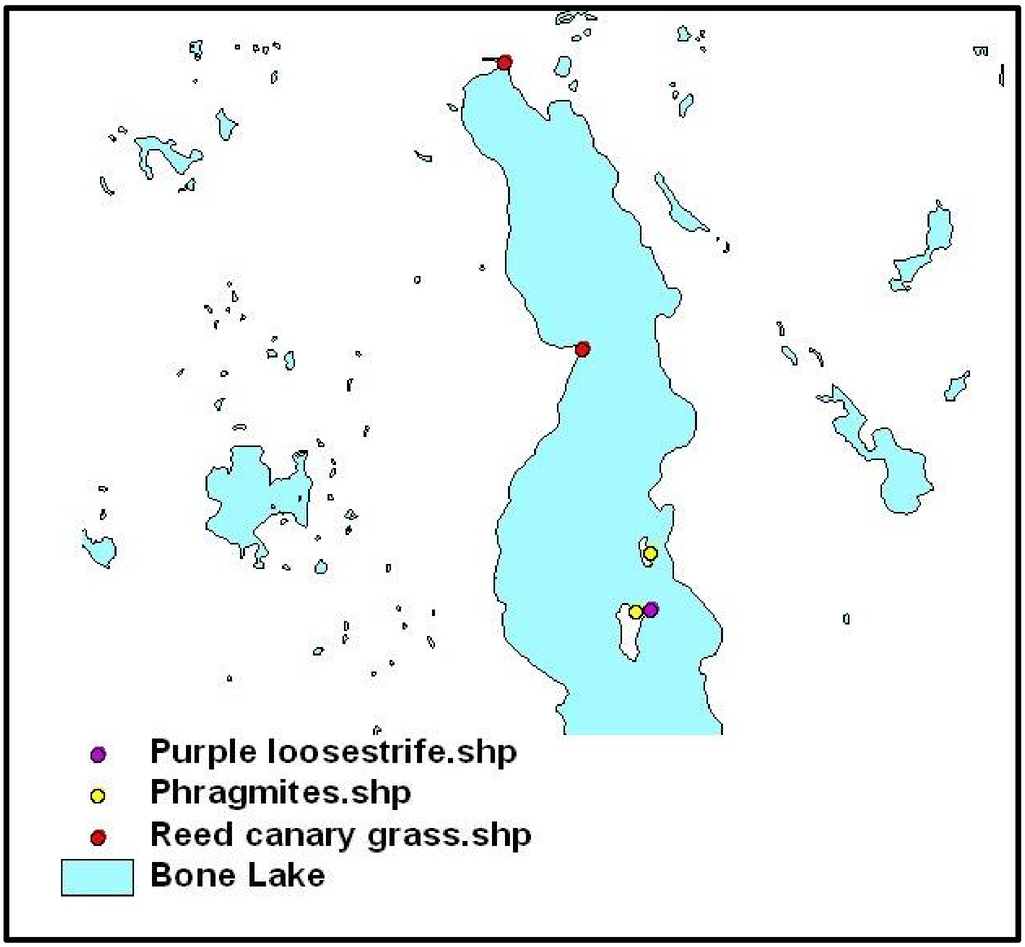


Figure 10: Locations of exotic species other than *Potamogeton crispus* observed on Bone Lake, 2012.

Floristic Quality Index

The plant community can indicate changes in habitat and water quality from human development by using a tool known as the Floristic Quality Index (FQI). This index uses the number of species sampled on the rake and a value given to certain plants known as conservatism. The greater the conservatism value (ranges from 1-10), the less tolerant the plant is to changes in habitat disturbances. The habitat changes are compared to pre-development characteristics in the lake (prior to human disturbances in lakes).

FQI value	Eco-region median	Bone Lake 2012
N	14	34
mean C	5.6	6.09
FQI	20.9	35.5

Table 5: Floristic Quality Index values and comparison of Bone Lake to the Eco-region median values.

