Walloon Lake Shoreline Survey 2020

By Tip of the Mitt Watershed Council

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SUMMARY

During the late spring and summer of 2020, the Tip of the Mitt Watershed Council conducted a comprehensive shoreline survey on Walloon Lake at the request of the Walloon Lake Association and Conservancy. Watershed Council staff and interns surveyed the entire shoreline in June and July to document conditions that can potentially impact water quality. The parameters of the survey are designed to assess the three biggest threats to lakes: nutrient pollution, habitat loss, and shoreline erosion.

Survey results indicate that human activity along the Walloon Lake shoreline is likely impacting the lake ecosystem and water quality. For Northern Michigan, Walloon Lake has the second highest amount of altered shoreline (behind Lake Charlevoix) and the fifth highest percentage of parcels with *Cladophora*. In addition to its position as one of the higher risk lakes in Northern Michigan, since 2001, the lake has experienced more development, an increase in shoreline alterations, and more properties exhibiting *Cladophora* growth. Greenbelt ratings and erosion scores are improving, possibly as new developments get established. While the entire lake is improving as a whole, certain areas are getting worse. For instance, the number of properties with seawalls and no greenbelts has increased in recent years.

To achieve the full value of this survey, the Walloon Lake Association and Conservancy and other stakeholders should engage in follow-up activities, including: 1) Educate riparian property owners about how to protect the water quality of Walloon Lake through shoreline property best management practices; 2) Disseminate a shore survey results summary to all shoreline residents; 3) Provide assistance to property owners whose shorelines have been identified through the survey as potentially impacting water quality (e.g. nutrient pollution, lack of greenbelt, erosion, etc.) to improve conditions; and 4) use MI Shoreland Stewards' resources to encourage self-evaluation and learning. The shoreline survey should be repeated every 5-10 years as shoreline ownership, management, and conditions continually change.

INTRODUCTION

Background:

During the late spring and summer of 2020, a shoreline survey was conducted on Walloon Lake by the Tip of the Mitt Watershed Council (Watershed Council) to document shoreline conditions that potentially impact water quality. The entire shoreline was surveyed to document the following: algae as a nutrient pollution indicator, erosion, shoreline alterations, greenbelts, and tributary inlets and outlets. This survey was funded by the Walloon Lake Association and Conservancy (WLAC) and performed at the request.

Including the 2020 survey, six shoreline surveys have been performed on Walloon since 1998. The most recent prior to this survey was completed in 2016 with funding from the Petoskey-Harbor Springs Area Community Foundation's Little Traverse Bay Protection and Restoration Fund.

The 2020 survey provides a comprehensive data set documenting shoreline conditions on Walloon Lake; a valuable data set that can be used as a lake management tool. Combined with follow-up activities, such as questionnaires and on-site visits, problems in shoreline areas that threaten the lake's water quality can be identified and corrected. These solutions are often simple and low cost, such as regular septic system maintenance, proper lawn care practices, and wise land use along the shoreline. Prevention of problem situations can also be achieved through publicity and education associated with the survey. Periodic repetition of shoreline surveys is important for identifying new and chronic problem sites, determining long-term trends of near-shore nutrient inputs and shoreline alterations associated with land-use changes, and for assessing the success of remedial actions.

Shoreline Development Impacts:

Lake shorelines are the critical interface between land and water where human activity has the greatest potential for degrading water quality. Traditional development of shoreline properties for residential, commercial or other uses invariably leads to negative impacts on the lake ecosystem. During the development process, the natural landscape is altered in a variety of ways: vegetation is removed; the terrain is graded; utilities are installed; structures are built; and areas are paved. These changes to the landscape and subsequent human activity in the shoreline area have consequences on the aquatic ecosystem. Nutrients from organic wastes, contaminants from cars and roads, and soils from eroded areas are among some of the pollutants that end up in and negatively impact the lake following shoreline development.

Nutrient pollution can have adverse impacts on aquatic ecosystems and pose a danger to human health. While nutrients are necessary to sustain a healthy aquatic ecosystem, excess nutrients will stimulate nuisance aquatic plant growth of both macrophytes (aquatic plants that grow in or near water and are either emergent, submergent, or floating) and algae. Additionally, algal blooms pose a public health risk as some species (i.e. blue green algae) produce toxins, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Excess plant and algae growth can also degrade water quality by depleting the ecosystem's dissolved oxygen stores. During nighttime respiration, plants compete with other organisms for a limited oxygen supply. Furthermore, the decomposition of algae and plants has the potential to deplete dissolved oxygen supplies due to the aerobic activity of decomposers, particularly in the deeper waters of stratified lakes.

In general, large, deep lakes, such as Walloon Lake, are less sensitive to nutrient pollution. Because larger lakes have a greater water volume and dissolved oxygen stores, they tend to be less susceptible to nutrient pollution. By contrast, small lakes generally have smaller stores of dissolved oxygen and a lesser ability to dilute nutrients; therefore, they are more susceptible to the indirect impacts of nutrient pollution.

Furthermore, nutrient pollution can be more problematic in small lakes due to extensive shallow areas that can support more aquatic macrophyte growth.

Walloon Lake has a naturally high buffering capacity that helps mitigate negative impacts from nutrient pollution due to its large surface area and depth (4,600 acres, maximum depth= 100’). Additionally, it is a drainage lake with inflows and an outflow, which provides a mechanism to flush excess nutrients through the system. Regardless of Walloon Lake’s attributes, unnaturally high nutrient concentrations can occur and cause problems in localized areas, particularly near nutrient sources in shoreline areas.

Surface waters receive nutrients through a variety of natural and cultural (human) sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from riparian (shoreline) areas, and atmospheric deposition. Springs and seeps, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter. Nearby wetland seepages may also discharge nutrients at certain times of the year. Cultural sources include septic systems, fertilizers, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural and forestry practices, which oftentimes result in soil erosion, and wetland destruction also contribute to nutrient pollution. Furthermore, some cultural sources (e.g., malfunctioning septic systems) pose a potential health risk due to bacterial and viral contamination.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators (a.k.a., bio-indicators). Although chemical analyses of water samples to check for nutrient pollution can be effective, they are oftentimes more labor intensive and costlier than other methods. Typically, water samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituents, such as chloride, can be measured. Physical measurements, such as water temperature and conductivity (i.e., the water’s ability to conduct an electric current), are primarily used to detect malfunctioning septic systems. Biologically, nutrient pollution can be detected along the lake shore by noting the presence of *Cladophora* algae, a bio-indicator.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in Northern Michigan lakes. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. It is found most commonly in the wave splash zone and shallow shoreline areas of lakes, and streams. It grows best on stable substrates, such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for its growth and detection in Northern Michigan lakes is from mid-May to early July, and September to October.

