Eastern Marathon County Lakes Study

Bass Lake

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EASTERN MARATHON COUNTY LAKES STUDY BACKGROUND

Lakes and rivers contribute to the way of life in Marathon County. Locals and tourists alike enjoy fishing, swimming, boating, wildlife viewing, and the peaceful nature of the lakes. Healthy lakes add value to our communities by providing places to relax and recreate, and by stimulating tourism. Just like other infrastructure in our communities, lakes require attention and management to remain healthy in our developing watersheds.

Eleven lakes in eastern Marathon County were selected for this study, which focused on obtaining a better understanding of the current conditions of the lakes' water quality, fisheries, habitat, and aquatic ecosystems. This information will help lake users, residents and municipalities by identifying ways to improve existing problems and make informed decisions to preserve and protect the lake from future issues. Data collected between fall 2010 and fall 2012 focused on fisheries, water quality, groundwater, algae, zooplankton, lake histories, shoreline habitats, watersheds, and resident and lake user opinions. This report contains the results of these studies for Bass Lake.

A resident survey was sent to all properties in the watersheds of the eastern Marathon County lakes. The majority of survey respondents expressed the importance of the lakes in their lives. The lakes provide special places for their families; many of their important family memories are tied to the lakes. The lakes seem to bring out the best in the respondents by providing environments where people can feel they are truly themselves and places where they can do what they most enjoy. The majority of respondents felt a sense of stewardship towards the lakes.

ABOUT BASS LAKE

To understand a lake and its potential for water quality, fish and wildlife, and recreational opportunities, we need to understand its physical characteristics and setting within the surrounding landscape. Bass Lake is located in the township of Norrie, east of County Highway Y, north of Bevent and southeast of Hatley. One public boat launch is located on its southwestern side. Bass Lake is a 79.7 acre seepage lake with surface runoff and groundwater contributing most of its water. The maximum depth in Bass Lake is 6 feet; the lakebed has a gradual slope (Figure 1). Its bottom sediments are mostly muck with some rock on the southern and southeastern parts of the lake and some sand dispersed throughout.

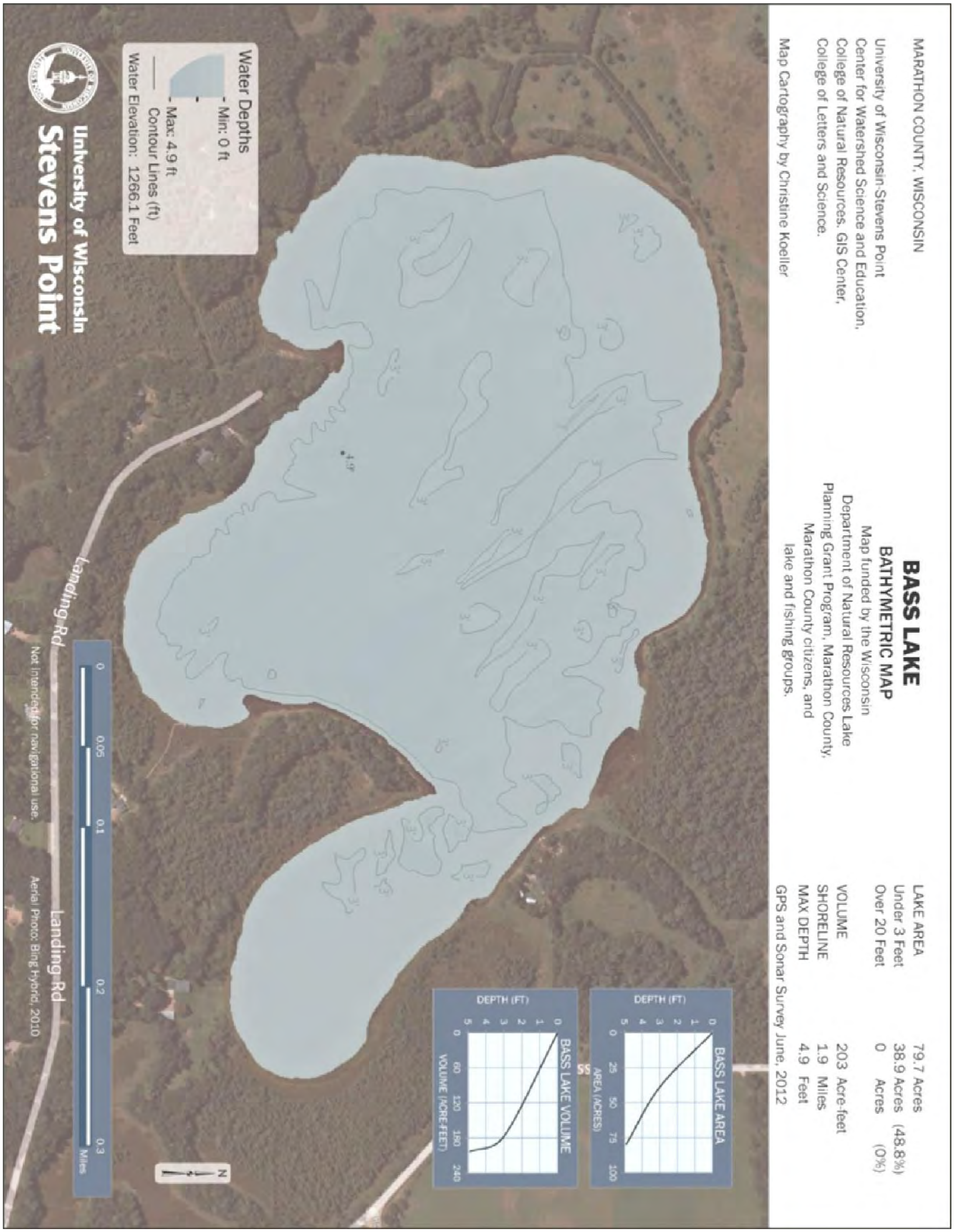


FIGURE 1. CONTOUR MAP OF THE BASS LAKE LAKEBED.

WHERE IS THE WATER COMING FROM? - WATERSHEDS AND LAND USE

The water quality in Bass Lake is a reflection of the land that drains to the lake. The water quality, the amount of algae and aquatic plants, the fishery and other animals in the lake are all affected by natural and man-made characteristics. The amount of land that drains to the lake, hilliness of the landscape, types of soil, extent of wetlands, and the type of lake are all natural characteristics that affect a lake. Within its watershed, alterations to the landscape, the types of land use, and the land management practices also affect the lake.

It is important to understand where Bass Lake's water originates in order to understand the lake's health. During snowmelt or a rainstorm, water moves across the surface of the landscape (runoff) towards lower elevations such as lakes, streams and wetlands. The land area that contributes runoff to Bass Lake is called a surface watershed. Groundwater also feeds Bass Lake; its land area (groundwater watershed) is different from the surface watershed.

The capacity of the landscape to shed or hold water and contribute or filter particles determines the amount of erosion that may occur, the amount of groundwater feeding a lake, and ultimately, the lake's water quality and quantity. Essentially, landscapes with a greater capacity to hold water during rain events and snowmelt help to slow the delivery of the water to the lake. Less runoff is desirable because it allows more water to recharge the groundwater which feeds the lake year round, even during dry periods or when the lake is covered with ice.

Land use and land management practices within a lake's watershed can affect both its water quantity and quality. While forests and grasslands allow a fair amount of precipitation to soak into the ground, resulting in more groundwater and better water quality, other types of land uses may result in increased runoff, less groundwater recharge, and may be sources of pollutants that can impact the lake and its inhabitants. Areas of land with exposed soil can produce soil erosion. Soil entering the lake can make the water cloudy, plug up fish spawning beds, and contains nutrients that increase the growth of algae and aquatic plants. Development often results in changes to natural drainage patterns, alterations in vegetation on the landscape, and may be a source of pollutants. Impervious (hard) surfaces such as roads, rooftops, and compacted soil prevent rainfall from soaking into the ground, which may result in more runoff carrying pollutants to the lake. Wastewater, animal waste, and fertilizers used on lawns, gardens, and agricultural fields can contribute nutrients that enhance the growth of algae and aquatic plants in our lakes.

A variety of land management practices can be put in place to help reduce impacts to our lakes. Some practices are designed to reduce runoff. These include protecting/restoring wetlands, installing rain gardens, swale and rain barrels, and routing drainage from roads and parking lots away from the lake. Some practices help reduce nutrients moving across the landscape towards the lake. Examples include manure management practices, eliminating/reducing the use of fertilizers, increasing the distance between the lake and a septic drainfield, protecting/restoring native vegetation in the shoreland, and using erosion control practices. Marathon County staff and other professionals can work with landowners to determine which practices are best suited to a particular property.

The surface watershed for Bass Lake is approximately 1,039 acres (Figure 2). The dominant land uses in the watershed are agriculture and forests. The lands closest to the lake often have the greatest impact on water quality and habitat; land uses near Bass Lake's shoreland include residential development, forests, wetlands, and agriculture.

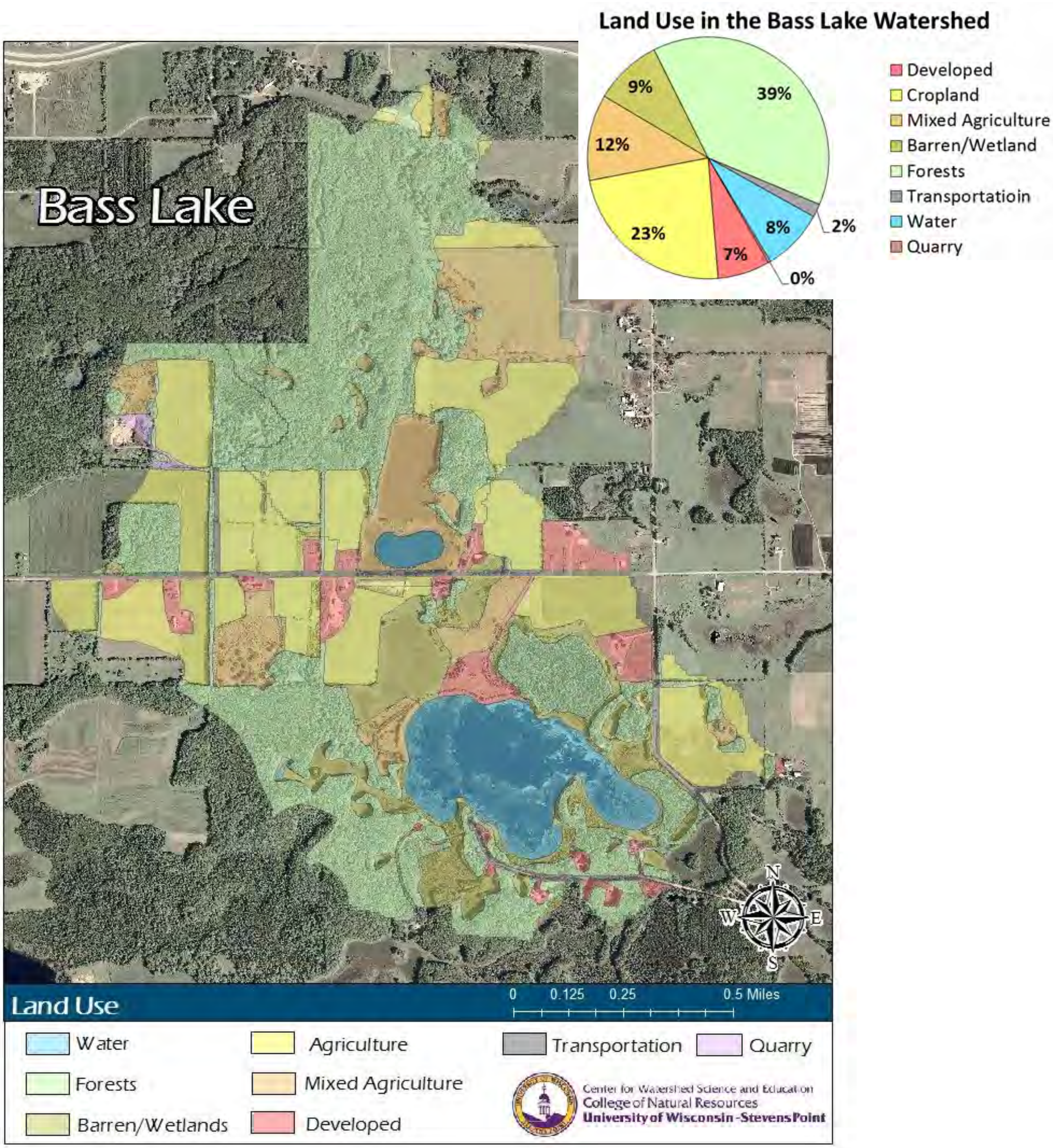
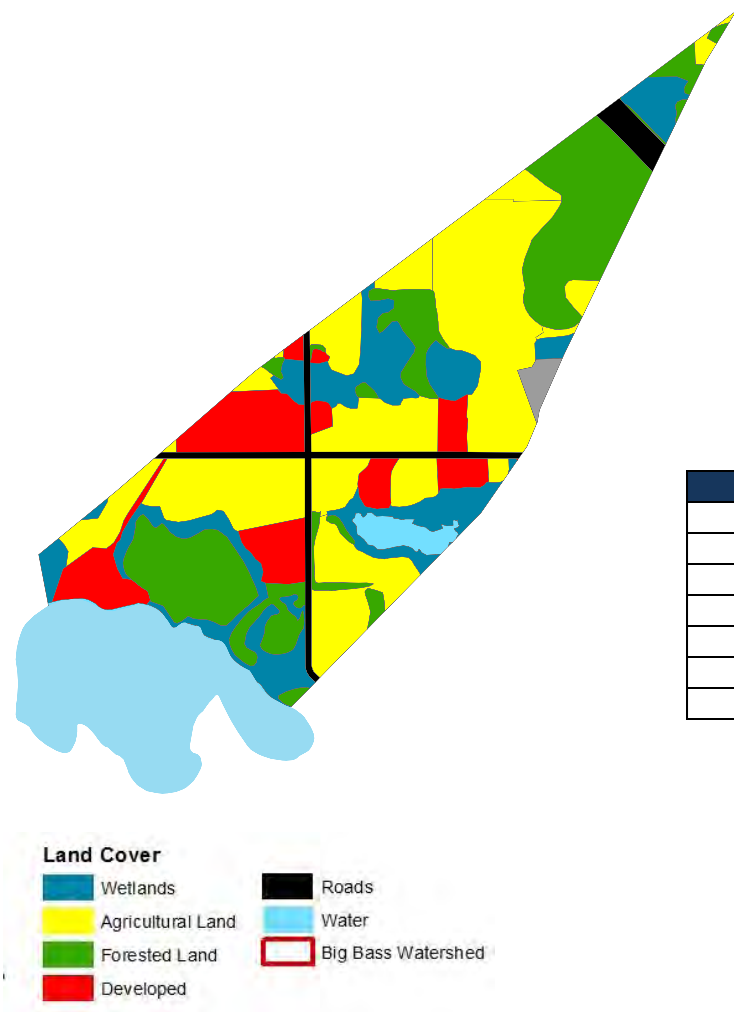


