Aquatic Invasive Species Management Plan

For

Thunder Lake

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October 2011

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Thunder Lake Aquatic Invasive Species Management Plan

Thunder Lake is located in the Town of Stephenson (T32N, R18E, S15) in Marinette County, Wisconsin (Figure 1). The purpose of this report is to develop a plan for managing of Eurasian watermilfoil (*Myriophyllum spicatum*) in Thunder Lake with the goal of minimizing its impact on the native plant community. The document also provides a plan for preventing the spread of Eurasian watermilfoil (EWM) and other aquatic invasive species between and among area lakes and flowages.

Thunder, Island, Eagle Area Lakes Association

The Thunder, Island, Eagle Area Lakes Association (T.I.E Area Lakes Association) is a voluntary organization open to landowners and concerned citizens in the community surrounding Thunder, Island, and Eagle Lakes. The T.I.E. Lakes Association has a long history of working to protect and improve Thunder, Eagle and Island Lakes. Since the discovery of Eurasian Water Milfoil (EWM) in Thunder Lake in 1992 the Association has worked to limit its impact on the lake and prevent its spread to neighboring lakes.

Figure 1. Thunder, Eagle, and Island Lakes.

The Association has taken an active role in studying the lakes and managing water quality including a lake management planning project in 1994 to study baseline water quality conditions and develop a comprehensive lake management plan, and a more recent project in 2006 to update the lake management plan, evaluate the EWM biocontrol efforts and make recommendations for EWM management. The 2006 management plan recommends selective management of EWM with 2,4-D or other selective herbicides to prevent EWM dominance in Thunder Lake.

Overview of Physical & Chemical Characteristics of Thunder Lake

Thunder Lake is a 135-acre hard water drainage lake with clear water of high transparency. Water quality is generally excellent. A lake study conducted in 1992 found an average growing season phosphorus concentration of 9 ug/l. Chlorophyll was correspondingly low during the period with an average of 2.2 ug/l. Water clarity measured by lake volunteers averaged 18.2 feet over the last 20 years with a maximum of 36 feet.

With a maximum depth of 62 feet, and more than 60% of the lake in excess of 20 feet deep, Thunder Lake experiences strong thermal stratification. Due to its excellent water quality and high transparency the lake retains adequate oxygen below the thermocline to support a two-tier fishery. The lake supports bass, bluegill, northern pike and trout. The inlet and outlet are classified as trout waters and the DNR stocks trout in the lake.

Public Access & Recreational Use

The town of Stephenson maintains a public boat launch on Thunder Lake with parking for at least 6 trailers. Thunder Lake is a very popular fishing destination for anglers targeting trout, largemouth bass, and northern pike. Due to its excellent water quality the lake is also popular with water skiers and personal watercraft users. Island and Eagle Lakes have carry-in access.

Overview of the Thunder Lake Fish Community

According to the Wisconsin DNR Thunder Lake supports a balanced bass-bluegill fishery along with good numbers of northern pike and rainbow trout. An electrofishing survey conducted in May 2010 captured 212 largemouth bass between 6 and 16 inches in length. Despite the high number of bass capture, only 4% exceeded the minimum legal size of 14 inches, indicating fairly high harvest rates. Northern pike were not well represented in the survey but pike are notoriously difficult to sample using electrofishing. No Walleye were found during the survey.

Panfish were abundant with bluegill dominating the community (58%) followed by rock bass (38%) and pumpkinseed sunfish (4%). The bluegill population had an excellent size structure with 53% of the fish above the quality management size of 6 inches.

Since 1964 the DNR has annually stocked Thunder Lake with rainbow and brook trout. The trout fishery is primarily a put-and-take fishery with little or no natural reproduction. However, since the inlet does support a native brook trout population there may be some natural recruitment of trout in Thunder Lake. Stocking records indicate that on a typical year 5,000 rainbow and 1000 brook trout in the 6-9 inch range are stocked. Brown trout are occasionally stocked in Thunder Lake.

The DNR continues to recommend that stocking in Thunder Lake be limited to rainbow and brook trout. According to WDNR Fisheries Supervisor Mike Donofrio (2010) survival of walleye fingerlings would be very low in due to the abundance of bass and northern pike. Donofrio also recommended promoting catch-and-release of larger bass to improve the size structure of the bass population.

Aquatic Plant Community

Thunder Lake supports a moderately diverse aquatic plant community. Low-growing plants such as muskgrass (*Chara sp.*), common waterweed (*Elodea canadensis*), stonewort (*Nitela sp.*), and variable-leaf pondweed (*Potamogeton graminaeus*) are the most common. A survey of the lake in 2006 identified 20 native aquatic plants and one exotic species, Eurasian watermilfoil (*Myriophyllum spicatum*) (Figure 2).

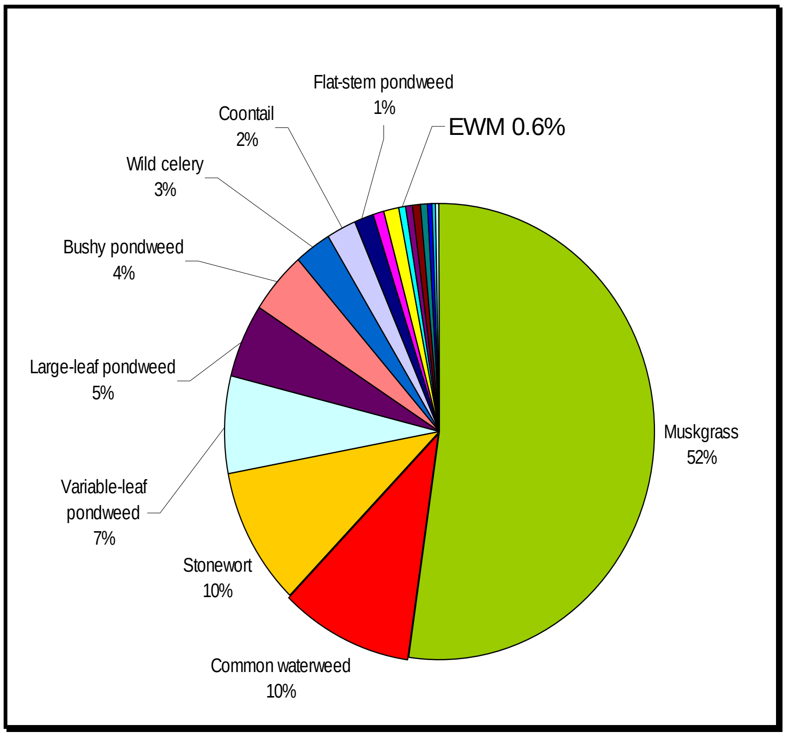


Figure 2. Relative abundance of aquatic plants in Thunder Lake

Much of the very shallow littoral zone is sandy and wave washed with limited aquatic plants. In deeper water plant growth is abundant but the community remains dominated by low-growing species. The clear unstained water allows for plant growth to a maximum depth of 22 feet.

Floating leaf plants are uncommon in Thunder Lake where they are limited to the well-protected bay by the lake inlet. Emergent plants are common but limited to a very narrow fringe along undeveloped shoreline areas.

History of Exotic Species Control Efforts

Eurasian watermilfoil (EWM) was first reported from Thunder Lake in 1992. Plant samples were collected and verified by the Freckman herbarium at UW-Stevens Point. For many years EWM density remained quite low with the exception of the area around the public access and the lake inlet. According to lake residents the EWM population expanded significantly in the late 1990's and early 2000's and began to spread to new areas around the lake.

The earliest effort at managing the growth and spread of EWM occurred in 1995 when bottom screens were placed near the boat landing to kill dense EWM beds and prevent its re-growth. However, maintenance and cleaning of the screens proved problematic and boats disrupted the screens, causing them to billow up and become a nuisance. The use of bottom screens was discontinued after a single season.

The TIE Area Lakes Association has also experimented with biocontrol efforts to manage EWM. In 2001 and again in 2005 the lake management consulting group Enviroscience Inc. stocked several thousand milfoil weevils (*Euhrychiopsis lecontei*) in Thunder Lake in an effort to control the growth and spread of EWM. While EnviroScience Inc. reported a decrease in EWM density following the initial stocking, survival and reproduction of the milfoil weevils was generally poor and the results were not sustained.

In the summer of 2009 the lake association treated 8.7 acres of EWM with 2,4-D with mixed results. The treatment date was later than ideal and EWM growth was already significant. A follow-up treatment early May of 2010 was much more successful in reducing the frequency and density of EWM throughout the lake.

Aquatic Plant Survey

The main focus of the Lake Management Planning Grant is to plan for the long-term management of EWM in Thunder Lake for the protection of the native plant community. To this end, a detailed aquatic plant survey was completed during the summer of 2010.

Survey Methodology

The 2010 aquatic plant survey was conducted using the Wisconsin DNR point/intercept sampling protocol (Hauxwell 2010). In areas less than 25 feet deep a point spacing interval of 25 meters (82 feet) was used to better describe the plant community. In the deeper central portion of the lake the point spacing interval was increased to 50 meters (165 feet). A total of 470 points were sampled. Coordinates for each of the sample points were loaded onto a Garmin Vista handheld GPS unit for navigation in the field.

At each sample location a special double-headed garden rake on an extendable aluminum pole was used to determine the water depth and sediment type and to sample aquatic plants. Plants were collected for identification by dragging the rake across the bottom for approximately 0.75 meters and bringing it to the surface. At sites deeper than 15 feet plant samples were collected using a double-headed garden rake attached to a rope. For each species of plant found on the rake a relative abundance measurement of 1 to 3 was recorded with 1 being sparse (species present) and 3 being abundant (species dominant by volume). Abundance was also recorded for the combined total amount of plant material on the rake as described in Hauxwell (2010).

The field survey was completed using a team of four individuals, a “navigator”, “driver”, “sampler”, and a “data recorder”. Volunteers from the Lake Association provided the boat and assistance with navigation. When a survey point was reached the sampler would call out the depth and bottom type and sample the vegetation. Typically the sampler could sort and call out the vegetation data before the next sample point was reached. Sample points that were clearly in excess of the maximum depth of plant colonization (22 feet) were not sampled for plants. At these sites depth was determined with an electronic depth finder and recorded.

Data was entered and analysis was completed using Microsoft Excel. A full report of the 2009 aquatic plant survey can be found in Appendix A. All sample location and associated data were mapped in the Marinette County Geographic Information Systems (GIS) database. Plant distribution maps for each species can also be found in Appendix A.

Sediment Type

Sediment type was determined at each sample location shallower than the maximum depth of plant growth by "feel" using the metal rake head attached to an aluminum pole. Data was recorded as muck, sand & gravel, or rock. Soft unconsolidated sediment was recorded as muck. Rock included everything from cobble size rock (2-3 inches) to boulders or bedrock. Sand and gravel are often mixed and difficult to distinguish by feel so they are grouped together.

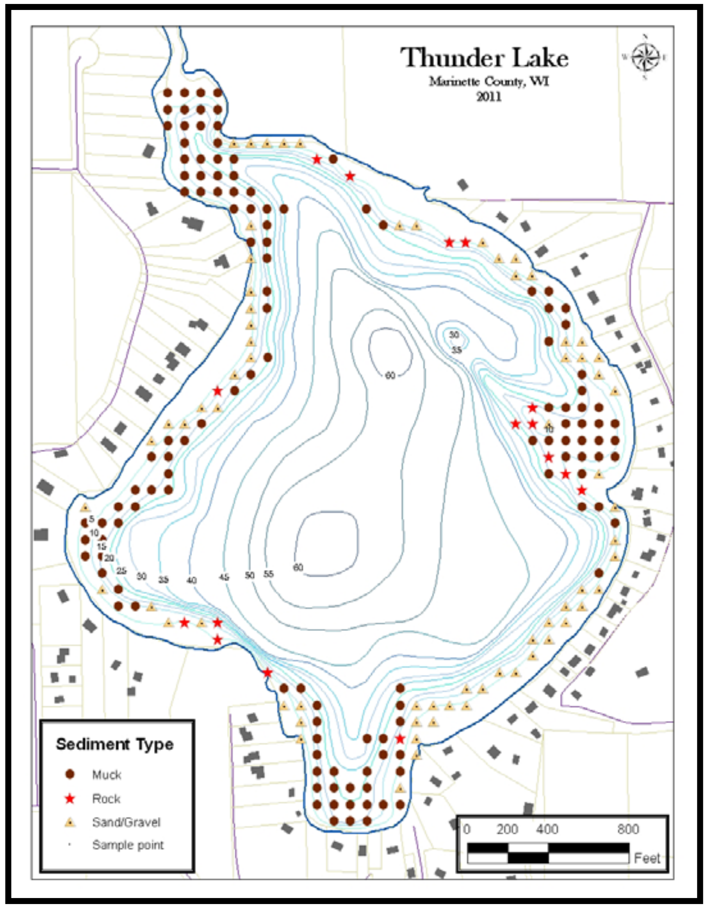


Figure 3. Thunder Lake sediment types.

Sediment type is largely determined by local soils, wave action and aquatic vegetation. Soil surrounding the lake is primarily Menahga sand that typically contains less than 2% gravel by weight. In shallow near-shore areas wave and ice action tend to keep the sand clear. At greater depth accumulations of organic matter (muck) cover the sand to varying degrees. Sediment is important because aquatic plants have differing sediment preferences. Muck generally supports the greatest diversity of aquatic plants.

Analysis of the data shows that the dominant sediment type in Thunder Lake is muck (59%) followed by sand & gravel (33%) and rock (8%) (Figure 3). Sand is typically found at a depth of 6 feet or less in wave washed areas. In deep water and in protected bays muck is the dominant sediment type.

Aquatic Plant Community Structure

The aquatic plant community of Thunder Lake is generally sparse with moderate diversity (Figure 4). Plant diversity and density was greatest in areas of moderate depth and over muck sediment. Shallow sandy areas typically had low plant diversity. During the survey 17 native species were identified along with the exotic Eurasian Watermilfoil.

In 2010 the maximum depth of plant growth in Thunder Lake was 22 feet. This zone of plant growth, which is determined by water clarity, is known as the littoral zone. In Thunder lake the littoral zone covers approximately 48 acres, or 35% of the lake area

The dominant plant in Thunder Lake, as measured by frequency of occurrence, is muskgrass, which was found at more than 70% of sample points in the littoral zone. After muskgrass, frequency of occurrence falls precipitously to only 13% for common waterweed and stonewort. Sample points beyond the littoral zone are not considered when calculating or reporting plant frequency or density data.

The following aquatic plants were found at 2% or more of sample points within the littoral zone and could be considered common in Thunder Lake. Descriptions are taken from *Through the Looking Glass, a Field Guide to Aquatic Plants* (Boreman 1997), a publication of the Wisconsin Lakes Partnership. Distribution maps for each species can be found in Appendix A.

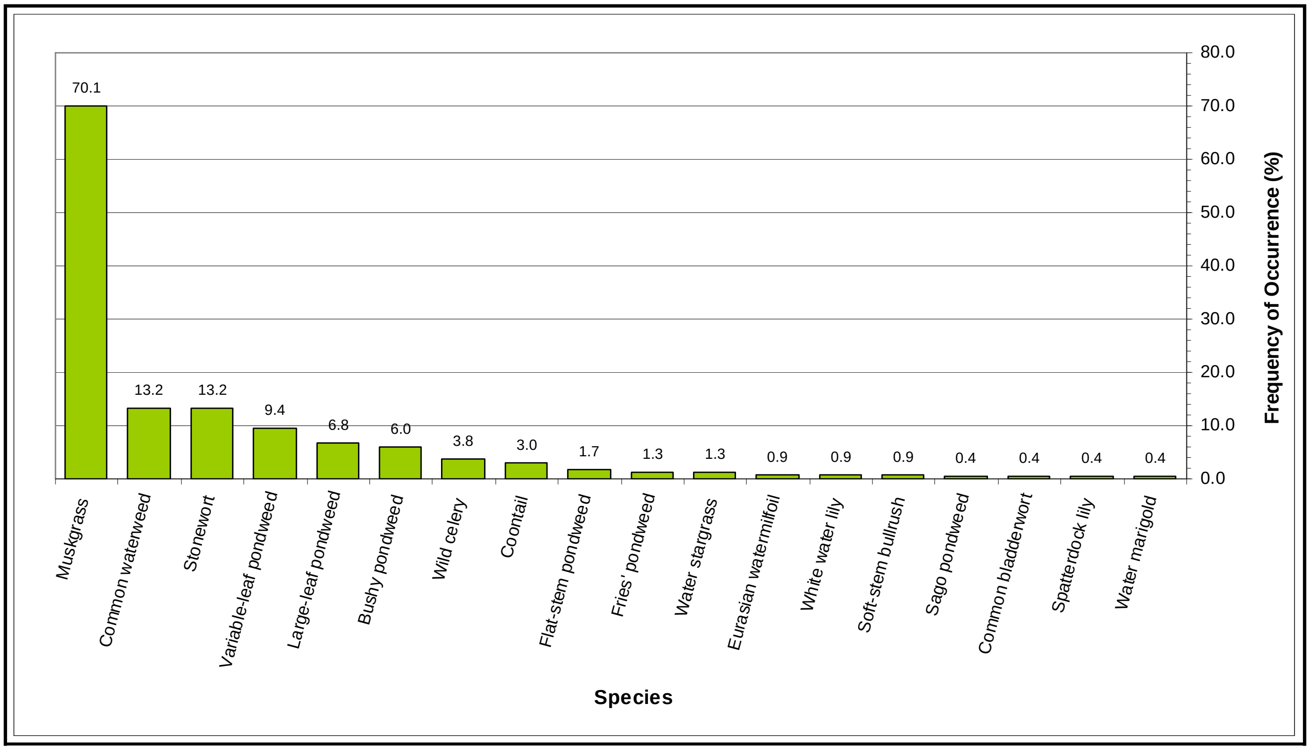
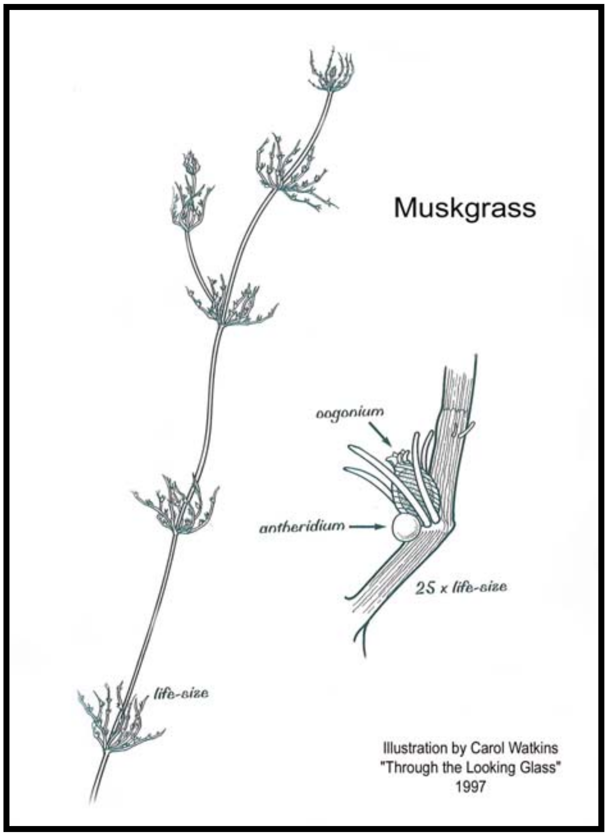


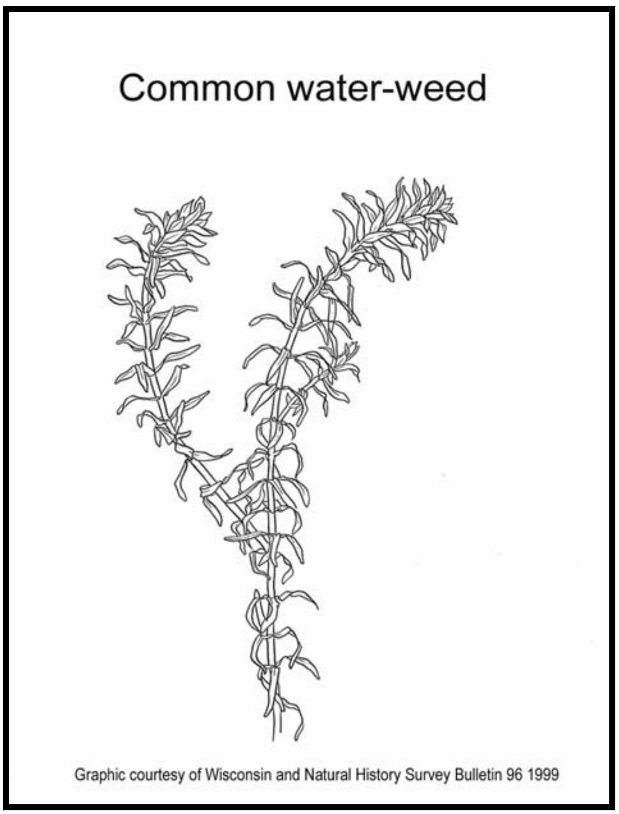
Figure 4. Aquatic plant frequency within the littoral zone of Thunder Lake.

Common Aquatic Plants

Muskgrass
Muskgrass (*Chara spp.*) is the most widely distributed, and the most abundant aquatic plant in Thunder Lake. It was found growing in 70% of sample points in the littoral zone. While outwardly appearing like many other aquatic plants, muskgrass is actually a type of colonial algae. Each "stem" and "leaf segment" is actually a separate algal cell. Muskgrass has branching slender "stems" with whorls of "leaves" at each joint. The main branches have ridges and the entire plant is often encrusted with calcium carbonate giving the plant a gritty or crusty feel. Muskgrass can be easily identified by its smell. When crushed the plant smells like skunk! In shallow sandy water muskgrass is often a diminutive plant no more than a few inches tall. In deep water it can sprawl along the bottom forming a dense mat. Due to its growth form muskgrass is seldom seen a nuisance.



Muskgrass is found in hard water lakes and prefers firm sediment. In Thunder Lake muskgrass shows no distinct sediment or depth preference. It is found growing in water from 1 to 21 feet in depth.

