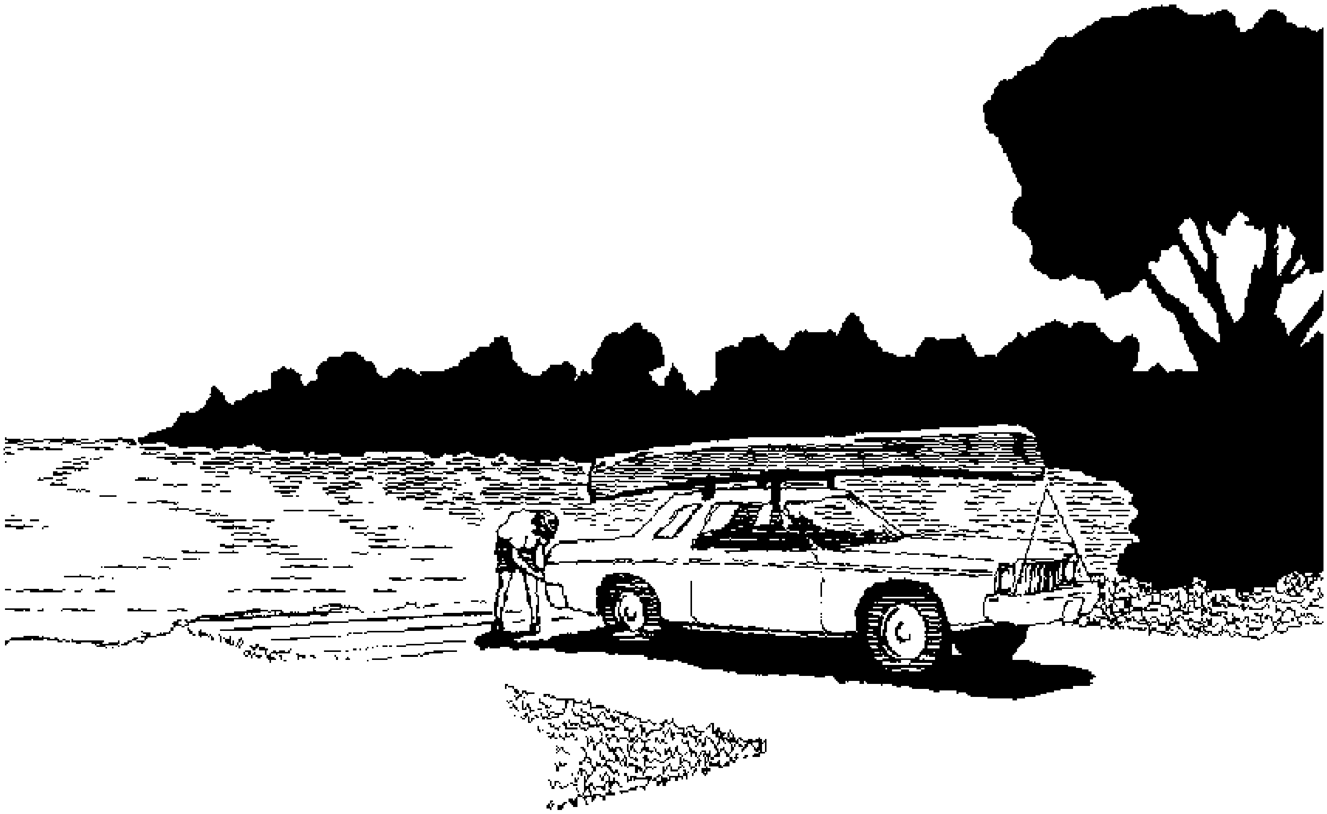
Marinette County
Lake Classification & Protection Grant
December 2009



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Project Description

The Marinette County Lakes Classification & Protection Project is part of the Marinette County Land & Water Conservation Divisions (LWCD) ongoing effort to expand our knowledge of Marinette County Lakes and promote land and water conservation practices to protect water quality and fish and wildlife habitat. To that end, the project contained a significant monitoring component designed to establish baseline water quality and habitat conditions on three recently subdivided and rapidly developing lakes and flowages. Numerous information and education efforts were also completed, targeting lake residents, earthwork contractors operating in the shoreland zone, and others concerned with the health of our lakes.

Project Setting

Two small lakes were chosen for in-depth water quality analysis and shoreline and aquatic habitat investigation; Shannon Lake, a hard-water drainage lake in northern Marinette County, and Simpson Lake, a hard-water spring lake in central Marinette County. Shoreline and aquatic habitat were also studied on four sites on High Falls Flowage in central Marinette County. Information and education efforts targeted concerned citizens, lakefront property owners, and shoreline contractors throughout Marinette County.

Water Quality Monitoring

Water quality monitoring was conducted on Shannon and Simpson lakes for the purpose of better understanding nutrient dynamics in the lakes and developing a baseline against which future changes in water quality can be compared. Monitoring was conducted in the summer of 2007 through fall turnover in 2008. Temperature, dissolved oxygen, pH, and conductivity were recorded in the field at one-meter intervals in the deepest part of the lake. Secchi disk was measured during the open water season. Samples were collected one meter from the surface and one meter above the bottom and analyzed for total phosphorus and dissolved reactive phosphorus during the summer and winter months. Spring turnover samples were also analyzed for total Kjeldahl nitrogen, nitrate plus nitrite, and ammonium.

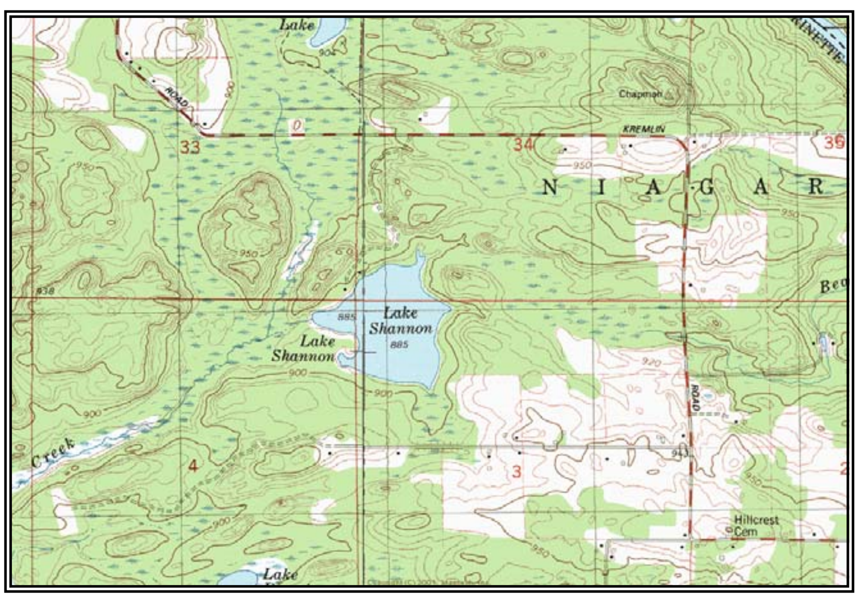

Figure 1. Shannon Lake

Shannon Lake

Shannon Lake (figure 1) is a hard water drainage lake located in the town of Niagara (T37N, R21E, S3). A dam that maintains a head of approximately 7 feet impounds the lake and the outlet flows intermittently. Using current aerial photography, it was determined that Shannon Lake is 47.3 acres in size. The lake has a maximum depth of 37 feet although large areas of the lake on the north and south shores are less than 5 feet deep with many stumps above or near the surface. These areas were flooded when the dam was built. Shannon Lake weakly stratifies during the summer months and experiences oxygen depletion in the hypolimnion.

In 2001 the entire shoreline of Shannon Lake was under single ownership and one cottage was located on the shore. In 2002 approximately 488 acres surrounding the lake and the entire shoreline was subdivided, resulting in 31 waterfront lots along more than 7100 feet of shoreline. At the conclusion of the monitoring period 10 cottages were located on the shore and 4 additional lots had campers parked on them.

Nutrient levels

In Shannon Lake the total nitrogen concentration in the spring of 2008 was 730 ug/l. The total phosphorus concentration was 18.0 ug/l, yielding a nitrogen to phosphorus (N:P ratio) of approximately 40:1 during the sampling period, indicating that Shannon Lake is phosphorus limited.