FIGURE 2. LAND USE IN THE BASS LAKE SURFACE WATERSHED.

The groundwater watershed is the area where precipitation soaks into the ground and travels below ground towards the lake. Bass Lake's groundwater watershed is approximately 384 acres (Figure 3). The primary land uses in the Bass Lake groundwater watershed are agriculture and forests. In general, the land adjacent to the lake where most of the groundwater is entering has the greatest immediate impact on water quality. Residential development, forests, and wetlands are all adjacent to Bass Lake where the groundwater enters.



Land Use	Acres
Agriculture	142
Developed	46
Forested	86
Quarry	3
Roads	16
Water	28
Wetland	63

FIGURE 3. LAND USE IN THE BASS LAKE GROUNDWATER WATERSHED.

Locally, groundwater enters some parts of the Bass Lake lakebed (inflow), has no connection to the lake in other parts, and exits the lake in other sections (outflow). Near shore, mini-wells were installed in the lake bed approximately every 200 feet around the perimeter of Bass Lake (Figure 4). Most of the groundwater entered the lake on the western side of the lake (green triangles). Groundwater outflow occurred on both the northeastern and southern sides of the lake (red flags). Areas with no connection between groundwater and the lake were observed sporadically around the rest of the lake (white circles). Additional groundwater is likely to be entering Bass Lake in areas that were deeper than the groundwater survey. It should be noted that the survey was conducted in 2011, which was a dry year with lower than normal groundwater levels. These conditions may result in less groundwater entering Bass Lake.

The more lake water interacts with groundwater (inflow and outflow), the more influence the geology has on the lake. The duration of time the water remains below ground impacts the temperature and chemistry of the groundwater. Groundwater temperatures are constant year round, so groundwater feeding Bass Lake will help to keep the lake water cooler during the summer months.

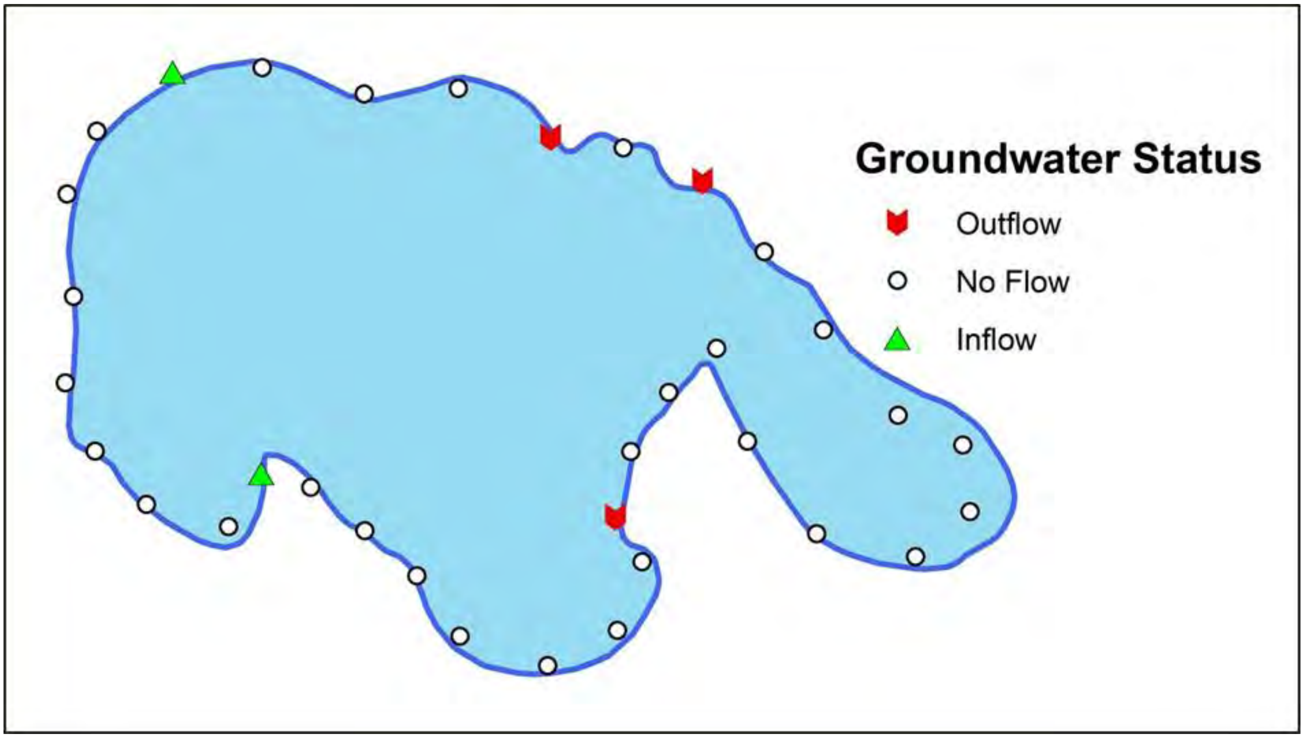
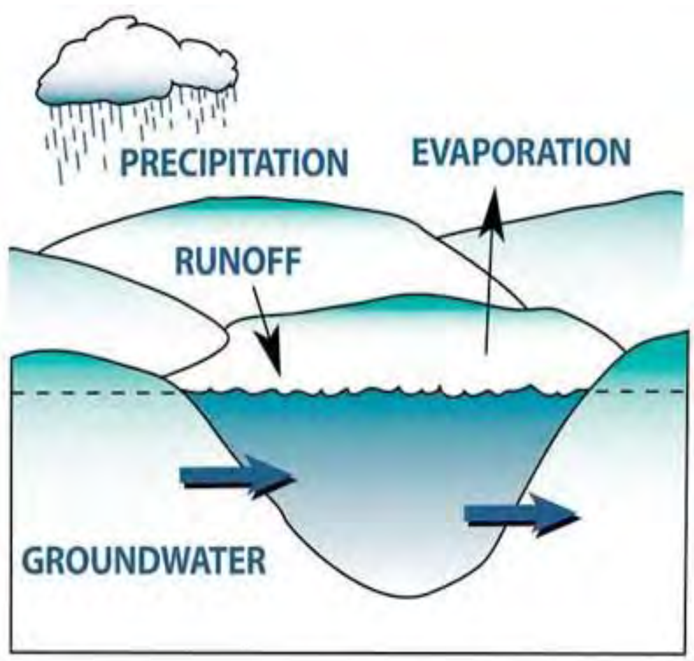


FIGURE 4. BASS LAKE GROUNDWATER INFLOW AND OUTFLOW, 2011.

Lake water quality is a result of many factors including underlying geology, climate and land use practices. Assessing lake water quality allows us to evaluate current lake health, changes from the past, and what is needed to achieve a more desirable state (or preserve an existing state) for aesthetics, recreation, wildlife and the fishery. During this study, water quality in Bass Lake was assessed by measuring different characteristics, including temperature, dissolved oxygen, water clarity, water chemistry, and the algal community.



The source of a lake's water supply is important in evaluating its water quality, quantity, and in choosing management practices to preserve or influence that quality or quantity. Bass Lake is classified as a seepage lake. Water enters and leaves seepage lakes primarily through groundwater, and may also enter the lake via surface runoff and direct precipitation (Figure 5). Seepage lakes generally have a longer retention time (length of time water remains in the lake), which affects contact time with nutrients that feed the growth of algae and aquatic plants. These lakes are also vulnerable to contaminants moving towards the lake in the groundwater. Sources of contaminants for Bass Lake may include septic systems, agriculture, and road salt.

FIGURE 5. CARTOON SHOWING INFLOW AND OUTFLOW OF WATER IN A SEEPAGE LAKE.

The geologic composition that lies beneath a lake has the ability to influence the temperature, pH, minerals, and other properties in a lake. As groundwater moves through the soil, some substances are filtered out, but other materials dissolve into the groundwater (Shaw et al., 2000). If the soils around the lake are sandy and composed primarily of insoluble minerals, hardness and alkalinity will be low. This is the case in many parts of Wisconsin where the groundwater moves through glacial deposits containing little limestone. This is also indicative of the thin top soil over granitic bedrock in the Bass Lake watershed.

The average hardness for Bass Lake during the 2010-2012 sampling period was 5.2 mg/L, which is considered soft (Table 1). Soft water does not provide the calcium necessary for building bones and shells for animals in the lake and may be limited in its ability to buffer the effects of acid rain. The average alkalinity was 8 mg/L, which is also low and results in reduced productivity when compared with similar lakes with higher alkalinity. Hardness and alkalinity play roles in the type of aquatic plants that are found in a lake (Wetzel, 2001).

TABLE 1. MINERALS AND PHYSICAL MEASUREMENTS IN BASS LAKE, 2010-2012.

Bass Lake	Alkalinity (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Total Hardness (mg/L)	Color (CU)	Turbidity (NTU)
Average	8	1.4	0.6	5.2	35.0	6.8

Chloride concentrations, and to lesser degrees sodium and potassium concentrations, are commonly used as indicators of how strongly a lake is being impacted by human activity. The presence of such compounds where they do not naturally occur indicates the movement of pollutants from the landscape to the lake. Bass Lake had low average chloride and sodium concentrations over the monitoring period (Table 2). The average potassium concentration, though slightly elevated, was typical for lakes in Marathon County. Atrazine (DACT), an herbicide commonly used on corn, was below the detection limit (<0.01 ug/L) in the two samples that were analyzed from Bass Lake.

TABLE 2. BASS LAKE AVERAGE WATER CHEMISTRY, 2010-2012.

Bass Lake	Average Value (mg/L)			Reference Value (mg/L)		
	Low	Medium	High	Low	Medium	High
Potassium		0.80		<.75	0.75-1.5	>1.5
Chloride	0.27			<3	3.0-10.0	>10
Sodium	0.4			<2	2.0-4.0	>4

Dissolved oxygen is an important measure in aquatic ecosystems because a majority of organisms in the water depend upon oxygen to survive. Oxygen is dissolved into the water from contact with the air, which is increased by wind and wave action. When sunlight enters the water, algae and aquatic plants also produce oxygen; however, the decomposition of algae and plants by bacteria after they die reduces oxygen in the lake. Some forms of iron and other metals carried by groundwater can also consume oxygen when they reach the lake.