The nutrients required for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of Northern Michigan. Therefore, shoreline locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake can be identified by noting the presence of *Cladophora*. Although the growth features of *Cladophora* can be influenced by factors such as current patterns, shoreline topography, substrate composition, and wave action, the presence or absence of any significant growth is a powerful lake-wide screening tool. It can reveal the existence of chronic nutrient loading problems and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient inputs due to changing land use.

Erosion along the shoreline has the potential to degrade the lake's water quality. Stormwater runoff through eroded areas carries sediments into the lake and impacts the lake ecosystem in a variety of ways. Sediments clog the gills of fish, aquatic insects and other aquatic organisms. Excessive sediments smother fish spawning beds and fill interstitial spaces that provide habitat for a variety of aquatic organisms. Suspended sediments absorb sunlight energy and increase water temperatures. In addition, nutrients adhere to sediments that wash in from eroded areas, which can lead to nuisance aquatic plant growth and algal blooms.

Shoreline greenbelts are essential for maintaining a healthy aquatic ecosystem. Greenbelts consisting of a variety of native woody and herbaceous plant species provide habitat for near-shore aquatic organisms as well as other shoreline-dependent wildlife. They also help to stabilize shorelines against wave and ice action with their extensive network of deep, fibrous roots. Greenbelts also provide shade to nearshore areas, which is particularly important for lakes with cold water fisheries. In addition, greenbelts provide a mechanism to filter pollutants carried by stormwater from rain events and snowmelt.

Tributaries have a significant potential for influencing a lake's water quality as they are one of the primary conduits through which water is delivered to a lake from its watershed. Inlet streams may provide exceptionally high quality waters that benefit the lake ecosystem; conversely, they have the potential to deliver polluted waters that degrade the lake's water quality. Outlet streams flush water out of the lake, providing the means to remove contaminants that have accumulated in the lake ecosystem. With regard to shore surveys, noting the location of inlet tributaries is very helpful when evaluating shoreline algae conditions because nutrient concentrations are generally higher in streams than in lakes. The relatively higher nutrient levels delivered from streams often lead to naturally heavier *Cladophora* and other algal growth in nearby shoreline areas.

Lake-friendly shoreline property management is paramount for protecting water quality and sustaining a healthy, thriving lake ecosystem. Septic system maintenance, stormwater management, erosion control, and the elimination of fertilizers, herbicides, and pesticides are among the many low-cost best management practices that minimize the impact of shoreline properties on water quality.

Study Area:

Walloon Lake is located in Bear Creek and Resort Townships of Emmet County and Bay, Evangeline, and Melrose Townships of Charlevoix County of the northwest Lower Peninsula of Michigan. Based on digitization of 2012 aerial orthophotography from Emmet and Charlevoix County Equalization/GIS departments, the shoreline of Walloon Lake measures 30.5 miles and the lake has a surface area of 4,586 acres. Walloon Lake extends approximately 9.5 miles in a southeast to northwest direction and is generally less than one mile wide throughout its length. A number of prominent land points project into the lake and define the boundaries of the lake's five distinct basins. The five basins in Walloon Lake include (from northwest to southeast) Mud Basin, the West Arm, the Main Basin, the Foot Basin, and the North Arm (Figure 1). Bathymetry maps show the deepest location to be near the center of the West Arm, with a maximum depth of 100 feet (Michigan GIS Open Data, 2020). Maximum depths in the other basins are as follows: 94 feet in the Foot Basin, 80 feet in the Main Basin, 52 feet in the North Arm, and 14 feet in Mud Basin. Broad, shallow areas are found between the various basins and throughout the Mud Basin.