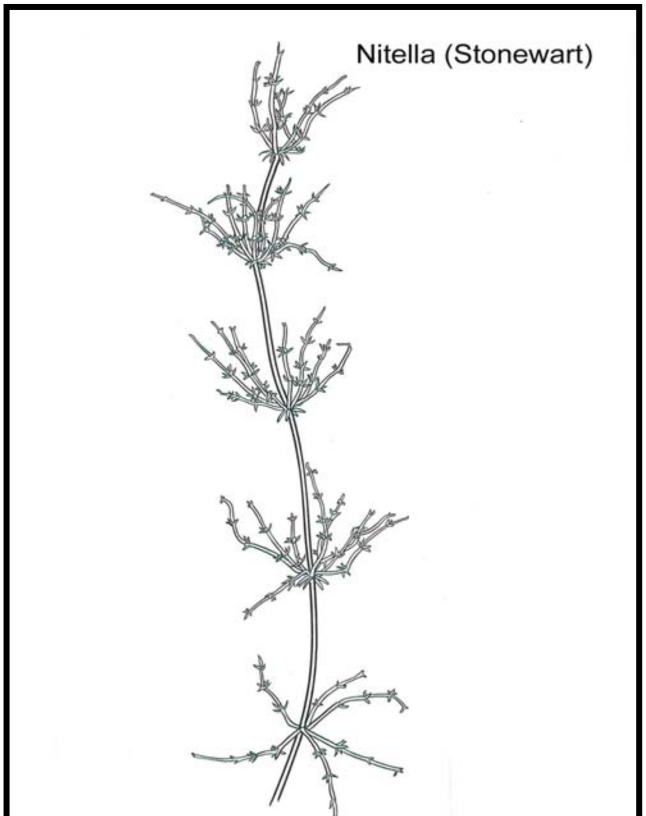


Muskgrass is a favorite food of waterfowl and provides excellent fish habitat. In very shallow sandy areas used by newly hatched fry (juvenile fish), muskgrass is often the dominant plant.

Common waterweed
Common waterweed (*Elodea Canadensis*) has small lance shaped leaves (1/16th to 1/8th inch wide, ¼ to ¾ inches long) attached directly to the stem in whorls of three. The plant branches profusely and often forms tangled mats on the lakebed.

Common waterweed bears male and female flowers on separate plants. However, it seldom produces seed, spreading primarily by fragmentation. In Thunder Lake it was found growing at 13% of the sample points, primarily at a depth of 10 to 15 feet. It was found almost exclusively in areas with muck sediment.
Common waterweed is important in the lake

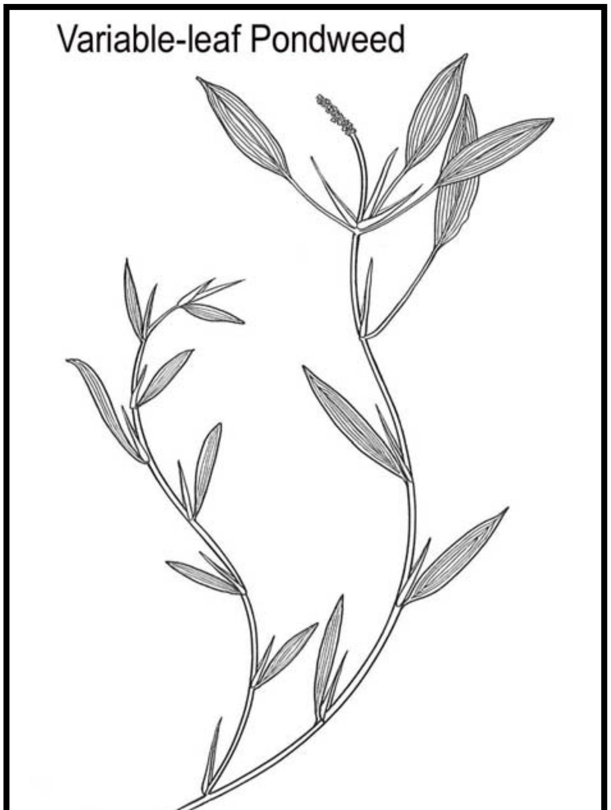
ecosystem because it over winters green and continues to produce oxygen under the ice in very low light conditions. Waterfowl eat the plant and it provides good winter habitat for fish and aquatic insects.



Graphic Courtesy of Through the Looking Glass

Stonewort
Like muskgrass, stonewort (*Nitella sp.*) is actually a type of algae. It has slender branching "stems" with whorls of bright green "leaves". The entire plant is smooth and translucent, looking almost jelly-like. While similar to muskgrass, stonewort typically has longer "leaves" and lacks the gritty calcium carbonate deposits and skunk-like odor.

Stonewort was found at 13% of sample points in Thunder Lake. It was only found growing in water more than 10 feet deep on muck sediment and was most abundant in water more than 17 feet deep. Stonewort is eaten by waterfowl and provides important deep-water habitat for fish.



Graphic courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

Variable-leaf pondweed
As the name implies, variable-leaf pondweed (*Potamogeton graminaeus*) varies greatly in growth form depending on depth and sediment type. Typically it has lance shaped leaves 1-3 inches long and 1/8th – 3/8th inches wide. The plant branches repeatedly and the side braches are very bushy. In Thunder Lake variable pondweed tends toward smaller leaves.

Like most pondweeds variable-leaf is a perennial plant. It spreads by seeds produced on stalks held above the water surface. When flowering it forms small floating leaves that are wider and more ellipse shaped than submerged leaves.

Variable-leaf pondweed was found at 10% of sample points. It shows a slight preference for muck sediment and was most abundant in water more than 6 feet deep. However, a smaller bushy form of the plant was also common growing on sand in two to five feet of water. Variable-leaf pondweed provides important habitat for juvenile fish, particularly in shallow water where it is one of the more abundant plants.

Large-leaf pondweed
Large-leaf pondweed (*Potamogeton amplifolius)* was found at 7% of sample points in the lake. It's one of the largest of the pondweeds and is known to fishermen as "cabbage" or "musky-weed". Large-leaf pondweed can be identified by its wide (1-2 in) arching leaves and by its thick seed stalk that's held above the water surface. When fruiting the plant also produces large egg shaped floating leaves.

Large-leaf pondweed prefers firm muck sediment and moderate water depths. It was most abundant in a narrow band along the drop-off in 6 to 12 feet of water and in the bay by the inlet. Large-leaf pondweed provides important cover for panfish and, as its name implies, feeding and ambush cover for large predatory fish such as bass, pike, and musky.

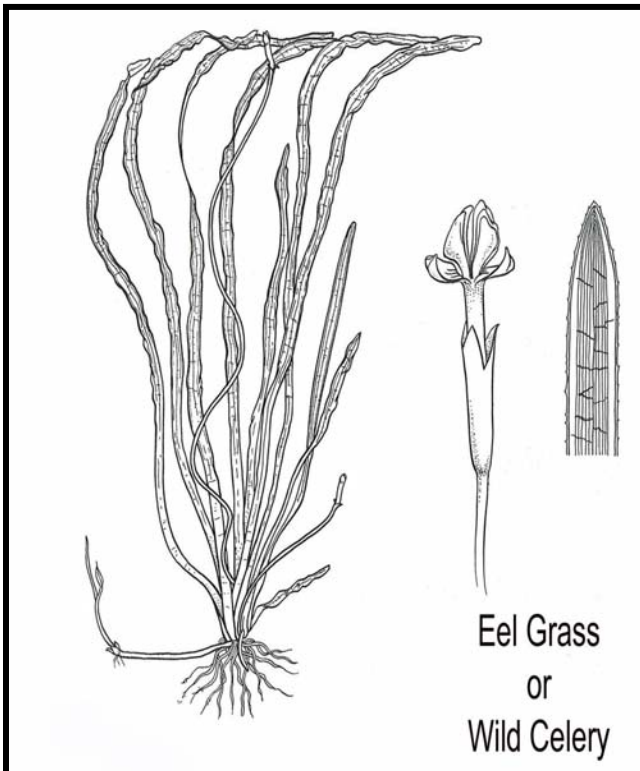
Bushy Pondweed
Bushy pondweed (*Najas flexilis*) is another plant that varies greatly in growth form depending on water depth and sediment type. In shallow sandy areas it's often compact and bushy while in deep water with muck sediment it tends to be long and wiry with widely scattered leaves. The leaves are very narrow (1/16th inch wide) with a broad base where they attach to the stem. Even in deep water the plants generally grow no more than 2 to three feet tall and it often forms tangled mats on the lakebed.

In Thunder Lake bushy pondweed was found at 6% of sample locations. It shows a preference for muck sediment and was most abundant between 7 and 12 feet of water.

Bushy pondweed is rather unique in that it's one of the few annual aquatic plants. It dies each winter and depends on seed to grow new plants each year. The plants and the seeds, which are produced in great abundance, are important food for waterfowl. Due to its short stature bushy pondweed is seldom reported as a nuisance plant.

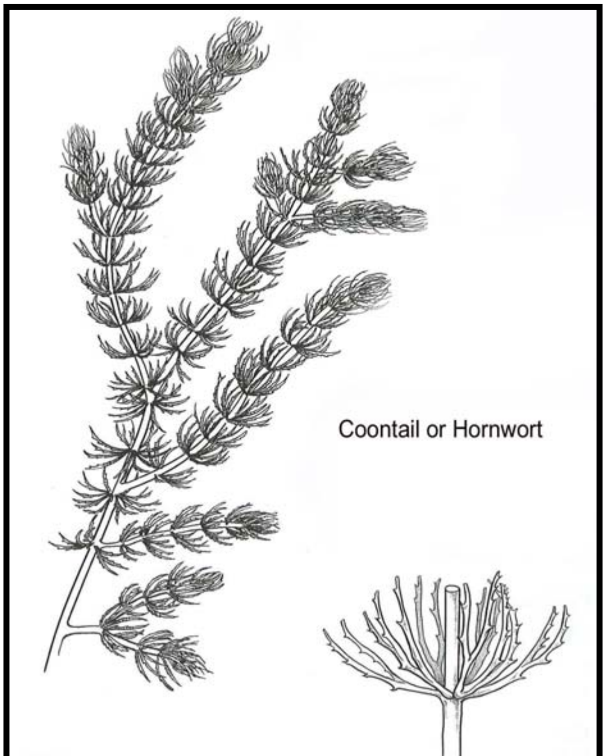
Wild Celery
Wild celery (*Vallisneria americana*) has long ribbon shaped leaves ¼ to ½ inch wide and up to 7 feet long that emerge from a central rosette. The leaves have a prominent central stripe and a cellophane-like consistency. The leaves are mostly submersed with just their tips trailing on the water surface. In late summer water celery produces tiny male flowers (1 mm wide) under water that break free and float to the surface where they pollinate female flowers held at the surface by a long spiral-coiled stalk.

Wild celery prefers hard substrate (sand or firm muck) and is quite tolerant of turbid water. It is a perennial plant that spreads by seed and by vegetative means. Vegetative growth occurs primarily by underground rhizomes, which produce "offsets" along their length, some of which can detach and float to new locations. The plant also produces abundant tubers prized by diving ducks, especially canvasbacks, which depend on them during migration flights.



Graphic courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

In Thunder Lake wild celery was found at 4% of sample points. It shows a strong preference for muck sediment and was most abundant in 6 to 10 feet of water.



Graphic courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

Coontail
Coontail (*Ceratophyllum demersum*) is the most common aquatic plant in Wisconsin. It has stiff spiny leaves arranged in whorls along branching wiry stems. The leaves tend to be dense near the ends of the stem, giving them the appearance of a raccoon tail.

Coontail has no true roots but anchors to the sediment using modified stems that develop wherever it touches the bottom. Due to its poor "rooting" ability, coontail prefers soft organic sediment. It rarely produces seed but spreads by fragmentation.

In Thunder Lake coontail was found at 3% of sample points. It was found growing exclusively in muck sediment and showed a preference for water more than 10 feet deep.

Coontail is important for fish habitat since it is slow to decompose and often stays alive under the ice. This habit makes it excellent winter habitat, attracting aquatic insects and the fish that feed on them.

Coontail is often mistaken for milfoil. However, milfoil has soft feather shaped leaves and true roots.

Graphy courtesy of WI Geological & Natural History Survey - Bulletin 96 - 1999

Flat-stem Pondweed
Flat-stem pondweed (*Potamogeton zosteriformis*) is identified, as the name implies, by its strongly flattened stems. The leaves are long (4"-8"), narrow (1/8"-1/4") and very stiff. The plant produces no floating leaves.

Flat-stem pondweed is a perennial that rarely reproduces by seed. Typically the entire plant dies back each year and re-grows from the root system. Like many of the pondweeds, flat-stem pondweed also spreads by producing winter buds, specialized leaves packed in a tight cluster that form at the end of some side branches. When the plant dies back the winter buds detach and fall to the sediment where they take root.

Flat-stem pondweed was found at 2% of sample points in Thunder Lake. It prefers a firm muck bottom and was only found in water more than 8 feet deep. Due to its affinity for deep water, flat-stem pondweed provides important foraging habitat for panfish and edge cover for gamefish. It also serves as a food source for waterfowl that graze on its leaves and eat the seeds.

Infrequent Submersed Aquatic Plants

The following native aquatic plants were found at fewer than 2% of the survey points on Thunder Lake. This does not necessarily mean they are rare. The survey methodology tends to under sample some plants due to their location or their growth form. As before, descriptions are taken from *Through the Looking Glass, a Field Guide to Aquatic Plants* (Boreman 1997).

Fine-leaved pondweeds
Fries' pondweed (*Potamogeton fresii*) and sago pondweed (*Stuckenia pectinata*) were also found on Thunder Lake. Both were found primarily in water from 4 to 12 feet deep with a muck bottom. The fine-leaved pondweeds can be notoriously difficult to identify. Leaf shape, winter buds, glands, and leaf sheaths are typically used to differentiate them.

Bladderworts
Common bladderwort (*Utricularia vulgaris*) was found at one sample point. Bladderworts are carnivorous plants that trap and digest zooplankton, small aquatic insects and other organisms. They do this by sucking prey into the bladders where it is slowly digested. Common bladderwort is a free-floating plant that is typically found growing in protected areas with little wave action.

Other submersed aquatic plants

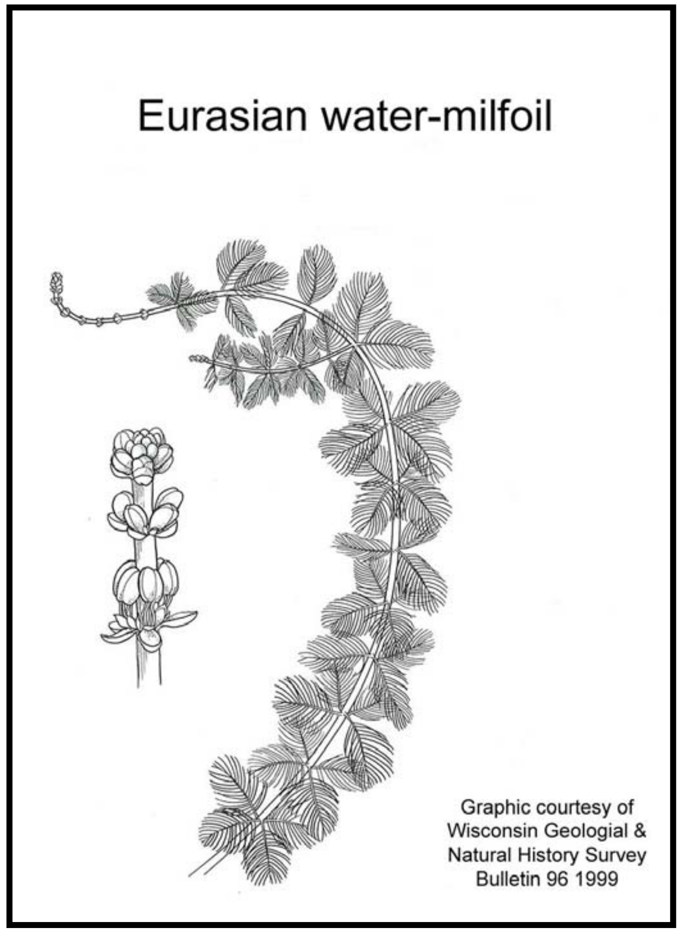
Two other submersed aquatic plants were identified in Thunder Lake. Water marigold (*Bidens beckii*) is often mistaken for a milfoil but can be distinguished by its branching instead of feather-like leaves.

Water stargrass (*Zosterella dubia*) is often confused with flat-stem pondweed or one of the small pondweeds. However, it is actually a member of the pickerelweed family. Water stargrass produces small yellow flowers held above the water surface. It typically inhabits a wide variety of sediment types and water depths.

Exotic Species

Eurasian watermilfoil (EWM)

Eurasian watermilfoil (*Myriophyllum spicatum*) is an invasive exotic species that first was first discovered in Thunder Lake in 1992. EWM Has soft feather like leaves arranged in groups of four and widely spaced along a thin stem. Depending on water clarity the plant can grow as tall as 15 feet. In shallow water EWM often reaches the surface where it branches profusely and spreads out to form a canopy that shades the water beneath. Eurasian watermilfoil is considered invasive since it has a habit of expanding rapidly and eliminating or drastically suppressing other plants.



EWM can over winter green or survive as sprouts on the rootstock. The plant begins rapid growth at a low water temperature and quickly reaches the surface. EWM spreads primarily by fragmentation, a process where even small fragments of the plant separated by boats or wave action drift to a new place and take root. The rapid growth, ease of spread, and its canopy forming habit, allows EWM to out compete many of the slower growing native plants.

In most lakes EWM shows a slight preference for moderately deep water. It also prefers muck sediment. While Eurasian watermilfoil provides some fish and wildlife habitat, studies show that native pondweeds typically support more diversity and greater numbers of insects (Engel 1990).

During the aquatic plant survey EWM was found at only four sample points (figure 5). This relative scarcity is due to an ongoing management campaign designed to reduce EWM abundance in the lake. Past experience and an aquatic invasive species survey of the lake show that EWM prefers areas with a muck bottom in 5 to 15 feet of water. Historically, EWM has been most abundant near the public access, near the inlet, and on the west side of the lake in a bay created by a long underwater point. In most other areas of the lake EWM has been limited to a narrow band of suitable habitat along the drop-off. Figure 5 shows areas treated for EWM during the last three years.

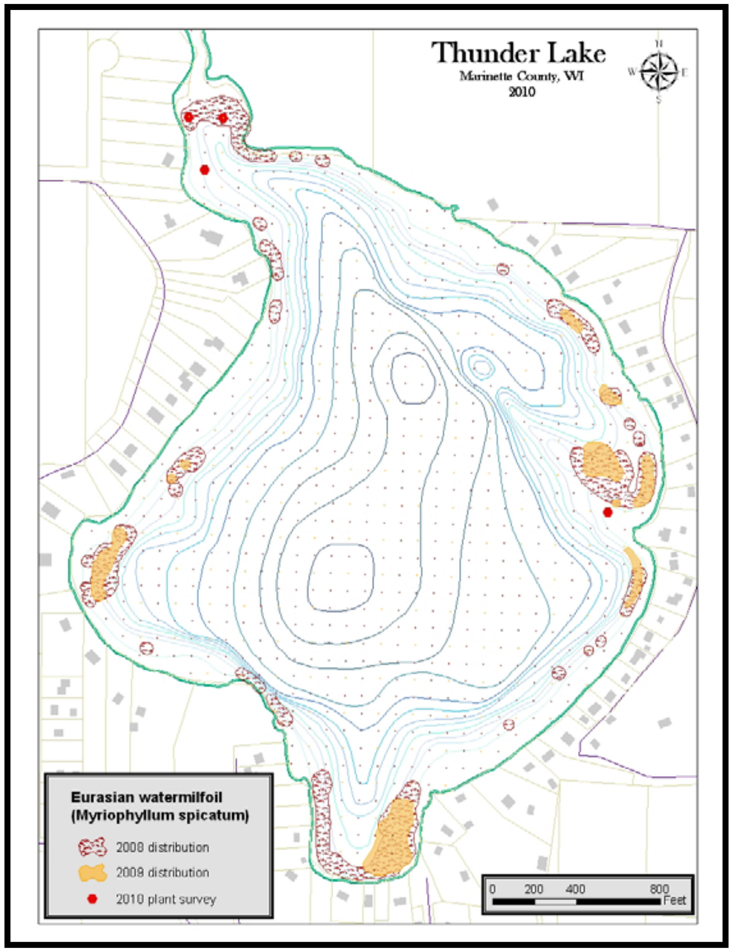


Figure 5. Recent historical distribution of EWM in Thunder Lake.

Floating-Leaf Plants

Floating-leaf plants include those with underwater stems and leaves that float on the surface. While many pondweeds also produce floating leaves when they flower, their primary leaves are under water. Floating-leaf plants are typically restricted to shallow water areas and most prefer soft organic (muck) sediment. The chosen aquatic plant survey methods do a poor job of sampling the floating leaf community. The point grids tend to under-sample very shallow areas where they grow best. Also, due to their growth form and tough stems, the sampling gear often fails to collect the plants.

White water lily (*Nymphaea odorata*) prefers shallow protected areas of a lake. On Thunder Lake it was only found near the inlet. Water lilies provide important habitat for juvenile fish and ambush cover for large bass and northern pike. All of the water lilies produce large tuberous root systems that provide energy for growth and aid in their spread.

While it did not appear in any sample points, water smartweed (*Polygonum amphibium*) was also identified in Thunder Lake. Water smartweed grows in and out of the water along muddy shorelines. It sprawls along the surface with thick fleshy stems and smooth dark green leaves. Water smartweed produces abundant pink flowers and its seeds are an important food source for waterfowl.

Emergent Vegetation

Plants such as cattails, bulrushes and others that reach above the surface of the lake are known as emergent vegetation. Most of these plants grow in water up to three feet deep or in saturated soil along the shoreline. Most are adapted to fluctuating water levels and are unharmed, or actually stimulated, by low water periods.

Due to their location on the shoreline emergents are typically under-sampled in grid surveys. Soft-stem bulrush (*Scirpus validus*) was the only emergent plant identified in the survey. However, a quick tour of the lake also revealed broad-leaved cattail (*Typha lattifolia*), rushes (*Juncus sp.*), and a variety of sedges

(*Carex sp.*) growing along the shore. A more intensive survey of shoreline vegetation would certainly identify several emergent species.

In general the emergent plant community on Thunder Lake is healthy along undeveloped portions of the shoreline. Where lawns are maintained to the waters edge shoreline vegetation typically suffers. Soft-stem bulrush and others that grow out into deeper water are damaged by waves and boat wakes.

Emergent plants are important in the lake ecosystem because of the habitat they provide for fish and amphibians that spawn on and amongst their underwater stems. Invertebrates (insects) and amphibians living in the shoreline fringe also form the base of the aquatic food web and are vital for a healthy lake.

Floristic Quality Index

One measure of aquatic plant community "health" is the Floristic Quality Index (FQI). The FQI is based on the number of native species and their "coefficient of conservatism"; a number assigned to every aquatic plant in the State representing how typical the plant is in pristine conditions. The FQI is based solely on the presence of a plant, not its abundance or dominance. The Statewide average FQI for lakes is 22.2. The FQI for Thunder Lake was 25.2, indicating good aquatic plant diversity and a quality aquatic plant population despite the presence of EWM.

Aquatic Plant Distribution

Each species of aquatic plant has habitat preferences. These include such factors as depth, light exposure and sediment type, among others. Together, these factors determine where a particular species grows or potentially can grow.

Depth

The area of a lake where there is sufficient light for aquatic plant growth is called the littoral zone. This area varies considerably among lakes and is determined primarily by water clarity. Water clarity is limited by suspended sediment, algae, and dissolved organic compounds such as tannins that give water a dark color. Thunder Lake has clear water with little color and low algal abundance. This allows for excellent transparency and an expanded littoral zone. Field investigation reveals that the maximum depth of plant colonization in Thunder Lake is approximately 22 feet. At this depth the littoral zone covers approximately 48 acres, or 35% of the lake bottom.