Water temperature in a lake changes throughout the year and may vary with depth. During winter and summer when lakes stratify (layer), the amount of dissolved oxygen is often lower towards the bottom of the lake. Dissolved oxygen concentrations below 5 mg/L can stress some species of cold water fish, and over time can reduce habitat for sensitive cold water species of fish and other critters.

Water temperature and dissolved oxygen were measured in Bass Lake from top to bottom at the time of sample collection during the 2010-2012 study. During much of the year (spring, fall and winter), temperatures in Bass Lake were consistent from the surface to the bottom (Figure 6).

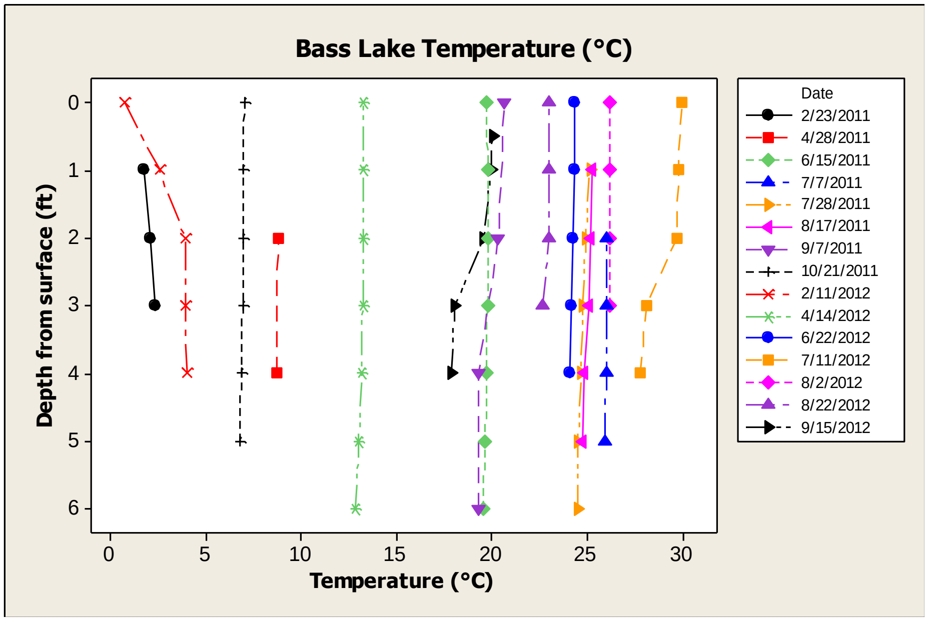


FIGURE 6. TEMPERATURE PROFILES IN BASS LAKE, 2010-2012.

During the study, dissolved oxygen concentrations were similar to the temperature profiles for Bass Lake, with relatively constant concentrations from the surface to the bottom throughout most of the year. Concentrations ranged from approximately 5 mg/L to approximately 11 mg/L (Figure 7); however, oxygen was almost completely depleted in the lake in February 2011 following a long winter. In February 2012, following a relatively mild winter, surface dissolved oxygen measurements were similar to those measured in other seasons, but quickly dropped off to approximately 3 mg/L in water depths of 4 feet. Due to its shallow depth, there is a potential for winter fish kills in Bass Lake, particularly when there are long periods of ice and snow cover.

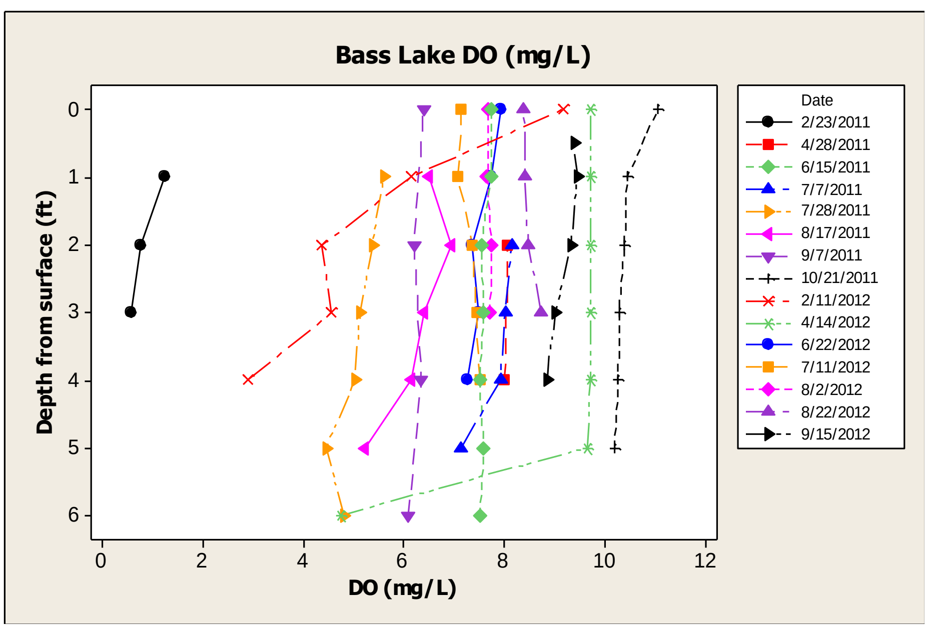
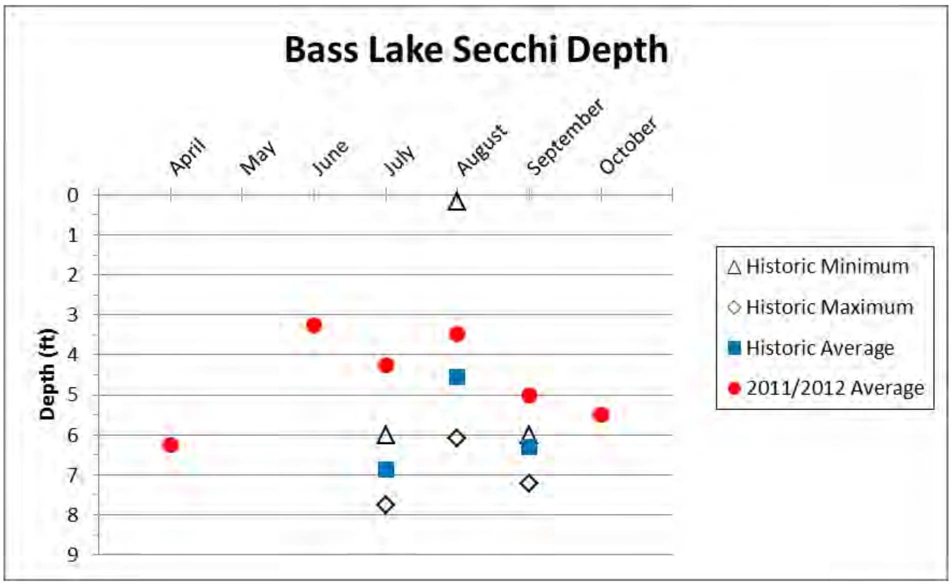


FIGURE 7. DISSOLVED OXYGEN PROFILES IN BASS LAKE, 2010-2012.

Water clarity is a measure of the depth that light can penetrate into the water. It is an aesthetic measure and is also related to the depth that rooted aquatic plants can grow. Water clarity is affected by water color, turbidity (suspended sediment), and algae, so it is normal for water clarity to change throughout the year and from year to year.

In Bass Lake, the color index was slightly elevated (Table 1). The variability in water clarity throughout the year is likely due mainly to fluctuating algae concentrations and re-suspended sediment following storm periods and/or heavy boating activity.

The water clarity measured in Bass Lake during the study was considered fair. For Bass Lake, water clarity ranged from 3 feet to 8 feet (Figure 8). When compared with past data (1979-2010), the average water clarity measured during the study was poorer for all comparable months. Water clarity in Bass Lake was typically poorer during the summer months, with the shallowest average water clarity measures observed in June and August.



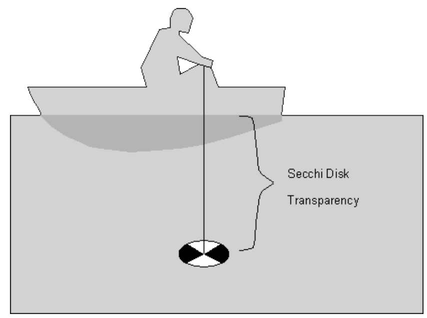


FIGURE 8. AVERAGE MONTHLY WATER CLARITY IN BASS LAKE, 2010-2012 AND HISTORIC.

Nutrients (phosphorus and nitrogen) are used by algae and aquatic plants for growth. Phosphorus is present naturally throughout the watershed in soil, plants, animals and wetlands. Additional sources from human activities include soil erosion, animal waste, fertilizers and septic systems.

The most common mechanism for the transport of phosphorus from the land to the water is through surface runoff, but it can also travel to the lake in groundwater. Once in a lake, a portion of the phosphorus becomes part of the aquatic system in the form of plant tissue, animal tissue and sediment. The phosphorus continues to cycle within the lake for many years.

Total phosphorus concentrations in Bass Lake ranged from a high of 86 ug/L in October 2010 to a low of 12 ug/L in September 2012 (Table 3). The summer median total phosphorus concentrations were 31 ug/L and 36.5 ug/L in 2011 and 2012, respectively. This is below Wisconsin's phosphorus standard of 40 ug/L for shallow seepage lakes, but above the proposed flag value of 15 ug/L.

TABLE 3. SUMMARY OF SEASONAL NUTRIENTS IN BASS LAKE, 2010-2012.

Bass Lake	Total Phosphorus (µg/L)			Dissolved Reactive Phosphorus (µg/L)			Total Nitrogen (mg/L)			Inorganic Nitrogen (mg/L)			Organic Nitrogen (mg/L)		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Fall	12	38	86	1	1	1	1.47	1.84	2.20	0.04	0.06	0.08	1.39	1.78	2.16
Spring	24	27	30	7	8	8	0.72	0.77	0.83	0.04	0.05	0.06	0.68	0.73	0.77
Summer	20	32	54												
Winter	13	18	22	1	2	3	0.92	1.17	1.41	0.11	0.30	0.49	0.81	0.87	0.92

During the study, inorganic nitrogen concentrations in samples collected during the spring averaged 0.05 mg/L. Concentrations above 0.3 mg/L are sufficient to enhance algal blooms throughout the summer (Shaw et al., 2000).

Estimates of phosphorus from the landscape can help to understand the phosphorus sources to Bass Lake. Land use in the surface watershed was evaluated and used to populate the Wisconsin Lakes Modeling Suite (WILMS) model. In general, each type of land use contributes different amounts of phosphorus in runoff and through groundwater. The types of land management practices that are used and their distances from the lake also affect the contributions to the lake from a parcel of land. Agriculture and forests comprised the greatest amount of land in the watershed, and modeling results indicated that agriculture had the greatest percentage of phosphorus contributions from the watershed to Bass Lake (Figure 9). The phosphorus contributions by land use category, called phosphorus export coefficients, are shown in Table 4. The phosphorus export coefficients were obtained from studies throughout Wisconsin (Panuska and Lillie, 1995).

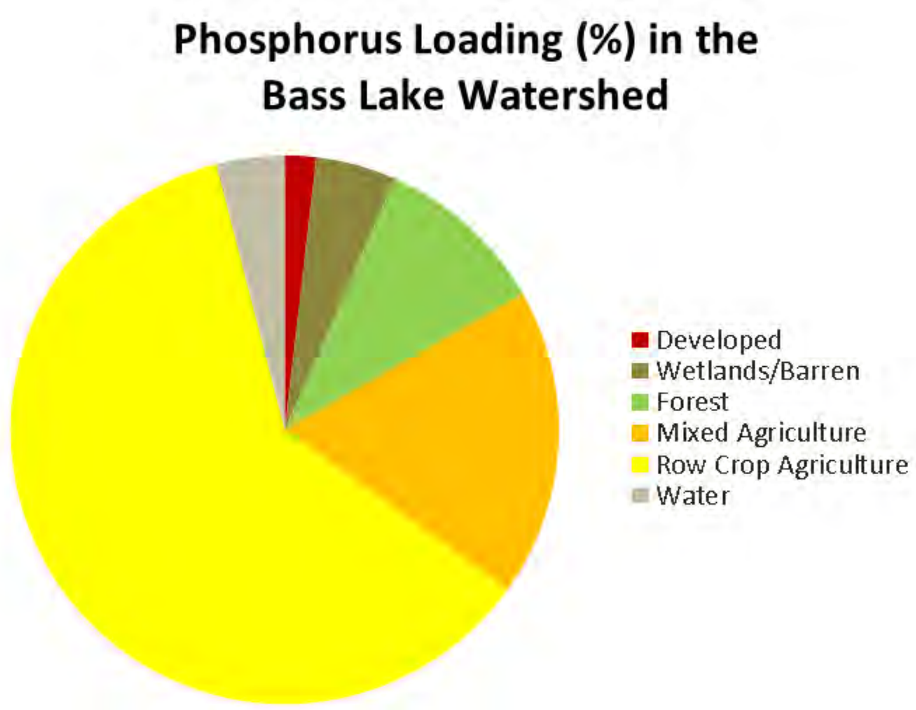


FIGURE 9. ESTIMATED PHOSPHORUS LOADS FROM LAND USES IN THE BASS LAKE WATERSHED.