The average surface total phosphorus concentration during the monitoring period was 18.9 ug/l, well below the statewide average of 23 ug/l for drainage lakes. The average summer phosphorus concentration at the surface was 19.0 ug/l, low enough to prevent nuisance algae blooms and associated poor water clarity.

Hypolimnetic phosphorus levels were slightly elevated in Shannon Lake due to internal loading from an anoxic hypolimnion. During the summer months hypolimnetic phosphorus levels averaged 34 ug/l. Since the hypolimnion is relatively small in volume compared to the oxygenated portion of the lake internal phosphorus loading does not appear to be problematic. During the monitoring period the spring turnover phosphorus level was not elevated. The fall turnover phosphorus level was slightly elevated at 27 ug/l.

Water Clarity

Shannon Lake has clear, slightly stained water of moderate transparency. The slight brown staining is due to tannins, dissolved organic compounds released by leaves and needles as they decompose in wetlands within the lakes watershed. The average Secchi disk depth during the 2-year study period was 10.7 feet with a low of 7.0 feet and a high of 13.0. Overall, the Secchi disk depth for Shannon Lake is better than the statewide average for similar lakes.

Chlorophyll-a

The average chlorophyll-a concentration for the sample period was 3.3 ug/l, with a low of 1.4 and a high of 5.0. This level is quite low and indicates limited production of planktonic (free floating) algae. This level is well below the statewide average and indicates that rooted aquatic plants and attached algae likely tie up most of the phosphorus, making it unavailable for planktonic algae production.

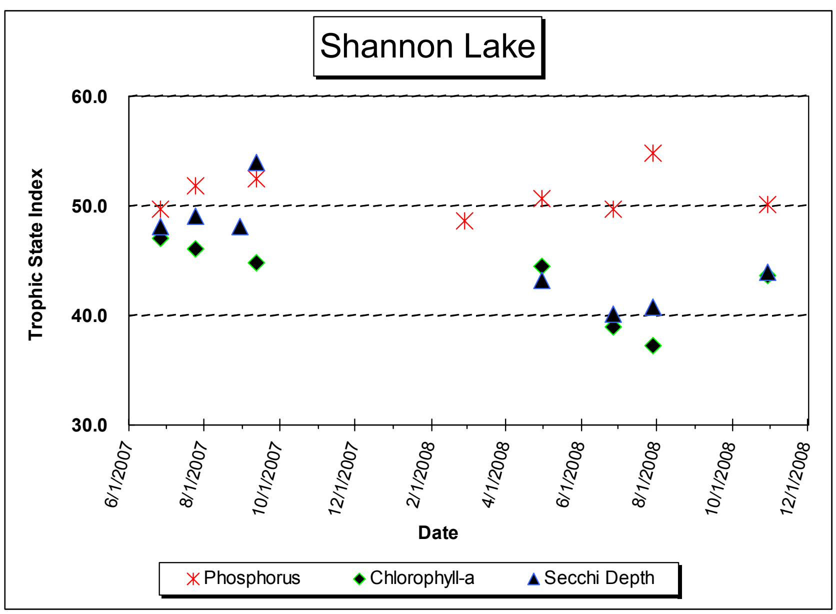

Figure 2. Shannon Lake trophic state values.

Trophic State
Using phosphorus as an indicator the trophic state for Shannon Lake during the study period averaged 50.7, which is in the low range of eutrophic, or nutrient rich. However, the Secchi TSI (43.5) and chlorophyll-a TSI (43.2) indicate the lake is in the lower mesotrophic range. As a whole, trophic state indices put Shannon Lake squarely in the mesotrophic range (figure 2) indicating good water quality.

Simpson Lake

Simpson Lake (figure 3) is a hard water spring lake located in the town of Stephenson (T33N, R19E, S13). A dam maintains a head of approximately 6 feet and the outlet flows to Middle Inlet Creek. Simpson Lake is 13.1 acres in size with a maximum depth of 24 feet. The lake remains mixed through most of the year with brief periods of thermal stratification.

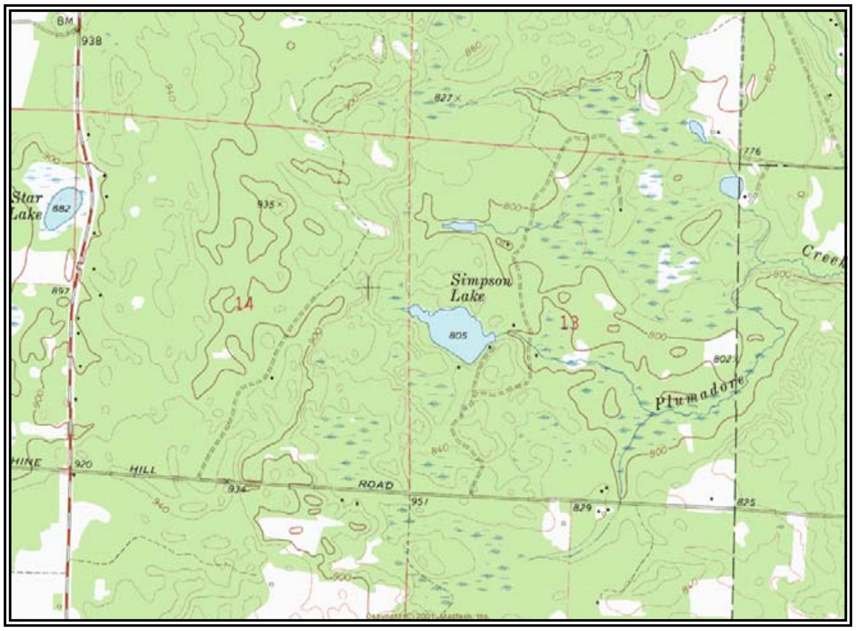

Figure 3. Simpson Lake

In 2006 there were 5 developed properties on the east end of Simpson Lake along approximately 860 feet of shoreline. In 2007 approximately 167 acres of land including more than 2,800 feet of shoreline on Simpson Lake was subdivided, adding 11 new lakefront lots and numerous back lots. By 2009 two of the new properties had new structures and two more had significant disturbance in the form of grading and vegetation removal.

Nutrient levels
In Simpson Lake the total nitrogen concentration in the spring of 2008 was 360 ug/l. The total phosphorus concentration was 14.0 ug/l, yielding a nitrogen to phosphorus (N:P ratio) of 26:1 during the sampling period, indicating that Simpson Lake is phosphorus limited.

The average surface total phosphorus concentration during the monitoring period was 13.5 ug/l, well below the regional average of 18 ug/l for seepage lakes (there is no published average for spring lakes and seepage lakes are closest in hydrology). The average summer phosphorus concentration at the surface was 14.4 ug/l, low enough to prevent nuisance algae blooms and poor water clarity. Hypolimnetic phosphorus levels were only slightly elevated in Simpson Lake (average 16.3 ug/l) indicating little internal loading and adequate mixing throughout the year.

Water Clarity
Simpson Lake has clear, slightly stained water of good transparency. The slight brown staining is due to tannins, dissolved organic compounds released by leaves and needles as they decompose in wetlands within the lakes watershed. The average Secchi disk depth during the 2-year study period was 12.7 feet with a low of 8.0 feet and a high of 21.0 feet. Overall, the Secchi disk depth for Simpson Lake is better than the statewide average for similar lakes.

Chlorophyll-a

The average chlorophyll-a concentration for the sample period was 3.1 ug/l, with a low of 1.3 and a high of 5.7. This level is quite low and indicates limited production of planktonic (free floating) algae. This level is well below the statewide average and indicates that rooted aquatic plants and attached algae likely tie up most of the phosphorus, making it unavailable for planktonic algae production.

Trophic State

Using phosphorus as an indicator the trophic state for Simpson Lake during the study period averaged 48.2, which is in the high mesotrophic range, or moderately nutrient rich. However, the Secchi TSI (41.2) and chlorophyll-a TSI (42.6) indicate the lake is in the lower mesotrophic range. As a whole, trophic state indices put Simpson Lake squarely in the mesotrophic range (figure 4) and indicate good water quality.