Within the littoral zone each plant species has a depth preference and a maximum depth at which it can grow. Some plants, such as water lilies, have floating leaves attached at the end of long underwater stalks. Other plants, such as bulrushes, need to extend above the lake surface and are limited to shallow water areas. Submersed plants are limited by the amount of available light, which decreases rapidly with depth. Most aquatic plants are perennials that die back to the sediment surface each year. Others sprout anew from specialized plant fragments (winter buds) lying on the lake bottom. These plants use energy stored in the roots or winter buds to extend upward towards the light each year. They must grow high enough and fast enough to reach the sunlight then grow and export nutrients to the roots to start next year's growth. Some species are more efficient at using limited light resources and are able to grow at greater depth.

The most common plant in Thunder Lake, the macro-algae known as muskgrass, shows no depth preference and is equally abundant in one or twenty-one feet of water. Its relative, stonewort, however was found exclusively in water greater than 10 feet deep. Most of the pondweeds were restricted to a depth range of 3 to 13 feet.

Sediment

Sediment type also plays a major role in aquatic plant distribution and abundance. Sediment preference can be related to physical properties of the sediment (coarseness, grain size, compaction etc.) or in the chemical properties of the sediment such as pH, or nutrient availability.

Rooted aquatic plants get most of their nutrients from the sediment, not the overlying surface water. Because of this, even lakes with low to moderate nutrient levels in the water column can support abundant aquatic plants if sediment nutrient levels and water clarity are sufficient. Sediment that erodes from upland sources is typically high in nutrients while sand typically has low nutrient availability.

Nutrient availability is closely tied to sediment coarseness. What most people refer to as muck is typically silt with a high percentage of organic particles from decomposing plant material. Organic sediment is typically high in nutrients. Sand, by itself can be very nutrient poor, however there is typically sufficient fine silt and organic matter mixed in to provide good growing medium for plants. Rock by itself will not support plant growth but it is often found mixed with sediment that will.

Among the dominant species muskgrass showed no preference for sediment type. Both stonewort and common waterweed displayed a strong preference for muck sediment. Among the pondweeds, only variable leaf was common in sandy or rocky areas, the rest showed a moderate to strong preference for muck sediment. EWM was found growing exclusively in muck sediment

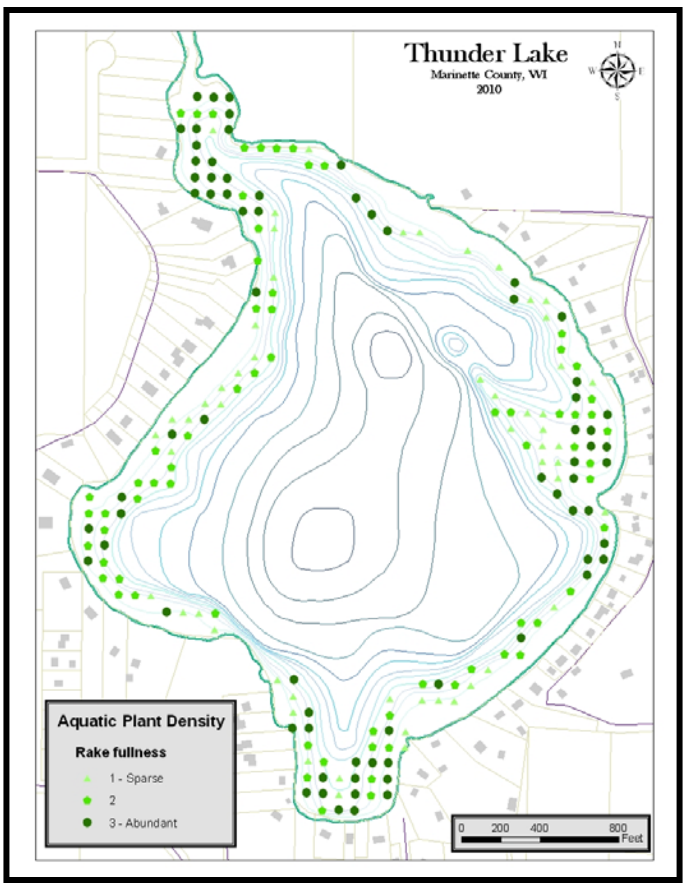


Figure 6. Overall plant density.

Aquatic Plant Abundance

In addition to describing patterns of aquatic plant distribution in Thunder Lake, the survey was designed to determine plant abundance (figure 6). At each sample point a rake "fullness" measure of 1 (sparse) to 3 (abundant) was used to estimate aquatic plant abundance. Abundance was recorded for each species independently and for all plants in aggregate at each site.

Overall plant abundance averaged 2.0 (moderate) at sties shallower than the maximum rooting depth of 22 feet. Abundance was relatively constant over the entire depth range with little variation between deep water and shallow water sites. Abundance did vary considerably by sediment type. Sites with muck sediment had an average plant abundance of 2.2 while vegetation was typically sparse at sandy (1.2) and rocky (0.9) sites.

The aquatic plants most frequently found in Thunder Lake also tended to be the most abundant. Muskgrass had an average rake fullness rating of 2.7 and stonewort had a fullness rating of 2.2. Both have a sprawling growth form that tends to dominate the community where they grow. Most of the large pondweeds, while they appear dominant due to their growth form, had an abundance rating less than 1.5. Where found, Eurasian watermilfoil had an abundance rating of 2.0.

Changes in the Aquatic Plant Community

One-time aquatic plant surveys are useful for describing the aquatic plant community but by themselves do not describe changes in the community. To identify changes the plant community needs to be tracked over time. Fortunately, the Wisconsin DNR conducted a point/intercept survey of the lake in 2006 using identical monitoring protocols. However, the point interval spacing in 2006 was 50-meters, yielding only 62 points shallower than the maximum depth of plant growth. The 2010 survey used a 25-meter spacing for 234 points in the littoral zone. While the 2006 survey was not as comprehensive it provides valuable information that can be used to make qualitative assessments of changes in the plant community.

In both surveys muskgrass was clearly the dominant species with a frequency of occurrence of 61% in 2006 and 70% in 2010. No other plant had a frequency of occurrence above 20% in either year. Stonewort, variable pondweed, and bushy pondweed were also common in 2006 and 2010. Notable differences were seen in the frequency of common waterweed and large-leaf pondweed. Common waterweed increased considerably from 2006 (3.2%) to 2010 (13.2%). Large-leaf pondweed was not identified at all in 2006 but found at 6.8% of the sites in 2010. However, the largest change was found in the frequency of EWM, which was present in 16.1% of the sample points in 2006, but less than 1% of sample points in 2010. Clearly demonstrating the effectiveness of recent control efforts.

Identification of Problems and Threats to the Thunder Lake

Eurasian watermilfoil

The most pressing issue confronting Thunder Lake is the continued expansion of EWM and the threat it poses to the native plant community, navigability, and recreational potential of the lake. Allowed to go unchecked, EWM would likely replace many of the native plants that share similar depth and sediment preferences. These include all of the large native pondweeds, elodea, and muskgrass. Given its preference for muck bottom and water depths between 5 and 15 feet EWM could potentially thrive in more than 16 acres of the lake as shown in figure 7.

Other aquatic invasive species

Future threats to the Thunder Lake include new introductions of aquatic invasive species. Currently nearby waters are infested with zebra mussels (*Dreissena polymorpha*) and the Bay of Green Bay is home to numerous invasive aquatic species, all of which have the potential to impact the lake. In 2007 hydrilla (*Hydrilla verticillata*) was also discovered in a private pond in Marinette County. The plant most likely arrived on ornamental water garden plants that were ordered from a nursery located in an area that is infested with hydrilla. While the infestation appears to have been successfully eradicated, its discovery underscores the continuing threat of invasive species.

Nutrient enrichment

The threat of increasing nutrient enrichment is one shared by most area lakes. As the shoreline of any lake is developed the volume of runoff increases, as does the amount of phosphorus in that runoff.

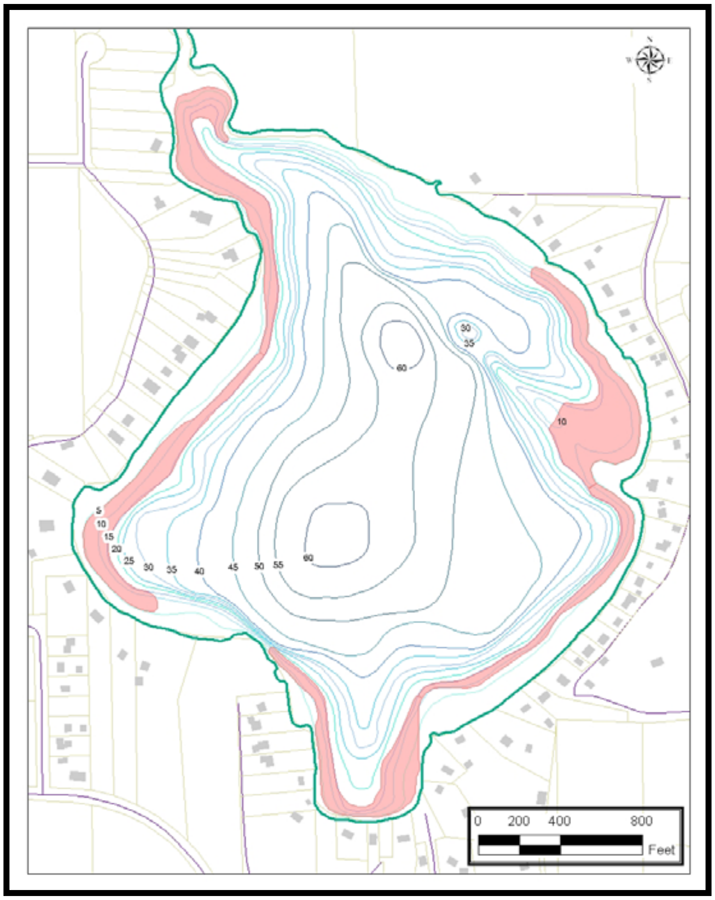


Figure 7. Areas of the lake with suitable EWM habitat.

Many studies have shown that phosphorus loading is directly correlated to the amount of development in a watershed and that phosphorus loading from lawns was eight times higher than from forested areas (WDNR 2003).

The effect of increased phosphorus loading is compounded by long-term climate trends. The Wisconsin Initiative on Climate Change Impacts predicts slightly warmer summers, a continuing trend of less precipitation during the summer months and slightly warmer winters. Annual precipitation is not predicted to change greatly but the distribution is. The prediction is for a wetter spring and winter but a drier summer. The net effect of these changes is a shorter period of ice cover and a longer and warmer growing season. These factors favor increased aquatic plant and/or algae production.

Aquatic Invasive Species Management Goals & Objectives

The goal of the Thunder Island Eagle Area Lakes Association is to: **Develop and implement a sustainable aquatic plant management program for Thunder Lake to reduce the prevalence of EWM and minimize its impact on the native plant community, and to prevent the spread of EWM and other invasive species between area lakes.** To achieve this goal specific management objectives have been identified and targets have been set to gauge success and guide the selection of management options.

Goal: Develop and implement a sustainable aquatic plant management program.

A sustainable aquatic plant management program will be cost-effective and should, as much as possible, be relatively easy to repeat as needed. In determining cost effectiveness the Association needs to consider both management cost and the duration of EWM control. In the final analysis management efforts that cost more may be preferable if they provide multi-year control. Permitting requirements should also be considered and figured into the management "cost".

Objective: <u>Place emphasis on aquatic plant management methods that provide multi-year control and reduce annual management costs.</u>

An aquatic plant management program that is sustainable over the long-term also needs to adapt as environmental conditions and aquatic plant populations change. To make the required adjustments those responsible for making management decisions need current information upon which to base their decisions.

Objective: <u>Track changes in the aquatic plant population so changes can be documented and past management efforts evaluated.</u>

Using an easily repeatable method like the point/intercept monitoring protocol used in the 2010 plant survey is the best way to track changes in the aquatic plant population. With some training in aquatic plant ID and a handheld GPS, lake residents are capable of collecting usable aquatic plant data.

Target *– Provide for two or three Association volunteers to be trained in aquatic plant ID and survey methods. Purchase equipment needed to conduct aquatic plant surveys.*

The recommended frequency of plant surveys depends on the frequency of changes in management methods. When new management methods are adopted surveys should be completed to track changes and determine management effectiveness. If, however management is routine the amount of time between plant surveys can be lengthened. Even in the absence of formal point/intercept surveys landowners should be routinely monitoring the lakes for early detection of new invasive species.

Target *- Conduct pre and post management aquatic plant surveys to evaluate effectiveness of new management tools.*

Target *- Conduct annual surveys of Thunder, Eagle, and Island lakes for new aquatic invasive species according to DNR AIS monitoring protocol.*

Target *- Conduct a full point/intercept survey of Thunder Lake every 5 years unless management conditions call for more frequent surveys.*

For any management program to be sustainable Association members need to understand and take ownership of the program. Good communication is essential so Association members are realistic about the expected outcomes and understand what they as landowners can do to help.

Objective: Communicate effectively with Association members.

While important, effective communication will require more than reports at the annual meeting. The Association should use other avenues to communicate information, goals and outcomes to its members.

Target *- Publish a regular newsletter to keep members informed about management practices and outcomes, and to share success stories.*

Target *- Provide aquatic invasive species educational materials to members.*

Goal: Reduce the prevalence of EWM and minimize its impact on the native plant community.

There are no management tools currently available that will allow for the eradication of EWM once it is established in a lake. The most realistic objective is to minimize its nuisance potential.

Objective: Reduce the frequency and abundance of EWM so that it does not dominate the aquatic plant community.

Since EWM has many competitive advantages that allow it to quickly exploit disturbed areas or suppressed plant communities, control methods that cause widespread disturbance in the aquatic plant community may be counterproductive. Therefore, control methods must be carefully chosen to selectively control EWM. Currently a diverse native community exists even within EWM infested areas. Selective control of EWM in these areas will allow the native community to thrive. A healthy native community resists EWM invasion better than a disturbed plant community.

At its peak in 2008 dense EWM covered close to 8 acres of Thunder Lake and was found at more than 16% of sample points. Since that time, targeted management efforts have greatly reduced the frequency and density of EWM. An appropriate target is to:

Target *– Reduce/maintain EWM frequency of occurrence to less than 5% of sample locations.*

Target *- Reduce the abundance of EWM so that, where found, it is not the dominant submersed plant as measured by rake fullness.*

Goal: Prevent the spread of EWM and other invasive species between area lakes.

Due to their proximity to High Falls Flowage and other high use lakes, Thunder, Eagle, and Island Lakes are at risk of exotic species invasion. Protecting the lakes from new aquatic invasive species and successfully responding to new invaders will require the Association to educate the public and lake residents, be on the lookout for invasive species, and have a plan in place to deal with new invasions.

Objective: Prevent new aquatic invasions, monitor for the presence of aquatic invasive species, and respond to new invasions should they occur.

Any plan for the prevention of aquatic invasive species will require an educational component, a plan to monitor the Lake on a routine basis, and a plan to respond quickly when new invasive species are discovered.

Target – *Develop an information and education program to target residents and visitors who bring watercraft to Thunder Lake from other water bodies.*

Target – *Develop a plan to have volunteers survey Thunder Eagle and Island lakes for aquatic invasive species on a routine basis.*

Target – *Work with local resource agencies to develop a plan for responding to new AIS invasions.*

Aquatic Invasive Species Management Alternatives

A successful aquatic invasive species management strategy must be tailored to the lake and species in question and will typically utilize multiple control methods as appropriate. A comprehensive review of AIS management alternatives follows. While each of the alternatives may be beneficial in certain situations, not all are currently applicable to managing EWM in Thunder Lake.

Do Nothing

Doing nothing is inexpensive, easy to do, and relatively uncontroversial. However, it is rarely effective. Lakes are complicated ecosystems and aquatic plant populations fluctuate within them due to a variety of factors. Large-scale climactic conditions and local weather cycles can impact water levels, temperature, and clarity, all of which effect aquatic plant growth. Plant populations also vary because of disease, species introduction, competition and other internal processes. Left to its own devices the plant community in Thunder Lake will continue to change over time.

In the case of Eurasian watermilfoil, doing nothing typically leads to EWM domination of the aquatic plant community. While the EWM dominance is often thought to be permanent, the history of EWM in Wisconsin shows this is not always the case. Carpenter (1980) reported that the duration of peak abundance in some Lake is approximately 10 years after which EWM may experience a significant decline. While the reason for these "natural" EWM declines is poorly understood some attribute it to a native milfoil weevil (*Euhrychiopsis lecontei*). Unfortunately this natural decline has not been seen everywhere and is not typically permanent. In some Lake EWM populations experience quite a bit of natural variability with periodic declines and subsequent increases without any active management.

In Thunder Lake the EWM was relatively "well behaved" for several years after its introduction but seems to have expanded considerably in the last few years despite biological control efforts with the milfoil weevil. In this case, doing nothing will likely lead to continued increased EWM abundance to the point where it becomes a serious nuisance.

Chemical Control

When properly planned and executed, chemical control of aquatic plants can be effective. However, if care is not taken in the selection timing, and application of aquatic herbicides the results can be less than desirable, or worse, have unintended consequences.

There are several herbicides approved for aquatic use in Wisconsin and each differs in its mode of action and in the species it controls. Contact herbicides kill exposed plant material but can leave the root system intact, allowing for rapid recovery and plant growth. Systemic herbicides are transported to the roots and kill the entire plant. Systemic herbicides provide longer-term control but may act slower than contact herbicides.

Herbicides can also be grouped into two general groups, "broad-spectrum" and "selective". Broad-spectrum herbicides control a relatively broad range of plants. Selective herbicides, as the name implies, are more-or-less selective and control fewer species while leaving others unharmed. Often selectivity is a function of application timing or herbicide concentration.

Eurasian watermilfoil (EWM) is very susceptible to several common aquatic herbicides. The plant is especially susceptible to formulations of 2,4-D, a systemic herbicide. Since most pondweeds and many other native aquatic plants are resistant or only slightly susceptible to 2,4-D the chemical can be used to selectively control milfoil while protecting many native species (Parsons, 2001). The best results have been seen with 2,4-D when treating early in the growing season, before the water temperature reaches 60 degrees F. Recommended treatment rates vary by depth and size of the treatment area. In Thunder Lake most of the EWM was found in water between 10 and 15 feet deep. In early May of 2009 an application of Navigate 2,4-D at 200 lbs/ac was very successful at controlling the EWM with no discernable impact on the dominant native plants in the treatment area.

When used in a selective manner it is possible to get multi-year control from herbicides. This is most likely to be achieved when the native community is relatively vigorous and can resist EWM reestablishment. Eventually EWM will return so even selective management will have to be repeated on a regular basis.

Good results have been seen on some lakes using low dose Fluridone to treat EWM. Fluridone is a newer systemic herbicide that acts slowly to kill target plants. Fluridone is only appropriate for whole lake treatments because the chemical concentration must be maintained for 60 to 90 days. This requires routine monitoring of herbicide levels and may require follow-up applications. While many native species are not susceptible to low doses of Fluridone, studies in Wisconsin Lake found that common waterweed and bushy pondweed are both susceptible at concentrations required to treat EWM (Wagner, 2007). Since common waterweed and bushy pondweed are both dominant species in Thunder Lake Fluridone may not be the best chemical to use.

Improper or excessive use of aquatic herbicides can have unintended consequences. Widespread use of broad-spectrum herbicides can leave large areas of suitable habitat exposed to colonization by nuisance species. Many of the more common nuisance plants, such as EWM, are aggressive pioneer species that can quickly invade disturbed areas. The decomposition of tons of aquatic plants also releases large amounts of nutrients to the water column. These nutrients can trigger algae blooms and fuel additional aquatic plant growth

Chemical treatment cost depends on the chemical formulation and application rate, the distance a certified applicator has to travel, and the time and equipment involved. In 2010 EWM treatment with Navigate granular 2,4-D could be expected to cost between $500.00 and $900.00 per acre depending on the application rate and size of the treatment area. Fluridone is rather expensive, costing up to $2,000.00 per acre if sequential treatments are required. In some instances the State of Wisconsin can provide funding for chemical treatment of Eurasian watermilfoil or other lake restoration activities recommended in a lake management plan approved by the DNR.

Chemical treatment of aquatic plants in Wisconsin always requires a permit from the Wisconsin DNR. This is to ensure that the proposed chemical treatment will use appropriate chemical(s), at the correct concentration and at the proper time of the year. In almost all situations the chemical applicator must have Wisconsin Department of Agriculture Trade and Consumer Protection certification.

Benthic Barriers

Benthic, or sediment barriers cover the sediment and prevent the growth of aquatic plants. The barriers work by physically disrupting plant growth or eliminating light at the sediment surface. When installed properly benthic barriers are very effective at eliminating all plant growth. However the difficulty of installing and maintaining these barriers prevent their widespread use.

Benthic barriers can be made of naturally occurring materials (sand and gravel) or artificial (synthetic plastic sheeting). Sand or pea gravel is commonly used to create weed-free swim areas. However, there are several common problems with sand and gravel benthic barriers. If deposited on soft sediment it can sink in and mix with the native sediment. Also, over time new sediment is deposited on top of the barrier. These factors will lead to eventual failure of the barrier.

Artificial barriers typically consist of sheets of polypropylene, polyethylene, fiberglass or nylon (Wagner 2004). All must be weighted to hold them in place against water currents, waves, and boat wakes. If constructed of non-porous material benthic barriers will be subject to billowing and may float free of the sediment as gasses from decomposition build up beneath them. Porous barriers are less subject to billowing but plant fragments that settle on top are better able to root through them. Both types of barriers require annual maintenance since sediment accumulation on top of the barriers will build up and support new aquatic plant growth.

Artificial benthic barriers are also relatively expensive and difficult to install and maintain. Maintenance consists primarily of annually removing accumulated sediment, which typically requires removal and replacement of the barrier. The use of any type of benthic barrier requires a DNR permit.

Dyes and Floating Covers
Dyes are liquid chemicals that are applied to change the color of the water. Covers physically cover the water surface. Both control aquatic plants by reducing the amount of light reaching the sediment.

Dyes typically color the water a deep blue or even black. For small ponds they are relatively inexpensive, long lasting, and effective. Effectiveness is limited in shallow water (2 feet or less) where the light reduction is seldom enough to prevent plant growth. Dyes must stay in the water throughout much of the growing season. Because of their dark color, dyes increase light absorption and can result in higher water temperatures. The increase water temperature can in-turn result in stronger stratification, lower dissolved oxygen and widespread changes in the aquatic community (Wagner 2004). Dyes are not an option in larger lakes and those with significant outflow.

Floating covers also disrupt plant growth by reducing light levels at the sediment surface. However, unlike dyes the floating covers prevent virtually all water use while they are in place. Floating covers can be difficult to install and effectively anchor.