TABLE 4. MODELING DATA USED TO ESTIMATE PHOSPHORUS INPUTS FROM LAND USES IN THE BASS LAKE WATERSHED (LOW AND MOST LIKELY COEFFICIENTS USED TO CALCULATE RANGE IN POUNDS).

Bass Lake Land Use	Phosphorus Export Coefficient (lbs/acre-yr)	Land Use Area Within the Watershed		Phosphorus Load	
		Acres	Percent	Pounds	Percent
Water	0.10	88	**8**	7-21	4
Developed	0.04	74	**7**	3-7	**2**
Wetland/Barren	0.09	96	**9**	9-26	**5**
Forest	0.04	409	**39**	18-33	**11**
Mixed Agriculture	0.27	122	**12**	33-87	**19**
Row Crop Agriculture	0.45	247	**24**	110-220	**64**
Quarry	0.04	3	**0**	0.1-0.3	**0**

Chlorophyll *a* is an indirect measurement of algae in the water. Concentrations greater than 10 ug/L may be perceived as a mild algae bloom, while concentrations greater than 20 ug/L are typically perceived as a nuisance. Chlorophyll *a* concentrations in Bass Lake varied throughout the monitoring season, ranging from a high of 15 ug/L in June 2012 to a low of 0.5 ug/L in August 2012. In Bass Lake, a relationship exists between chlorophyll *a* and total phosphorus concentrations. Generally, as total phosphorus concentrations increase, concentrations of chlorophyll *a* also increase (Figure 10).

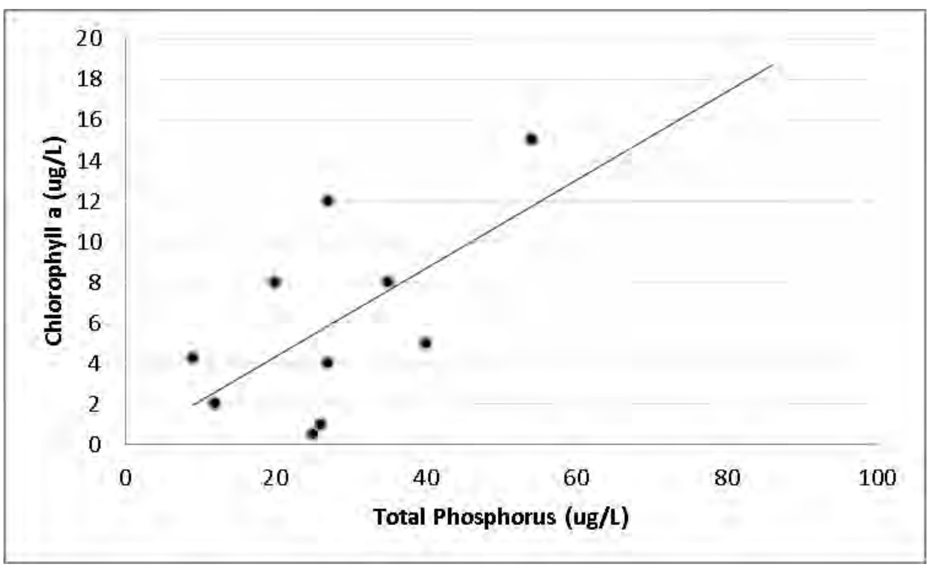
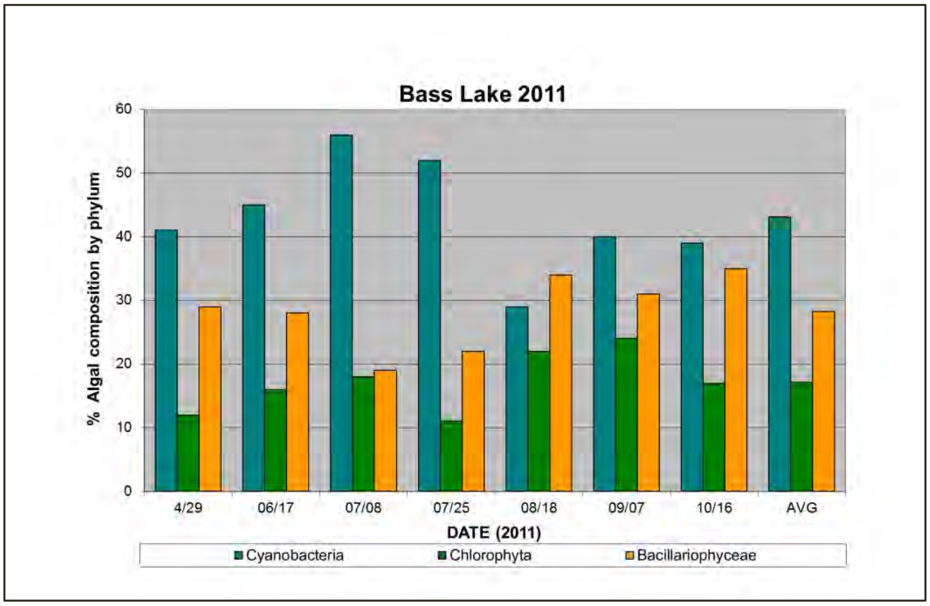


FIGURE 10. CHLOROPHYLL *A* AND TOTAL PHOSPHORUS CONCENTRATIONS IN BASS LAKE.

Algae are microscopic, photosynthetic organisms that are important food items in all aquatic ecosystems. Different algal groups increase or decrease during the year and they can be used to analyze a lake's water quality because there are more varieties of algae than fish or aquatic plant species. Conclusions can be drawn about water temperature, nutrient availability, and overall water quality of a lake using algal populations.

In Marathon County lakes, there are three dominant groups of algae: blue-green algae (Cyanobacteria), green algae (Chlorophyta), and diatoms (Bacillariophyceae). The algal communities of Bass Lake were strikingly similar in 2011 and 2012 (Figure 11), and dominated by blue-green algae characteristic of eutrophic lakes (43% and 51% average composition, respectively). The blue-green algae dominated early in both years with a small mid-summer depression, before a dominating fall rebound. The diatoms displayed a typical early and late season distribution, but only represented 20-25% of the algal community. The most common diatom species found are associated with eutrophic waters. The green algae made up only 10-20% of the algal community and the most common species found are common in nutrient-enriched conditions.

The high nutrient load, shallow depth, decreasing water clarity, and an algal community dominated by species historically associated with eutrophic lakes suggest Bass Lake has transitioned into a eutrophic state and may continue to decline. These conditions could lead to oxygen depletion and possible fish kills.



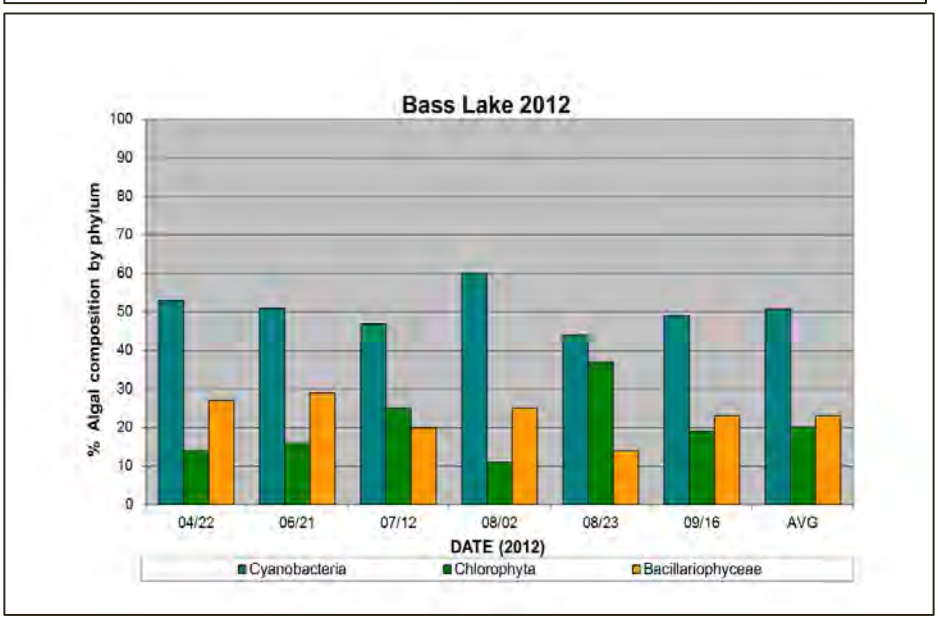


FIGURE 11. ALGAL COMPOSITION (PERCENT) IN BASS LAKE, 2011 AND 2012.

SHORELAND HEALTH

Shoreland vegetation is critical to a healthy lake's ecosystem. It provides habitat for many aquatic and terrestrial animals including birds, frogs, turtles, and many small and large mammals. It also helps to improve the quality of the runoff that is flowing across the landscape towards that lake. Healthy natural vegetation includes a mix of layers such as tall grasses/forbs, shrubs, and trees.

The addition of manmade features near the shoreland area can lead to more impervious surfaces. Runoff from driveways, rooftops, and buildings carries pollutants and sediments into the nearby lake. Minimizing the presence of impervious surfaces in the shoreland area can help reduce the amount of phosphorus and sediment transported to the lake. Overdeveloped shorelines cannot support the fish, wildlife and clean water that may have attracted people to the lake in the first place. Rip-rap, seawalls and docks also contribute to an unhealthy shoreline. While it might seem that one lot's development may not have a quantifiable impact on the lake's water quality, the collective effect of many properties can be significant.

The results of the shoreline survey conducted on the eastern Marathon County lakes will serve as a tool for citizens and the Marathon County staff to identify locations of shoreland areas in need of restoration, as well as recognize natural shorelands for protection. In addition, this information will provide a baseline database from which to measure and monitor success.

BASS LAKE SHORELAND SURVEY RESULTS

This survey assessed the vegetation present around the lake's shoreland and identified buildings at or near the water's edge. This information can be used to assess lakeshore development's potential impact on in-lake and shoreland habitat, which may affect fish spawning grounds, shoreland wildlife habitats, and shoreline beauty.

In 2011, shoreland vegetation was recorded by mapping and estimating the depth of three categories of vegetation and the length of shoreline. Researchers in a boat navigated the shoreline and recorded the classifications of vegetation observed from the lake. The three rings surrounding Bass Lake in Figure 13 depict the depth of vegetation along Bass Lake's shore. The first ring represents the depth inland where plants occur that are 0.5 to 3 feet tall (native grasses/forbs). The second ring represents plants ranging from 3 to 15 feet tall (shrubs). The outermost ring represents all plants taller than 15 feet (trees). A greater vegetative shoreland "buffer" provides more habitat, protection from soil erosion, and improved water quality of runoff. A healthy vegetative "buffer" extends at least 35 feet inland from the water's edge and includes a mixture of grasses, forbs, shrubs and trees.

Bass Lake has 1.9 miles of shoreline. Around Bass Lake, most of the shoreline had adequate shoreland vegetation. The overall findings showed that 10,012 linear feet of shoreline were classified as having a grass/forb buffer depth of 35 feet, the minimum depth required by Wisconsin and Marathon County shoreland zoning ordinances. Similar results were found for the shrub layer. The tree layer was also abundant, especially in the 35-50 foot buffer depth category; however, over 4,000 feet of shoreline was classified as having a tree buffer width of only 5-15 feet inland from the water's edge. Shoreland survey results are displayed in Figure 12. Although Bass Lake's shoreland is in good shape now, changes can easily occur as development takes place. In order to minimize impacts from future development, prospective developers should have the information needed to make good decisions, and zoning should be in place to achieve habitat, water quality, and aesthetic goals for Bass Lake.