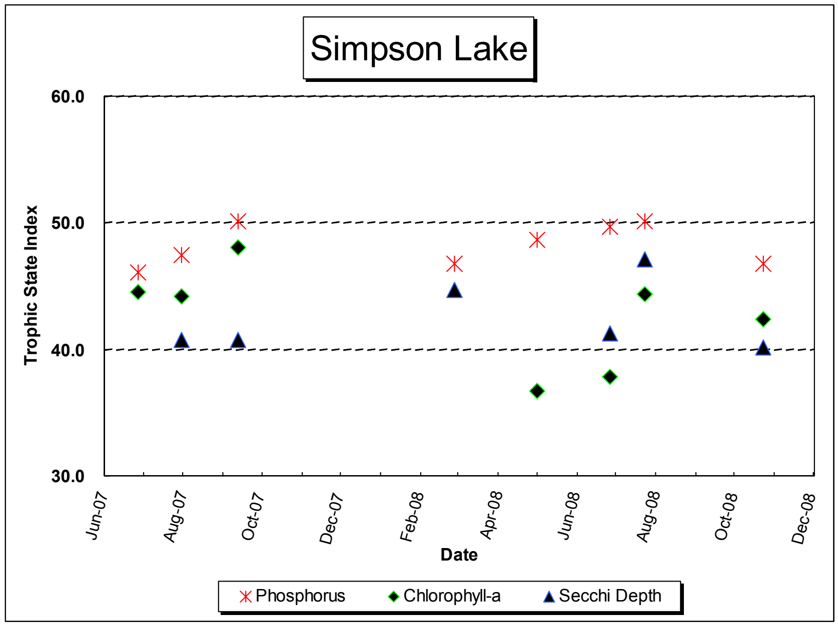

Figure 4. Simpson Lake trophic state values.

Shoreline Habitat Evaluations

Shoreline habitat was evaluated on Simpson Lake, Shannon Lake, and four sites on High Falls Flowage to establish as baseline against which future surveys can be compared to evaluate the effects of development over time. Due to the fact that some development had already taken place during the course of the study limited comparisons can already be made between developed and undeveloped sites.

The shoreline habitat evaluations include both aquatic and upland habitat monitoring. Aquatic habitat was evaluated using a modified transect survey. At each sample site three transects 10 meters apart were laid out perpendicular to shore. At each transect a line with a heavy weight was thrown out perpendicular to shore then dragged tight and anchored to shore at the ordinary high water mark. The number of logs greater than 10 cm in diameter intersecting the line within the first 10 meters was recorded. Depth, sediment type, percent of small woody cover (< 4cm diameter), and a count of medium woody cover (4-10 cm diameter) were recorded in one square meter quadrates located 0.5, 2, 5, and 9 meters from shore. Emergent vegetation within the quadrates was measured by estimating emergent plant coverage, recording the species found, and counting the number of emergent plants (stem count). Percent cover and species presence were also recorded for both floating-leaf species and submersed vegetation.

Upland habitat was also evaluated at each sample site along three transects, each 50 meters apart. Each transect began at the ordinary high water mark and was laid out perpendicular to the shore. Along each transect groundcover and shrub layer vegetation was measured at 1, 3, 12, and 30 meters from the ordinary high water mark. To measure the groundcover layer all grasses, forbs, and tree seedlings in a 0.25 square meter sample quadrate was identified and counted at each location. The shrub layer was described by identifying and counting all shrubs, ferns, and trees less than 1" diameter at the ground, in a 1 square meter sample quadrate. All plant inventories were completed in late summer to early fall so spring ephemerals are not well represented. At the 12 and 30-meter locations all trees equal or greater than 2" diameter at breast height (dbh) were identified, measured and recorded in a 1/10th acre sample plot (37-foot radius circle). Trees smaller than 2" dbh and at least 6' tall were counted as saplings.

Evaluation of Development Effects

At several monitoring sites the effects of development on shoreline habitat were already evident, particularly changes to upland vegetation. At each sample site it was noted whether the vegetation had been altered as a result of development pressures. An analysis of development effects was completed where applicable.

The Marinette County shoreline zoning code restricts cutting of shoreline vegetation within 50 feet (15.2 m) of the OHWM to one 30-foot wide view & access corridor for each lot. The corridor must lie roughly perpendicular to the shore and must retain sufficient trees to screen structures. Outside of the view & access corridor vegetation cutting is prohibited except for dead trees, which may be removed but must then be replaced. Developing properties on High Falls Flowage face additional restrictions imposed by the Wisconsin Public Service Corporation since the utility company still owns all of the land within 200 feet of the OHWM and has entered into lease agreements allowing access and certain riparian rights to adjoining owners.

Shannon Lake

At Shannon Lake six points were established by randomly choosing a compass heading and drawing a line from the center of the lake to shore along that heading. The first point was located where the compass heading and shoreline intersected. Each successive point was placed equidistant around the shore. At each point the first transect was located at the point and each additional transect was located the prescribed distance away moving in a clockwise direction around the lake (figure 5).

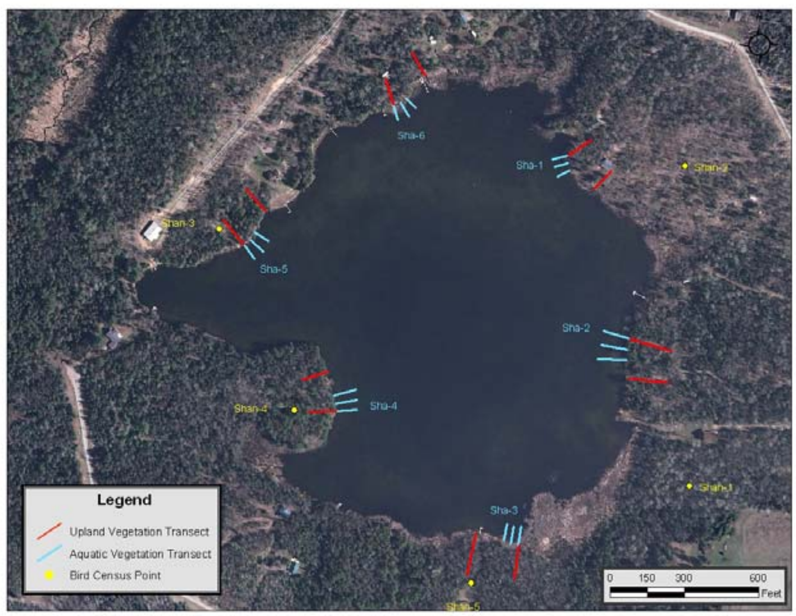

Figure 5. Shannon Lake Survey Transects

Upland Habitat Conditions

Most of the shoreline of Shannon Lake is moderately sloping. Soils are typically sandy with areas of rock outcrop. Tree species are dominated by balsam fir, red maple, white birch, and sugar maple. Most of the riparian zone has been recently logged so the forest is quite young. The average tree count for non-altered sites is 1,140 trees/acre and tree size is correspondingly small. 65% of the trees are balsam fir with an average size of less than 4" dbh. Trees of any species greater than 10" diameter are rare. Throughout the area balsam fir is dense in the understory.

With such a dense understory of trees the shrub layer is somewhat limited in diversity and density. At one, three and twelve meters bracken fern dominates the shrub layer. Tag alder and sensitive fern are also common one meter from the OHWM. At 30 meters maple-leaf viburnum, bracken fern, and tree seedlings dominate. As the distance from shore increases the number of shrubs and ferns decreases substantially, from 9.4/m^2 at one meter to 2.3/m^2 at 30 meters.

Sedges dominated the groundcover vegetation at all distances. Close to the lake (1 meter sample quadrate) lake sedge was the dominant plant. At 3,12, and 30 meters Pennsylvania sedge was the dominant species. Diversity was fairly limited with an average of just over 4 species at one and three meters, falling to 2 species at 30 meters where the tree canopy was dense.

Development Effects

Even with the limited amount of development on Shannon Lake there are obvious changes in upland vegetation at all levels (groundcover, shrub layer, and tree layer). Most alterations to the vegetation were the result of tree and shrub removal. Very little evidence of routine mowing was evident and only one transect crossed into an established lawn of turf grass.