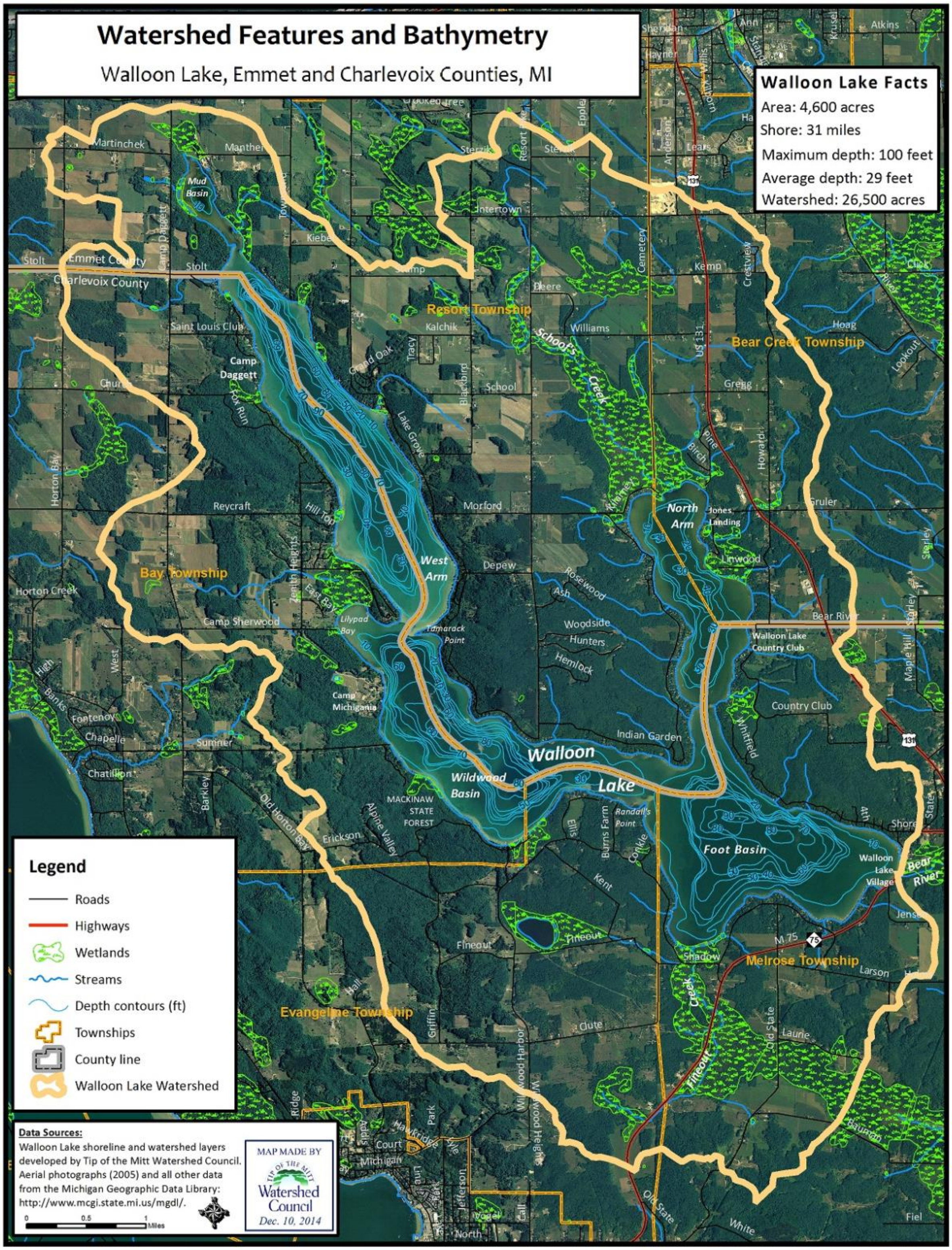


Figure 1. Map of Walloon Lake and its Watershed

Walloon Lake is a drainage lake with water flowing into and out of the Lake. The primary inlets include Schoof's Creek in the north end of the North Arm and South Arm Creek (AKA, Fineout Creek) in the south end of the Foot Basin. The only outlet is the Bear River, which flows out the east end of the Foot Basin at Walloon Lake Village. Extensive wetland areas are found in the lower Schoof's and South Arm Creeks' Watersheds, as well as the perimeter of the Mud Basin.

Using elevation data acquired from the State of Michigan, Watershed Council staff developed watershed boundary files for Walloon Lake in a GIS (Geographical Information System). Based on these data, the Walloon Lake Watershed encompasses approximately 26,500 acres of land and water (Figure 1). A watershed ratio of 4.75 was calculated by dividing the Lake surface area into the watershed area (not including the lake), indicating that there are under five acres of land in the Watershed for each acre of Walloon Lake's water surface. This ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover. Relative to other lakes in Northern Michigan, Walloon Lake has a low watershed ratio and therefore a smaller buffer to protect the lake from impacts associated with watershed development.

Land cover statistics were generated for the Watershed using remote sensing data from the National Oceanic Atmospheric Association's Coastal Change Analysis Program (Table 1). The most recent data available at the time of this report was from remote sensing data collected in 2016. Based on this data, the majority of the Watershed's landcover is natural, consisting primarily of forest, wetlands, and grassland. There is a moderate amount of agricultural landcover (~22%), but little urban (4%). The majority of agriculture is located around Fineout and Schoof's Creeks and is concentrated in between the North Arm and West Basin (Figure 2). Both agricultural and urban landcover increased by roughly one percent between 2000 and 2010.

Table 1. Walloon Lake Watershed land cover statistics.

Land Cover Type	Acres (2000)	Percent (2000)	Acres (2016)	Percent (2016)	Change, Acres (2000-2016	Change, Percent (2000-2016)
Agriculture	5499	21	5850	22	351	1.3
Barren	35	0	21	0	-14	-0.1
Forested	10101	38	10274	39	173	0.6
Grassland	3163	12	2022	8	-1141	-4.3
Scrub/Shrub	521	2	661	2	140	0.5
Urban/residential	691	3	939	4	248	0.9
Wetland	1789	7	2037	8	248	0.9
Water	4711	18	4723	18	12	0.0
TOTAL	26510.1	100	26527	100	NA	NA

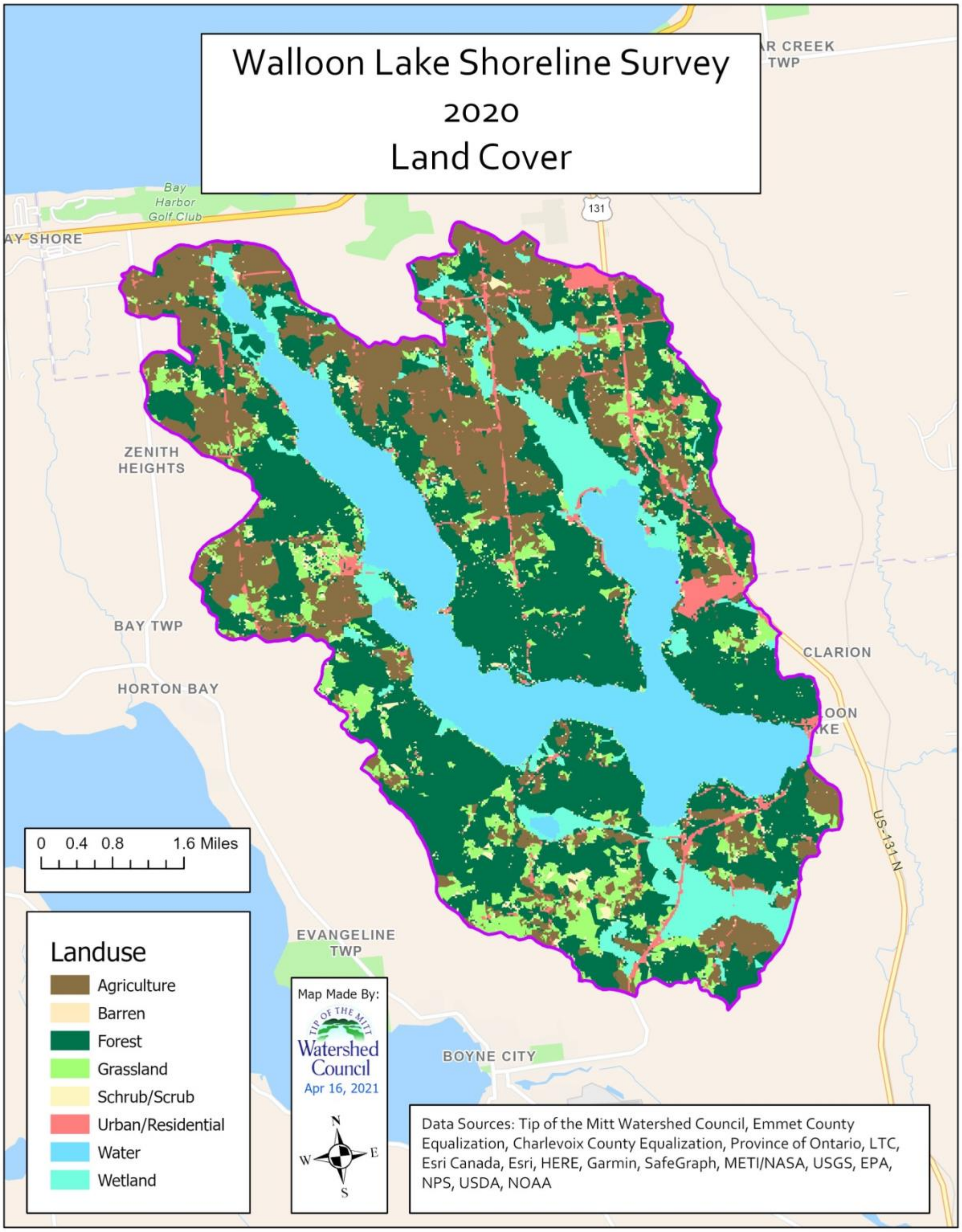
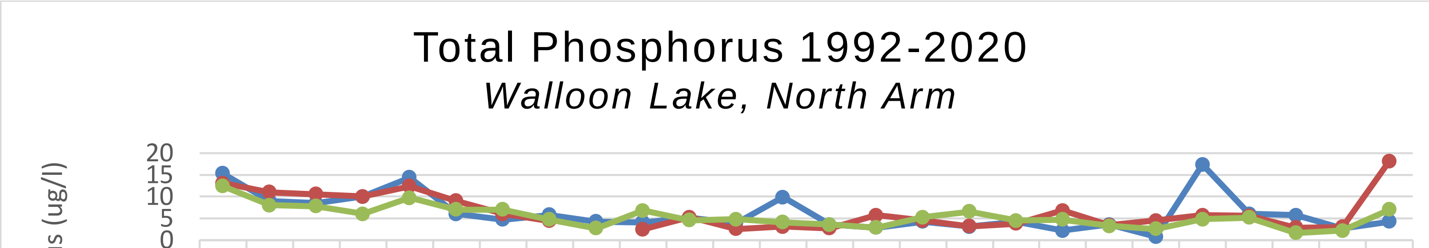