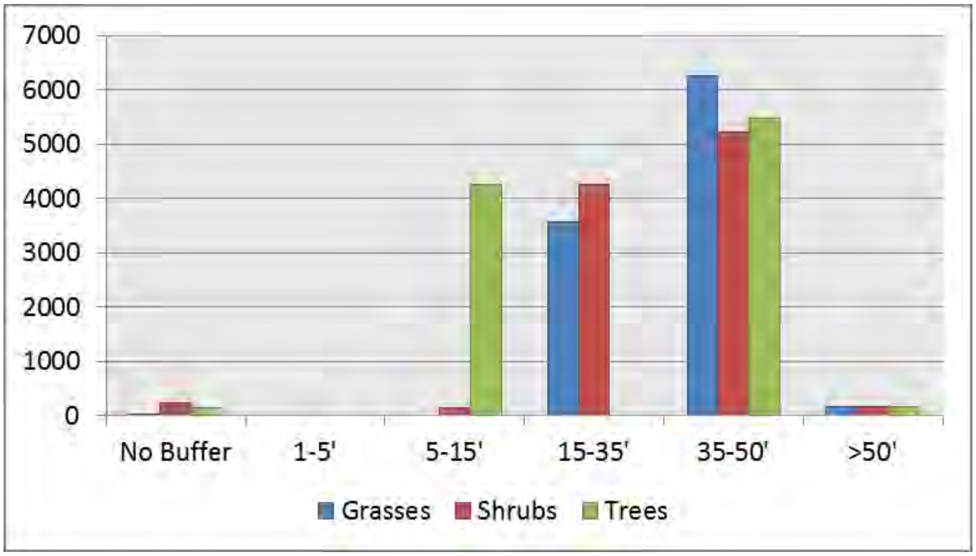


FIGURE 12. SHORELAND VEGETATION SURVEY RESULTS BY BUFFER DEPTH AROUND BASS LAKE, 2011.

On the same day the vegetation surveys were conducted, an assessment of manmade disturbances was conducted around Bass Lake. Surveyors paddled along the shoreline and documented artificial beaches, docks, rip-rap, seawalls, erosion, and any structures built near the water's edge. Manmade disturbances observed on Bass Lake are identified in Table 5 and Figure 14. Structures such as seawalls, rip-rap (rocked shoreline), and artificial beaches often result in reduction of habitat. Docks and artificial beaches can result in altered in-lake habitat with denuded lakebeds that provide good opportunities for invasive species to become established and reduce habitat that is important to fish and other lake inhabitants. Erosion can contribute sediment to the lake, which can alter spawning habitat and carry nutrients into the lake. Unmanaged runoff from the rooftops of structures located near shore can also contribute more sediment to the lake. Alone, each human-made feature may not pose a large problem for a lake, but on developed lakes their collective impact can be a problem for lake habitat and water quality.

TABLE 5. DISTURBANCES IDENTIFIED ON BASS LAKE, 2011.

Disturbance	No. of Occurrences
Artificial Beach	0
Dock	8
Rip-rap	0
Seawall	0
Erosion	0
Structures w/in 35'	0
Structures 35-75'	0

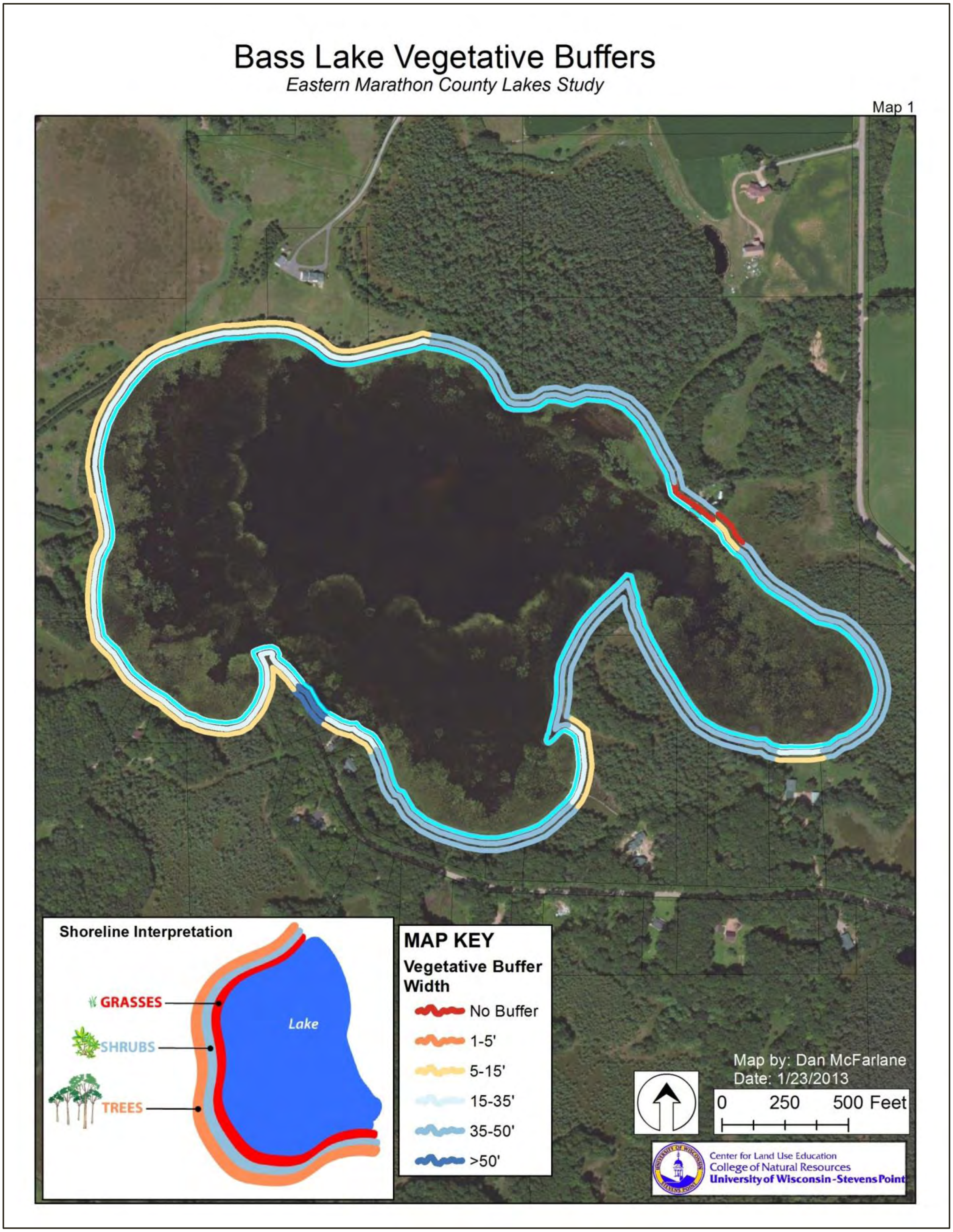


FIGURE 13. SHORELAND VEGETATION AROUND BASS LAKE, 2011.

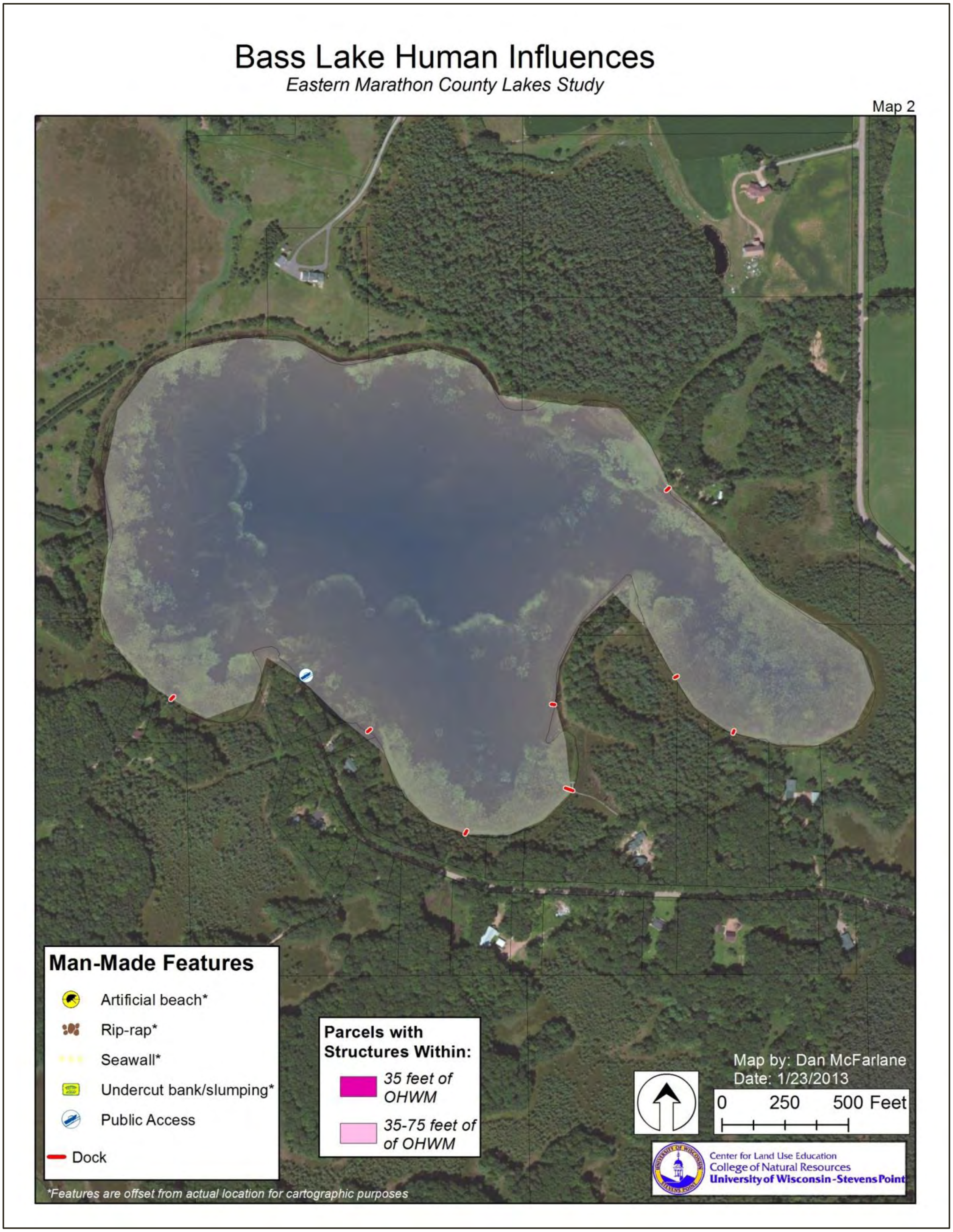


FIGURE 14. SHORELINE DISTURBANCE SURVEY OF BASS LAKE, 2011.

A healthy fishery is one that is in balance with the lake's natural ability to support the fish community, and is adaptable to fishing practices that do not cause declines in fish populations. A healthy fish community has a balance between predator and prey species, and each fish species has different needs to be met in order to flourish, including adequate food sources, habitat, appropriate spawning substrate, and water quality.

People are also an important part of a healthy fishery, as they can both remove fish and add fish. The numbers and sizes of fish taken out of the lake can influence the entire ecosystem, so it is important to adhere to appropriate fishing regulations to help maintain a healthy balance of prey and predatory species, and to adjust the regulations as the fish community changes and adapts. If stocking does occur, choosing the wrong fish species for a lake's conditions will result in a less sustainable fishery and may require outside inputs such as aeration or further stocking. Each fish species has different water quality requirements, with preferred tolerance ranges for dissolved oxygen, pH, water clarity, temperature, and hardness. A few predatory species such as largemouth bass prefer good water clarity to effectively hunt prey; other species such as walleye prefer more turbid waters. Even within a species, water quality preferences may vary during different stages of reproduction.

Bass Lake supports a warm water fish community. In 2012, five fish species were sampled and identified out of the seven total species that have been observed since a 1967 survey conducted by the Wisconsin Department of Natural Resources (Table 6). Although most species identified in 2012 have been previously reported, central mudminnows (*Umbra lima*) and black crappie (*Pomoxis nigromaculatus*) were newly documented. Species documented previously but not detected during the 2012 survey were largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*). Black bullhead (*Ameiurus melas*) was most abundant during the 2012 survey, with a maximum length of 7.9 inches (Table 7). Least commonly sampled were pumpkinseed (*Lepomis gibbosus*), black crappie, and central mudminnow. Although infrequently encountered, black crappie reached a maximum length of 12.2 inches. Crayfish were not encountered during the sampling period.

TABLE 6. FISH SPECIES IN BASS LAKE, 2012 SURVEY AND HISTORICAL WISCONSIN DEPARTMENT OF NATURAL RESOURCES RECORDS.