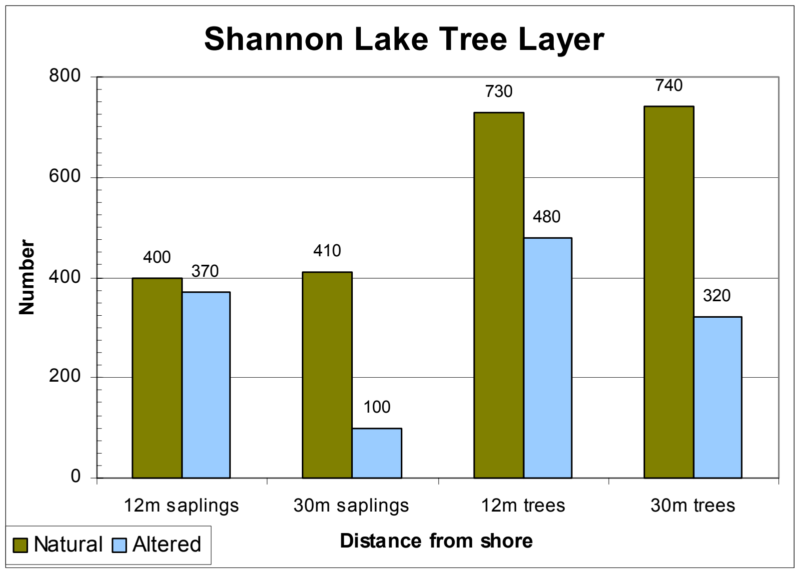

Figure 6. Effect of development on tree layer vegetation at Shannon Lake.

At Shannon Lake 23% of the groundcover sample quadrates had been altered. There was no significant decline in the number of species found except at 3 meters where there was a 65% decline. There was however a noticeable decline in the number of groundcover plants at altered sites at all distances. This was most noticeable when Pennsylvania sedge was removed from the data set since Pennsylvania sedge often increased in number as the overstory was thinned or removed. At all distances the number of plants at altered sites fell by more than 40%.

Impacts from development were also seen in the shrub layer (figure 6). Altered sites at one and three meters saw a 100% reduction in density. This was due to the fact that the quadrates in question fell in view corridors or in areas where excessive vegetation cutting had been done. Shrub density at altered sites was 29% lower at 12 meters and 76% lower at 30 meters. The effect of development on tree cover was also evident, particularly at 30 meters where tree density dropped from 740 trees/ac to 480 trees/ac, a reduction of 64%. Saplings saw an even greater reduction, falling nearly 75% from 410 to 100 saplings/ac. At 12 meters the density of trees at altered sites fell 24% while the sapling density was 7% less.

Aquatic Habitat

A shallow sloping bottom with marl sediment, moderately dense chara, abundant water lilies, and sparse emergent vegetation typifies the near-shore littoral zone of Shannon Lake. As in many marl lakes, the aquatic plant community of Shannon Lake is not very diverse. Stonewort (*Chara sp.*) is the most abundant submersed plant species followed by common bladderwort (*Utricularia vulgaris*) and bushy pondweed (*Najas flexilis*). In all, only seven species of submersed plants were identified during the transect surveys. Submersed vegetation was moderate in density, covering 20% to 50% of the bottom. A main reason for the lack of submersed plants may be the density of floating-leaf plants, with aerial coverage between 38% and 48%. White water lily (*Nymphea odorata*) was the dominant floating-leaf plant. Emergent vegetation was common but density was low with the exception of isolated cattail stands, which were often extremely dense. Emergent and floating-leaf vegetation was also mapped using a Trimble-Geo-XT GPS for future reference (figure 7).

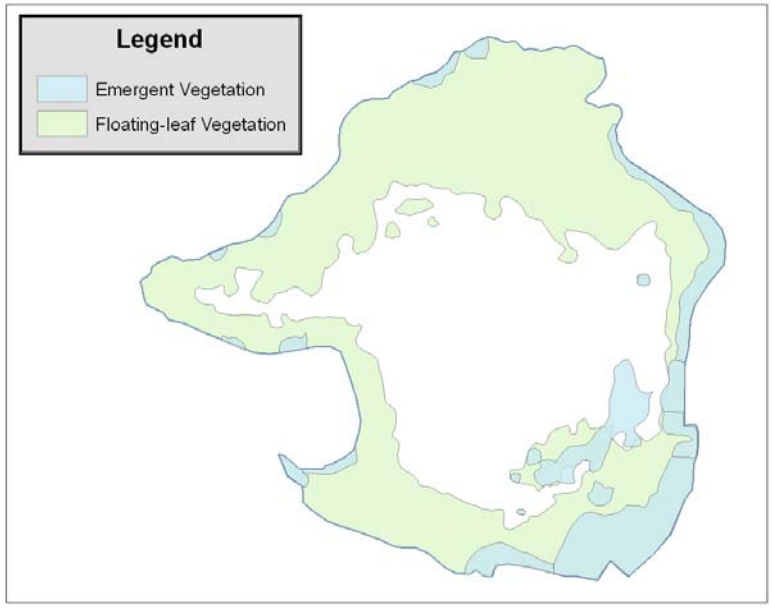

Figure 7. Shannon Lake emergent and floating-leaf vegetation.

Woody habitat was also studied. Small woody habitat covered 23% of the bottom at the 0.5-meter quadrate but declined sharply to 4.4% cover at 2 meters and 0.6% at 5 meters. Despite the abundance of stumps in the lake, medium and large woody cover was not very abundant at the measured transects. Medium woody cover averaged less than 1 piece in each quadrate at all sample distances. Likewise, large woody cover averaged only 0.7 pieces in each transect.

No obvious habitat disturbances were noted during the aquatic plant survey. Of course, the shallow depth and mucky bottom are not contusive to swimming beaches and no motorized boats were noted on the lake during the survey.

Simpson Lake

At Simpson Lake four sites were established by randomly choosing a compass heading and drawing a line from the center of the lake to shore along that heading. The first site was located where the compass heading and shoreline intersected. Each successive site was placed equidistant around the shore. At each site the first transect was located at the site and each additional transect was located the prescribed distance away moving in a clockwise direction around the lake (figure 8).

Upland Habitat Conditions

Most of the immediate shoreline surrounding Simpson Lake is steeply sloping. Soils are typically sandy and well drained. Tree species are dominated by red maple with lesser numbers of sugar maple, red oak, and white pine. Much of the area recently subdivided was select-cut prior to sale but abundant mature trees remain throughout the area. The average tree count for non-altered sites is 495 trees (2"dbh or larger) and 430 saplings (<2"dbh) per acre. At 12 meters the density of tree saplings was nearly twice as high as at 30 meters.

On Simpson Lake the shrub layer is diverse and relatively dense. At one-meter beaked hazel and bracken fern are the dominant shrub layer species. At all other distances maple-leaf viburnum is dominant. Maidenhair fern, witch hazel, tag alder, and tree seedlings are also common. As the distance from shore increases the number of shrubs and ferns increased substantially, from 4.7/m^2 at one meter to 13.0/m^2 at 12 meters. At 30 meters the shrub layer density declined slightly to 10.3/m^2 .

Sedges dominated the groundcover vegetation at all distances. Close to the lake (1 meter sample quadrate) lake sedge was the dominant plant. At 3,12, and 30 meters Pennsylvania sedge was the dominant species. Diversity was good with an average of 4 to 6 species at each sample point and more than 40 species identified in the groundcover layer. Diversity was highest at the shoreline and decreased as distance from the shore increased.

Figure 8. Simpson Lake transect locations.

Development Effects

Although the number of developed sites on Simpson Lake was limited there are still some obvious changes in the vegetation community. Most changes can be directly or indirectly attributed to the cutting of trees and shrubs in the riparian zone. In all, 25% of the groundcover quadrates had been altered.

At the both the one and three meter quadrates only one of the sites had been altered. In both cases shrubs had been cut leading to an increase in the number of sedges and ferns. Both showed a decrease in species diversity and a drop in the number of non-sedge species found in the sample plot. At 12 meters two quadrates were altered. These sites showed a 73% decrease in the number of shrubs, a 29% increase in groundcover vegetation attributed to Pennsylvania sedge, and a 48% decrease in the number of groundcover species. Significant shrub removal (71%) was noted at half of the 30-meter quadrates. This was accompanied by a significant (32%) increase in the density of Pennsylvania sedge and a 62% drop in the density of non-sedge species.