Figure 2. Land cover in the Walloon Lake Watershed (2016).

The water quality of Walloon Lake has been monitored consistently for three decades. WLAC has actively supported water quality monitoring programs by providing volunteers for monitoring programs coordinated by the Watershed Council. In addition, Walloon Lake is monitored by Watershed Council staff as part of the Comprehensive Water Quality Monitoring program (CWQM) every three years and the years in between through an agreement between the Watershed Council and WLAC. Watershed Council databases contain Volunteer Lake Monitoring and CWQM data that date back to 1989 and 1992, respectively.

Data collected through these programs indicate that water quality has been consistently high. Total phosphorus data collected in the CWQM program and annual monitoring show that levels dropped considerably from nearly 16 micrograms per liter (µg/l) in 1992 to around 1 µg/l in 2015 (Figure 3). In 2016 and 2020, there were a few spikes of total phosphorus, similar or higher to levels found in 1992. High quality lakes typically have total phosphorus levels of 10 µg/l or below. Volunteer Lake Monitoring data indicate that biological productivity decreased in Walloon Lake until 2016. The decrease is likely due to the proliferation of invasive zebra mussels (*Dreissena polymorpha)*. It's possible that the increased biological productivity and total phosphorus since 2016 indicate a rebound from the invasion of zebra mussels. Trophic status index scores for three of the four basins monitored by volunteers now generally fall into the oligotrophic category, which indicates low biological productivity (Figure 3, Figure 4). Oligotrophic lakes are characteristically large, deep, and nutrient poor, but have ample stores of dissolved oxygen and, in general, high water quality.



	1992	1995	1996	1997	1998	1999	2000	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Bottom	15.	9.0	8.5	10.	14.	6.0	4.7	5.8	4.3	4.1	5.1	3.9	9.9	3.6	2.9	4.3	3.1	4.3	2.2	3.6	0.8	17.	6.0	5.7	2.6	4.2
Middle	13.	11.	10.	10.	12.	9.0	6.0	4.4		2.5	5.3	2.6	3.1	2.7	5.7	4.5	3.2	3.8	6.8	3.4	4.5	5.7	5.6	2.8	3.0	18.
Surface	12.	8.0	7.8	6.0	9.7	7.0	7.0	4.7	2.7	6.8	4.6	4.8	4.1	3.6	2.9	5.3	6.5	4.5	4.7	3.3	2.6	4.8	5.2	1.6	2.2	7.0

Figure 3. Chart of phosphorus data from Walloon Lake.