Species	1967	2012
Bluegill	x	x
Black bullhead	x	x
Black Crappie		x
Largemouth bass	x	
Central Mudminnow		x
Yellow Perch	x	
Pumpkinseed	x	x

TABLE 7. TOTAL CATCH AND LENGTHS (MIN/MAX/AVERAGE) OF FISH SPECIES IN BASS LAKE, 2012 SURVEY.

Species	Min Length (in)	Max Length (in)	Average Length (in)	Total Catch
Black Bullhead	1.2	7.9	4.1	124
Bluegill	1.4	8.3	4.9	71
Black Crappie	8.8	12.2	10.9	4
Pumpkinseed	7.0	7.5	7.2	2
Central Mudminnow	2.4	2.4	2.4	1

There is limited documentation of management activities on Bass Lake in Wisconsin Department of Natural Resources files. In 1967, winter fish kills were noted, likely due to low oxygen levels. Bullhead biomass dominance is another indicator of winterkill as bullhead is more tolerant of low dissolved oxygen than many other species. A proposal to dredge areas of Bass Lake was first documented in 1969; however, no documents were filed describing the proposed dredging effort. Regardless, average depth remains shallow, with a maximum depth of less than five feet measured in the 2012 survey. In 1988, a request for dredging was denied due to the historic use of chemicals on Bass Lake and because the lake habitat supported a variety of wildlife. Fish stocking records for Bass Lake date back to 1977 in Wisconsin Department of Natural Resources files (Table 8). Historic stocking consisted primarily of adult northern pike (*Esox lucius*), but brown trout (*Salmo trutta*) and largemouth bass have also been stocked. Since Bass Lake is a shallow seepage lake, it is unlikely that natural reproduction of brown trout is occurring.

TABLE 8. WISCONSIN DEPARTMENT OF NATURAL RESOURCES FISH STOCKING SUMMARY FOR BASS LAKE, INCLUDING SPECIES, AGE CLASS, NUMBER STOCKED, AND AVERAGE LENGTH IN INCHES.

Year	Species	Age Class	Number Fish Stocked	Avg Fish Length (IN)
1977	Northern pike	Adult	150	
1978	Northern pike	Adult	116	
1979	Northern pike	Adult	250	
1992	Brown trout	Yearling	2,000	8
2001	Largemouth bass	Fingerling	2,100	6

BOTTOM SUBSTRATE AND COARSE WOODY HABITAT

To successfully sustain a healthy fish population, a lake must have the habitat to support it. Habitat needs of fish include healthy aquatic plants and woody structure such as logs, fallen trees, and stumps. Woody structure provides places for fish to hide, as well as habitat for invertebrates that many fish species use as food sources. Many fish use lily pads and bulrushes, as well as gravel and cobble substrates, for spawning habitat.

In-lake habitat was examined from the shoreline to a distance of 90 feet using side-scan sonar (Figure 15). Substrate was primarily a soft, muck bottom (96.4%); however, harder substrates including gravel/cobble and sandy areas were also present. Gravel areas are used as spawning habitat for many sunfish (bluegill, pumpkinseed, black bass), where males will construct nests and guard their young. Black crappie construct nests and guard young in bulrush habitat on gravel or sand substrates. Bulrush is present along areas of the eastern shoreline. Yellow perch prefer near-shore cobble substrate in oxygen-rich environments for spawning activity and offer no parental care. In the absence of sand and coarser substrates such as gravel, largemouth bass and sunfish are also known to build nests on soft bottoms. Depressions are deepened until small amounts of coarser substrate, mostly fragments of snail shells, accumulate in the bottom of the nests. In areas of soft substrate, largemouth bass also spawn on woody habitat swept clear of sediments. The presence of young bluegill indicated their reproduction was successful in Bass Lake; however, determining the reproductive success of other species would require additional sampling efforts.

Coarse woody habitat (CWH), including downed trees and logs are sparse in Bass Lake (Figure 15). This structure is used by young prey fish and other aquatic organisms for foraging, protection, and spawning. The fish community may benefit from the addition of CWH.

Activities in and around a lake which can affect a fishery may include the disturbance of aquatic plants or substrates, chemical additions, removal of woody habitat, and shoreline alterations. Shoreland erosion can cause sediment to settle onto the substrate, causing the deterioration of spawning habitat. Ways in which habitat can be improved include restoring shoreland vegetation to control erosion, minimizing the removal of aquatic plants, and protecting wetlands and other areas of critical habitat.

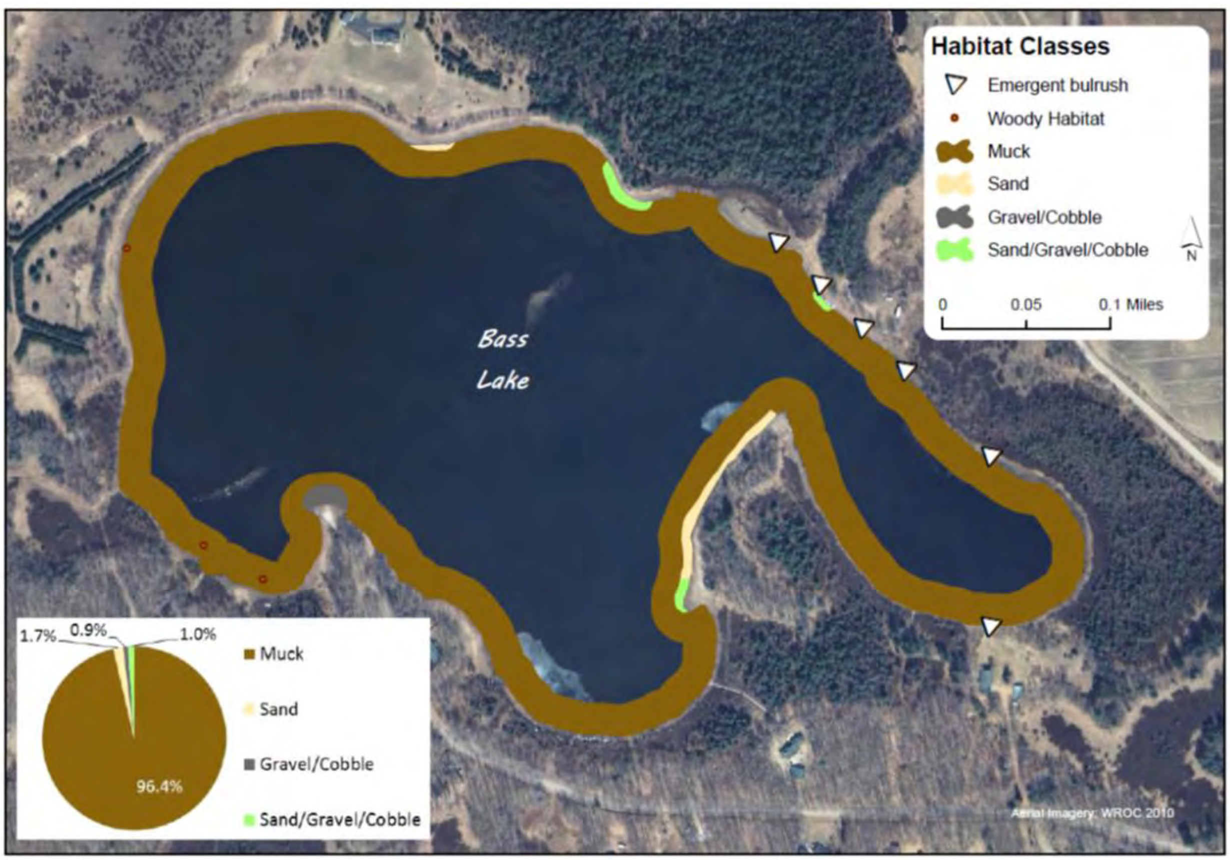
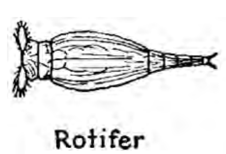


FIGURE 15. DISTRIBUTION OF SUBSTRATE, COARSE WOODY HABITAT, AND BULRUSH IN BASS LAKE, 2012.

Zooplankton are microscopic invertebrate animals that swim or drift in water. They are the primary consumers at the base of the food chain in our lakes and are an important food for many fish. Most zooplankton are filter feeders, using their appendages to strain bacteria and algae from water, so they help to keep algae populations under control. While zooplankton can reproduce rapidly, with populations capable of doubling in a few days, they live short and productive lives. Food (bacteria and algae), temperature, and water chemistry are important in determining the types of zooplankton that can live in a particular lake. Fish predation can also have a profound impact on zooplankton abundance and community composition.

While the semi-transparency and small size (0.01 – 4.0 mm) of zooplankton are effective deterrents to fish predation, it is the timing of zooplankton abundance that frequently determines the success of a lake's larval fish community. The abundance and slow-moving nature of zooplankton make them the primary food of young fish (fry). The interdependence of algae, zooplankton, and young fish as predators and prey forms the primary food web in most lakes. Some of the non-native and invasive zooplankton species are much larger in size than native zooplankton. The non-native zooplankton can disturb the fishery in a lake because they are often too large to fit in the mouth of young fish.

In Marathon County lakes, three dominant groups of zooplankton were observed – **Rotifers** (microscopic wheel organisms), **Cladocerans** (water fleas), and **Copepods**. The various zooplankton groups and species within these groups wax and wane during the ice-free season as algae, temperature and fish predation change.



www.revistadele

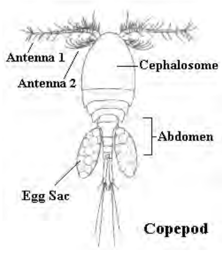
Rotifers are small invertebrate animals with simple body designs. They are usually not found uniformly throughout lakes, but congregate in areas of high food abundance (bacteria, algae, and other rotifers). Generally, a lake's trophic status influences, or can be predicted by, the abundance and diversity of rotifers. Eutrophic lakes show greater abundance and diversity of rotifers than oligotrophic systems.


http://www.oocities.org

Cladocerans, commonly called water fleas, are a widespread group occurring in all but a few of the most extreme freshwater habitats. Cladoceran richness in a lake depends on several factors such as water chemistry, lake size, productivity, the number of adjacent lakes, and biological interactions.

Cladoceran populations usually peak in early summer and fall immediately after algal population peaks, since algae are the preferred food of cladocerans. It is the cladocerans that are responsible for increasing water clarity in mid-summer by filtering algae that cause summertime blooms.

Many cladocerans exhibit a behavior called diel vertical migration, swimming to deep water during the day and rising to the surface at night. This is an avoidance response to heavy fish predation and can result in lower than expected cladoceran numbers during daytime collections.



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Copepods, like cladocerans, can fluctuate in abundance and composition due to food limitation, temperature and predation within a lake. They can occur in high densities, and populations can double in 1 to 2 weeks. There is a documented positive relationship between copepod numbers and increased eutrophy; as lakes become more nutrient-rich, copepod numbers increase. Also, like cladocerans, native copepods are a favorite prey for young fish.

The zooplankton community of Bass Lake was moderately diverse during the 2011-2012 sampling season (Table 9 and Table 10). Zooplankton were classified based on two general size categories: nano-plankton (80 um or less) or net plankton (210 um or less).

The dominant group of nano-plankton was rotifers, with copepods and cladocerans as subdominants.

- There were 1,195 individuals counted during this period:
    - 853 rotifers, 208 cladocerans, 134 copepods

The dominant group of net plankton was cladocerans, with copepods and rotifer subdominants.

- There were 292 individuals counted during this period:
    - 20 rotifers, 232 cladocerans, 41 copepods

Rotifers were the dominant taxa in three of four sample periods during the 2011-12 season, being abundant from early summer through winter before falling to subdominance in early spring. Different species of cladocerans were present year-round, with some more abundant in fall and winter and others dominant in spring and summer. Copepods appeared most abundantly in spring and fall.

The seven genera of rotifers, four genera of cladocerans, and three genera of copepods identified during the sample periods were relatively common and the majority are not classified as invasive or exotic. A stable, little-changing zooplankton community dominated by smaller nano-plankton (rotifers and cladocerans), as was seen in Bass Lake, suggested a fairly eutrophic environment. When considered in relation to the algal, phosphorus and nitrogen values seen in Bass Lake, the zooplankton community's indication of a fairly eutrophic lake was reinforced.

TABLE 9. MOST COMMON (NANO) ZOOPLANKTON BY DATE IN BASS LAKE, APRIL 2011 TO MARCH 2012.