Both dyes and floating covers require DNR permits. The main permitting issue with floating covers is the disruption of public water rights (fishing and navigation) that they cause while installed.

Automated Mechanical Bottom Disturbance
Several automated systems exist that control plants by physically disrupting them throughout the growing season. Modes of action include physically raking or rolling over the sediment, or spraying the sediment with jets of water. The Weed Roller™ is one of the more common devises. It has a central motor that attaches to a dock, boatlift or other fixed point. The motor slowly drives a series of cylindrical rollers back and forth across the bottom of the lake in an arc of up to 270 degrees. Fins on the rollers disturb the sediment and plants, removing existing plants and preventing the establishment of new ones.

In two studies weed rollers were found to cause a significant reduction in fine sediment and a nearly complete elimination of aquatic plants (James 2004, James 2006). Sediment displaced from the site was often deposited immediately outside of the impacted area.

These devices are only appropriate for small areas in shallow water to maintain swimming areas etc. Negative environmental impacts include sediment disturbance, which may lead to local increases in turbidity and suspended phosphorus. This may lead to major nutrient increases if the practice is widespread. While studies have not been conducted on the impact these devices have on aquatic organisms, the periodic bottom disturbance likely reduces or eliminates many aquatic insects and would surely prevent successful fish spawning in the impacted area.

Cost for the Weed Roller™ starts at approximately $3,000 for motor, mounting hardware, and a 21-foot roller (2009 pricing). Other comparable devises have similar price tags. This and other automated mechanical bottom disturbing devises require a Wisconsin DNR permit.

Manual Plant Harvesting

Manual plant harvesting is a widely accepted aquatic plant management alternative that can be effective on a small scale. Individual landowners often manually clear small areas around their dock or swim area. Typically this is accomplished by using one of several specially designed aquatic plant rakes and/or hand-held cutting implements. Under current Wisconsin Law landowners can manually harvest plants without a permit if the plant removal is not in a DNR designated sensitive area and is limited to a 30-foot wide area (measured parallel to shore). There is no limit on how far out into the lake a landowner can harvest by hand if they stay within the 30-foot wide corridor. The control area must be around existing piers, boat lifts, and swim rafts and the cut plants must be removed from the water. Manual removal of exotic invasive species does not require a DNR permit.

Manual harvesting can be effective as a "mop-up" operation where EWM growth is widely scattered and/or very limited in density. Manual removal is best accomplished by marking visible EWM plants with buoys from the surface while divers remove the plant and its root system. For hand pulling a good technique is for the diver to wrap larger plants around his or her forearm then reaching into the sediment to pull as many roots as possible. Plants and roots can be placed in a fine mesh bag such as a laundry bag. A stiff wire can be added to the rim so the bag stays open underwater.

Suction Harvesting

Suction harvesting is a form of hand pulling with the assistance of an underwater vacuum system to transport harvested plants to the surface. The suction harvester consists of a gasoline powered venturi pump on a pontoon boat with tanks for filtering out the harvested plants and fragments before returning the water to the lake. A diver controls the suction hose, using it like a shop-vac to suck up plants and root systems that are dislodged by hand. Using this method a diver can "harvest" far more plants than by hand pulling alone while preserving the surrounding native plants.

Like hand pulling, suction harvesting works best where water clarity is good so plants can be seen and marked from the surface and where the EWM can be easily distinguished from other plants in the lake. In these respects Thunder Lake is an ideal lake for manual EWM removal. The water clarity in Thunder Lake is typically excellent and the dominant native plants are typically low growing and form a mat on the lakebed. EWM in Thunder tends to stand out and be readily identifiable.

Use of a suction harvester to remove plants would require a DNR permit for harvesting. Since any sediment removal is minimal and incidental to plant harvesting this method has not required a dredging permit.

Mechanical Plant Harvesting
Large scale harvesting is typically accomplished using specially designed aquatic plant harvesters that cut and collect aquatic plants in one operation. The size and capacity of these harvesters varies greatly but the larger ones can cut a 10-foot wide swath up to 6 feet deep and hold more than 16,000 lbs of cut plants.

Like most aquatic plant management alternatives does not eliminate plants. Much like cutting your lawn, harvesting leaves the root system intact and plants will re-grow. In some cases repeated harvesting close to the sediment surface can stress plants enough to cause mortality. Species that depend on seed production for their spread may be partially controlled by harvesting if seeds are repeatedly removed.

Plants that spread by fragmentation such as EWM and coontail can actually be spread through harvesting when cut fragments escape the harvester and drift to other areas of the lake. For this reason, harvesting should only be used as a tool for managing EWM if the plant has already taken over a lake. With early infestations, or where EWM growth is limited, harvesting will likely increase the rate of spread throughout the lake.

Large Scale mechanical harvesting can be an expensive proposition. Commercial harvesting is available in Wisconsin and can range from $300 to $500 per acre plus travel costs. As with many services the unit cost is typically lower when the harvest area is larger. The Wisconsin Lakes website has information regarding private commercial harvesting vendors.

Typically when a lake undertakes a long term harvesting program they purchase and operate their own equipment. Initial costs for a new harvester can range from $50,000 to $100,000 depending on the size of machine. A truck is also required to transport plants to a disposal site and a shoreline conveyor to transfer cut plants from the harvester to the truck. Wisconsin does provide financial assistance for harvester and related equipment purchases through the Wisconsin Waterways Commission. Grants are awarded on a competitive basis and cover 50% of equipment purchase price. Operating and maintenance costs vary depending on the amount of use and the labor source. While volunteer operators are of course free, in the long run it may be best for the equipment and for the harvesting program to hire a dedicated harvesting crew to operate and maintain such expensive and complicated equipment.

According to WI. Administrative code NR109 A Wisconsin DNR permit is required to harvest aquatic plants using any mechanical device powered with a gas or electric motor. A DNR approved aquatic plant management plan is required to obtain a harvesting permit. An approved plan is also required for a Waterways Commission harvester grant.

Biological Plant Control
Biological control (biocontrol) typically utilizes bacteria, fungi, or insects to control an unwanted plant. Biocontrol of exotic species often involves finding the natural control mechanism in the exotic plants country of origin and importing it to the US. Since there is always a risk that introducing a new organism may lead to unintended impacts to non-target species a lot of study is required to approve the use of new biocontrol agents.

In a rather unusual twist, one of the most promising biocontrol agents for Eurasian watermilfoil is a native insect. The milfoil weevil (*Euhrychiopsis lecontei*) is a native species that normally feeds on northern water milfoil. The adult weevil lays its eggs on the growing tips of milfoil where the larvae feed and weaken the plant. Older larvae also burrow into the stems, often causing enough damage to cause the plants to loose buoyancy and sink. The stout stems and shoots of northern water milfoil typically show little damage from this feeding activity. Eurasian water milfoil however has relatively weak stems that are readily damaged by the insects. Studies have shown that milfoil weevils actually prefer EWM and increase in population when EWM is the dominant food source (Lillie, 1997). It's believed that the natural decline in EWM infestations in some Lake may be due to the native milfoil weevil that has been found to be widespread in Wisconsin lakes (Jester, 1998).

Since its discovery as a control agent "stocking" milfoil weevils to control Eurasian watermilfoil has been used with mixed results. In Wisconsin it was found that in twelve lakes where weevils were stocked a few experienced milfoil declines while others saw little or no change (Jester 1999). Several factors seem to affect the success of EWM biocontrol. Jester found better results when EWM had already reached its maximum distribution. The study also found that weevil density was positively correlated with increasing water temperature, distance of plant beds from shore (closer was better), and the percent of natural shoreline. The amount of natural shoreline is important because the adult weevils over winter in leaf litter on the forest floor within several yards of the water. Other studies have found that sunfish species (bluegill, pumpkinseed etc.) are very efficient predators of milfoil weevils and play a major role in reducing their effectiveness (Newman 2004, Ward 2006). Environmental factors such as winter severity, disease, etc. can also affect weevil abundance and may play a role in variable biocontrol results.

In 2001 the T.I.E Lakes Association contracted with EnviroScience Incorporated to conduct a milfoil biocontrol program. Approximately 13,000 weevil eggs and larvae were stocked at five sites throughout the lake. While EnviroScience did report reductions in biomass at the weevil stocking sites, the results were not long-lived. An additional 9000 adult weevils were stocked in the summer of 2005. No follow-up survey was conducted after the 2005 weevil stocking.

In general, the Lake Association has not been satisfied with the results of the biocontrol efforts and have discontinued weevil stocking. This previous experience along with the significant expense (more than $1.70 per weevil) makes it hard to recommend continued weevil stocking as a control measure.

Exotic Species Monitoring and Prevention

As is often the case, an ounce of prevention is worth a pound of cure. With exotic species this is doubly true. In most lakes, and for most exotic species, the primary mode of introduction is by boat, trailer, or bait bucket. While public access points are particularly susceptible, many exotic species have been introduced on lakes without any public access.

Once established in a water body it is extremely difficult to eradicate an exotic species. In the few cases where eradication has been successful the introduction was detected early. For this reason routine monitoring to detect new invasive species is an important step in any aquatic plant management effort. The Wisconsin DNR and University of Wisconsin Extension have many good publications and websites to help the layperson identify exotic species. Periodically these agencies also offer exotic species identification and control training to landowners.

AIS Management Recommendations

Over the past three years the T.I.E. Area Lakes Association has made significant progress in controlling EWM in Thunder Lake. Currently EWM is far less abundant than it has been in the past and occupies a fraction of its potential habitat. The association should continue to use all available options for the long-term control of EWM as conditions warrant.

Recommendation #1 – Form an aquatic invasive plant committee to coordinate EWM control efforts. The Association should appoint a committee to oversee efforts to track EWM populations, recommend an annual management strategy, and coordinate information and education efforts.

Recommendation #2 – Continue early season herbicide treatment of large EWM colonies. Past experience shows that larger EWM colonies can be successfully controlled with an early season application of Navigate 2,4-D. Good results have been seen in water up to 12 feet deep with an application rate of 200 lbs/acre conducted before the water temperature reaches 60 degrees F. The Association should consult with the Marinette County LWCD for assistance with mapping larger EWM colonies and setting up treatment blocks.

Recommendation #3 – Control small EWM colonies and isolated plants with manual harvesting. Manual harvesting is an effective method for eliminating isolated EWM plants and small groups of plants. For best results the plants, roots, and plant fragments need to be removed.

For very small colonies or widely scattered single plants hand pulling can be used. However, to greatly improve efficiency and reduce the amount of herbicide treatment required, the Association should consider acquiring a suction harvesting system. This would reduce the need for chemical control.

Recommendation #4 – Conduct routine EWM reconnaissance on Thunder Lake. The timing and frequency of EWM reconnaissance is dictated by the chosen control methods. Each year in the late summer or early fall all areas of dense EWM growth should be mapped using GPS to track changes in the plant community, evaluate past management efforts, and facilitate an early season herbicide treatment if needed. More frequent reconnaissance and marking may be needed to guide manual and/or suction harvesting efforts.

Recommendation #5 –Utilize Aquatic Invasive Species Implementation Grants for EWM control efforts. The T.I.E. Area Lakes Association should consider applying for an aquatic invasive species control grant. These grants pay 70% of the cost of EWM control efforts including herbicide treatments, suction harvesting, and required plant monitoring.

Recommendation #6 – Reduce nutrient loading to the lake from developed shoreline properties. The Wisconsin Legislature recently banned the use of lawn fertilizer containing phosphorus except where soil tests show it is in short supply. Still, the Association should promote the wise use of fertilizer (if any) on lakeshore properties. It is recommended that applications of nitrogen be limited to 3-4 lbs of nitrogen per 1000 square feet annually.

The Association should also promote the restoration of natural shorelines. These "shoreline buffers" reduce pollutant loading primarily by increasing infiltration. Additional benefits include improved shoreline habitat and less time spent mowing! The Marinette County LWCD has limited cost-share funds available to defray the cost of shoreline habitat restoration.

Monitoring and Evaluation Plan

In order to evaluate and make changes to the management program the Association needs to track changes in the aquatic plant community. The management plan also needs to be evaluated on a regular basis and changed to meet shifting needs and address new challenges.

Recommendation #1 – Conduct aquatic plant surveys to evaluate management effectiveness and track changes to the lakes aquatic plant community. Surveys of the aquatic plant community should be completed with the application of any new management tool. For herbicide use, aquatic plant surveys should be completed before and after the treatment in and around areas to be treated.

Periodically the entire lake should be surveyed to evaluate lake-wide changes to the plant community. These routine surveys should be completed approximately every 5 years. Sooner if sudden changes in the plant community are noticed. All plant surveys should be completed using the same DNR point/intercept aquatic plant sampling protocol used in the 2010 plant survey.

Where State grants are obtained to assist in aquatic plant management the cost of professional aquatic plant surveys can be included in the grant. Eventually however the Association should develop this capability from within its own ranks. The DNR and Wisconsin Lakes Partnership have many aquatic plant ID resources and offer periodic aquatic plant identification training. The Marinette County Land & Water Conservation Division can also assist.

Recommendation #2 – Appoint a committee to annually evaluate the aquatic plant management program and recommend changes to the Board. The T.I.E. Area Lakes Association should appoint an aquatic invasive plant committee to coordinate management activities, oversee data collection, and preserve aquatic plant management data. The committee should evaluate the management program and recommend changes to the Association Board.

Information & Education Plan

With aquatic invasive species (AIS) an ounce of prevention truly is worth a pound of cure. A strong information and education effort is an important part of any AIS prevention program. It is also important to effectively communicate with Association members when trying to implement a flexible aquatic plant management plan.

Recommendation #1 – Maintain signage at public access points and provide educational materials to visitors to Thunder, Eagle, and Island Lakes. Maintain educational signage at the Thunder Lake boat landing and the Eagle Lake carry-in access to inform visitors about the danger of AIS and how they can help prevent the spread. Signage should be clear and uncluttered. Handouts should be provided to boaters through the "Clean Boats, Clean Waters" program during busy periods. Signage and educational materials can be obtained from the Peshtigo DNR office or on line at the Wisconsin Lakes Partnership website **http://www.uwsp.edu/cnr/uwexlakes/CBCW/pubs.asp** .

Recommendation #2 – Publish a regular newsletter, provide educational materials, and update lake residents about AIS management efforts. The Association should publish a regular newsletter as a way of distributing educational materials and keeping members abreast of lake management issues. E-newsletters can be a cost effective alternative or supplement. The Association should also sign members up to receive the Lake Tides Newsletter, a free quarterly publication by the Wisconsin Lakes Partnership.

Recommendation #3 – Continue as a member of Wisconsin Lakes and take advantage of their resources. Wisconsin Lakes (formerly known as the Wisconsin Association of Lakes) is a statewide lake organization that promotes sound lake policy and provides training opportunities for lake groups throughout the state. The Association should send a few members each year to the annul lakes convention, a three day event featuring numerous speakers, workshops and presentations concerning lake management, operating effective lake organizations, and other current issues affecting lakes.

Aquatic Invasive Species Prevention, Monitoring and Rapid Response Plan

Unfortunately, Eurasian watermilfoil is not the only aquatic invasive species threatening our lakes. South of Marinette County curly-leaf pondweed (*Potamogeton crispus*) is an emerging problem. Other species including Hydrilla (*Hydrilla verticillata*), Brazilian waterweed (*Egaria densa*) and yellow floating heart (*Nymphoides peltata*) have been spreading north and may threaten our lakes in the future. Beyond the plant world we have Zebras mussels (*Drissena polymorpha*), Rusty crayfish (*Orconenctes rusticus*), exotic zooplankton, and fish diseases such as VHS to worry about. The best way to deal with these invaders is to be proactive and prevent their introduction. The T.I.E. Area Lakes Association should also adopt an exotic species monitoring plan to detect early invasions and a rapid response plan to deal with new invasive species if they are found.

Prevention

An effective AIS prevention plan should focus on the most common routes of AIS invasion, boats, and water gardens. Boats traveling between lakes can carry plant fragments or zebras mussels attached to the boat or trailer. Water in the boat or bait buckets can carry plants, zebra mussels, zooplankton, algae, and disease causing organisms. While the information and education program can provide valuable information regarding the spread of AIS a more effective case can be made when delivering the message face-to-face.

Recommendation #1 – Continue with the "Clean Boats, Clean Waters" watercraft inspection and information campaign. Additional volunteers should be trained to conduct watercraft inspections and talk to boaters about the danger of spreading invasive species. This is a good project in which to get youth involved. The Wisconsin Lakes Partnership sponsors the CBCW program.

Recommendation #2 – Promote/support watercraft inspection and AIS education at nearby source waters. Studies show it is more efficient to target AIS efforts at the source waters than at the receiving water. In Marinette County the most likely source waters are Green Bay, High Falls Flowage, Cauldron Falls Flowage, Lake Noquebay, and the Menominee River Flowages. The Association should promote and support AIS education and watercraft inspection efforts at these waters.

Recommendation #2 – Focus education efforts on the dangers of water gardening and the unintentional releases associated with the hobby. The most important pathway for introduction of AIS is through the movement of watercraft between waterbodies. Increasingly, however, intentional and unintentional introductions have been traced to private water gardens. A recent investigation of the water garden industry found that plants known to be invasive are available and routinely shipped around the country. Contamination of orders with other species, including invasive species, is also rampant (Maki, 2004). AIS education efforts aimed at lake residents and visitors should focus on these modes of infestation.

Recommendation #4 – Keep current on AIS prevention and management strategies. Work with the Marinette County AIS coordinator and the Peshtigo DNR office to maintain current knowledge of evolving AIS threats, prevention strategies, and management strategies. The Wisconsin DNR website **http://dnr.wi.gov/invasives/** contains up-to-date AIS information and regulations (Chapter NR 40).

Monitoring

Effective management of aquatic invasive species is much easier when the invader is detected early. In some cases it may even be possible to eradicate an invasive species if it is discovered early enough.

Recommendation #1 – The Association should continue participation in the Citizen Lake Monitoring Network and train several members in AIS monitoring procedures. While the information & education program should equip all Association members with a basic knowledge of invasive species, several should be trained specifically for AIS monitoring. The Marinette County LWCD in cooperation with the Citizen Lake Monitoring Network (CLMN) holds workshops to train volunteers in AIS monitoring protocols focused on detecting several aquatic invasive species including plants, snails, minnows, mollusks, and zooplankton. The Citizen Lake Monitoring website contains valuable AIS monitoring tools and information about the AIS monitoring program. (http://www4.uwsp.edu/cnr/uwexlakes/clmn/).

Recommendation #2 – Volunteer AIS monitors should conduct annual AIS surveys of the lakes. Aquatic plant surveys, although very beneficial, are not designed to find many types of aquatic invaders and may even miss pioneer plant invasions. A better method is to look specifically for different invasive species at the optimal time and in the most likely habitats. The ideal monitoring time varies by species but can typically be covered with one early and one late season survey.

Trained volunteers should conduct annual invasive species surveys. Findings should be reported to the Association Board and the Citizen Lake Monitoring Network.

Recommendation #3 – Report any suspected aquatic invasive species to local resource professionals. If any suspected exotic species are found report it immediately to the Peshtigo DNR office or the County LWCD. Collect a sample of any suspected exotic species and keep it wet and refrigerated in a zip-lock bag until it can be positively identified.

Rapid Response

When a new invasive species is positively identified the Association needs to act quickly. Depending on the species found, length of time since invasion, and where the pioneer colony is found, there may be a possibility for eradication. The following steps should be followed:

Step #1 – Notify Association Board and local resource agencies and explore grant funding opportunities. The Association Board should immediately notify the Wisconsin DNR, arrange a meeting to explore control measures, and determine if and AIS Rapid Response grant is advisable. These grants are designed to deal with pioneer AIS infestations. The typical grant application process is bypassed so grant funds can be made available for quick action in hopes of eradication or control.

Step #2 – Notify membership of the discovery and what the Board plans to do about it. Notify Lake Association members of the discovery and measures they can take to prevent its further spread within the lake or to other waters. Let them know how the Board plans on dealing with the invasion.

Step #3 – Conduct a thorough survey of the lake to determine the extent of the AIS infestation. Working with County or DNR staff, conduct a thorough survey of the lake. Map location of the invasive species and record its density as well as any other physical data that may be important such as water depth, sediment type etc.

Step #4 – Determine if eradication is a possibility or if management is the only option. Work with local resource agencies and outside experts where necessary to determine if eradication is possible. Where eradication is not feasible begin revising the lake management plan to deal with the new species.

Step #5 - Develop an action plan based on species and extent of invasion. Work closely with the experts to develop a customized plan aimed at eradication or control. If outside consultants are needed for things like herbicide treatment or scuba diving bring them into the process early. Many consultants can also help with things like mapping and planning.