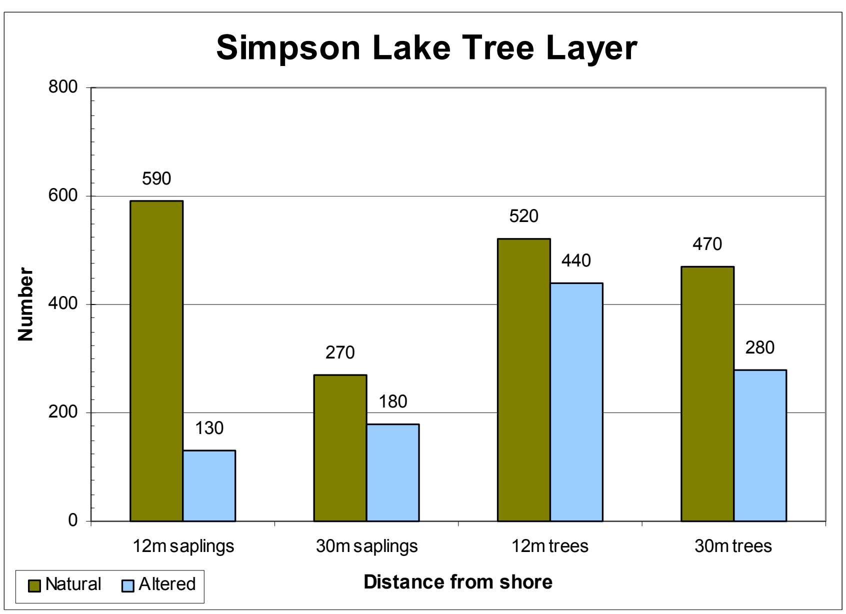

Figure 9. Effect of development on tree layer vegetation at Simpson Lake.

The effect of development on tree cover was also striking at many sites on Simpson Lake (figure 9), particularly at 30 meters where tree density fell 40% from 470 trees/ac to 280 trees/ac. The number of saplings at 30 meters fell from 270 to 180 per acre, a drop of 34%. At 12 meters the density of trees at altered sites fell only 15%, however the number of saplings declined precipitously (78%) from 590 to 130 saplings per acre.

Aquatic Habitat
Simpson Lake has a gently sloping bottom profile and an extensive littoral zone. The sediment is predominantly marl and muck covered with marl. Emergent vegetation is moderately dense along much of the shoreline and sparse in scattered beds throughout the lake. Floating-leaf vegetation is sparse to moderate in density but widespread throughout the littoral zone. White water lily (*Nymphea odorata*) and spatterdock lily (*Nuphar variegata*) are equally abundant. Flat-leaf bladderwort (*Utricularia intermedia*) is the most abundant plant in the lake followed closely by stonewort (*Chara sp.*). Fourteen species of submersed plants were identified during the transect surveys. The density of submersed vegetation was low at 0.5 and 2 meters (less than 22%), increasing to 60% at 5 meters and 82% at 9 meters.

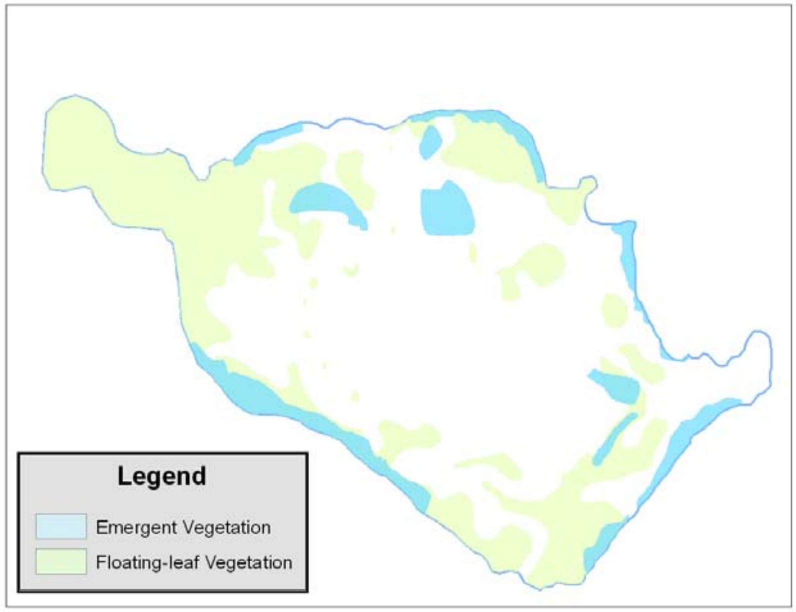

Figure 10. Simpson Lake emergent and floating-leaf vegetation.

Floating leaf vegetation and emergent vegetation were also mapped using a Trimble-Geo-XT GPS for future reference (figure 10).

Woody cover was sparse in Simpson Lake. Small woody habitat covered less than 3% of the bottom at the 0.5 and 9 meter sites and was not found at 2 or 5 meters. Medium and large woody cover were not very abundant, averaging less than 1 piece in each quadrate at 0.5 and 2 meters.

No obvious habitat disturbances were noted during the aquatic plant survey. The shallow depth and mucky bottom are not contusive to swimming beaches and no motorized boats were noted on the lake during the survey.

High Falls Flowage
High Falls Flowage is an impoundment of the Peshtigo River located in the Town of Stephenson in Marinette County. The 1,500-acre flowage is a popular tourist destination and is heavily used by fishermen and pleasure boaters alike. Prior to 2004 the Wisconsin Public Service Corporation (WPS), an electric utility company that owns and operates the dam, owned all but a few hundred feet of the 22 miles of shoreline. In 2004 WPS sold most of its holdings to the Wisconsin DNR, establishing the Peshtigo River State Forest. However, approximately 170 acres at two separate locations were subdivided into 45 lots and sold at public auction. WPS maintained ownership of a 200-foot wide natural shoreline area adjacent to the water, which was to remain undeveloped and open to limited public use. Owners of the adjacent developed lots were granted easements allowing access to the

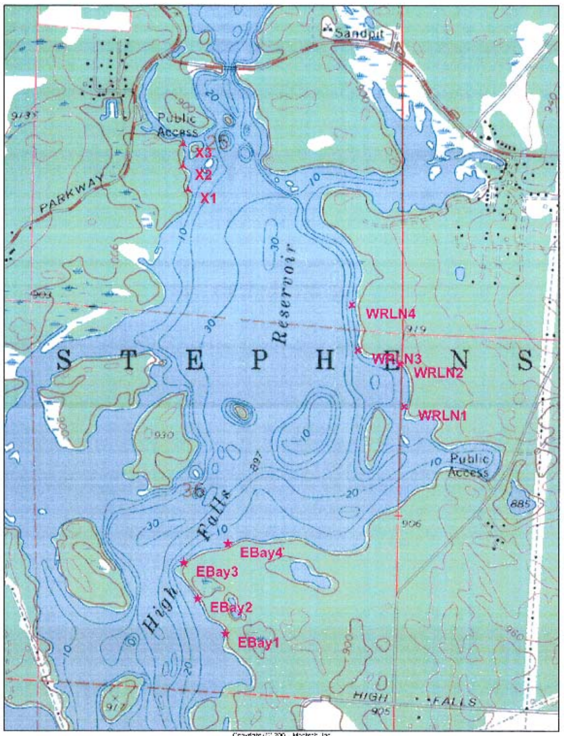

Figure 11. Hyw X, Wruk Lane, and East Bay study areas.

flowage, maintenance of a path to the water, and placement of a pier for their exclusive use. Vegetation cutting in the natural shoreline area is restricted to dead trees and shrubbery in a designated view corridor. No live trees larger than 2" diameter were to be cut.