**Total phosphorus measured in ug/l, which is milligrams per liter or parts per billion.*

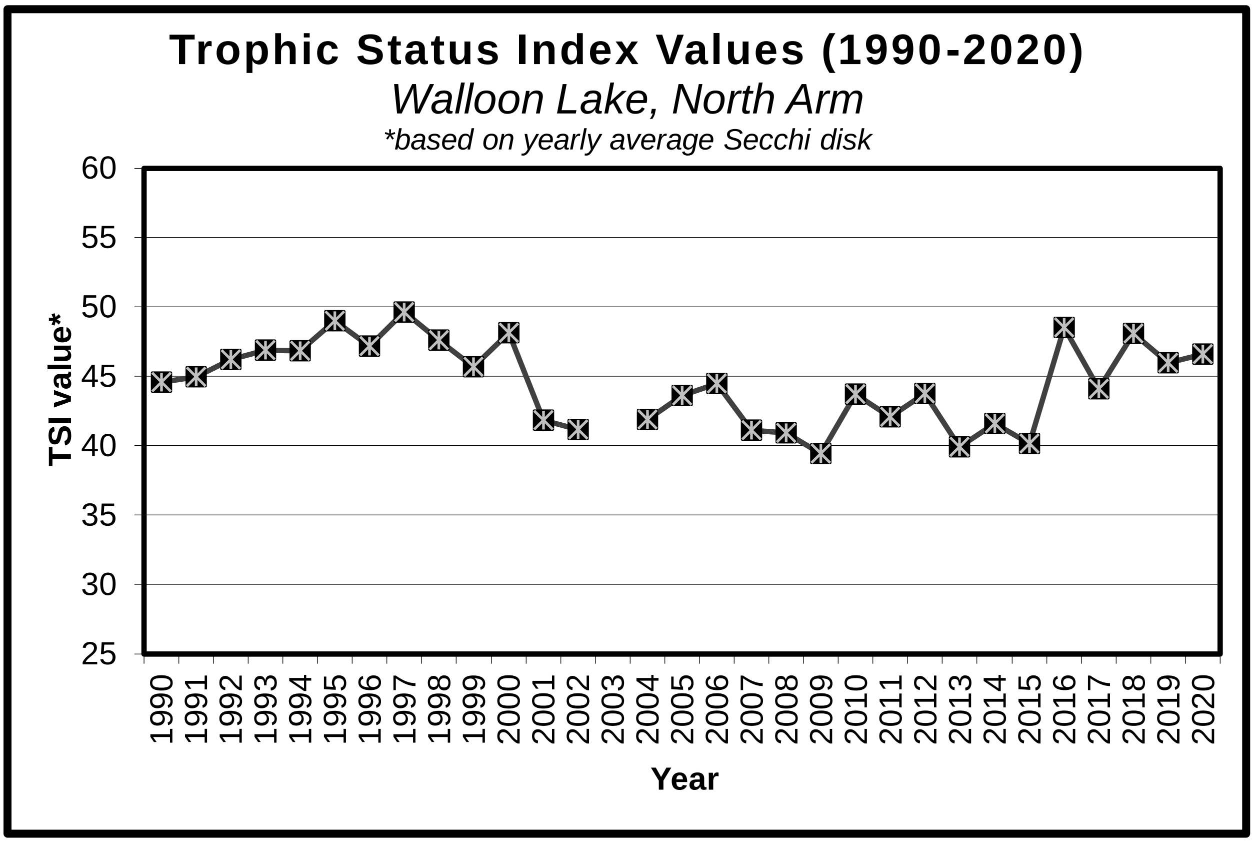


Figure 4. Chart of trophic status index data from Walloon Lake.

**Trophic Status Index values based on annual averaged Secchi disc depth data and represent the trophic status (biological productivity) of the lake: 0-38 = oligotrophic (low productive system), 39-49 = mesotrophic (moderately productive system), and 50+ = eutrophic (highly productive system).*

METHODS

The Walloon Lake shoreline was comprehensively surveyed from mid-June to early July to document shoreline conditions that can potentially impact water quality. Shoreline conditions were surveyed by traveling in kayak as close to the shoreline as possible (usually within 20 feet) and noting *Cladophora* growth, substrate type, erosion, greenbelt health, shoreline alterations, and tributaries. Information for each property was recorded on iPads using ArcCollector, which immediately linked it with property owner data from county equalization records dated June 2020.

Field Survey Parameters

A feature class with shoreline property outlines and ownership information were collected from Emmet and Charlevoix County Equalization in June 2020. The parcels from each county were merged into a single feature class. Only shoreline parcels were selected using a buffer around a shapefile of Walloon Lake. Fields for each survey parameter were set up in an attribute table with owner, property identification numbers, and address information. Domains were described in each field according to options available under each parameter. The feature class was uploaded to ArcGIS online and options were set for editing offline in ArcCollector. The lake was split into five zones. Each zone was downloaded separately on the ArcCollector app in iPad for data collection.

Shoreline property features were documented by photographing and noting physical features in the ArcCollector app on iPads. Physical features include building descriptions, public access sites, and county road endings. Building descriptions were recorded in an abbreviated style such as *"Red 2 sty, brn rf, wht trm, fldstn chim, lg pine"* means that the property has a red two-story house with a brown roof, white trim, fieldstone chimney, and a large pine tree in the yard.

Developed parcels were noted in ArcCollector and included as a separate column in the database. Properties described as developed indicate the presence of buildings or other significant permanent structures, including roadways, boat launching sites, and recreational properties (such as parks with pavilions and parking lots). Properties with only mowed or cleared areas, seasonal structures (such as docks or travel trailers), or unpaved pathways were not considered developed. Additionally, large parcels that had structures in an area far from the water's edge were not considered developed. The length and area of developed versus undeveloped shoreline was not calculated.

Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes. Positive identification of these species usually requires the aid of a microscope. However, *Cladophora* usually has an appearance and texture that is quite distinct to a trained surveyor, and these were the sole criteria upon which identification was based. Other species of filamentous green algae can respond to an external nutrient source in much the same way as *Cladophora*, though their value as an indicator species is not thought to be as reliable. When other species occurred in especially noticeable, large, dense growths, they were recorded on the data sheets and described the same as those of *Cladophora*.

When *Cladophora* is observed, it will be described in terms of the length of shoreline, with growth, the density of growth, and any observed shoreline features potentially contributing to the growth (Table 2). Each piece of information will be a separate field in ArcCollector. Both shoreline length and growth density will be subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora* using the following categorization system:

Table 2. Categorization system for *Cladophora* density.

Density Category	Field Notation	Substrate Coverage
None	(N) or leave blank	0%
Very Light	(VL)	A green shimmer
Light	(L)	1- 25%
Light to Moderate	(LM)	25-49%
Moderate	(M)	50-59%
Moderate to Heavy	(MH)	60-74% (substrate mostly covered)
Heavy	(H)	75-99% coverage (substrate entirely covered)
Very Heavy	(VH)	100% coverage (long filamentous growth: shaggy)*

** Very Heavy overlaps with heavy and is distinguished by both high percentage of substrate coverage and long filamentous growth.*

Among other things, the distribution and size of each *Cladophora* growth is dependent on the amount of suitable substrate present. The extent of suitable substrate should therefore be taken into account when interpreting the occurrence of individual growths and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. Substrate types were noted during the survey using the following abbreviations: m = soft muck or marl, s = sand, g = gravel (0.1" to 2.5" diameter), r = rock (2.5" to 10" diameter), b = boulder (>10" diameter), and w = woody debris. Substrate suitable for *Cladophora* growth include the g, r, b, and w types. The extent of suitable substrate along a shoreline parcel in terms of distance was not documented.

Erosion was noted based on shoreline areas that exhibited areas of bare soil, leaning or downed trees, exposed tree roots, undercut banks, slumping hunks of sod, or excessive deposits of sediments. Similar to *Cladophora*, shoreline erosion was recorded in ArcCollector with estimates of its extent and relative severity (minor, moderate, or severe). Additional information about the nature of the erosion, such as potential causes, was also noted.

Greenbelts (i.e., shoreline vegetation) were rated based on the length of shoreline with a greenbelt and the average depth of the greenbelt from the water's edge landward. Ratings for length ranged from 0 to 4, while ratings for depth ranged from 0 to 3. Ratings were based on the following:

Length .... 0: None, 1: 1-10%, 2: 10-25%, 3: 25-75%, 4: >75%
Depth .... 0: None, 1: <10 ft, 2: 10-40 ft, 3: >40 ft

Greenbelt ratings for length and depth were summed to produce an overall greenbelt score. Greenbelt scores ranged from 0 to 7, representing the greenbelt status or health. Scores of 0 were considered very poor, 1-2=poor, 3-4=moderate, 5-6=good, and 7=excellent.

Shoreline alterations were surveyed and noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)	BB = boulder bulkhead
CB = concrete bulkhead	RR = rock rip-rap
WB = wood bulkhead	BR = Mixed boulder/rock riprap
BH = permanent boathouse	BS = beach sand
G = groin	DP = discharge pipe
PD= permanent dock	BL = boat launch
IP = intake pipe	PH = pumphouse

Abbreviations were sometimes mixed or varied from what is listed above.