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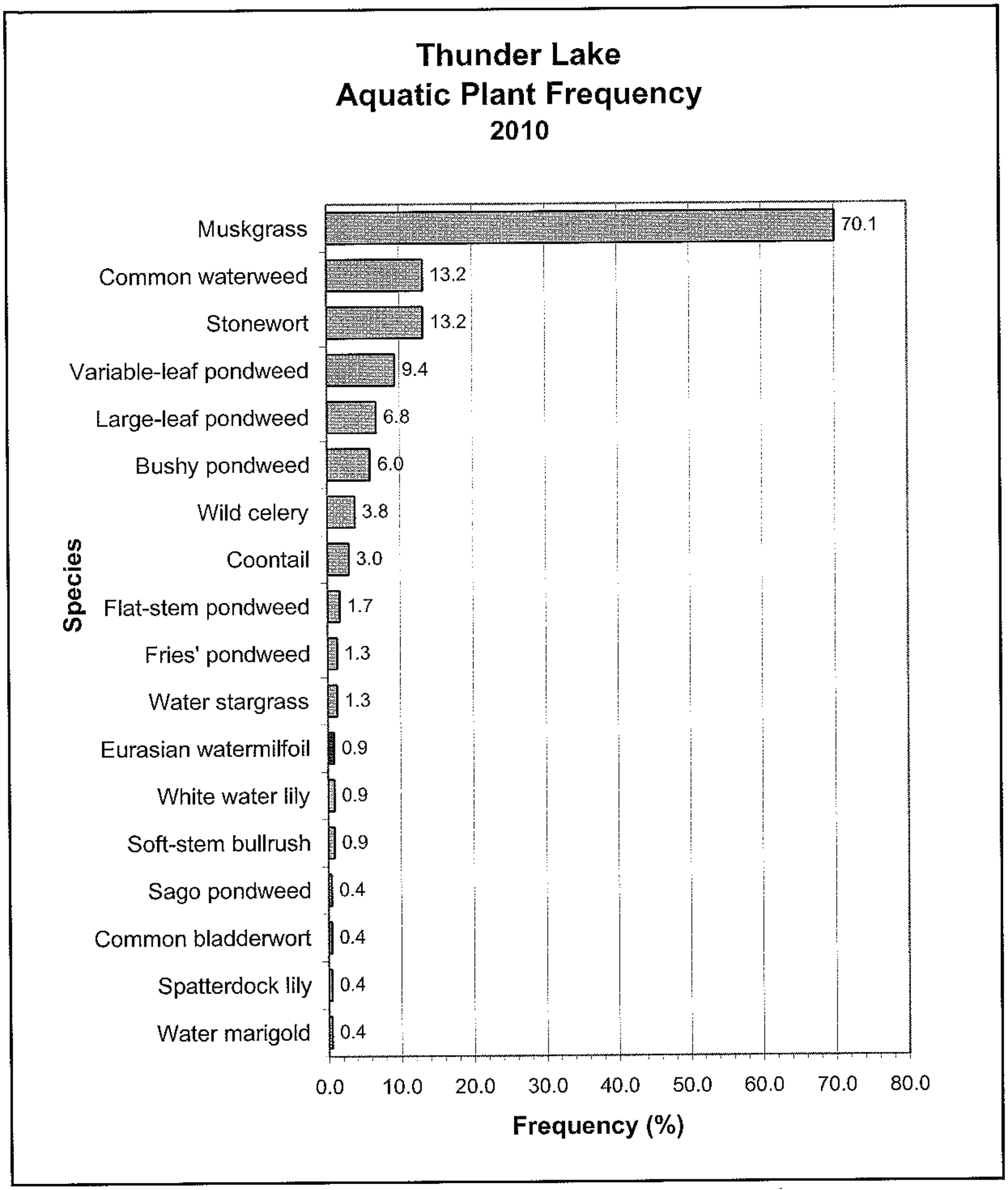
Aquatic Invasive Species Management Plan
For
Thunder Lake

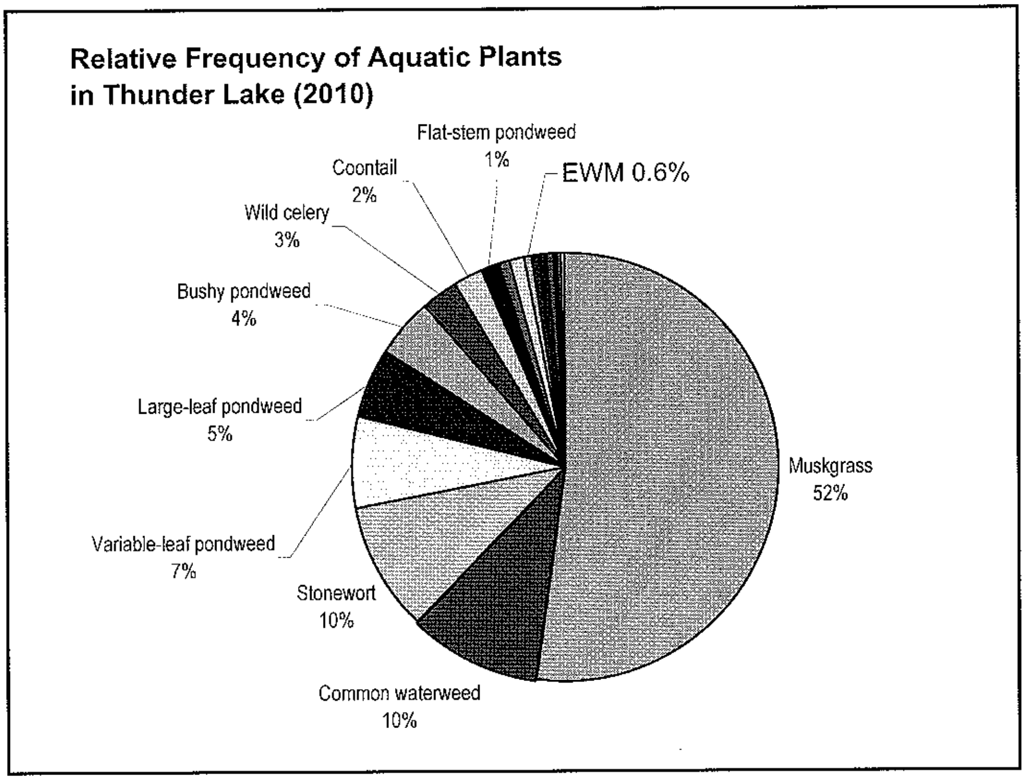
Appendix A

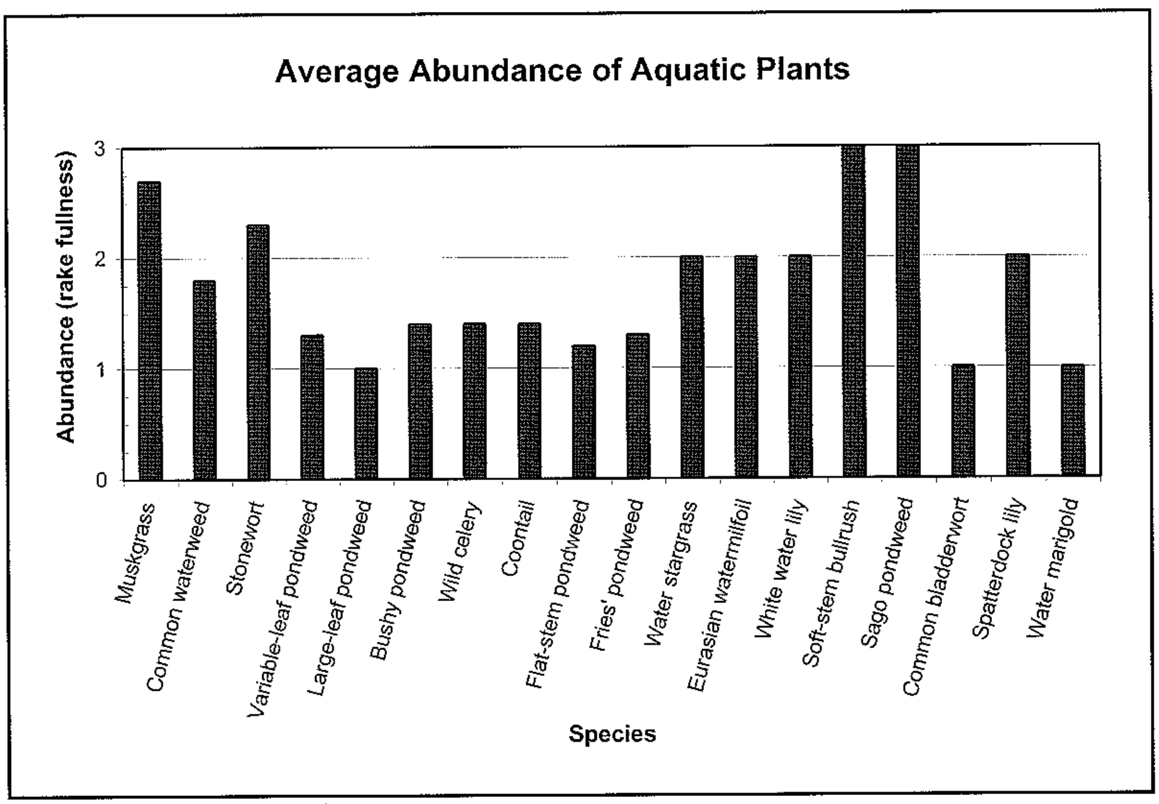
Aquatic Plant Survey Data

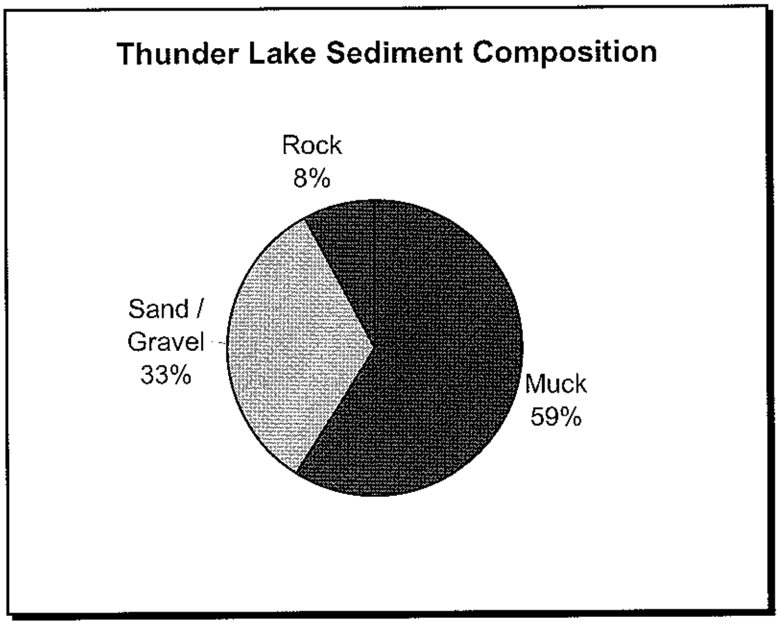
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	**STATS**	Total vegetation	Myriophyllum spicatum	Potamogeton crispus	Chara sp.	Potamogeton amplifolius	Elodea canadensis	Nitella sp.	Najas flexilis	Potamogeton fresii	Ceratophyllum demersum	Potamogeton gramineus	Stuckenia pectinata	Vallisneria americana	Potamogeton zosteriformis	Zosterella dubia	Utricularia vulgaris	Nymphaea odorata	Nuphar variegata	Scirpus validus	Bidens beckii	Potamogeton richardsonii	Polygonum amphibium	X
2	Thunder Lake																							
3	Marinette																							
4	533600																							
5	07/12/10																							
6	**INDIVIDUAL SPECIES STATS:**																							
7	Frequency of occurrence within vegetated areas (%)		1.01		82.83	8.08	15.66	15.66	7.07	1.52	3.54	11.11	0.51	4.55	2.02	1.52	0.51	1.01	0.51	1.01	0.51			
8	Frequency of occurrence at sites shallower than maximum depth of plants		0.85		70.09	6.84	13.25	13.25	5.98	1.28	2.99	9.40	0.43	3.85	1.71	1.28	0.43	0.85	0.43	0.85	0.43			
9	Relative Frequency (%)		0.6		52.2	5.1	9.9	9.9	4.5	1.0	2.2	7.0	0.3	2.9	1.3	1.0	0.3	0.6	0.3	0.6	0.3			
10	Relative Frequency (squared)	0.30	0.00		0.27	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
11	Number of sites where species found		2		164	16	31	31	14	3	7	22	1	9	4	3	1	2	1	2	1			
12	Average Rake Fullness	2.09	2.00		2.70	1.00	1.84	2.32	1.43	1.33	1.43	1.32	3.00	1.44	1.25	2.00	1.00	2.00	2.00	3.00	1.00			
13	#visual sightings		2		5	11	1		1	1			1		2					5		1	1	
14	present (visual or collected)		present		present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	
15																								
16	**EXOTICS SPECIES STATS:**																							
17	# at surface		0																					
18	# within 1 ft of surface		0																					
19	# > 1 ft from surface		0																					
20	# sparse		0																					
21	# dense		0																					
22	# unknown		0																					
23																								
24	**SUMMARY STATS:**																							
25	Total number of points sampled	470																						
26	Total number of sites with vegetation	198																						
27	Total number of sites shallower than maximum depth of plants	234																						
28	Frequency of occurrence at sites shallower than maximum depth of plants	84.62																						
29	Simpson Diversity Index	0.70																						
30	Maximum depth of plants (ft)	22.00																						
31	Number of sites sampled using rake on Rope (R)	70																						
32	Number of sites sampled using rake on Pole (P)	0																						
33	Average number of all species per site (shallower than max depth)	1.34																						
34	Average number of all species per site (veg. sites only)	1.58																						
35	Average number of native species per site (shallower than max depth)	1.33																						
36	Average number of native species per site (veg. sites only)	1.58																						
37	Species Richness	18																						
38	Species Richness (Including visuals)	20																						

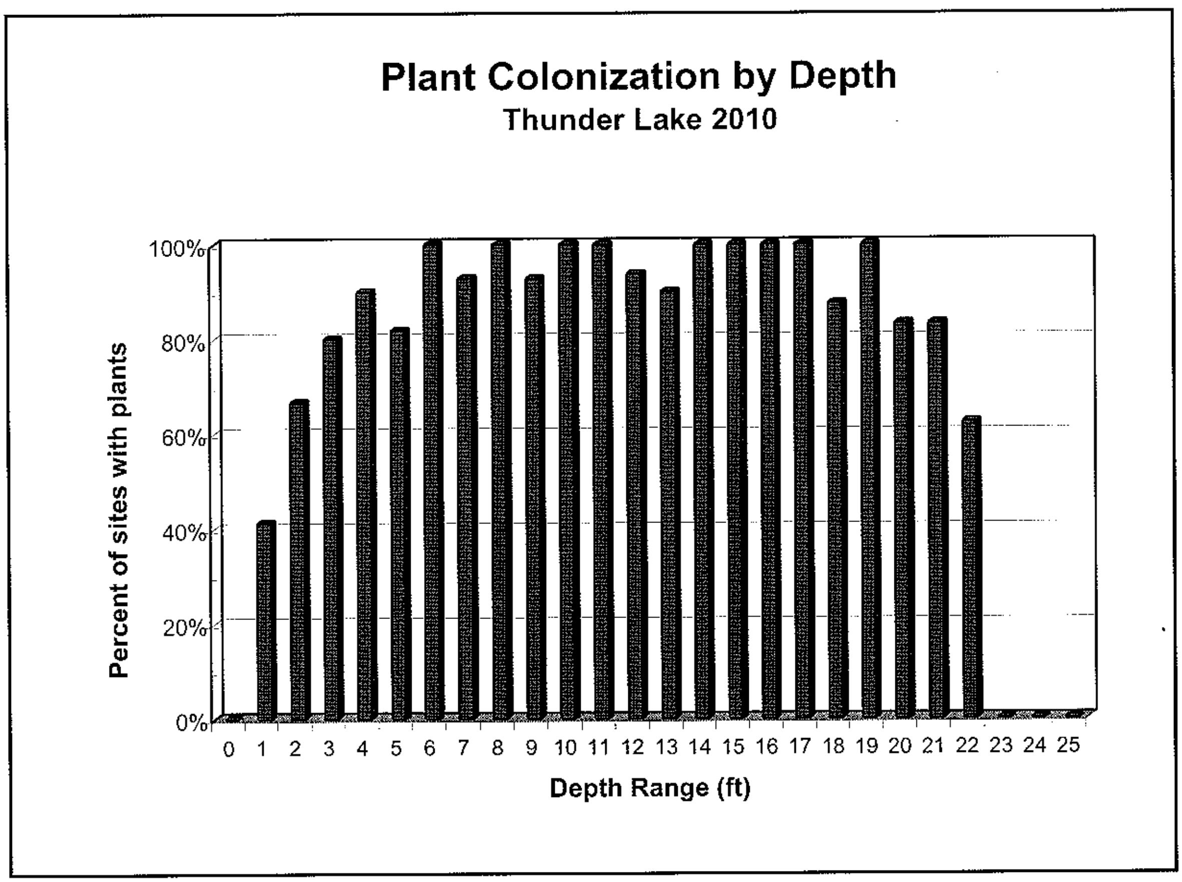


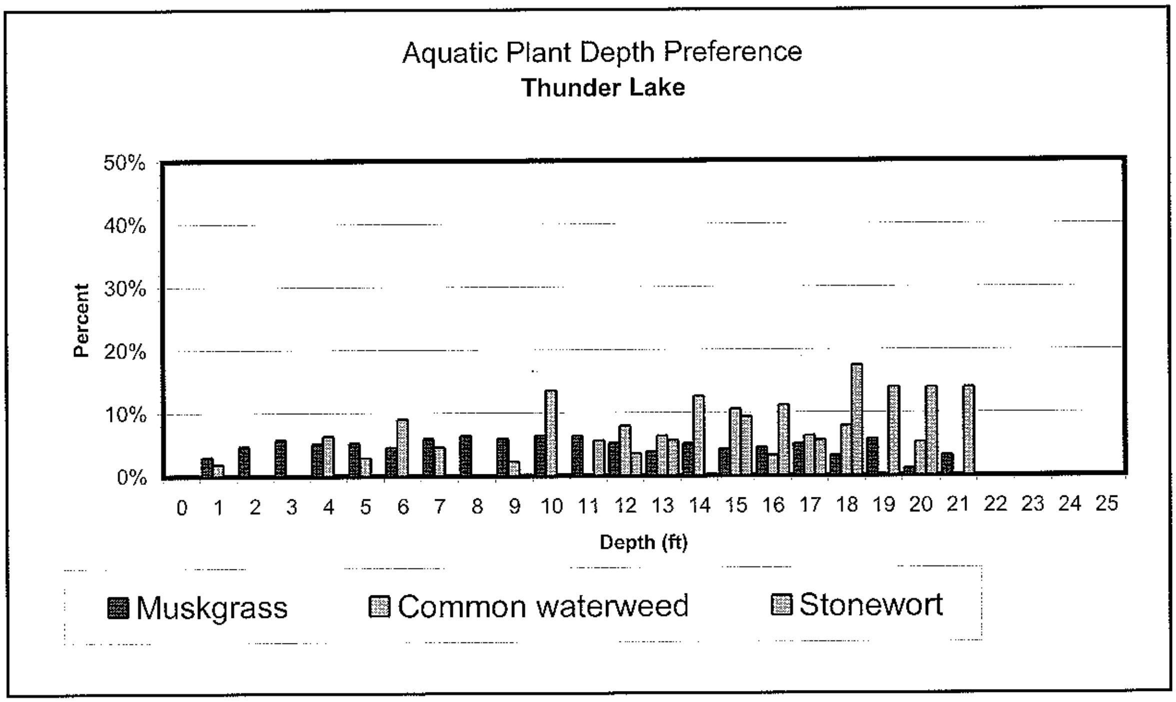
Thunder Lake
Aquatic Plant Frequency
2010
Muskgrass
Common waterweed
Stonewort
Variable-leaf pondweed
Large-leaf pondweed
Bushy pondweed
Wild celery
Coontail
Flat-stem pondweed
Fries' pondweed
Water stargrass
Eurasian watermilfoil
White water lily
Soft-stem bullrush
Sago pondweed
Common bladderwort
Spatterdock lily
Water marigold
70.1
13.2
13.2
9.4
6.8
6.0
3.8
3.0
1.7
1.3
1.3
0.9
0.9
0.9
0.4
0.4
0.4
0.4
Species
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
Frequency (%)

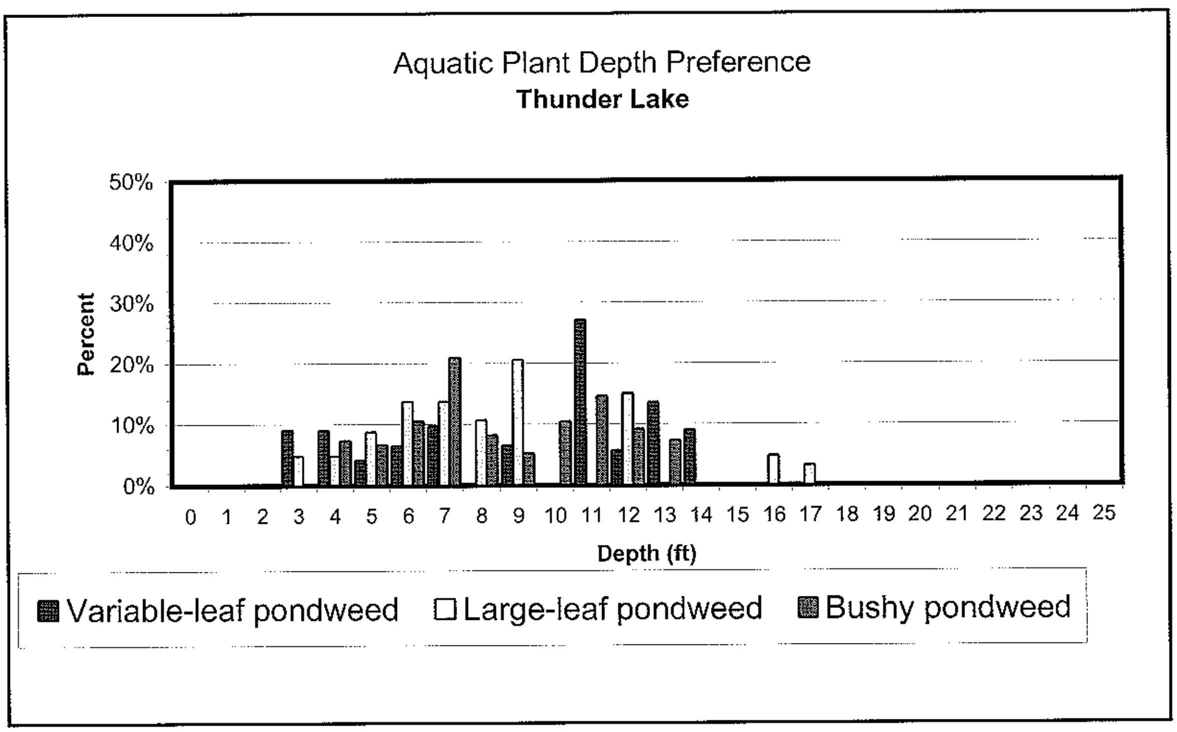

Relative Frequency of Aquatic Plants
in Thunder Lake (2010)
Flat-stem pondweed
1%
EWM 0.6%
Coontail
2%
Wild celery
3%
Bushy pondweed
4%
Large-leaf pondweed
5%
Variable-leaf pondweed
7%
Stonewort
10%
Common waterweed
10%
Muskgrass
52%