Date	Primary dominant	Species	Secondary dominant	Species	Tertiary dominant	Species
April 28	Rotifer	*Synchaeta oblonga*	Copepod	Nauplii	Rotifer	*Keratella cochlearis*
June 20	Rotifer	*Keratella cochlearis*	Cladoceran	*Bosmina longirostris*	Copepod	Nauplii
October 21	Rotifer	*Polyarthra vulgaris*	Rotifer	*Notholca* spp.	Rotifer	*Keratella cochlearis*
March 4	Rotifer	*Polyarthra vulgaris*	Cladoceran	*Chydorus* spp.		

TABLE 10. MOST COMMON (NET) ZOOPLANKTON BY DATE IN BASS LAKE, APRIL 2011 TO MARCH 2012.

Date	Primary dominant	Species	Secondary dominant	Species	Tertiary dominant	Species
April 28	Rotifer	*Synchaeta oblonga*	Copepod	*Cyclopoid copepodite*		
June 20	Cladoceran	*Bosmina longirostris*	Cladoceran	*Ceriodaphnia* spp.	Cladoceran	*Daphnia retrocurva*
October 21	Cladoceran	*Chydorus* spp.	Copepod	*Skistodiaptomus reighardi*		
March 4	Cladoceran	*Chydorus* spp.				

Aquatic plants are the forested landscape within a lake. They provide food and habitat for a wide range of species including fish, waterfowl, turtles, and amphibians, as well as invertebrates and other aquatic animals. They improve water quality by releasing oxygen into the water and utilizing nutrients that would otherwise be used by algae. A healthy lake typically has a variety of aquatic plant species which creates diversity that makes the aquatic plant community more resilient and can help to prevent the establishment of non-native aquatic species.

During the 2012 aquatic plant survey, twenty species of aquatic plants were found in Bass Lake (Table 11), with the greatest diversity located in the shallows on the eastern side of the lake (Figure 16). Of the sites sampled, ninety-one percent (200 of 220) of the sampled sites had vegetative growth, with an average depth of 4 feet and a maximum depth of 7 feet. Bass Lake had an average number of species compared with the other lakes in the Eastern Marathon County Lakes Study.

The dominant plant species in the survey was large purple bladderwort (*Utricularia purpurea*), followed by water-thread pondweed (*Potamogeton diversifoliu*) and white water lily (*Nymphaea odorata*). Large purple bladderwort is a species of special concern in Wisconsin and offers invertebrate habitat as well as foraging sites for fish. Bladderworts are carnivorous plants using vacuums in their bladders to catch tiny insects. Water-thread pondweed is also a species of special concern in Wisconsin. The fruit it produces is an important food source for waterfowl, muskrat and beaver. The seeds produced by white water lily are also a food source for waterfowl, and the broad, floating leaves of the plant provide shade and shelter to fish and other species.

The Floristic Quality Index (FQI) evaluates the closeness of a plant community to undisturbed conditions. Each plant is assigned a coefficient of conservatism (C value) that reflects its sensitivity to disturbance. These numbers are used to calculate the FQI. C values range from 0 to 10, with higher values designating species that are more intolerant of disturbance. The FQI for Bass Lake was 29.9. This value was above average and was the fourth highest ranked lake within the Eastern Marathon County Lakes Study.

Of the aquatic plant species within Bass Lake, nine had a C value of eight or greater (Table 11). This number of species ranked Bass Lake third out of the eleven lakes within the Eastern Marathon County Lakes Study. Out of these seven species, two are designated as species of special concern in Wisconsin: water-thread pondweed (*Potamogeton diversifolius*) and large purple bladderwort (*Utricularia purpurea*). Bass Lake was one of only four lakes within the Eastern Marathon County Lakes Study having any species of special concern.

The Simpson Diversity Index (SDI) quantifies biodiversity based on a formula that uses the number of species surveyed and the number of individuals per site. The SDI uses a decimal scale of zero to one with values closer to one representing higher amounts of biodiversity. Bass Lake had a SDI value of 0.76, which was below average when compared with the other lakes in the Eastern Marathon County Lakes Study.

Two species of non-native aquatic plants were found near Bass Lake during the survey. Purple loosestrife (*Lythrum salicaria*) is a woody and fast-growing shoreland species that out-competes native species. It is currently widespread in Wisconsin and much of the Midwest. Reed canary grass (*Phalaris arundinacea*) was also found near Bass Lake. This invasive grass prefers disturbed, wet sites where it can form dense stands along the shoreline and into water depths of 1 to 2 feet. This non-native species has low food and habitat value and crowds out native species through its aggressive growth.

Overall, the aquatic plant community in Bass Lake can be characterized as having good species diversity and a number of relatively uncommon species for central Wisconsin. The habitat, food source, and water quality benefits of this diverse plant community should be focal points in future lake management strategies.

TABLE 11. AQUATIC PLANTS IDENTIFIED IN THE AQUATIC PLANT SURVEY OF BASS LAKE, 2012.

Common Name	Scientific Name	Coefficient of Conservatism Value (C Value)
Emergent Species		
common arrowhead	*Sagittaria latifolia*	3
pickerelweed	*Pontederia cordata*	8
three-way sedge	*Dulichium arundinaceum*	9
creeping spikerush	*Eleocharis palustris*	6
softstem bulrush	*Schoenoplectus subterminalis*	
bur-reed	*Sparganium, spp.*	
purple loosestrife	*Lythrum salicaria*	0
reed canary grass	*Phalaris arundinacea*	0
Floating Leaf Species		
watershield	*Brasenia schreberi*	6
spatterdock	*Nuphar variegata*	6
white water lily	*Nymphaea odorata*	6
floating leaf pondweed	*Potamogeton natans*	5
Oakes' pondweed	*Potamogeton oakesianus*	10
Submergent Species		
pipewort	*Eriocaulon aquaticum*	9
brown fruited rush	*Juncus pelocarpus*	8
dwarf watermilfoil	*Myriophyllum tenellum*	10
water-thread pondweed*	*Potamogeton diversifolius*	8
twin-stemmed bladderwort	*Utricularia geminiscapa*	9
large purple bladderwort*	*Utricularia purpurea*	9
muskgrass	*Chara*	7
aquatic Moss		

*Species shaded in gray are species of special concern in Wisconsin.

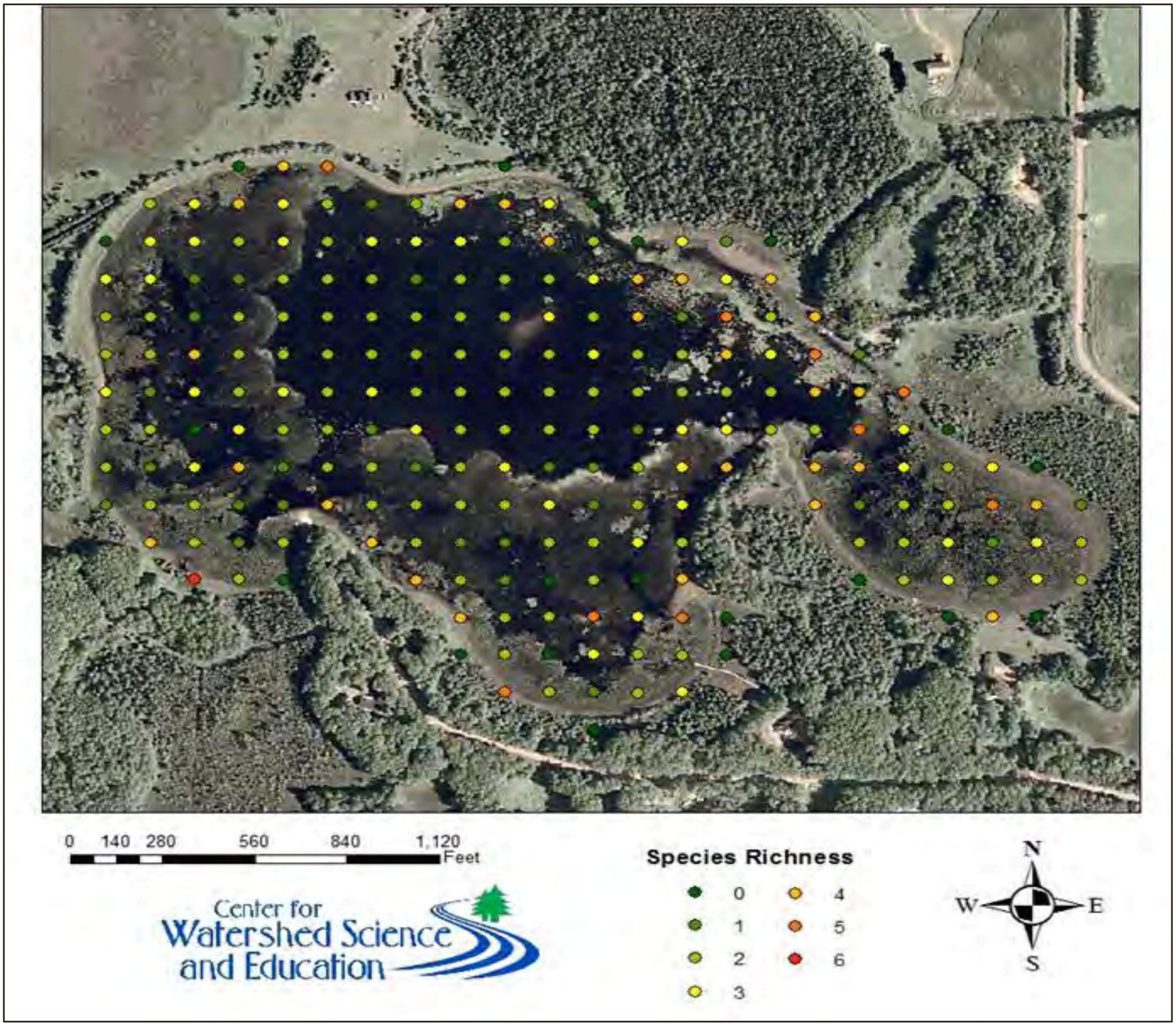

FIGURE 16. SPECIES RICHNESS AT SAMPLE SITES IN BASS LAKE.

CONCLUSIONS & RECOMMENDATIONS

Bass Lake is a nutrient-rich lake. Its soft water makes it particularly susceptible and responsive to additions of nutrients, especially phosphorus; therefore, care should be taken to minimize additions of phosphorus to the lake from erosion, addition of nutrients to the landscape within the watershed, and re-suspension of lake sediments from boat wakes and/or disturbing the protective layer provided by aquatic plants.

- The average hardness for Bass Lake during the 2010-2012 sampling period was 5.2 mg/L, which is considered soft.
- Bass Lake had low average chloride, sodium, and inorganic nitrogen concentrations over the monitoring period. The average potassium concentration, though slightly elevated, was typical for lakes in Marathon County. Atrazine (DACT), an herbicide commonly used on corn, was below the detection limit (<0.01 ug/L) in the two samples that were analyzed from Bass Lake.
- Total phosphorus concentrations in Bass Lake ranged from a high of 86 ug/L in October 2010 to a low of 12 ug/L in September 2012. The summer median total phosphorus concentrations were 31 ug/L and 36.5 ug/L in 2011 and 2012, respectively. This is below Wisconsin's phosphorus standard of 40 ug/L for shallow seepage lakes, but above the proposed flag value of 15 ug/L.
- In Bass Lake, chlorophyll *a* concentrations (a measure of algae) in Bass Lake varied throughout the monitoring season, ranging from a high of 15 ug/L in June 2012 to a low of 0.5 ug/L in August 2012. In Bass Lake, a relationship exists between chlorophyll *a* and total phosphorus concentrations. Generally, as total phosphorus concentrations increase, concentrations of chlorophyll *a* also increase.

Algae are microscopic, photosynthetic organisms that are important food items in all aquatic ecosystems. Different algal groups increase or decrease during the year and they can be used to analyze a lake's water quality because there are more varieties of algae than fish or aquatic plants. Conclusions can be drawn about water temperature, nutrient availability, and overall water quality of a lake using algal populations.

- The algal communities of Bass Lake were strikingly similar in 2011 and 2012, and dominated by blue-green algae (43% and 51% average composition, respectively) characteristic of eutrophic lakes. The blue-greens dominated early in both years with a small mid-summer depression before a dominating fall rebound.
- The diatoms displayed a typical early and late season distribution, but only represented 20-25% of the algal community, and the most common species found are associated with eutrophic waters.
- The green algae made up only 10-20% of the algal community and the most common species found are common under nutrient-enriched conditions.
- The high nutrient load, shallow depth, decreasing water clarity, and an algal community dominated by species historically associated with eutrophic lakes suggested Bass Lake has transitioned into a eutrophic state and may continue to decline. These conditions occasionally lead to oxygen depletion and possible fish kills, especially in late winter.