Dr. Stanley Nichols of UW-Extension surveyed numerous lakes in various eco-regions around Wisconsin. He then calculated the median number of species, median conservatism value, and the median FQI for each eco-region (Nichols, 1999). All parameters in the FQI are higher than the Eco-region median for North Central Hardwood Forests. The FQI for Bone Lakes demonstrates that the plant community is healthy and is showing little negative response to any habitat changes in Bone Lake. An FQI of 35.5 is high and is due largely to the high diversity but also the high conservatism value for the plants sampled in Bone Lake. See survey comparison section for a 2007 and 2012 FQI comparison.

Comparison of 2007 survey (Schieffer, 2007) to 2012 survey

One significant difference in the data from 2007 to 2012 is the number of sample points in the defined littoral zones that had plants present. In 2007, the littoral zone had 80% of the sample points with plants, while in 2012, that value was much lower at 64% (see figure 11). One potential contributing factor in this was that in 2007 the maximum depth with plants was 16.7 ft, while in 2012 that depth was 20.7 feet. This increases the number of point less than the maximum depth of plants in 2012. Since most of the plants growing in Bone Lake occurs in depths of 13 feet or less, this increased number of deeper littoral zone sample points could decrease this percentage since no plants were present at most of the additional points. No other data suggests that this is due to significant reduction in plant growth in Bone Lake from 2007 to 2012. There may be other causes, but they are not evident.