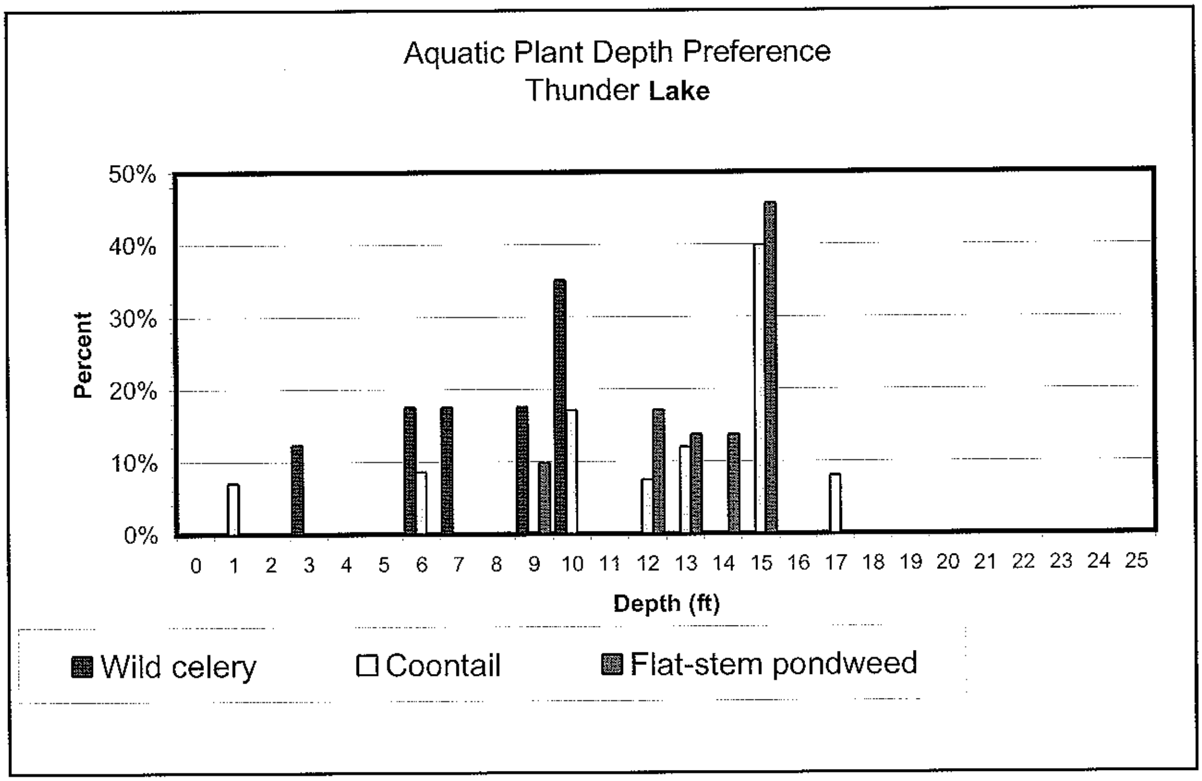

Average Abundance of Aquatic Plants
Abundance (rake fullness)
0
1
2
3
Muskgrass
Common waterweed
Stonewort
Variable-leaf pondweed
Large-leaf pondweed
Bushy pondweed
Wild celery
Coontail
Flat-stem pondweed
Fries' pondweed
Water stargrass
Eurasian watermilfoil
White water lily
Soft-stem bullrush
Sago pondweed
Common bladderwort
Spatterdock lily
Water marigold
Species

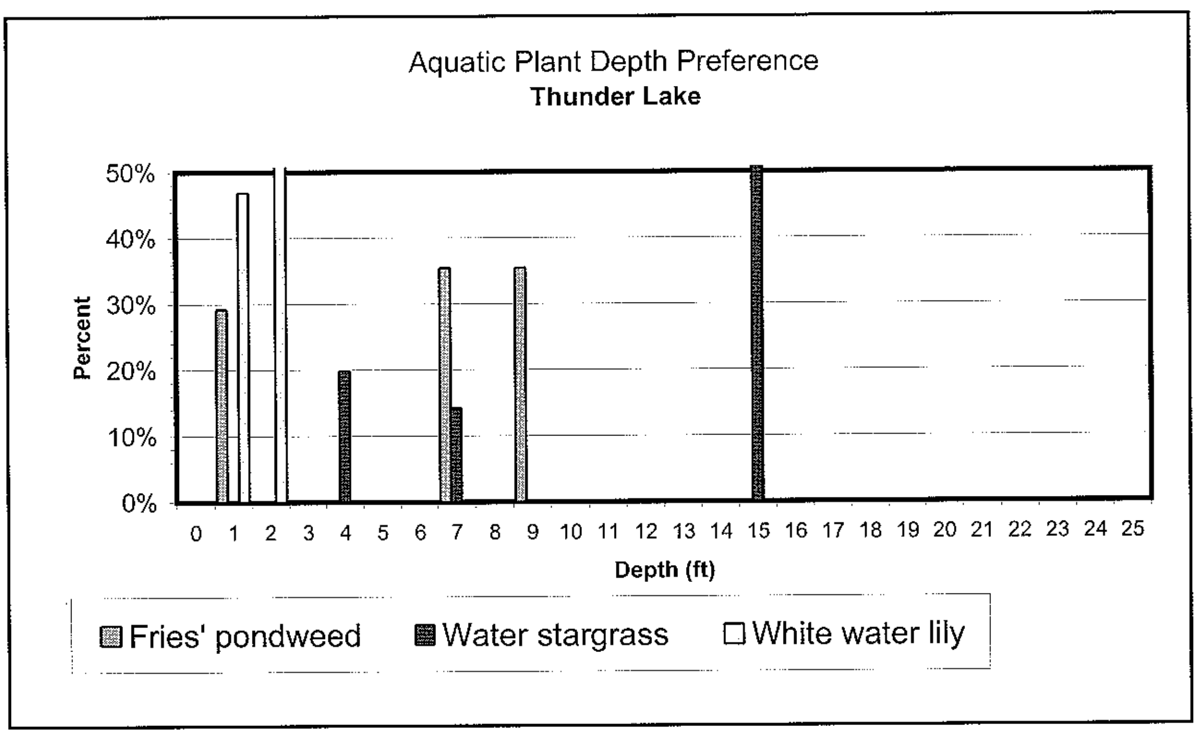

Thunder Lake Sediment Composition
Rock
8%
Sand /
Gravel
33%
Muck
59%

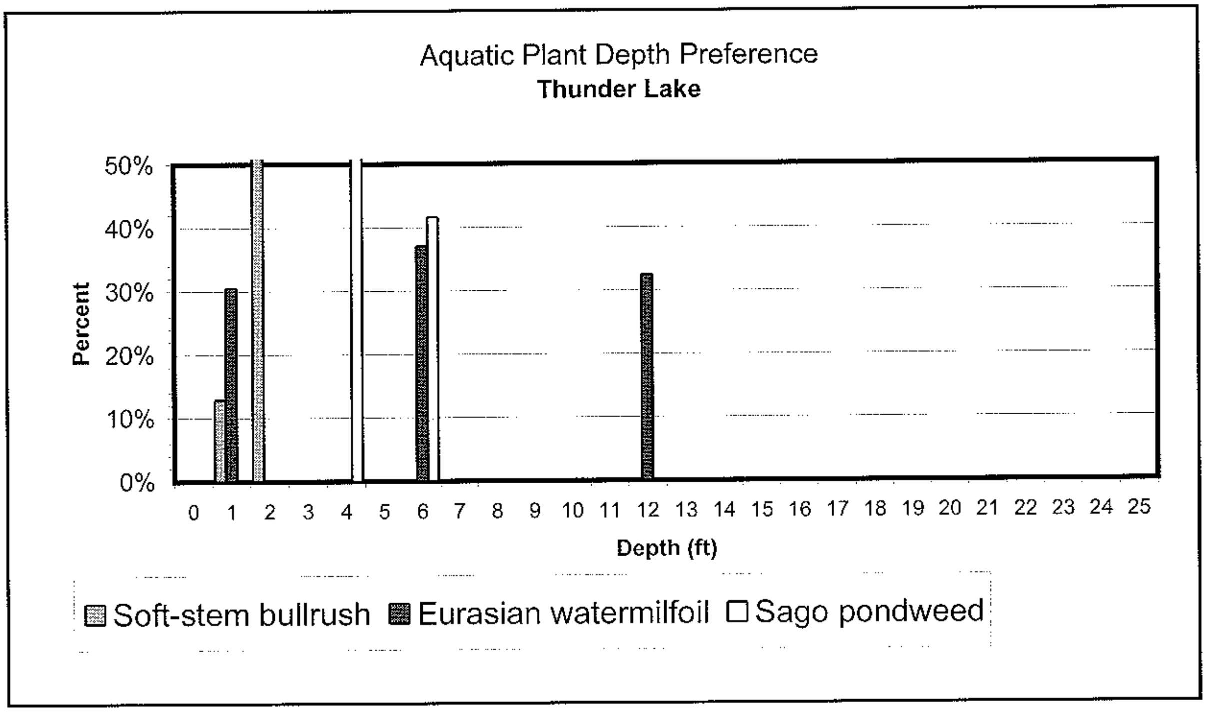

Plant Colonization by Depth
Thunder Lake 2010
Percent of sites with plants
100%
80%
60%
40%
20%
0%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Depth Range (ft)

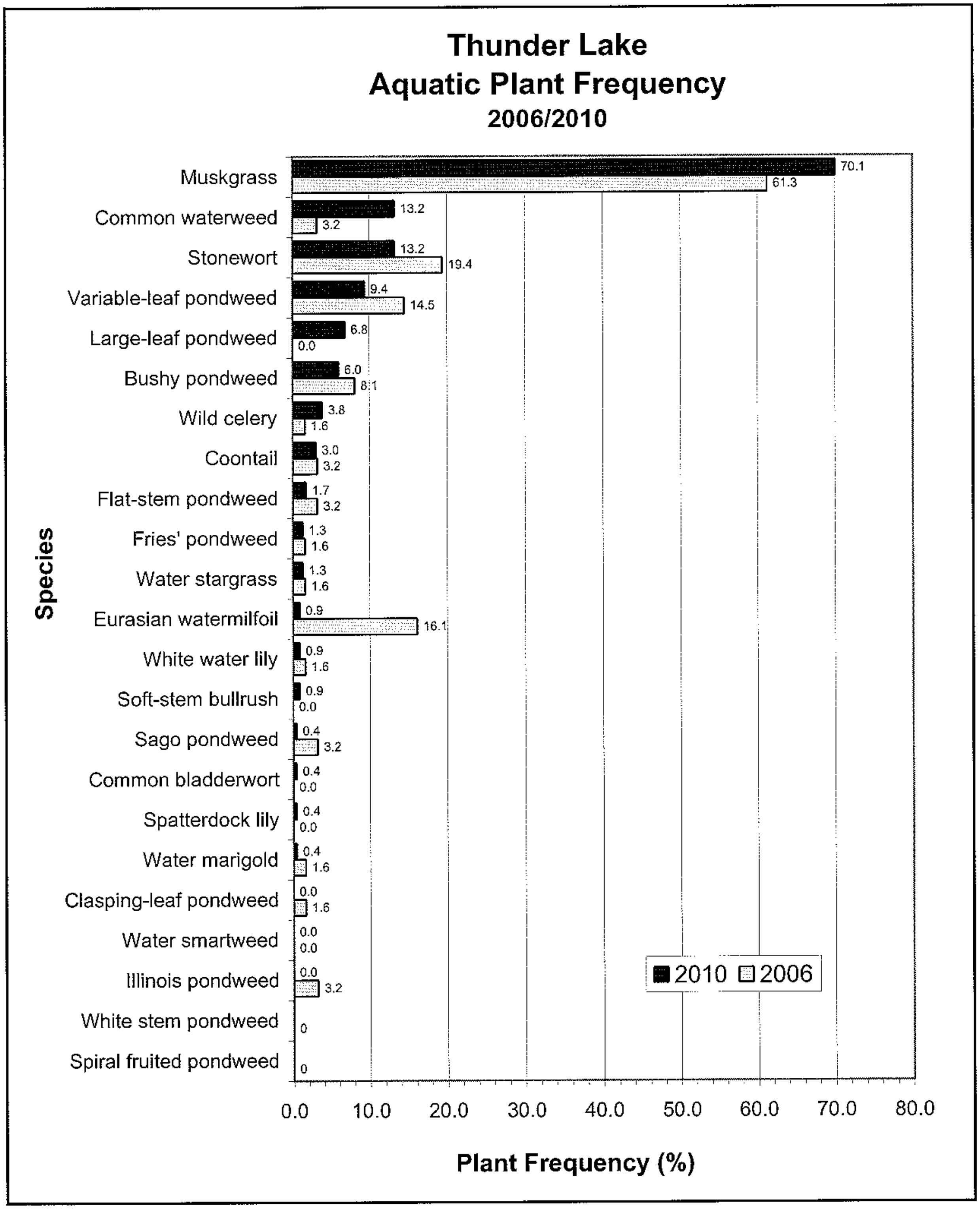

Aquatic Plant Depth Preference
Thunder Lake
Percent
50%
40%
30%
20%
10%
0%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Depth (ft)
Muskgrass
Common waterweed
Stonewort

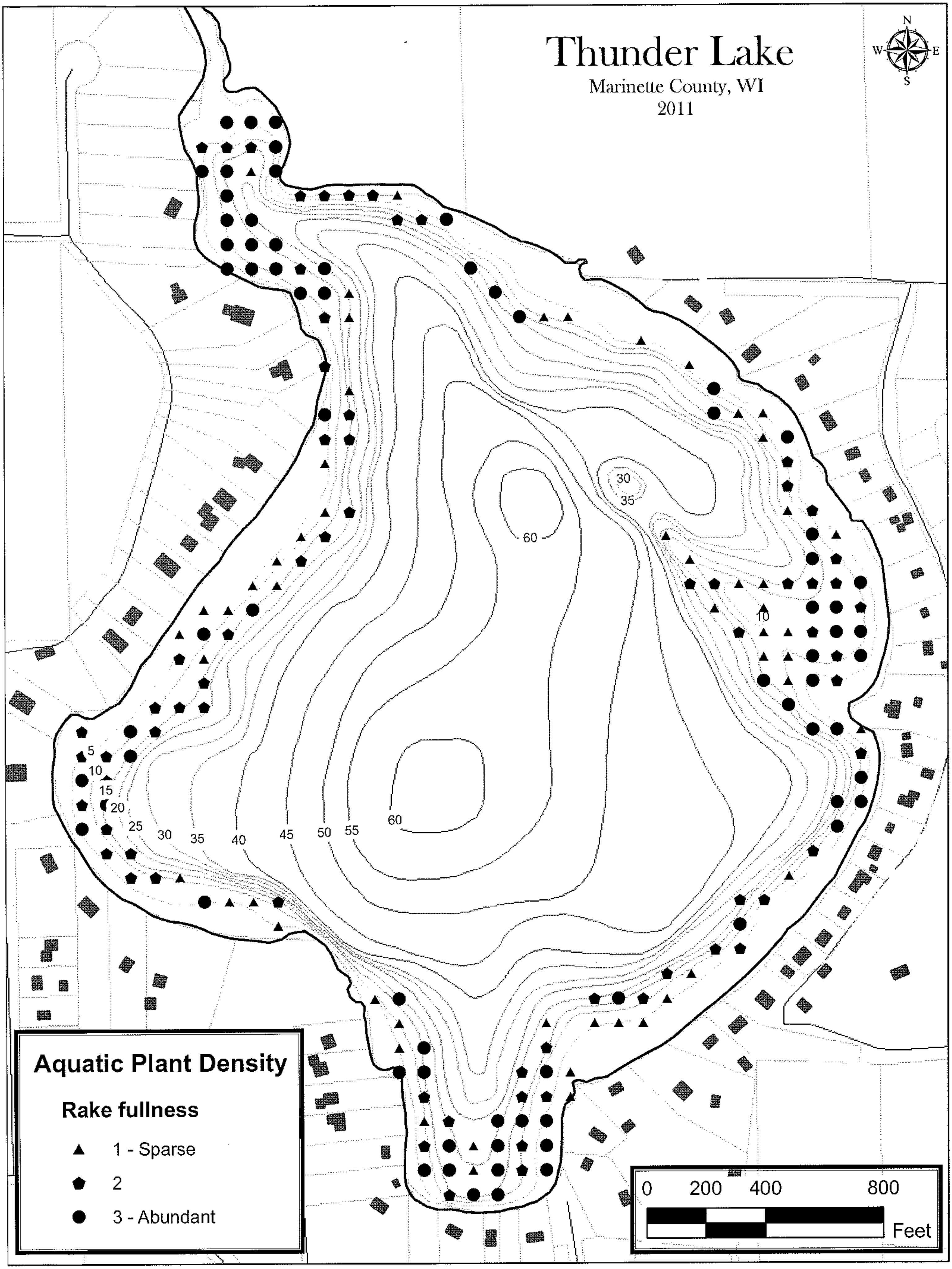

Aquatic Plant Depth Preference
Thunder Lake
Percent
50%
40%
30%
20%
10%
0%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Depth (ft)
Variable-leaf pondweed
Large-leaf pondweed
Bushy pondweed

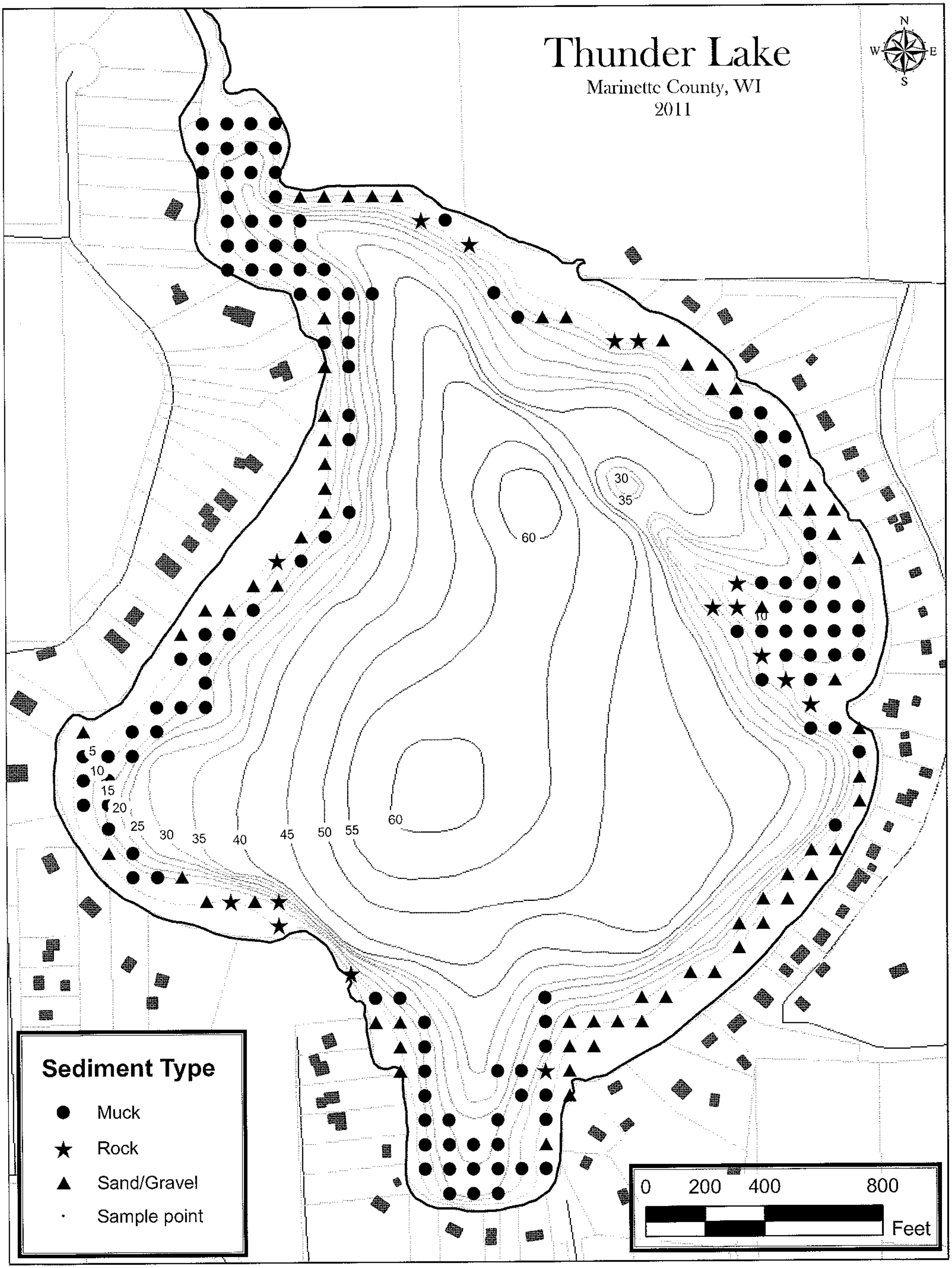

Aquatic Plant Depth Preference
Thunder Lake
50%
40%
30%
20%
10%
0%
Percent
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Depth (ft)
Wild celery
Coontail
Flat-stem pondweed


Aquatic Plant Depth Preference
Thunder Lake
50%
40%
30%
20%
10%
0%
Percent
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Depth (ft)
Fries' pondweed
Water stargrass
White water lily

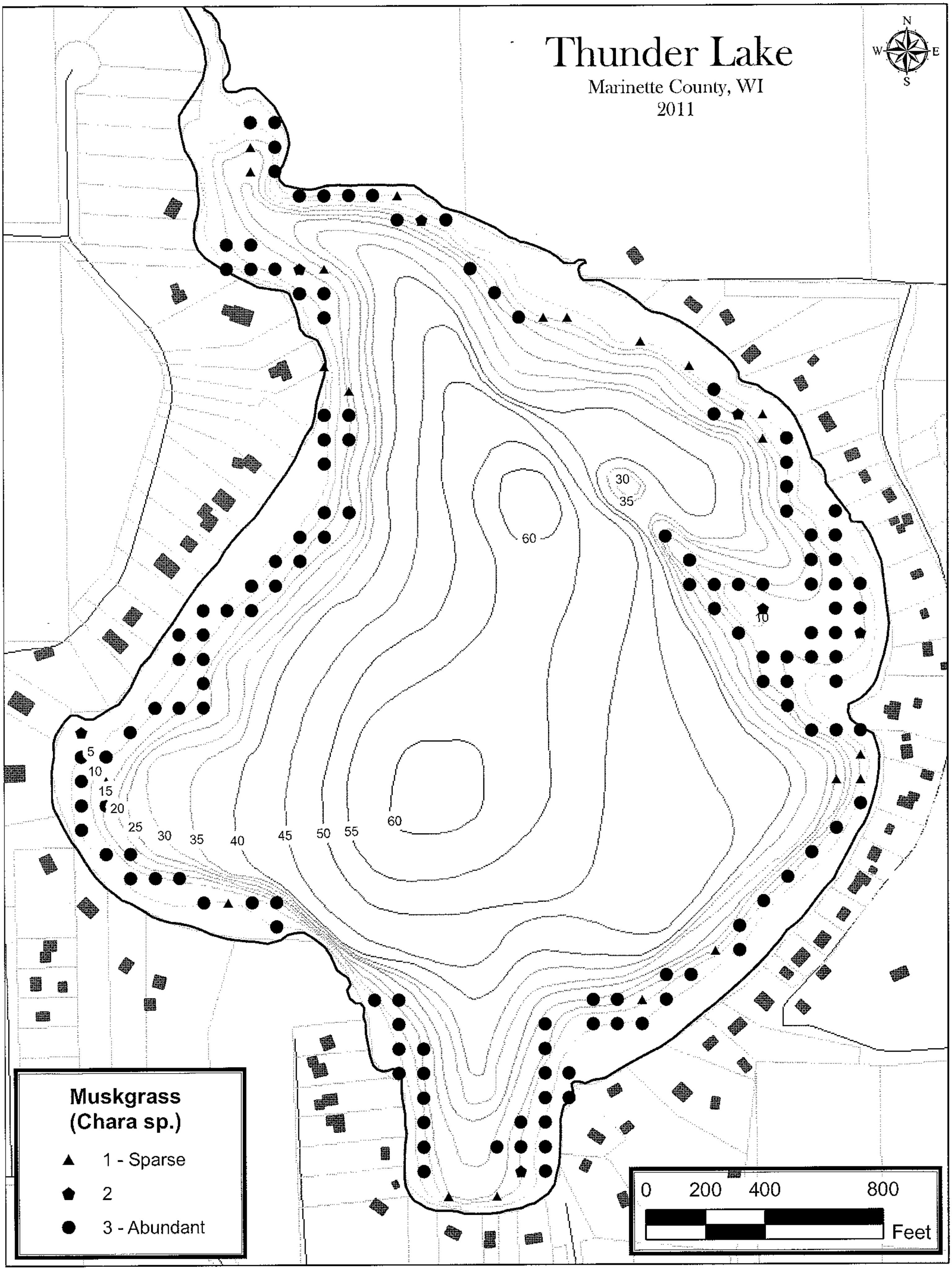

Aquatic Plant Depth Preference
Thunder Lake
50%
40%
30%
20%
10%
0%
Percent
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Depth (ft)
Soft-stem bullrush
Eurasian watermilfoil
Sago pondweed