Four separate study areas were chosen for long-term monitoring of aquatic and shoreline habitat on High Falls Flowage. Wruk Lane (figure 11) and Woods Creek (figure 12) are in developing areas while East Bay and Hwy X are located in the Peshtigo River State Forest and serve as control sites. While water quality analysis was not conducted on High Falls Flowage, the full range of habitat assessments was conducted on the developing areas and control areas. At each study site the first point was set by generating a random number and using that as a distance from the south boundary of the study area, additional points were established a set distance from the first in a northerly direction. Four points, 200 meters apart, were established at the Wruk Lane and East Bay locations while three points, 100 meters apart, were established at Hwy X and Woods Creek. Two transects were established at each point with the exception of Woods Creek where three transects were established. Each transect was located 50 meters from the first in a northerly direction.

Upland Habitat Conditions

Menahga sand, a deep, excessively drained soil with a poorly developed topsoil layer, is the dominant soil type at all of the study areas. Areas of rock outcrop are common throughout. The tree community is dominated by red maple, quaking aspen, pin oak, and jack pine with lesser numbers of black cherry and bigtooth aspen. Much of the area surrounding High Falls Flowage has been hard hit by gypsy moths and oak wilt in the last few years. Pin oaks in particular have experienced significant declines in many areas. During the vegetation surveys dead standing trees were not counted. The average tree count at Woods Creek, Hwy X, and East Bay was 245 trees/ac and 373 saplings/acre. For the tree count in particular there was very little variation among the three study areas or between the 12-meter and 30-meter sample sites (figure x). The Wruk Lane study area however was significantly different with 180 trees/acre and 700 saplings/acre in undisturbed areas. This may be due to the fact that many of the large oaks have succumbed to the combination of gypsy moth and oak wilt disease. In many areas standing dead oaks are common and pioneer species such as maple and aspen are flourishing.

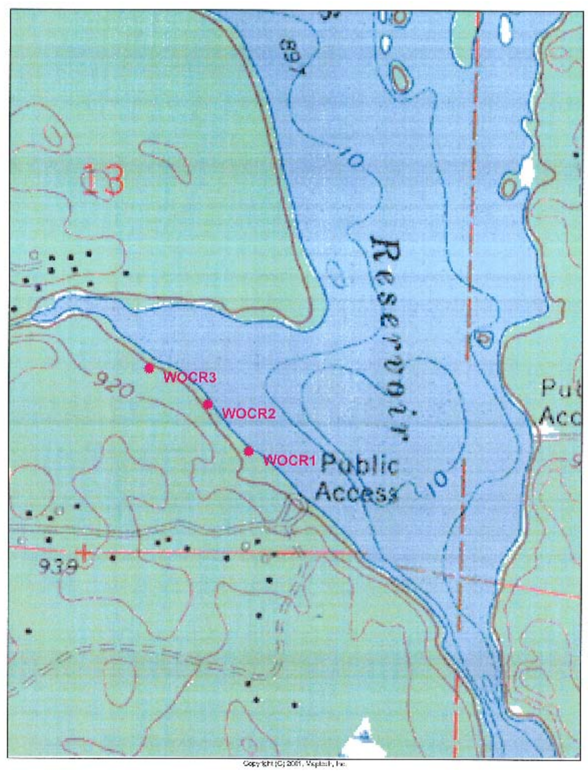

Figure 12. Woods Creek study area

On High Falls Flowage the shrub layer is dominated by blueberry, bracken fern, beaked hazel, and June berry. Tree seedlings are also common at all sites; particularly where the tree canopy is open. Tag alder is common in wet areas. Despite similar soil types, there was considerable variation between study areas. Areas where the tree canopy was more closed such as East Bay and Woods Creek were dominated more by ferns and blueberry while Hwy X and Wruk Lane had more beaked hazel and other tall shrubs. It was evident after analyzing the data that more shrub quadrates are needed to adequately describe the vegetation at these sites. Beaked hazel in particular, with its dense multi-stemmed clones was difficult to estimate. At the Hwy X and Wruk Lane sites it was often growing in densities that made it hard to walk through but the data does not reflect it very well.

Sedges, primarily Pennsylvania sedge, dominated the groundcover layer in all of the study areas and at all distances, averaging 250 to 390 stems per square meter and representing 70% to 95% of the groundcover vegetation at most of the points. Woods Creek had the most diverse groundcover layer with 35 species found and an average of 98 non-sedge plants per square meter. East Bay was the least diverse with just 19 species and an average of only 12 non-sedge plants per square meter. Wruk Lane and Hwy X had 40 to 45 non-sedge plants per square meter.

Development Effects

Although both Woods Creek and Wruk Lane are adjacent to developed sites, only the latter had received any development pressure at the time of the study. Despite the restrictions placed on vegetation removal within the "natural shoreline area" there were notable changes at the site as a result of development pressures. This was seen at all vegetation "layers" and all distances from the shore.

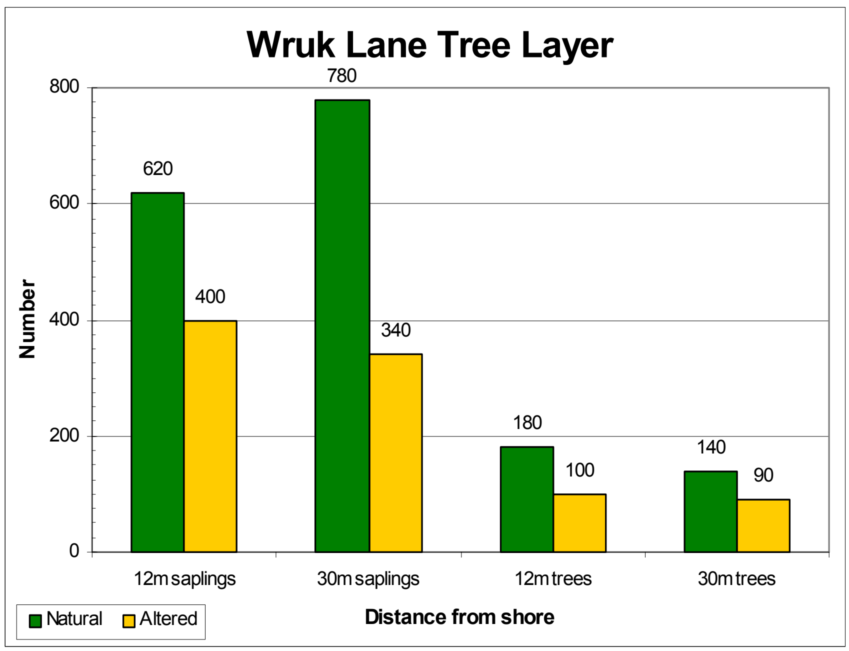

Figure 13. Effect of development on tree layer vegetation at the Wruk Lane site.

The tree layer at impacted sites had 49% fewer trees and 35% fewer saplings at 12 meters (figure 13). At 30 meters the number of trees fell 36% while saplings fell 56%. At first glance there was little change in the shrub layer due to development impacts. However, during the survey there appeared to be a notable decline in larger shrubs. When the data was analyzed further there was an obvious shift in the dominant shrub species at impacted sites (figure 14). At one meter and three meters the number of tall shrubs at impacted sites fell 91% and 83% respectively. Likewise, the number of tall shrubs at 30 meters was 61% lower at impacted sites than natural sites. At 12 meters the number of tall shrubs was actually 34% higher at impacted sites. The data at 12 meters was skewed by one quadrate that fell on a dense beaked hazel clone. At all of the impacted sites there was a corresponding increase in blueberry plants and tree seedlings at the shrub layer. A similar change in the vegetation at impacted sites was also evident at the groundcover layer. A significant drop in species diversity was seen as the number of species per quadrate fell from 3 to 1.2. Overall the number of groundcover plants increased slightly at impacted sites but the change was due entirely to an increase in Pennsylvania sedge. When sedges were

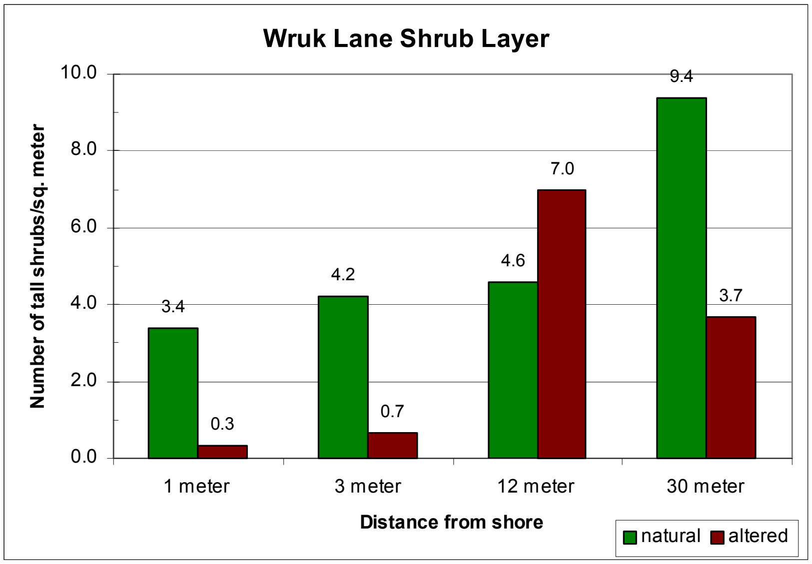

Figure 14. Effect of development on shrub layer vegetation at the Wruk Lane site.

removed from the dataset there was a 95% drop in the number of plants found at impacted sites compared to natural sites. Clearly, there was an overall decline in species diversity and a simplification of the habitat due to development pressures at the Wruk Lane study area.