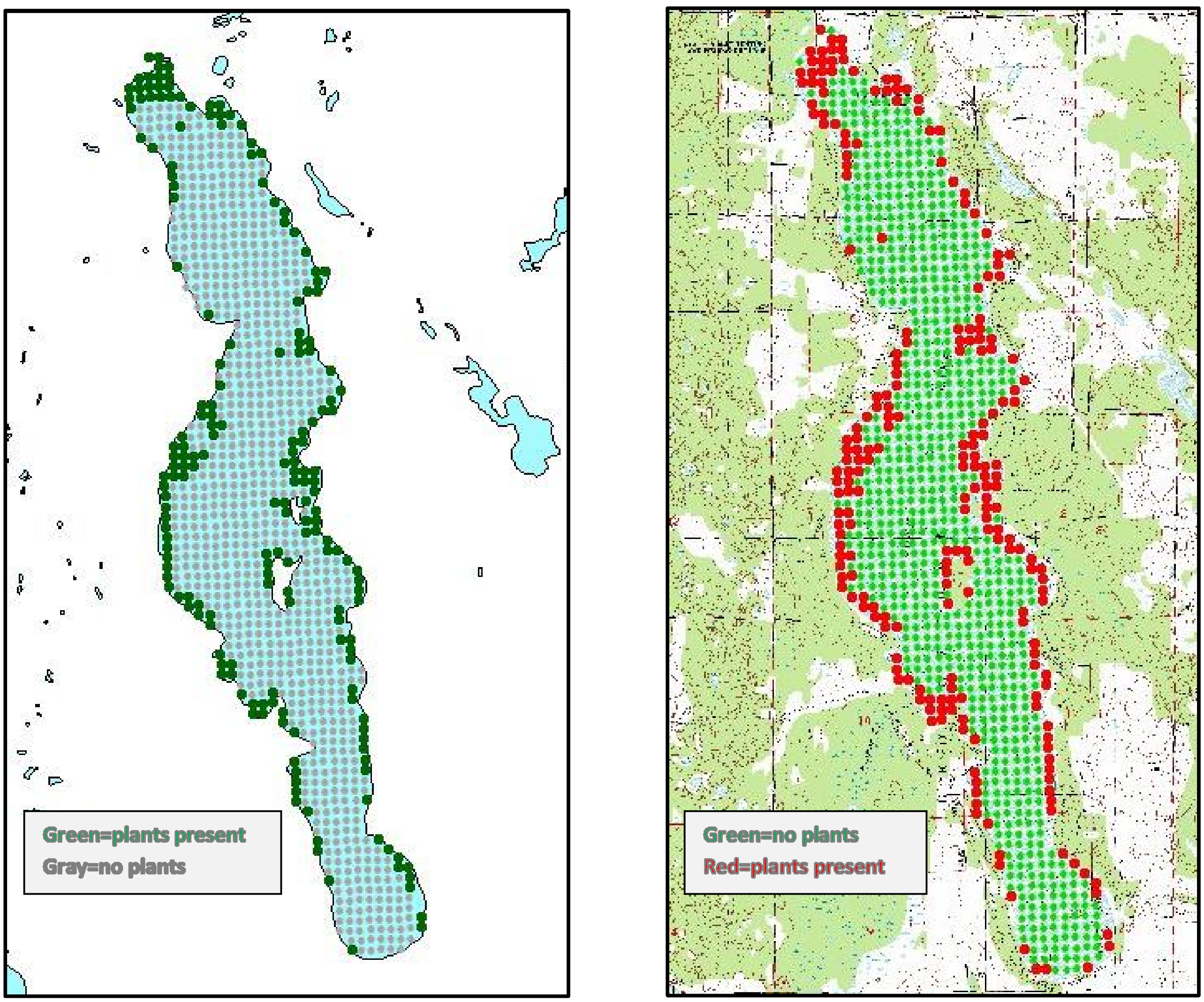


Figure 11: Maps of 2012 points with plant growth compared to 2007 plant growth locations.

PI survey statistic	2007	2012
Species richness	**31**	**36**
Simpson's diversity index	**0.92**	**0.92**
Mean number of native species per sample point.	**3.25**	**2.61**
Maximum depth of plant growth	**17.9**	**20.7 ft**
3 most dominant plants	1. Wild celery 2. Chara sp. 3. Slender naiad	1. Chara sp. 2. Wild celery 3. Coontail
FQI[1]	N=29 Mean C=6.28 **FQI=33.8**	N=34 Mean C=6.06 **FQI=35.5**

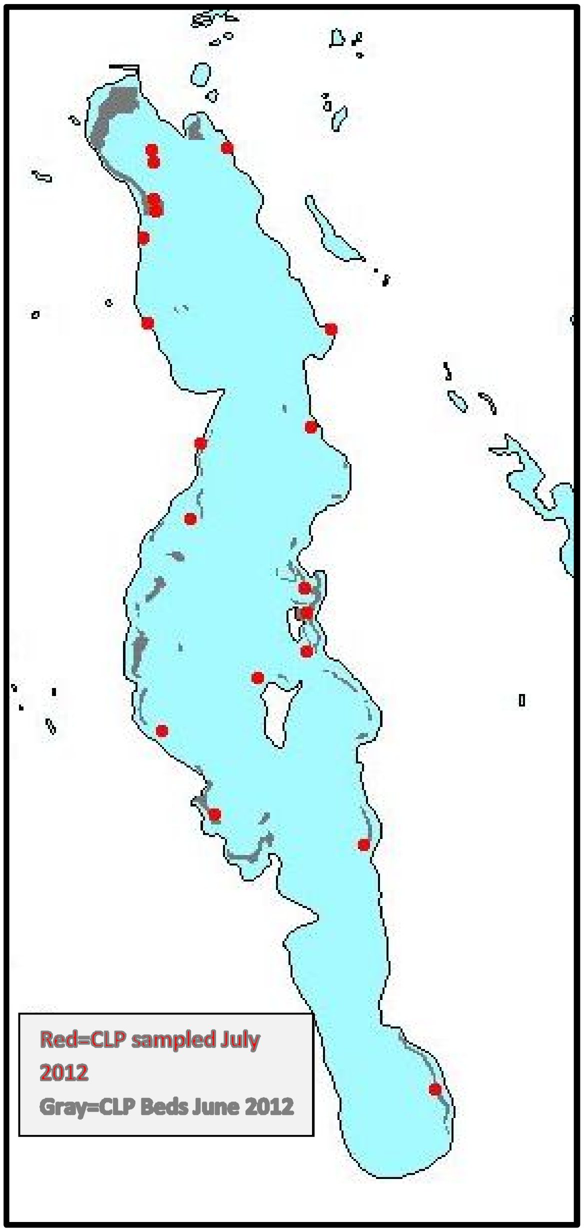
Table 6: Comparison of 2007 survey statistics to 2012 survey.

The dominant species did vary somewhat, but nothing that is cause for any concern. The FQI for both surveys were very comparable, indicating little change in the plant community resulting from human activity. The number of species at each sample point was less in 2012, but the Simpson's diversity indices were exactly the same, and the species richness is higher in 2012, so no major changes are evident.