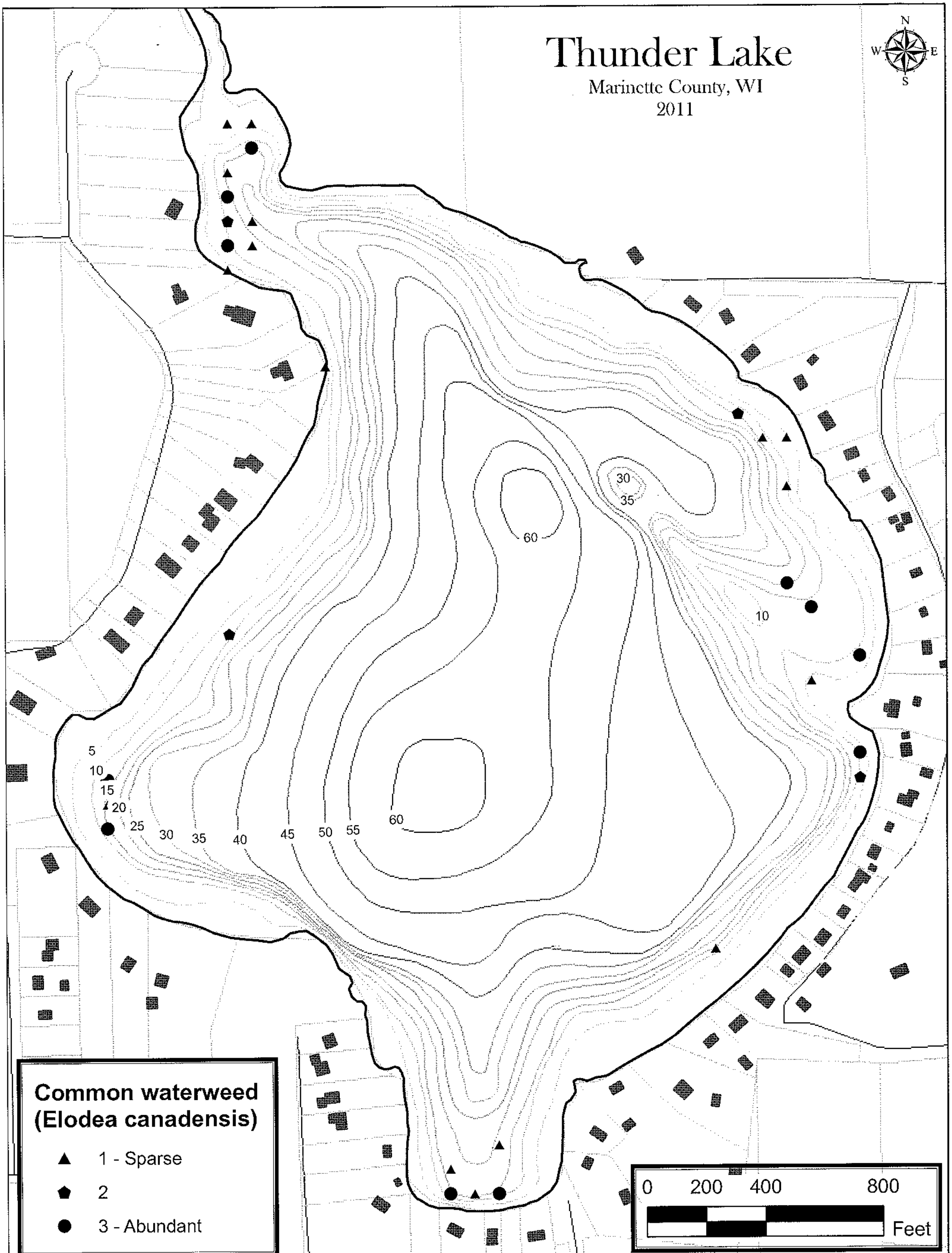

Thunder Lake
Aquatic Plant Frequency
2006/2010
Muskgrass 70.1 61.3
Common waterweed 13.2 3.2
Stonewort 13.2 19.4
Variable-leaf pondweed 9.4 14.5
Large-leaf pondweed 6.8 0.0
Bushy pondweed 6.0 8.1
Wild celery 3.8 1.6
Coontail 3.0 3.2
Flat-stem pondweed 1.7 3.2
Fries' pondweed 1.3 1.6
Water stargrass 1.3 1.6
Eurasian watermilfoil 0.9 16.1
White water lily 0.9 1.6
Soft-stem bullrush 0.9 0.0
Sago pondweed 0.4 3.2
Common bladderwort 0.4 0.0
Spatterdock lily 0.4 0.0
Water marigold 0.4 1.6
Clasping-leaf pondweed 0.0 1.6
Water smartweed 0.0 0.0
Illinois pondweed 0.0 3.2
White stem pondweed 0
Spiral fruited pondweed 0
Species
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0
Plant Frequency (%)
2010 2006


Thunder Lake
Marinette County, WI
2011
N
S
E
W
30
35
60
10
5
10
15
20
25
30
35
40
45
50
55
60
Aquatic Plant Density
Rake fullness
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet

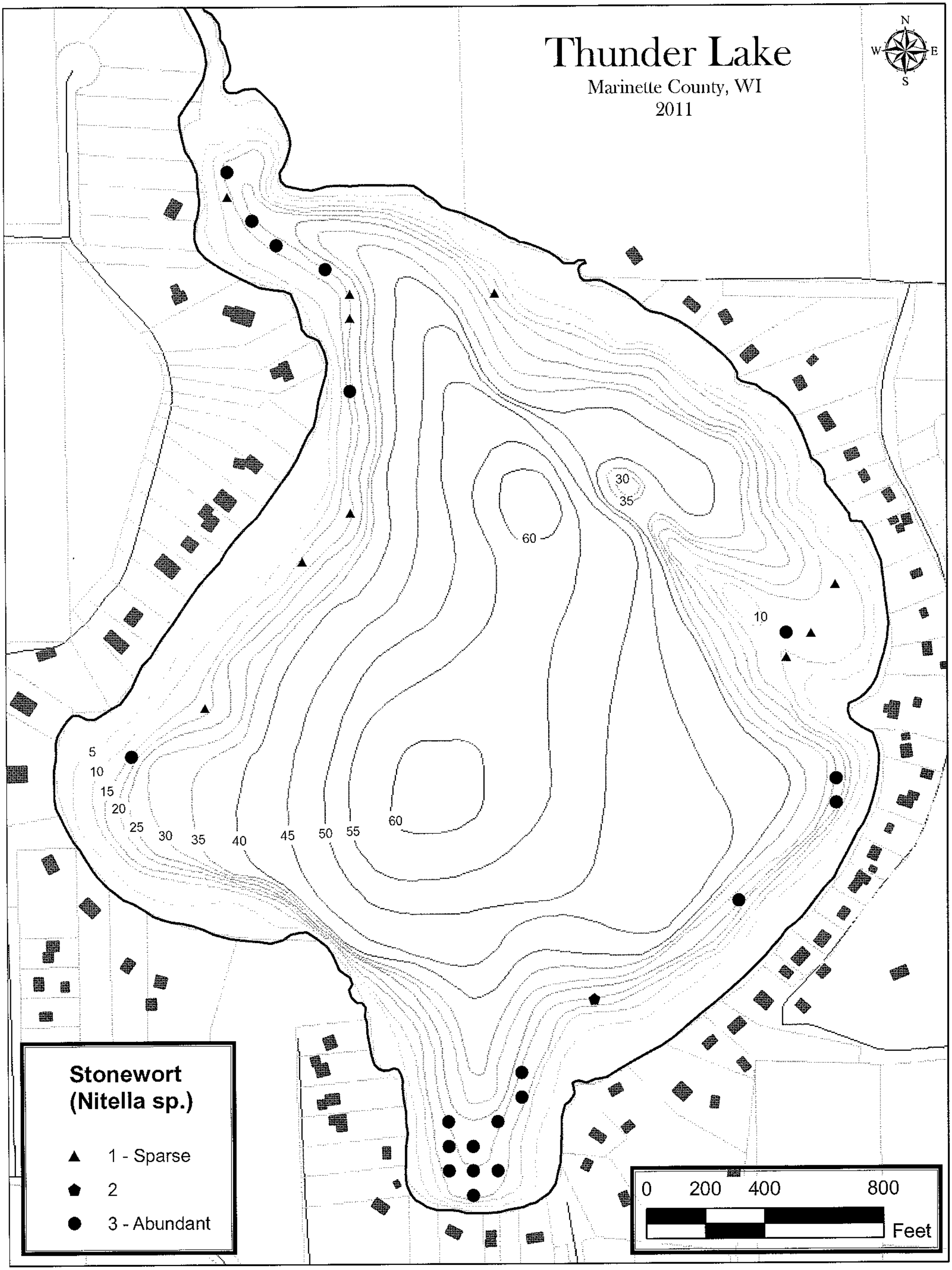


Thunder Lake
Marinette County, WI
2011
N
W
E
S
5
10
15
20
25
30
35
40
45
50
55
60
60
30
35
10
Sediment Type
Muck
Rock
Sand/Gravel
Sample point
0
200
400
800
Feet

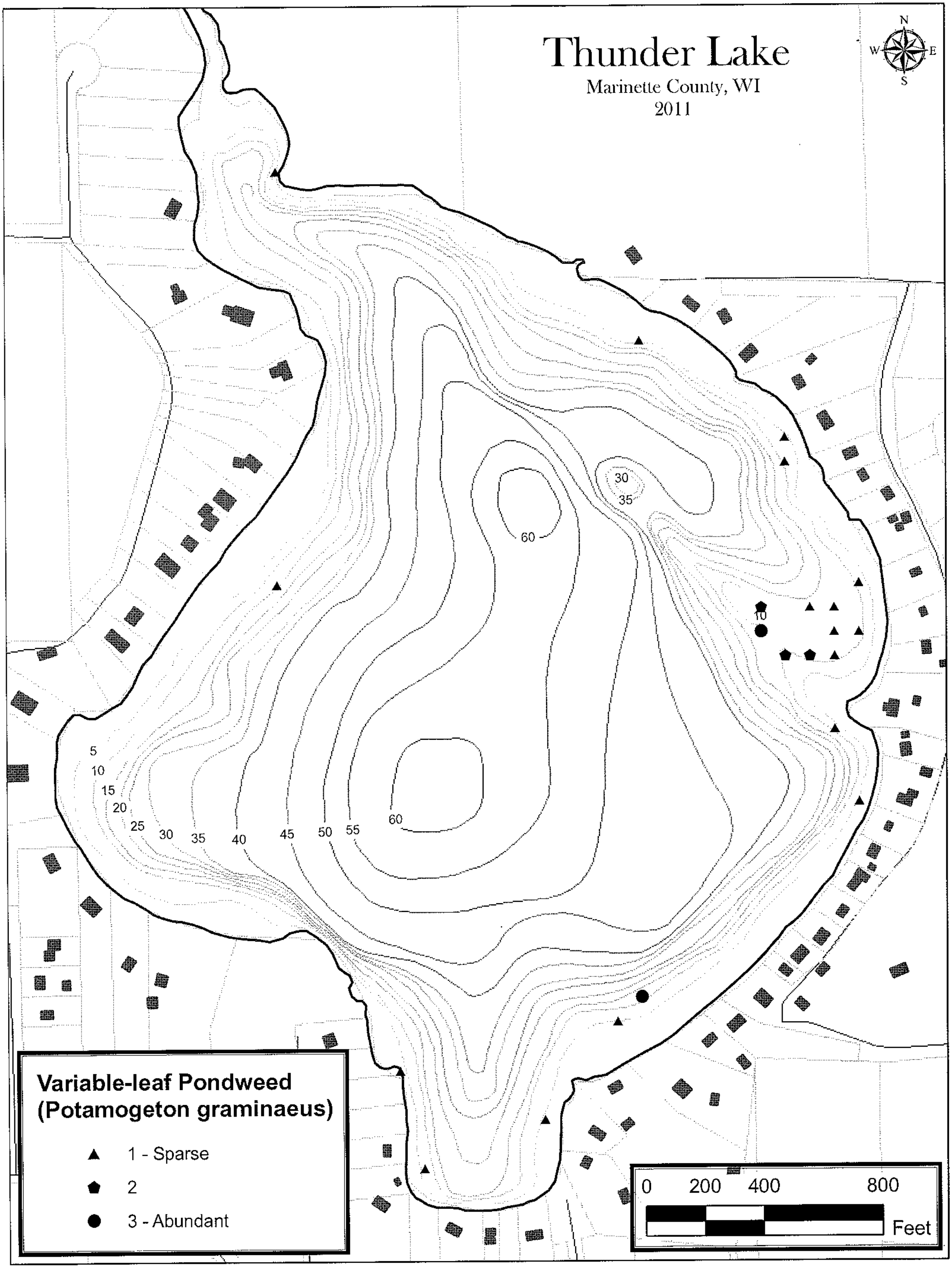

Thunder Lake
Marinette County, WI
2011
N
W
E
S
30
35
60
10
5
10
15
20
25
30
35
40
45
50
55
60
Muskgrass
(Chara sp.)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet

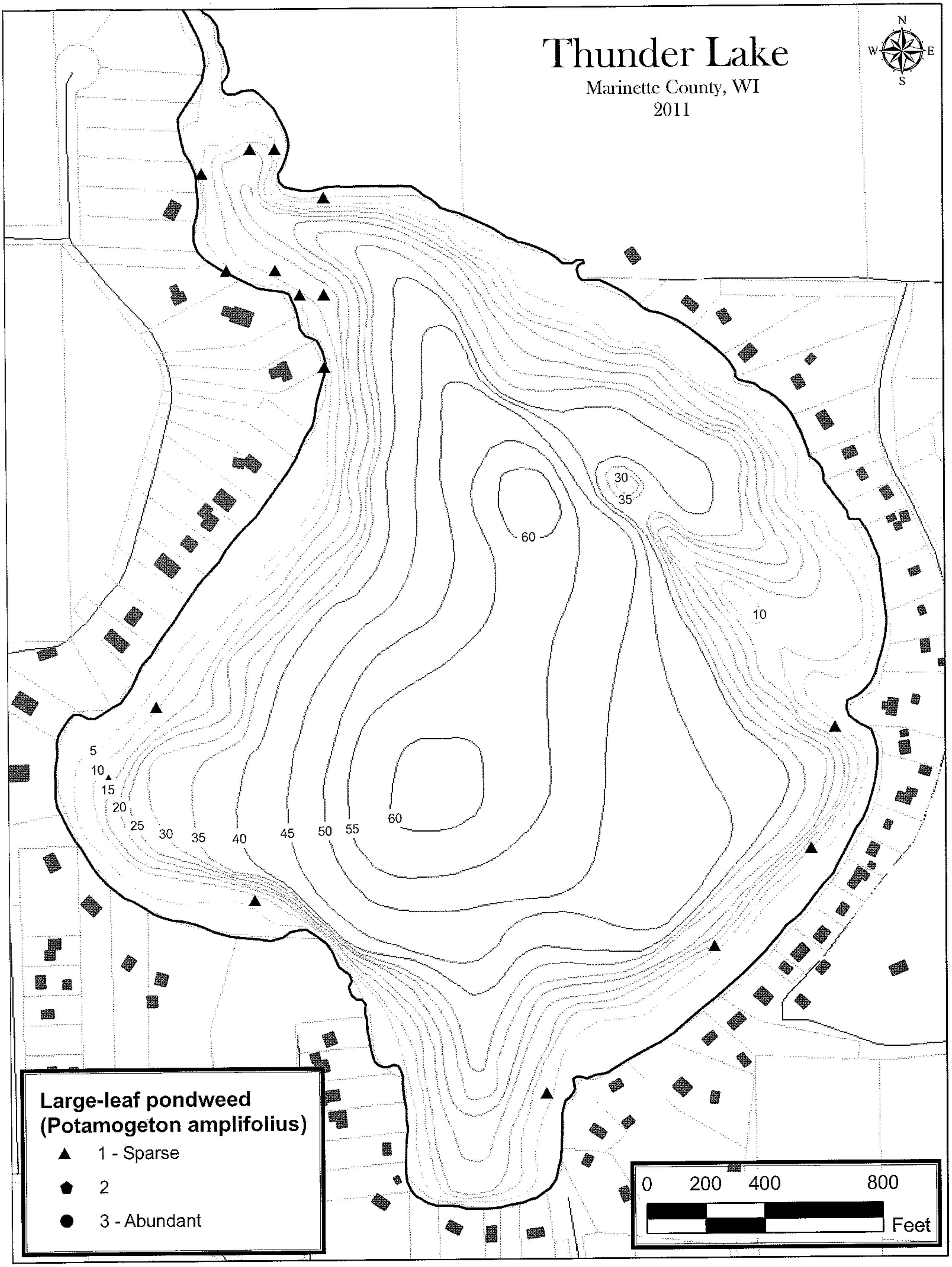


Thunder Lake
Marinette County, WI
2011
N
S
E
W
30
35
60
10
5
10
15
20
25
30
35
40
45
50
55
60
Common waterweed
(Elodea canadensis)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet



Thunder Lake
Marinette County, WI
2011
N
S
E
W
Stonewort
(Nitella sp.)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet
5
10
15
20
25
30
35
40
45
50
55
60


Thunder Lake
Marinette County, WI
2011
N
S
E
W
Variable-leaf Pondweed
(Potamogeton graminaeus)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet
5
10
15
20
25
30
35
40
45
50
55
60
60
30
35
10


Thunder Lake
Marinette County, WI
2011
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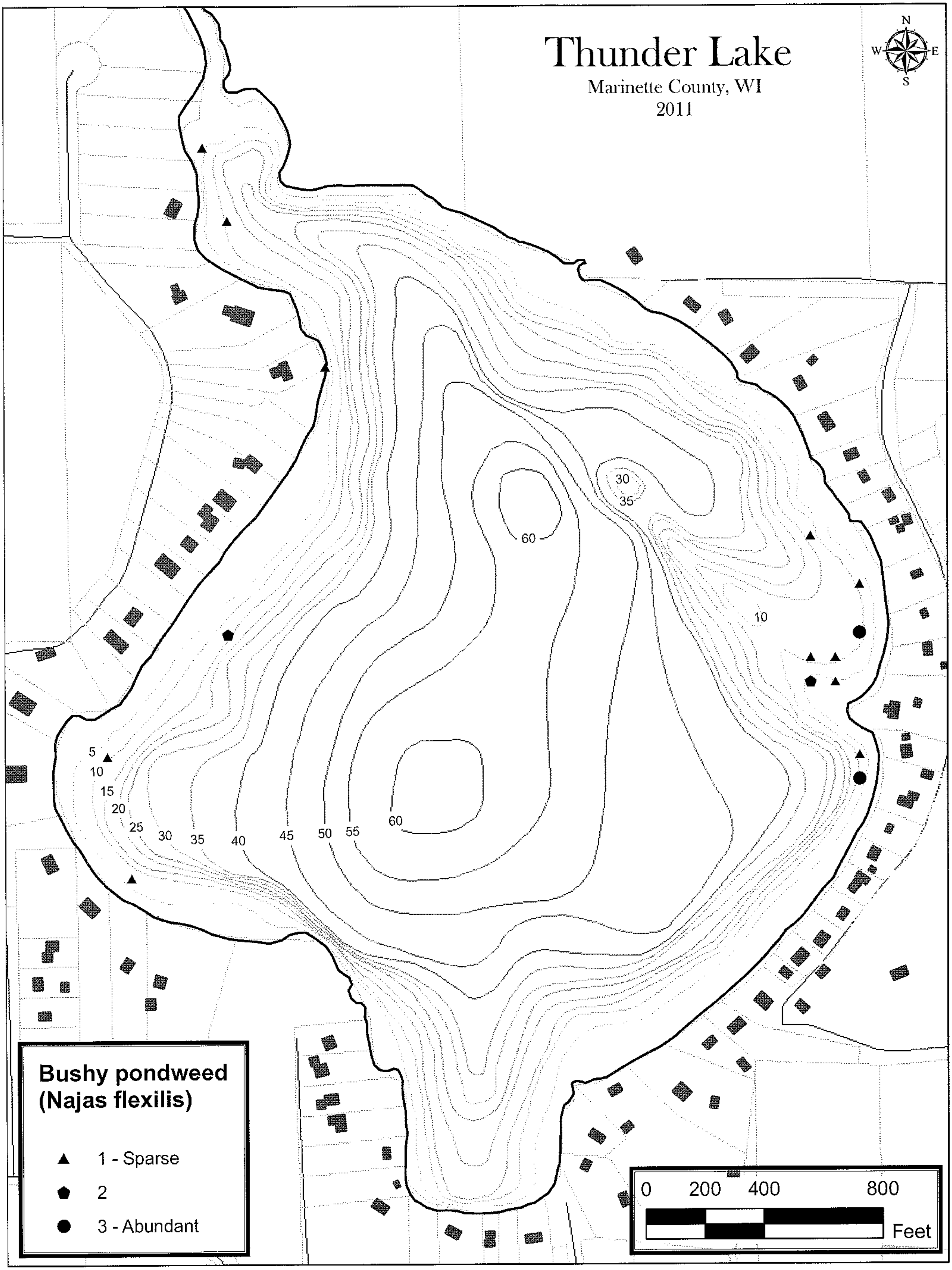
Large-leaf pondweed
(Potamogeton amplifolius)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet



Thunder Lake
Marinette County, WI
2011
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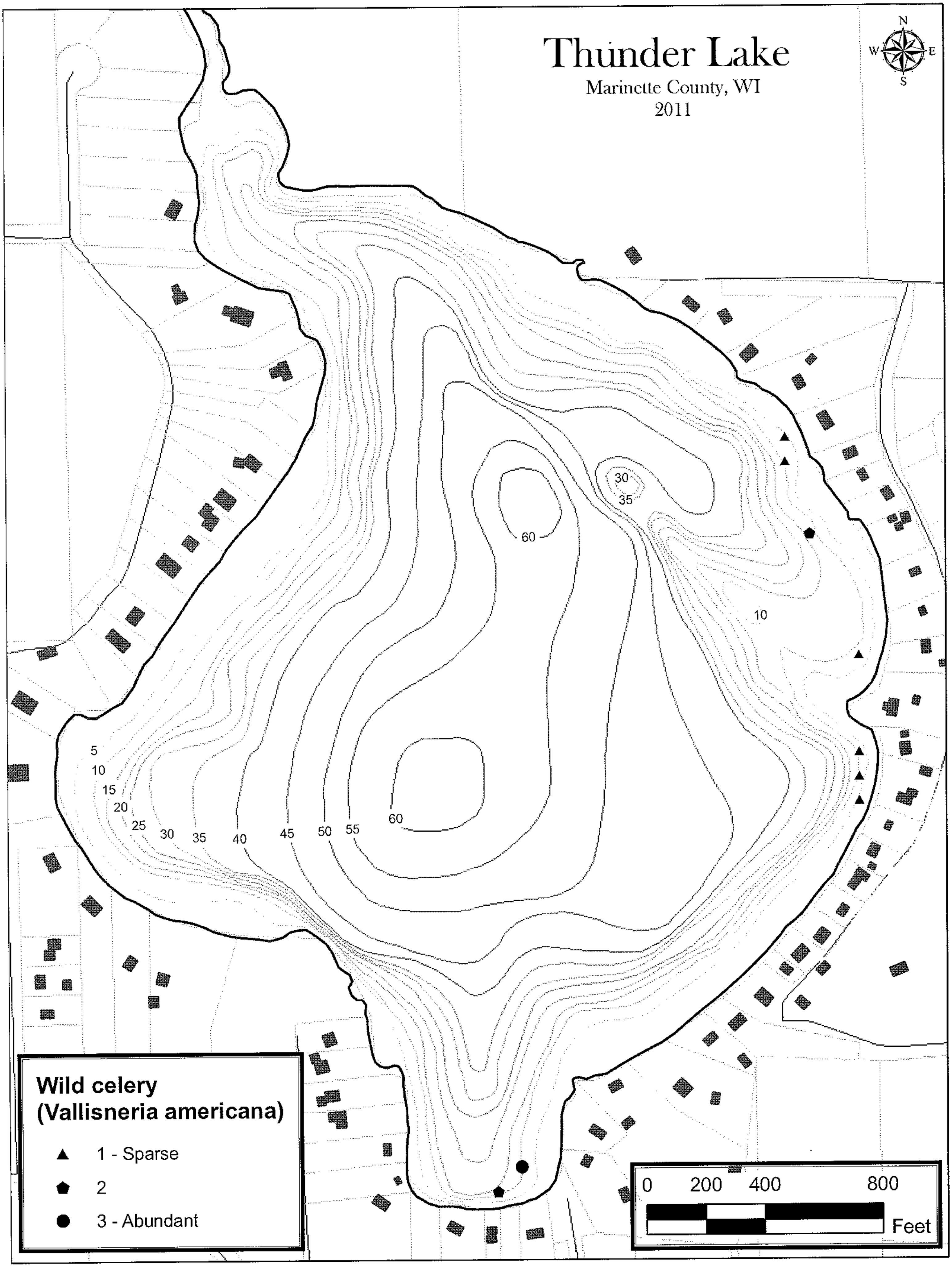
Bushy pondweed
(Najas flexilis)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet


Thunder Lake
Marinette County, WI
2011
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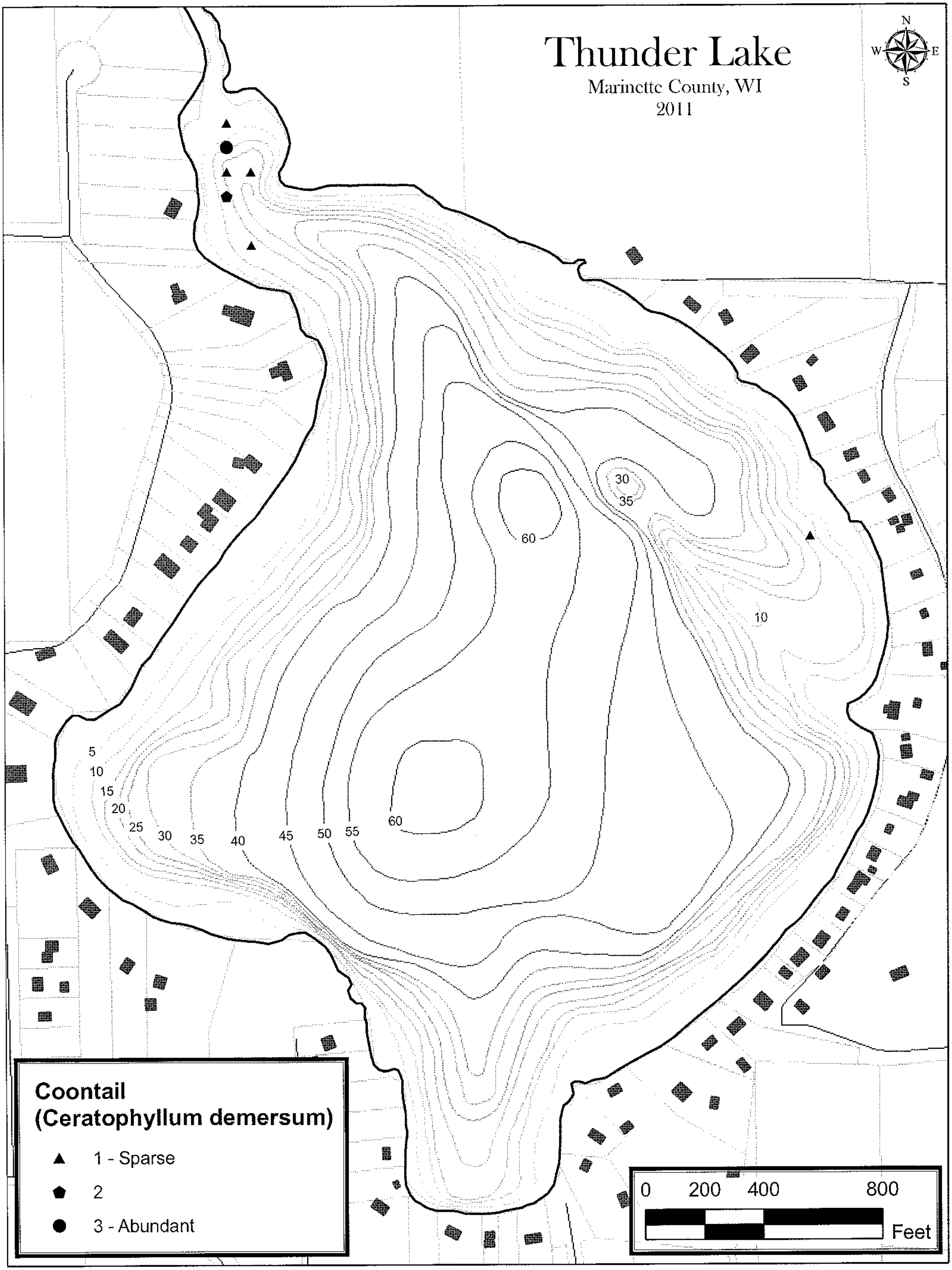
Wild celery
(Vallisneria americana)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet


Thunder Lake
Marinette County, WI
2011
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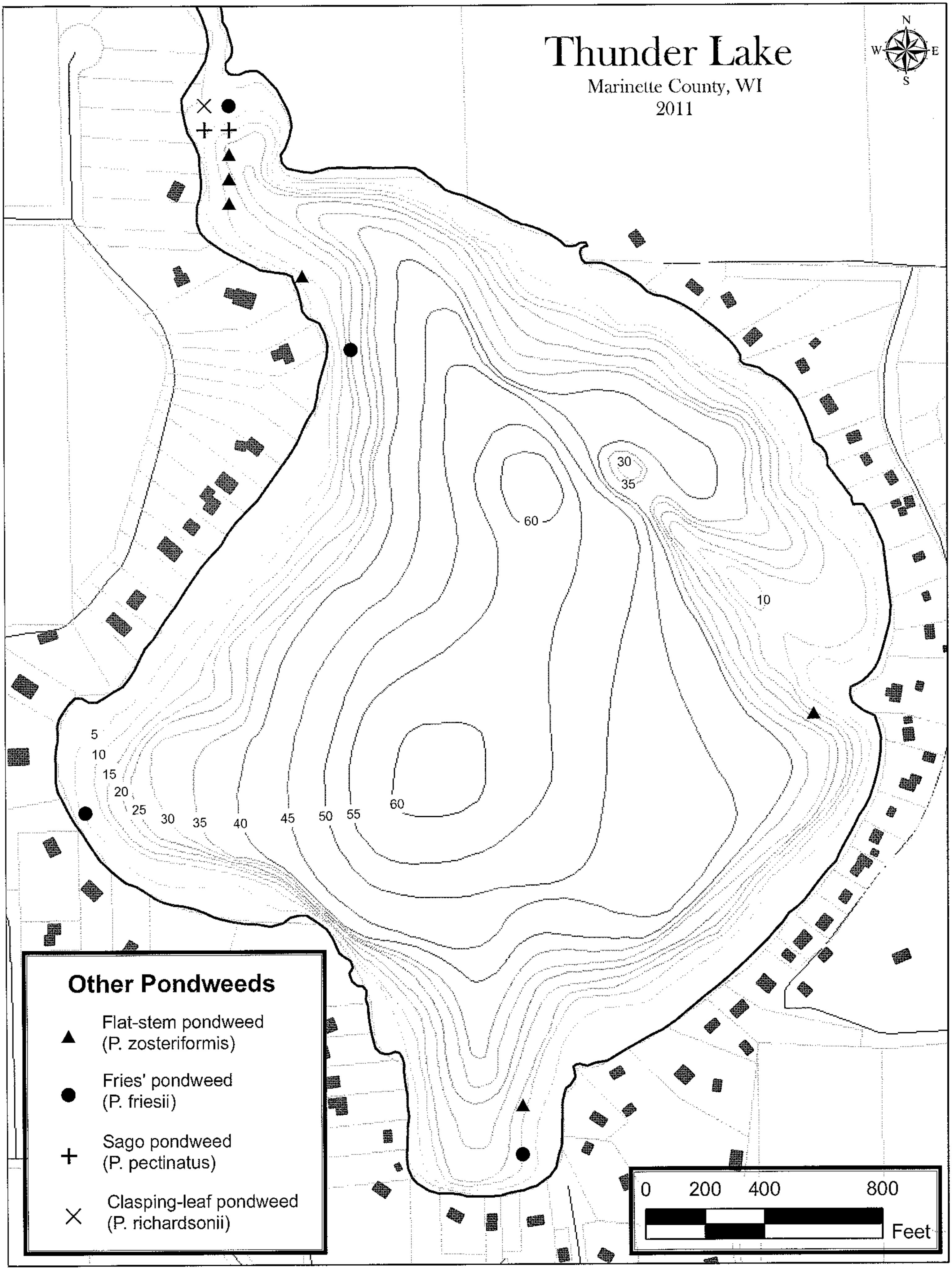
Coontail
(Ceratophyllum demersum)
1 - Sparse
2
3 - Abundant
0
200
400
800
Feet



Thunder Lake
Marinette County, WI
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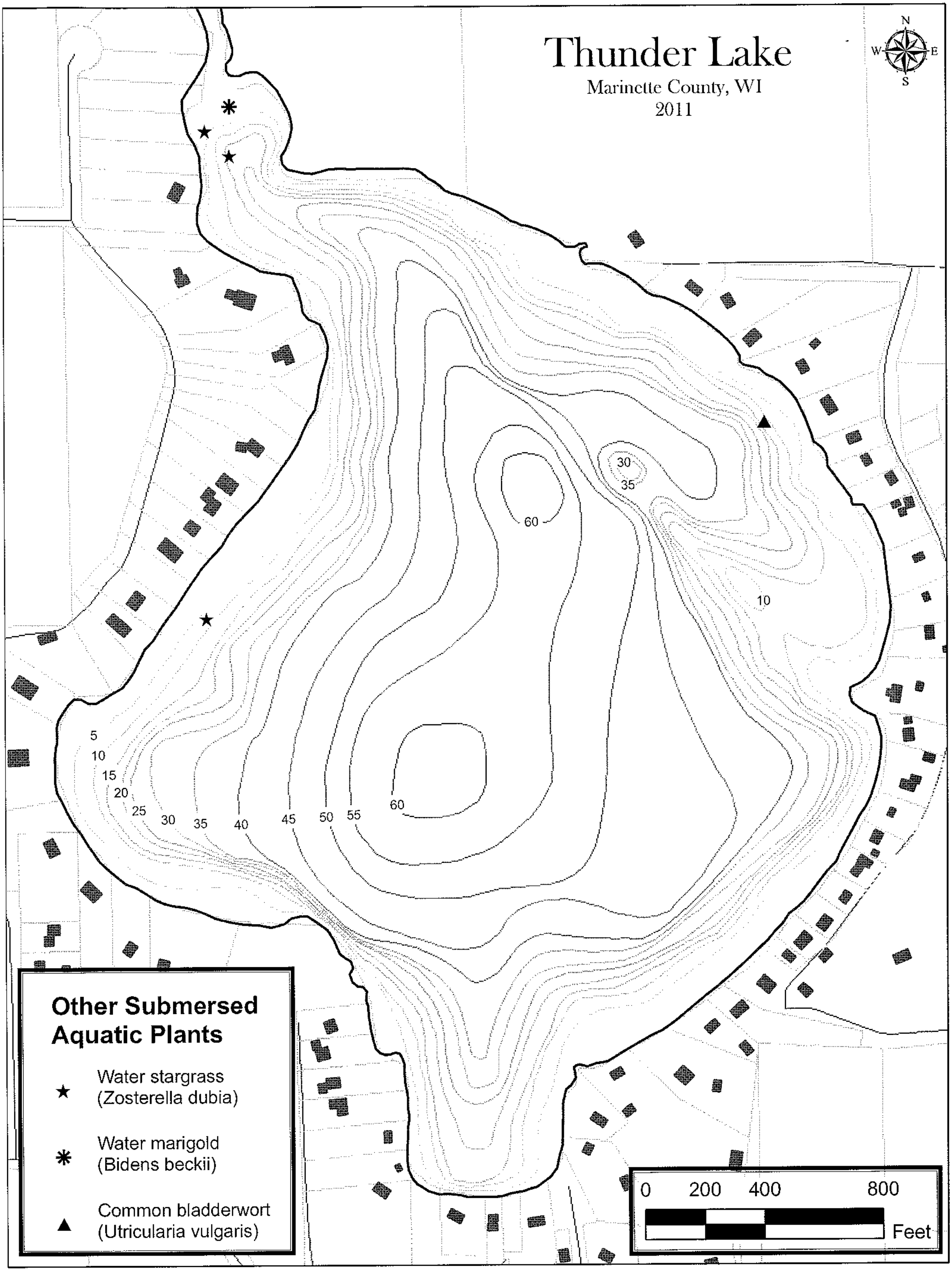
Other Pondweeds
Flat-stem pondweed
(P. zosteriformis)
Fries' pondweed
(P. friesii)
Sago pondweed
(P. pectinatus)
Clasping-leaf pondweed
(P. richardsonii)
0
200
400
800
Feet


Thunder Lake
Marinette County, WI
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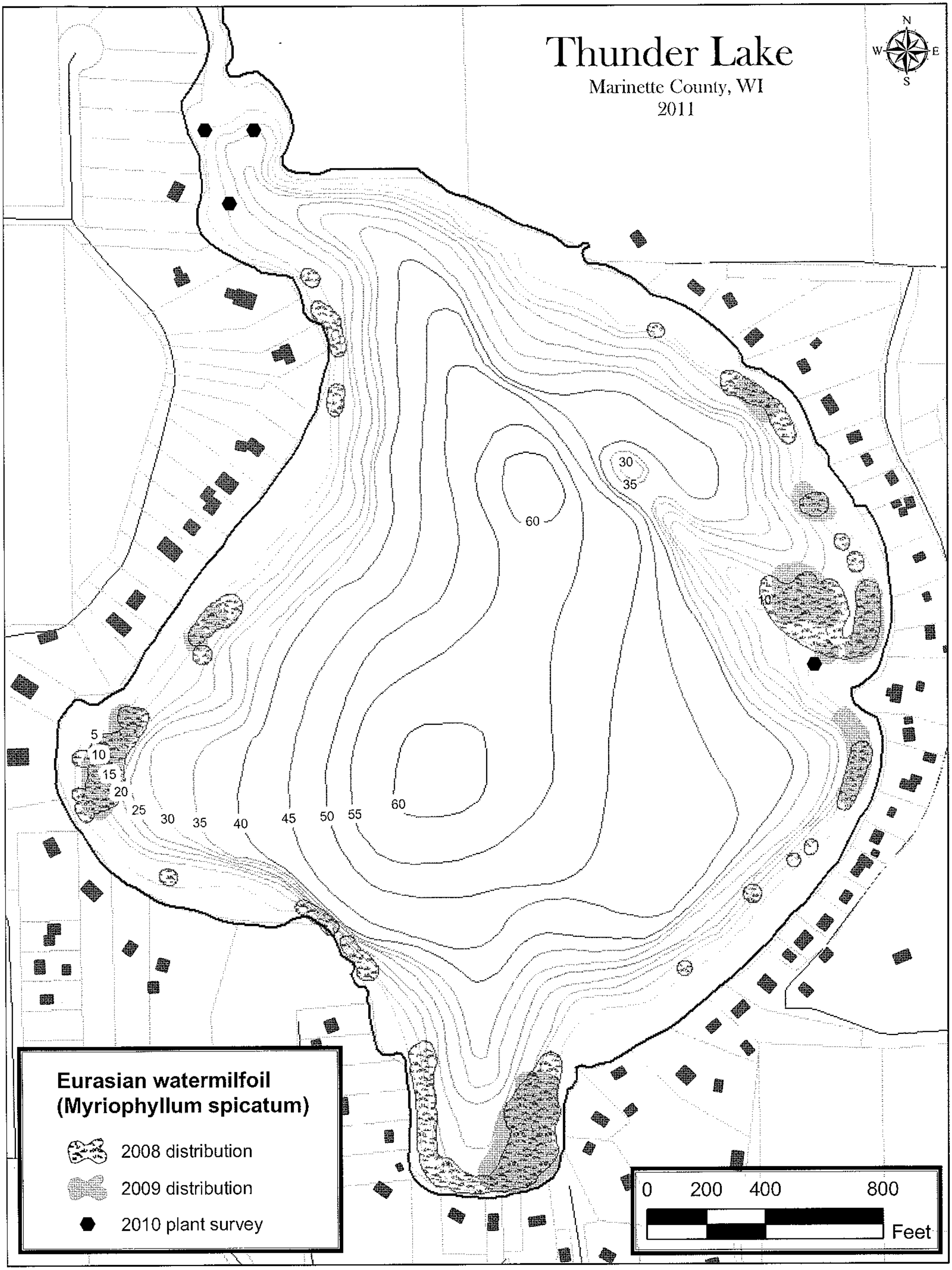
Other Submersed Aquatic Plants
Water stargrass (Zosterella dubia)
Water marigold (Bidens beckii)
Common bladderwort (Utricularia vulgaris)
0 200 400 800
Feet



Thunder Lake
Marinette County, WI
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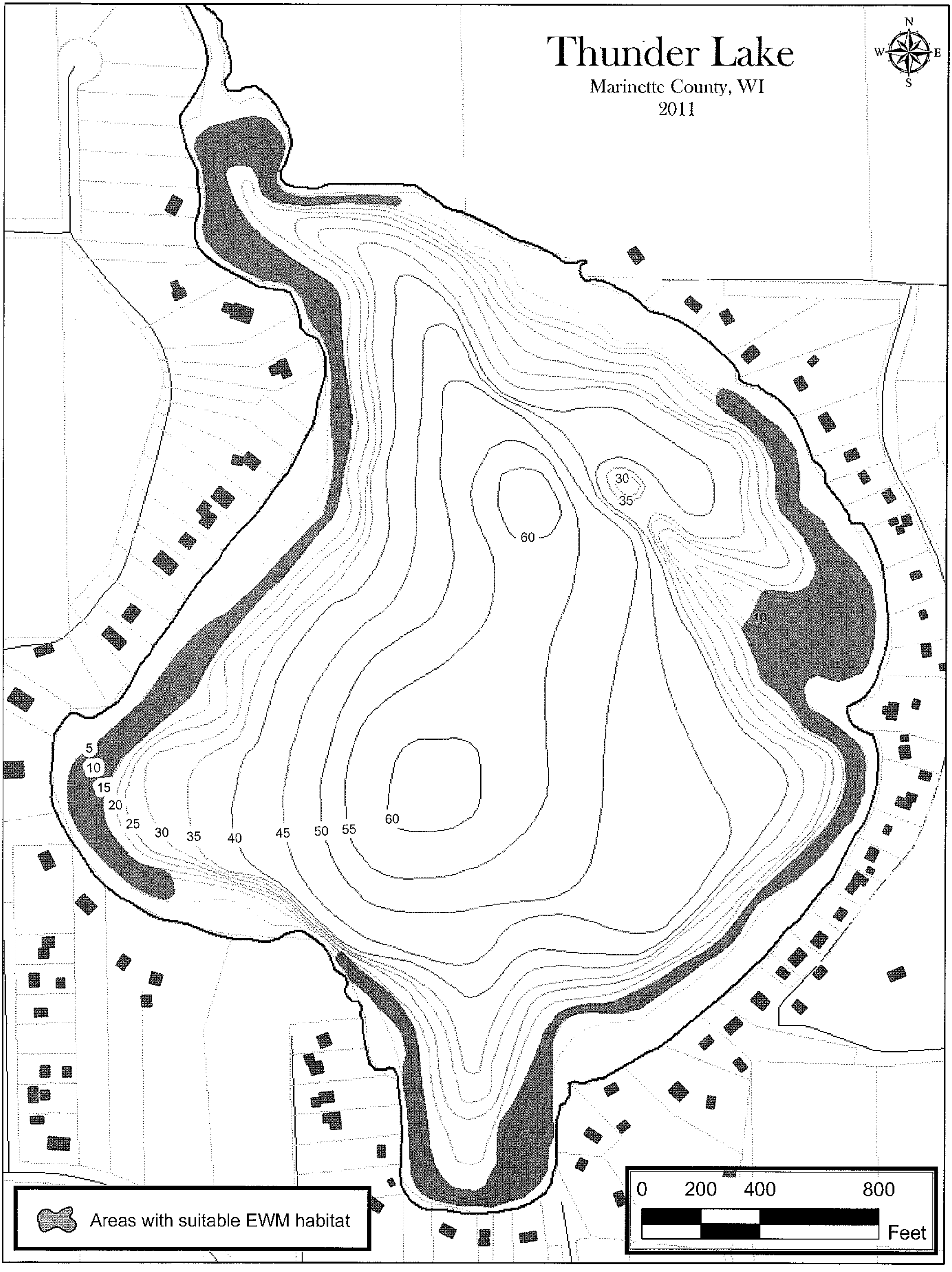
Eurasian watermilfoil
(Myriophyllum spicatum)
2008 distribution
2009 distribution
2010 plant survey
0
200
400
800
Feet


Thunder Lake
Marinette County, WI
2011
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Areas with suitable EWM habitat
0
200
400
800
Feet