Tributaries (i.e., rivers and streams) were noted on the field data sheets and included in a separate column in the database. Parcels with bioengineering present were also marked (yes or no). Aquatic plants within 20 feet of the water's edge were documented in groups of emergent, submergent, or floating. Additional information regarding shoreline property features or shoreline conditions recorded on field data sheets was included in the database in a "comments" column.

Drone Imagery

In addition to the conventional survey done in kayaks, a DJI Phantom 4.0 V2 drone was used to capture aerial imagery on the North Arm. The DJI GO app was used to pilot and take images at approximately 30-50 feet above the water's surface and 40 feet offshore. Images were taken manually to ensure proper exposure and overlap. Images were imported as GPS points to the ArcGIS Pro project and overlaid against shoreline surveys. Drone images were linked to parcels based on property descriptions. Drone imagery was scored separately from kayak surveys using the same parameters above and compared to determine if drone imagery was as useful as kayak surveys.

Data Processing

Data was collected using ArcCollector offline maps. Offline maps were synced daily to a web map on ArcGIS online. Data was downloaded weekly from the ArcGIS shapefile. Approximately 12 parcels did not have information synced during data processing due to errors in syncing using wireless internet. ESRI tech support provided a workaround to connect iPads to a computer and manually take data from the program and add it to ArcGIS as a shapefile. On North Arm parcels, occasionally scores were changed based on aerials viewed during post-processing.

In order to display survey results without pinpointing specific parcels, a new map layer was developed using the parcel map data layer acquired from the county equalization departments and a Walloon Lake shoreline layer. The new map layer consists of a 100 meter band following the shoreline, split into polygons that contain field and equalization data. Parcels were generalized and squared off so the public data layer does not match actual parcel size and shape.

Final products include a comprehensive database with attached photos, GIS data layers of shoreline parcels that include both county equalization and shore survey data, and a story map displaying results. The database contains all data collected in the field and identification numbers in the database correspond to those in the GIS data layer and on hard-copy maps.

RESULTS

This survey documented shoreline conditions at 1,011 parcels on Walloon Lake. The length of shoreline per parcel varied from less than 20 feet to more than a mile. Approximately 89% (900) of shoreline properties on Walloon Lake were considered to be developed or partially developed, a number that has gone unchanged since 2016 (Figure 5).

Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 669 properties (66%). Over half (56%) of parcels had no visible *Cladophora* growth. The majority (73%) of parcels where *Cladophora* growth was observed in 2020 consisted of light to very light growth (Table 3). Results show there are fewer parcels with a moderate amount of *Cladophora* overall, but a few more with moderate-heavy, heavy, and very heavy amounts.

Table 3. *Cladophora* density results.

***Cladophora* Density**	**2016 Parcels**	**2016 Percent**	**2020 Parcels**	**2020 Percent**
Very light	233	22.6	163	36.63
Light	263	25.5	164	36.85
Light to Moderate	71	6.9	60	13.48
Moderate	53	5.1	34	7.64
Moderate to Heavy	13	1.3	20	4.49
Heavy	2	0.2	3	0.67
Very Heavy	1	0.1	1	0.22
TOTAL	636	100.00	445	100.00

Notably, the outlets of Schoof's and Fineout Creeks exhibited very heavy and moderately heavy *Cladophora* growth. Light to moderate growth of *Cladophora* was dispersed along both sides of the West Basin, the Foot Basin, along Lake Grove Rd.

and Indian Garden Rd. (Figure 6). Low density *Cladophora* was a common occurrence throughout Walloon Lake. Baseline *Cladophora* conditions (those not directly indicative of nutrient pollution) range from none to light.