The same GPS coordinates for the sample grid were same for 2007 and 2012. However, a GPS has some error in the position reading, so there can be minor differences in the surveyor's actual position on the lake. This can result in small differences in sampling or not sampling low frequency plants. There can be minor differences in sample data from one survey to the next, rather than any differences in plant growth. Furthermore, aquatic plant growth can vary from year to year. The difference in CLP growth in areas not treated with herbicides demonstrates this. In any given area the plants may have high density with large aerial coverage one season and much less in a subsequent season. These growth variations, which appear natural, can cause sampling differences as well.

The increase in the maximum depth of plants may be encouraging. This could indicate that the water clarity has improved from 2007 to 2012, although analysis of mean secchi disk readings would be necessary. A better indicator of improved water clarity based upon plant growth would be consistent sampling of a particular species at greater depths, rather than one plant outlier (see figure 2 of depth distribution of plants). Sampling one plant at significantly greater depth doesn't necessarily indicate a trend.

[1] The FQI for 2007 was adjusted based upon new FQI methods implemented prior to 2012 but after 2007.



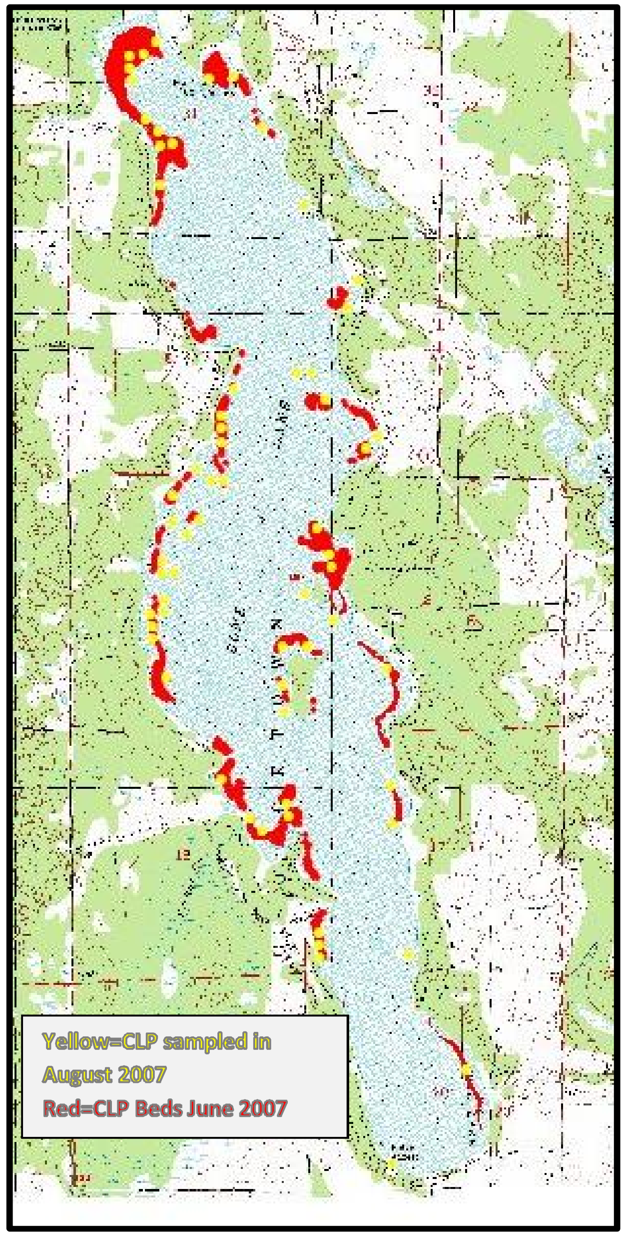


Figure 12: Maps of 2012 and 2007 CLP beds and sample locations in late season survey.

Figure 12 shows a comparison in CLP beds and point sampled in the late season survey, 2012 and 2007. As these maps show, the CLP coverage is quite different in 2012 and has less coverage. This is likely due to management of CLP and variation in growth in areas not treated with herbicide.