The interdependence of algae, zooplankton, and young fish as predators and prey form the primary food web in most lakes. Zooplankton are microscopic invertebrate animals that swim or drift in water. They are the primary consumers at the base of the food chain in our lakes and are an important food for many fish. Most zooplankton are filter feeders, using their appendages to strain bacteria and algae from water, so they help to keep algal populations under control. It is the timing of zooplankton abundance that frequently determines the success of a lake's larval fish community. The abundance and slow-moving nature of zooplankton make them the primary food of young fish (fry).

- The types of zooplankton identified during the sample periods were relatively common and the majority of those were not classified as invasive or exotic. Some of the non-native and invasive zooplankton are much larger in size than native zooplankton; therefore, non-native zooplankton can disturb the fishery in a lake because they are often too large to fit in the mouth of young fish. This can result in significant changes in the fishery in a lake.
- A stable, little-changing zooplankton community dominated by smaller nano-plankton (rotifers and cladocerans), as was seen in Bass Lake, suggested a fairly eutrophic environment. When considered in relation to the algal, phosphorus and nitrogen values seen in Bass Lake, the zooplankton community's indication of a fairly eutrophic lake was reinforced.

A healthy fishery is one that is in balance with the lake's natural ability to support the fish community, and is adaptable to fishing practices that do not cause declines in fish populations. A healthy fish community has a balance between predator and prey species, and each fish species has different needs to be met in order to flourish, including adequate food sources, habitat, appropriate spawning substrate, and water quality.

- Bass Lake supports a warm water fish community. Five fish species were collected during the 2012 survey, making a total of seven species recorded in this survey and in a 1967 survey conducted by the Wisconsin Department of Natural Resources.
- Although most species identified in 2012 had been previously reported, central mudminnow and black crappie were newly documented.
- Largemouth bass and yellow perch were previously documented, but not observed during the 2012 survey.
- Black bullhead was most abundant during the 2012 survey, with a maximum length of 7.9 inches.
- The least abundant in the 2012 samples were pumpkinseed, black crappie, and central mudminnow. Although infrequently encountered, black crappie reached a maximum length of 12.2 inches.
- Crayfish were not encountered during the sampling period.

To successfully sustain a healthy fish population, a lake must have the habitat to support it. Habitat needs of fish include healthy aquatic plants and woody structure such as logs, fallen trees, and stumps. Woody structure provides places for fish to hide, as well as habitat for invertebrates that many fish species use as food sources. Many fish use lily pads and bulrushes, as well as gravel and cobble substrates, for spawning habitat.

- Substrate in Bass Lake primarily consists of a soft, muck bottom (96.4%); however, harder substrates including gravel/cobble and sandy areas also exist.
- In the absence of sand and coarser substrates such as gravel, largemouth bass and sunfish are known to build nests on soft bottoms. Depressions are deepened until some small amounts of coarser substrate, mostly fragments of snail shells, accumulate in the bottom of the nests. In areas of soft substrate, largemouth bass are also reported to spawn on woody habitat swept clear of sediments.
- Gravel areas are utilized as spawning habitat for many sunfish (bluegill, pumpkinseed, black bass), where males will construct nests and guard their young.
- The presence of young bluegill indicates reproduction is successful in Bass Lake; however, determining the reproductive success of other species would require additional sampling efforts.
- Bulrush is present along areas of the eastern shoreline in Bass Lake. Black crappie utilize bulrush habitat on gravel or sand substrates where they construct nests and guard young.

- Yellow perch prefer near-shore cobble substrate in oxygen-rich environments for spawning activity and offer no parental care.
- Coarse woody habitat (CWH), including downed trees and logs, are sparse in Bass Lake. This structure is utilized by young prey fish and other aquatic organisms for foraging, protection, and spawning. The fish community may benefit from the addition of CWH.

Aquatic plants are the forested landscape within a lake. They provide food and habitat for a wide range of species including fish, waterfowl, turtles, and amphibians, as well as invertebrates and other aquatic animals. They improve water quality by releasing oxygen into the water and utilizing nutrients that would otherwise be used by algae. A healthy lake typically has a variety of aquatic plant species which creates diversity that makes the aquatic plant community more resilient and can help to prevent the establishment of non-native aquatic species.

- During the 2012 survey, twenty species of aquatic plants were found in Bass Lake, with the greatest diversity located in the shallows on the eastern side of the lake. This was an average number of species compared with the other lakes in the Eastern Marathon County Lakes Study.
- The dominant plant species in the survey was large purple bladderwort, followed by water-thread pondweed and white water lily.
    - Large purple bladderwort is a species of special concern in Wisconsin which offers invertebrate habitat as well as foraging sites for fish. Bladderworts are carnivorous plants, using vacuums in their bladders to catch tiny insects.
    - Water-thread pondweed is also a species of special concern in Wisconsin. The fruit it produces is an important food source for waterfowl, muskrat and beaver.
    - The seeds produced by white water lily provide a food source for waterfowl and the broad, floating leaves of the plant provide shade and shelter for fish and other species.
    - Bass Lake was one of only four lakes within the Eastern Marathon County Lakes Study with species of special concern.
- The Floristic Quality Index (FQI) evaluates the closeness of a plant community to undisturbed conditions. The FQI for Bass Lake was 29.9, which was above average and ranked fourth highest within the Eastern Marathon County Lakes Study.
- Of the aquatic plant species within Bass Lake, nine were considered high quality plants with a C value of eight or greater, ranking Bass Lake the third highest of the eleven lakes within the Eastern Marathon County Lakes Study.
- The Simpson Diversity Index (SDI) quantifies biodiversity using the number of species surveyed and the number of individuals per site. The SDI for Bass Lake was below average when compared with the other lakes in the Eastern Marathon County Lakes Study.
- Two species of non-native aquatic plants were found near Bass Lake during the survey: purple loosestrife and reed canary grass.
    - Purple loosestrife is a woody and fast-growing shoreland species that out-competes native species. It is currently widespread in Wisconsin and much of the Midwest. Purple loosestrife can be controlled by the introduction of beetles (*Galerucella calmariens*) that feed solely on this plant.
    - Reed canary grass was also observed near Bass Lake. This invasive grass prefers disturbed, wet sites where it can form dense stands along the shoreline and into water depths of 1 to 2 feet. This non-native species has low food and habitat value and crowds out native species through its aggressive growth.

- The amount of disturbed lakebed from raking or pulling plants should be minimized, since these open spaces are "open real estate" for aquatic invasive plants to establish.
- Early detection of aquatic invasive species (AIS) can help to prevent their establishment should they be introduced into the lake. Boats and trailers that have visited other lakes can be a primary vector for the transport of AIS.
- Programs are available to help volunteers learn to monitor for AIS and to educate lake users at the boat launch about how they can prevent the spread of AIS.

In general, each type of land use contributes different amounts of phosphorus, nitrogen, and pollutants in runoff and through groundwater. The types of land management practices that are used and their distances from the lake affect the contributions to the lake from a parcel of land. Bass Lake's surface and groundwater watersheds provide most of the water to the lake. Forests comprised nearly half of the 1,039 acre surface watershed, followed by agriculture which comprised about 35% of the watershed. In the groundwater watershed, agriculture had the greatest percent land use (35%), followed by forests (22%).

- Water quality modeling results indicated that agriculture had the greatest percentage of phosphorus contributions from the watershed to Bass Lake.
- Over-application of chemicals and nutrients should be avoided. Landowners in the watershed should be made aware of their connection to the lake and should work to reduce their impacts through the implementation of water quality-based best management practices.
- The Marathon County Conservation Department and Natural Resources Conservation Service (NRCS) have professional staff available to assist landowners interested in learning how they can improve water quality through adjustments in land management practices.

Shoreland health is critical to a healthy lake's ecosystem. Bass Lake's shoreland was assessed for the extent of vegetation and disturbances. Shoreland vegetation provides habitat for many aquatic and terrestrial animals, including birds, frogs, turtles, and many small and large mammals. Vegetation also helps to improve the quality of the runoff that is flowing across the landscape towards the lake. Healthy shoreland vegetation includes a mix of tall grasses/flowers, shrubs and trees extending at least 35 feet inland from the water's edge. Alone, each manmade disturbance may not pose a problem for a lake, but on developed lakes, the collective impact of these disturbances can be a problem for lake habitat and water quality.

- Bass Lake has 1.9 miles of shoreline. Most of the shoreline had adequate shoreland vegetation.
- 10,012 linear feet of shoreline were classified as having grass/forb and shrub buffer depths of 35 feet, the minimum depth required by Wisconsin and Marathon County shoreland zoning ordinances.
- The tree layer was also abundant, especially in the 35-50 foot buffer depth category; however, over 4,000 feet of shoreline were classified as having a tree buffer width of only 5-15 feet inland from the water's edge.
- Although Bass Lake's shoreland is in good shape now, changes can easily occur as development takes place. Minimizing impacts to Bass Lake from future development should include planning to ensure that prospective developers have the right information to make good decisions and that zoning is in place to achieve habitat, water quality, and aesthetic goals.

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GLOSSARY OF TERMS

Algae: One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provide the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

Atrazine: A commonly used herbicide. Transports to lakes and rivers by groundwater or runoff. Has been shown to have toxic effects on amphibians.

Blue-Green Algae: Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N2) from the air to provide their own nutrient.

Calcium (Ca++): The most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed. Reported as milligrams per liter (mg/1) as calcium carbonate (CaCO3), or milligrams per liter as calcium ion (Ca++).

Chloride (Cl-): The chloride ion (Cl-) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll *a*: Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae, and is therefore used as a common indicator of algae and water quality.

Clarity: See "Secchi disk."

Color: Color affects light penetration and therefore the depth at which plants can grow. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. Measured in color units that relate to a standard. The average color value for Wisconsin lakes is 39 units, with the color of state lakes ranging from zero to 320 units.

Concentration units: Express the amount of a chemical dissolved in water. The most common ways chemical data is expressed is in milligrams per liter (mg/l) and micrograms per liter (ug/l). One milligram per liter is equal to one part per million (ppm). To convert micrograms per liter (ug/l) to milligrams per liter (mg/l), divide by 1000 (e.g. 30 ug/l = 0.03 mg/1). To convert milligrams per liter (mg/l) to micrograms per liter (ug/l), multiply by 1000 (e.g. 0.5 mg/l = 500 ug/l).

Cyanobacteria: See "Blue-Green Algae."

Dissolved oxygen: The amount of oxygen dissolved or carried in the water. Essential for a healthy aquatic ecosystem in Wisconsin lakes.

Drainage basin: The total land area that drains runoff towards a lake.

Drainage lakes: Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems, but generally have shorter residence times than seepage lakes.

Emergent: A plant rooted in shallow water and having most of its vegetative growth above water.

Eutrophication: The process by which lakes and streams are enriched by nutrients, and the resulting increase in plant and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Groundwater drainage lake: Often referred to as a spring-fed lake, it has large amounts of groundwater as its source and a surface outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.

Hardness: The quantity of multivalent cations (cations with more than one +), primarily calcium (Ca^{++}) and magnesium (Mg^{++}) in the water expressed as milligrams per liter of $CaCO_3$. Amount of hardness relates to the presence of soluble minerals, especially limestone or dolomite, in the lake watershed.

Intermittent: Coming and going at intervals, not continuous.

Macrophytes: See "Rooted aquatic plants."

Marl: White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. Marl may contain many snail and clam shells. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Mesotrophic: A lake with an intermediate level of productivity. Commonly clear water lakes and ponds with beds of submerged aquatic plants and mediums levels of nutrients. See also "eutrophication".

Nitrate (NO_3^-): An inorganic form of nitrogen important for plant growth. Nitrate often contaminates groundwater when water originates from manure, fertilized fields, lawns or septic systems. In drinking water, high levels (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO_3-N) plus ammonium-nitrogen (NH_4-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

Oligotrophic: Lakes with low productivity, the result of low nutrients. Often these lakes have very clear waters with lots of oxygen and little vegetative growth. See also "eutrophication".

Overturn: Fall cooling and spring warming of surface water increases density, and gradually makes lake temperatures and density uniform from top to bottom. This allows wind and wave action to mix the entire lake. Mixing allows bottom waters to contact the atmosphere, raising the water's oxygen content. Common in many lakes in Wisconsin.

Phosphorus: Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Rooted aquatic plants (macrophytes): Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects and provide food for many aquatic and terrestrial animals. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Secchi disk: An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration).

Sedimentation: Materials that are deposited after settling out of the water.

Stratification: The layering of water due to differences in density. As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion. Common in many deeper lakes in Wisconsin.

Watershed: See "Drainage basin."