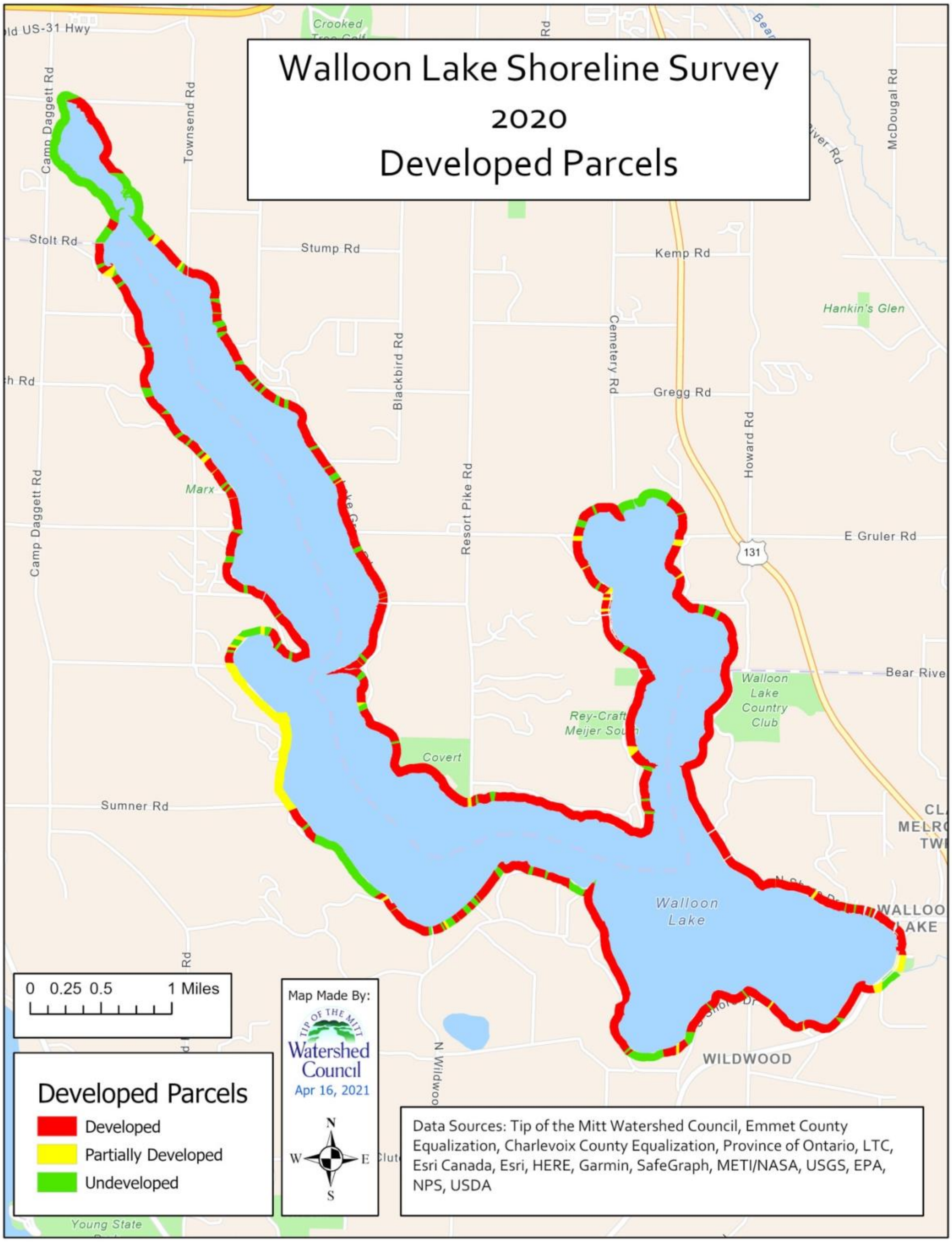


Figure 5. Developed parcels along Walloon Lake's shoreline.

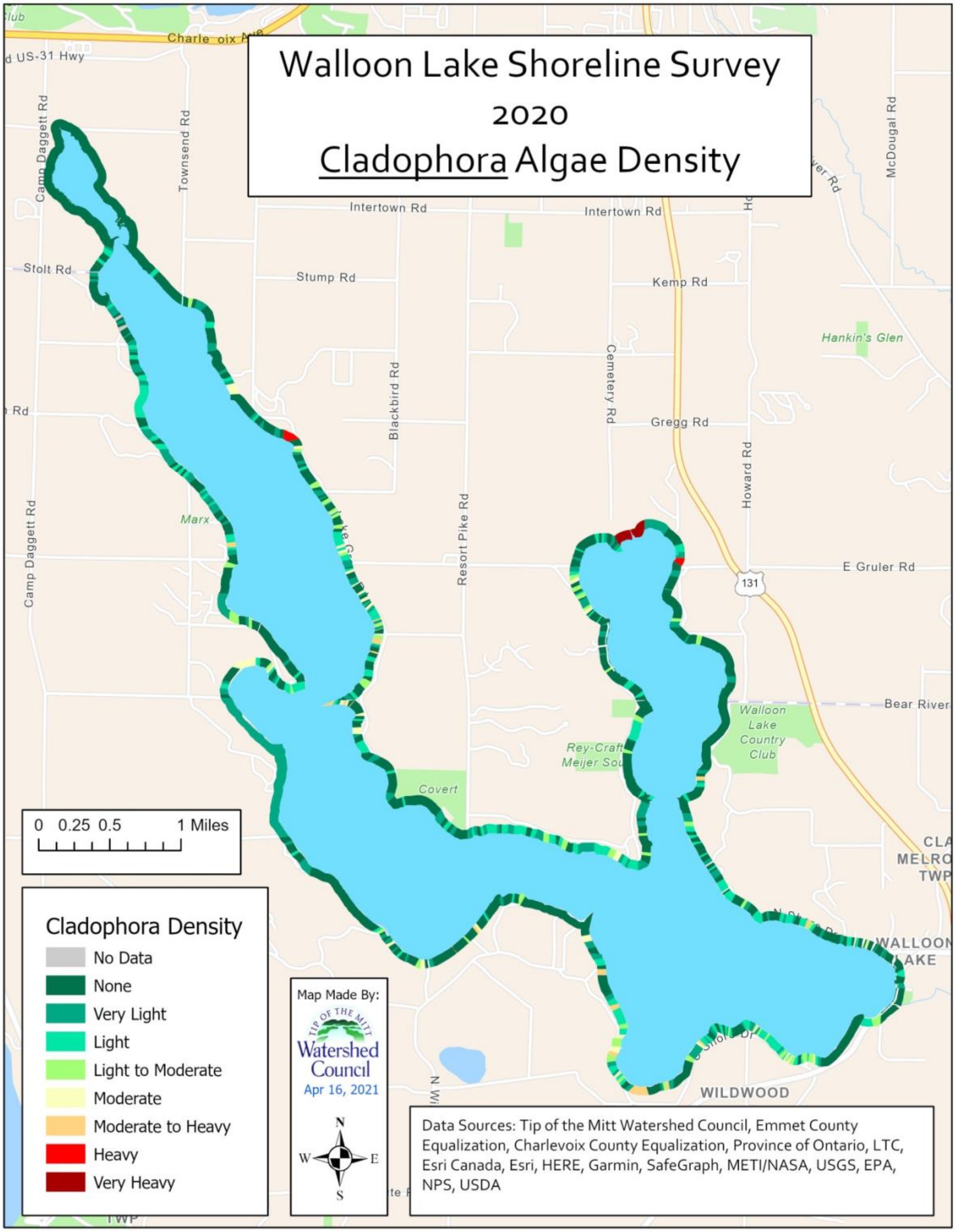


Figure 6. *Cladophora* algae density results for Walloon Lake

Greenbelt scores ranged from 0 (little to no greenbelt) to 7 (exemplary greenbelt) (Table 4). More than half of greenbelts (52%) along the Walloon Lake shoreline were found to be in good or excellent condition, while 30% of properties were rated poor or very poor.

Table 4. Greenbelt rating results.

Greenbelt Rating		2020 Parcels	2020 % Parcels
0	Very Poor (absent)	177	17.5
1-2	Poor	125	12.4
3-4	Moderate	184	18.2
5-6	Good	343	34
7	Excellent	182	18.0

Greenbelt status ranged, in general, from moderate in the eastern portions of Walloon Lake to good in the western portions of Walloon Lake (Figure 7, Figure 8). Although clusters of properties with poor greenbelts occurred throughout the lake, they are more prevalent in the North Arm and Foot Basin. The North Arm had the poorest average greenbelt score, 3.3 (Table 5). Mud Basin was the only basin to achieve an average greenbelt score falling within the "excellent" category.