Aquatic Habitat

The four study areas at High Falls Flowage can be divided into two distinct groups based on bottom type and the existing aquatic plant communities. At East Bay (undeveloped) and Wruk Lane (developing) the bottom is very gently sloping, wave-washed sand with sparse vegetation. Both sites are on the east shore of the flowage and receive quite a bit of wave energy from the predominant west wind and from often heavy boat traffic. No emergent or floating-leaf vegetation was found at either site. Submersed vegetation averaged less than 10% coverage at the 0.5 and 2-meter quadrates and less than 20% coverage at the 5 and 9-meter quadrates. At both sites chara and bushy pondweed were the dominant species. Woody cover was likewise rather sparse at the East Bay and Wruk Lane sites. Small woody cover was nearly identical between sites with less than 5% coverage at 0.5 and 5 meters, 12.6% at 2 meters. No small woody cover was found at 9 meters. Medium and large woody cover averaged less than 1 piece per quadrate at all distances.

At Hwy X (undeveloped) and Woods Creek (developing) the bottom is covered with muck and aquatic vegetation is much more diverse and abundant. Both sites are on the west shore of the flowage. Woods Creek is in a bay and the Hwy X site is protected by islands and shallow boulder strewn water that deters boat traffic. At both sites emergent vegetation is still rather sparse beyond the immediate land-water interface with an average of less than 10% cover in the first two meters and much less at 5 and 9 meters. Common bur-reed is the most common emergent species at both sites. Floating-leaf vegetation was found throughout the study areas at the 5 and 9-meter quadrates but the coverage was still quite low. At both sample areas submersed vegetation coverage was greatest at the 9-meter distance where it ranged from 89% to 95% and lowest at 0.5 meters where it covered 15% to 38% of the sample quadrates. A review of submersed species frequency shows remarkable similarity between the two sites. Common waterweed (*Elodea canadensis*) Eurasian watermilfoil (*Myriophyllum spicatum*) were each found in nearly one quarter of the sample quadrates. Water stargrass (*Heteranthera dubia*) was found in nearly 15% of the quadrates. Common minor species included bushy pondweed (*Najas flexilis*), white water crowfoot (*Ranunculus longirostris*), water celery (*Vallisneria Americana*), coontail (*Ceratophyllum demersum*), and a handful of pondweeds (*Potamogeton spp*.).

Woody habitat was only slightly more abundant at the Woods Creek and Hwy X study areas. Small woody cover was especially abundant at Woods Creek where coverage averaged 33%. Medium woody cover was also more abundant at Woods Creek than the Hwy X site.

No obvious aquatic habitat disturbances were noted during the aquatic plant survey. At the Woods Creek site only two docks had been installed and no plant or woody habitat removal was noted. At Wruk Lane there were 7 docks installed at the time of the survey. Most were at least 100 feet long and located in sandy areas with little submersed vegetation.

Frog Call Survey

The Green Frog (*Rana clamitans*) has been used as an ecosystem indicator organism to study the effects of development on Wisconsin Lakes (Meyer 1997). The Green frog is well suited for this use since they are habitat generalists, known to inhabit every type of permanent water, and call loudly to defend a territory and attract a mate. Green Frog surveys were conducted at night by canoeing along the entire lake shoreline or, in the case of High Falls Flowage, each study area. The numbers of green frogs calling were recorded and their approximate positions estimated. All surveys were conducted during periods of light wind (<10mph). Each Lake or study area was surveyed once in 2007 and 2008. The Marinette County study is designed to track changes in the green frog population over time due to the impacts of shoreline development.

Shannon Lake

The entire shoreline of Shannon Lake is excellent green frog habitat. Shallow water, abundant sedges and wetland shrubs, frequent emergent aquatic plants, and numerous stumps and logs typify the shoreline. In 2007 42 green frogs were counted along the shore, increasing slightly to 44 frogs in 2008. The only shoreline area with habitat alterations sufficient to affect green frog habitat was approximately 100 feet of shore located adjacent to the oldest home on the lake. At this property upland vegetation had been converted to lawn and sand had been deposited in a 50-foot wide area to create a beach.

Simpson Lake

Green frog habitat at Simpson Lake was also abundant. Sedges dominate the shoreline fringe along with many areas of alder and dense overhanging shrubs. Even the existing developed properties had natural shorelines with little or no habitat alterations. In 2007 only 15 frogs were counted, increasing to 26 in 2008. The variability is likely due to weather or other conditions since there was no change in habitat during the period.

High Falls Flowage

On High Falls Flowage the Wruk Lane and East Bay sites do not provide good green frog habitat. Both are characterized by sandy wave washed shorelines with limited wetland vegetation. During the two-year study only one green frog was recorded at East Bay and none at Wruk Lane. At East Bay three are two inland wetlands close to the shoreline where green frogs were noted both years.

At the Woods Creek and Hwy X sites the shoreline habitat was much more “frog friendly”. Both sites have abundant aquatic vegetation and wetland fringe at the shoreline. At Hwy X the number of green frogs increased from 2 in 2007 to 11 in 2008. Similarly, at Woods Creek the number increased from 8 frogs in 2007 to 12 in 2008.

Analysis and Future Data Gathering

The limited frog call surveys do not yet provide sufficient data for meaningful analysis. The increase in frog numbers seen at most study areas is likely due to weather conditions or other events. Also, while changes in upland vegetation have been noted at Simpson Lake, Shannon Lake, and the Wruk Lane site at High Falls Flowage there have not been any significant changes in the adjacent aquatic habitat.

In the future, frog-calling data will be collected at least every other year to develop a baseline at undeveloped sites and to track future changes in the green frog population resulting from lakefront development and associated shoreline habitat alterations. The Wruk Lane and East Bay sites will likely be dropped from the survey since they do not provide good green frog habitat even in their current "undeveloped" states.

Bird Census

A Wisconsin Department of Natural Resources (WDNR) study conducted on 17 developed and 17 undeveloped northern Wisconsin lakes (Meyer, 1997) looked at the effects of riparian residential development on breeding birds. The study found that "…habitat alteration is a primary factor influencing the shift in avian community structure on these lakes." Following survey methods similar to the WDNR study, Marinette County Land and Water Conservation Division (LWCD) staff conducted point counts at ten near shore sites on High Falls Flowage, four sites on Simpson Lake and five sites on Shannon Lake. Unlike the WDNR study, the goals for the LWCD study are not to compare the local avian community structure between lakes, but to document changes to the bird populations on each lake over time.

Both Shannon and Simpson Lakes are fully subdivided and over time are likely to be developed up to the limits of the Marinette County Shoreline-Wetland Zoning Ordinance. At High Falls Flowage, portions of the riparian areas are subdivided for development and significant development has already occurred, although Wisconsin Public Service retained ownership of a 200-foot wide strip of land in between the ordinary high water mark and the privately owned parcels. Most of the flowage is owned by the State of Wisconsin and will not be developed. Therefore in addition to looking at bird population responses to landscape alteration on developed lots, it will be possible to compare the monitoring results to undeveloped reference sites. While bird census points do not correspond exactly to the vegetation monitoring sites, the bird census data should reflect changes in the vegetation over time. Bird census points can be found in Appendix A. Aerial photos of the study areas can be found in Appendix C.