Wild Rice

One concern on Bone Lake, as well as other Wisconsin lakes is the potential decline of wild rice. Historically, Bone Lake supposedly had a relatively robust wild rice population on the very north end of the lake, although no data has been evaluated for this survey. The survey in 2007 showed limited coverage of wild rice at the sample points. There were only two locations that rice was at or near an actual sample point, but the north end had somewhat more rice than is shown in the map since it was growing beyond the coverage of the sample point grid. The survey in 2012 showed a continued low frequency of rice. Again there were only two sites sampled and there were more sites than is shown on the map (which only show sample points). There may have appeared to be less rice in 2012 due to the shortness of the plants. Most of the tops were missing and looked as though something had been feeding on them. This is probable as geese are known to eat wild rice, as other wildlife may also. It is valid to say the rice population did not look healthy in 2012. The rice was not mapped in 2007 or 2012 so a quantitative comparison beyond the sample points is not possible. It may be prudent to do this mapping in the future.

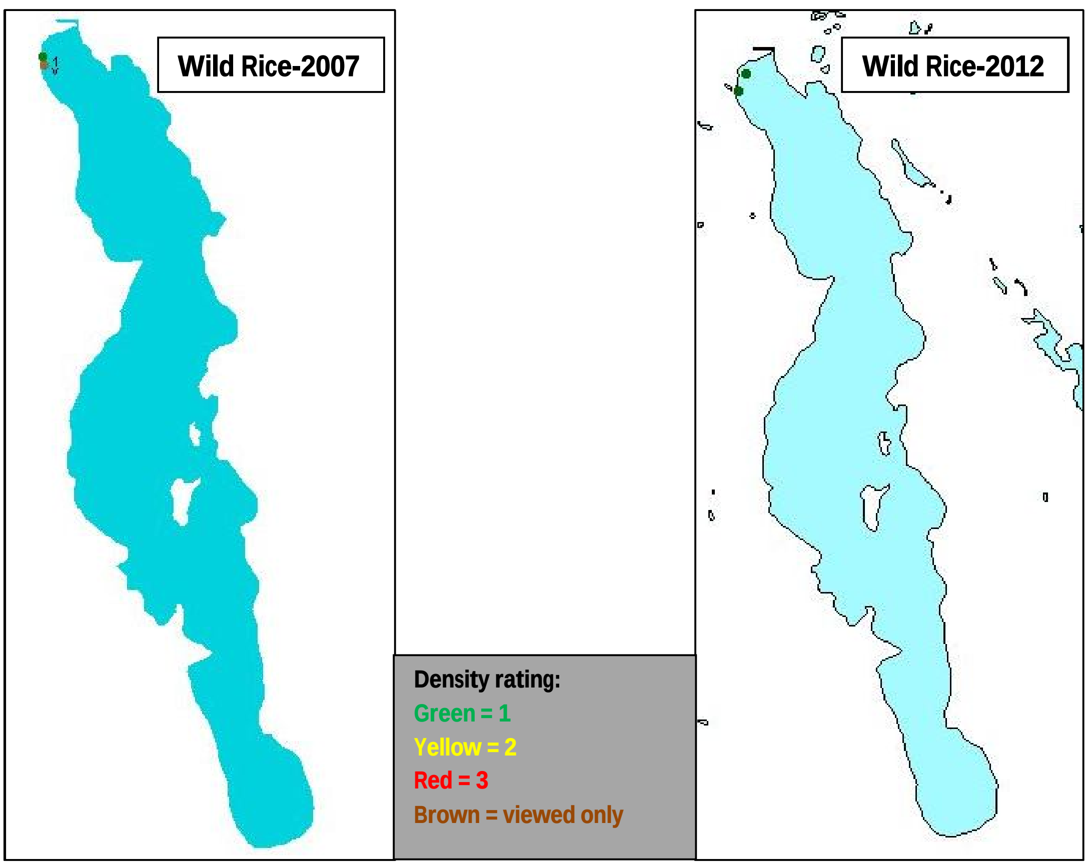


Figure 13: Wild rice distribution comparison for 2007 and 2012.

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