Methods

Ten-minute point counts were conducted at each site between 4:48am and 8:00am. In 2007 they were conducted on June 20, 26, and 27 and in 2008 on July 1–4. During the counts all birds seen or heard were recorded on data sheets that contained a 50-meter circle within a 100-meter circle. North was determined before the start of the count. Direction and distance from the center of the 50-meter circle were estimated for each individual bird. Wind velocity and sky condition were noted during each count to account for wind or rain affecting the ability to hear birds. Point counts were not conducted during rain events.

Analysis and Future Data Gathering

With only two seasons of data gathering completed, little can be deduced about the bird population structures at this time. A total of 60 different species were found. The highest number of species recorded at any site was fifteen. The highest number of individual birds at one site was twenty-one. As might be expected, the two most common bird species were the Red-eyed Vireo (*Vireo olivaceous*) and the Ovenbird (*Seiurus aurocapillus*). The Red-eyed vireo was detected at all nineteen sites and the Ovenbird at fourteen sites. For a full breakdown of the numbers and species detected in each point count, see Appendix A. Moving forward each point count will be repeated every other year to track changes and assess the effects of shoreline development on the bird community.

Information & Education

The grant project also contained a significant information and education component designed to increase awareness among concerned citizens and lakefront property owners about the threats facing our lakes and streams from overdevelopment, runoff pollution, and invasive exotic species. Expanding participation in the Citizen Lake Monitoring Network was a key goal of the project. The LWCD also sought to increase knowledge concerning shoreland zoning rules, and the need for protecting riparian areas, among contractors who work in the shoreland zone.

Citizen Lake Monitoring

The LWCD took every opportunity to educate citizens about AIS monitoring and prevention. Between 2007 and 2009 the department published ten articles in the Northwoods Journal dealing with aquatic invasive species prevention, monitoring, emerging threats in Marinette County, and ongoing control efforts. The County also sponsored Citizen lake Monitoring Network workshops for AIS monitoring in the spring of 2008 and 2009. 19 individuals representing 9 lakes attended the workshop and received AIS monitoring kits. The department also sponsored “Clean Boats, Clean Waters” workshops in 2008 and 2009 to train volunteer watercraft inspectors on Marinette County lakes. 16 individuals from 7 lakes attended the workshops and a CBCW watercraft inspection program has been adopted on four county lakes. Additional AIS monitoring and CBCW workshops will be held in the future to increase monitoring and prevention efforts on Marinette County lakes.

Contractor Certification

Many of the most serious shoreland and wetland violations; placement of structures too close to the water; excessive vegetation removal; grading on steep slopes; insufficient erosion control; and wetland filling; involve earthwork contractors during all or part of the process. In an effort to reach this important audience and head off problems before they occur the LWCD held a contractor training and certification workshop in the spring of 2007. The three-hour workshop featured presentations by Marinette County LWCD and Shoreland Zoning staff, along with Wisconsin DNR Water Management staff. The agenda included the reason for shoreland/wetland protection and an overview of current State and local rules and regulations for the protection of lakes, rivers, and wetlands (Appendix B). 42 individuals representing 19 local earthwork contractors attended the workshop along with several landscape contractors, engineers, and public officials. Contractors who attended the workshop were included on the Counties official list of certified contractors. The list is provided to the public when they inquire about contractors to work on projects in the shoreland/wetland zone.

Nonpoint Source Evaluations

The grant proposal also called for a county wide nonpoint source runoff evaluation to identify high hazard areas for manure spreading. To accomplish this a county wide manure spreading layer was created in GIS. Utilizing the soils and hydrology layers it was possible to analyze areas unsuitable for winter manure spreading due to excessive slope, wetness, excessive drainage, or proximity to water. The combined data creates a map of areas unsuitable for winter spreading of manure (figure 15). While the product provides a good starting point for large-scale analysis, it is not adequate for farm-by-farm analysis of winter spreading and manure storage needs. The GIS layer misses many of the smaller scale drainage features that can transport manure-laden water during spring runoff events.

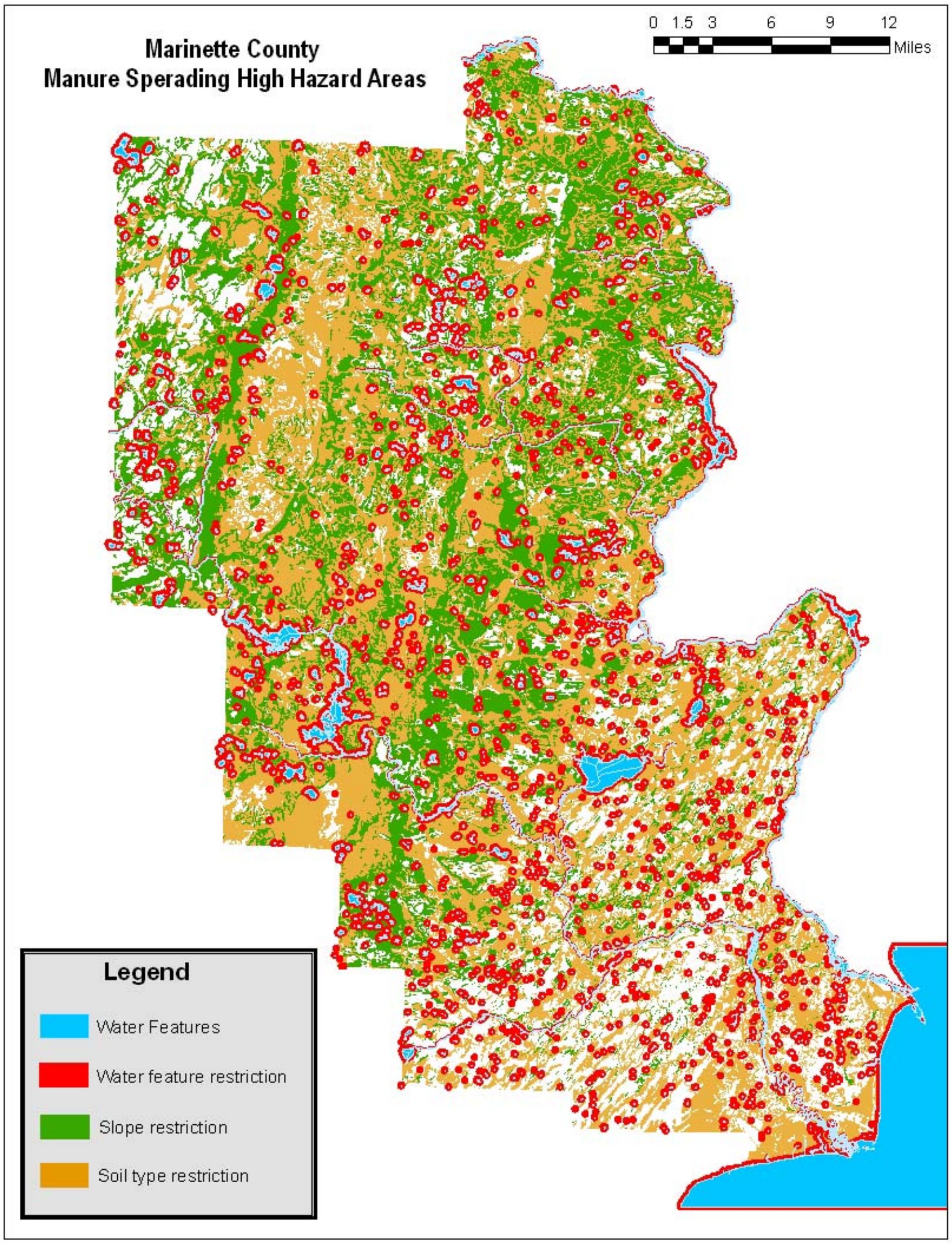

Figure 15. Manure spreading restrictions map for Marinette County

References

Meyer, M., J. Woodford, and S. Gillum, 1997. Shoreline Regulations Do Not Adequately Protect Wildlife Habitat in Northern Wisconsin. Bureau of Integrated Science Services, Wisconsin Department of Natural Resources.