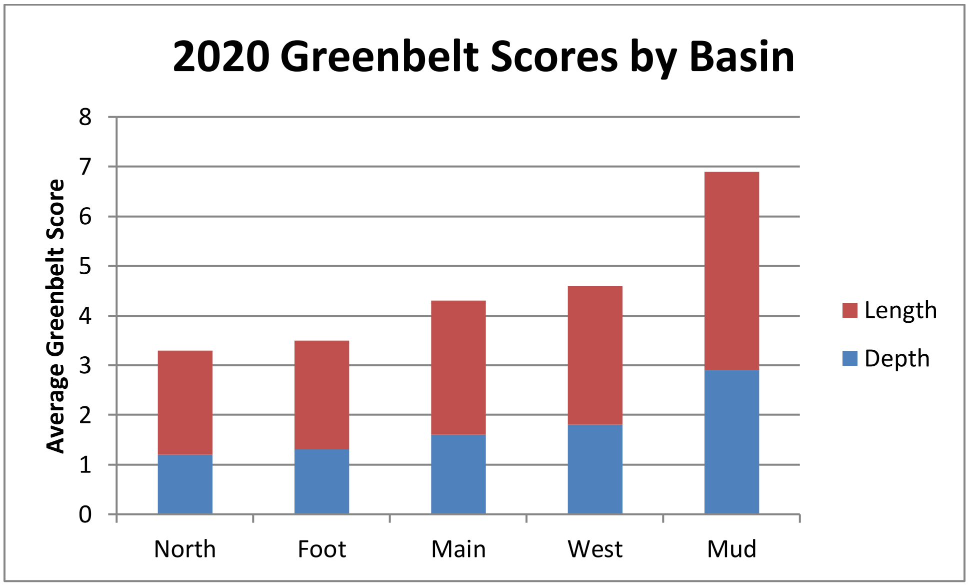


Figure 7. Greenbelt scores by Walloon Lake basin.

Table 5. Average greenbelt scores by Walloon Lake basin.

Greenbelt Scores by Basin	Total Score	Depth	Length
All	4	1.5	2.5
North	3.3	1.2	2.1
Foot	3.5	1.3	2.2
Main	4.3	1.6	2.7
West	4.6	1.8	2.8
Mud	6.9	2.9	4

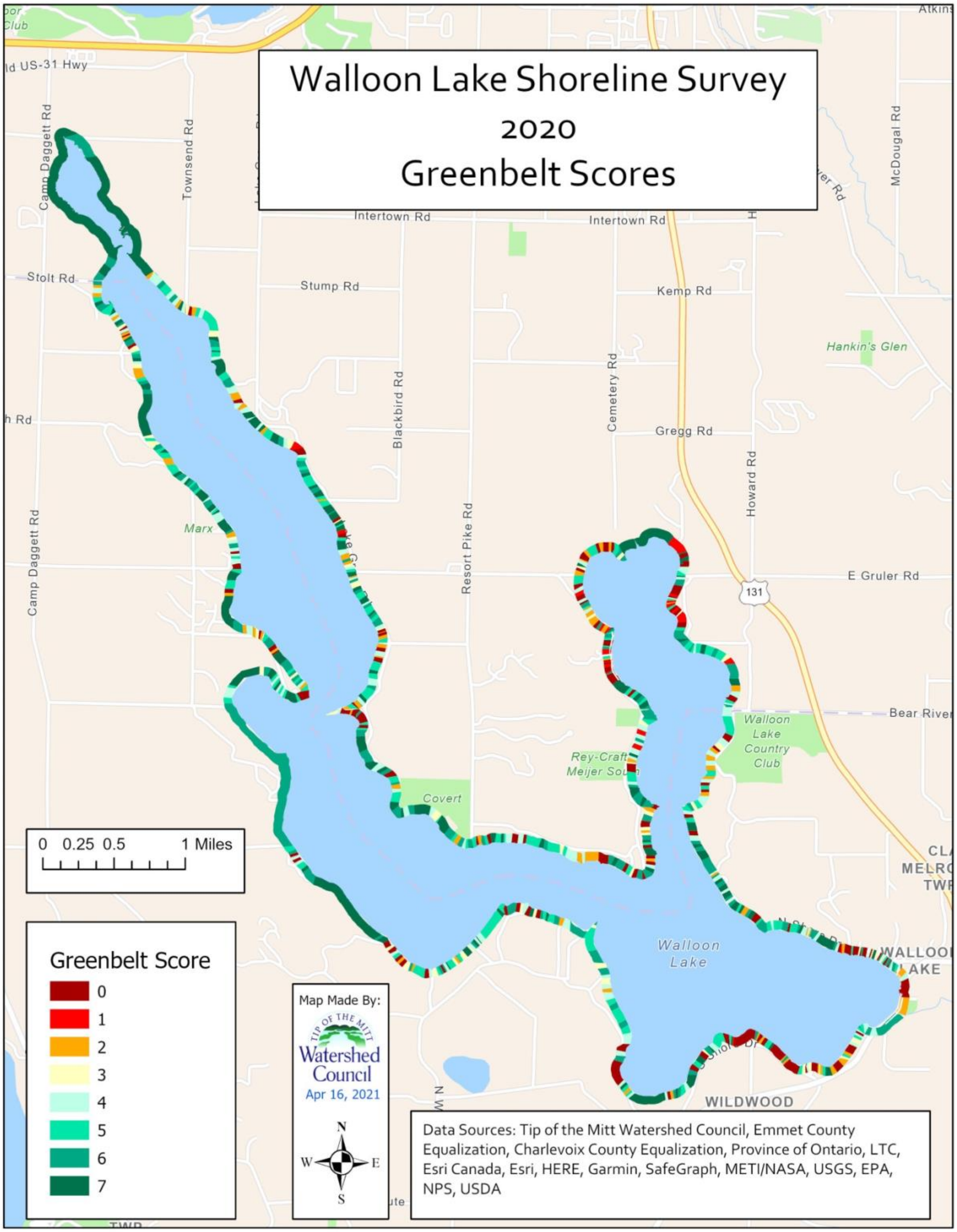


Figure 8. Greenbelt score totals results for Walloon Lake

Some form of shoreline alteration was noted at 81% of shoreline properties (Table 6). The majority of alterations (70.5%) were composed of some sort of riprap. Boulders were tallied as rock riprap (2.5” to 10” rocks), big boulder riprap (greater than 10” diameter), or mixed boulder and rock riprap. Of the parcels that had alterations, most of them only had one. 22% had more than one alteration (Figure 9). The alterations contribute to 79% of the lake shoreline being hardened, which includes all types of riprap, seawalls, and boat launches (Figure 10).

Table 6. Types of alterations on Walloon Lake.

Type of Alteration	Number of Parcels	Percent
Mixed rock and boulder riprap	381	34.23
Rock riprap	291	26.15
Big boulder riprap	113	10.15
Beach sanding	86	7.73
Metal seawall	12	1.08
Discharge pipe	33	2.96
Boat launch	22	1.98
Permanent dock	6	0.54
Pumphouse	1	0.09
Intake pipe	18	1.62
Concrete seawall	48	4.31
Wood seawall	27	2.43
Boathouse	15	1.35
Total	1113	100

**Numbers quantify alteration type, many parcels had multiple alterations*

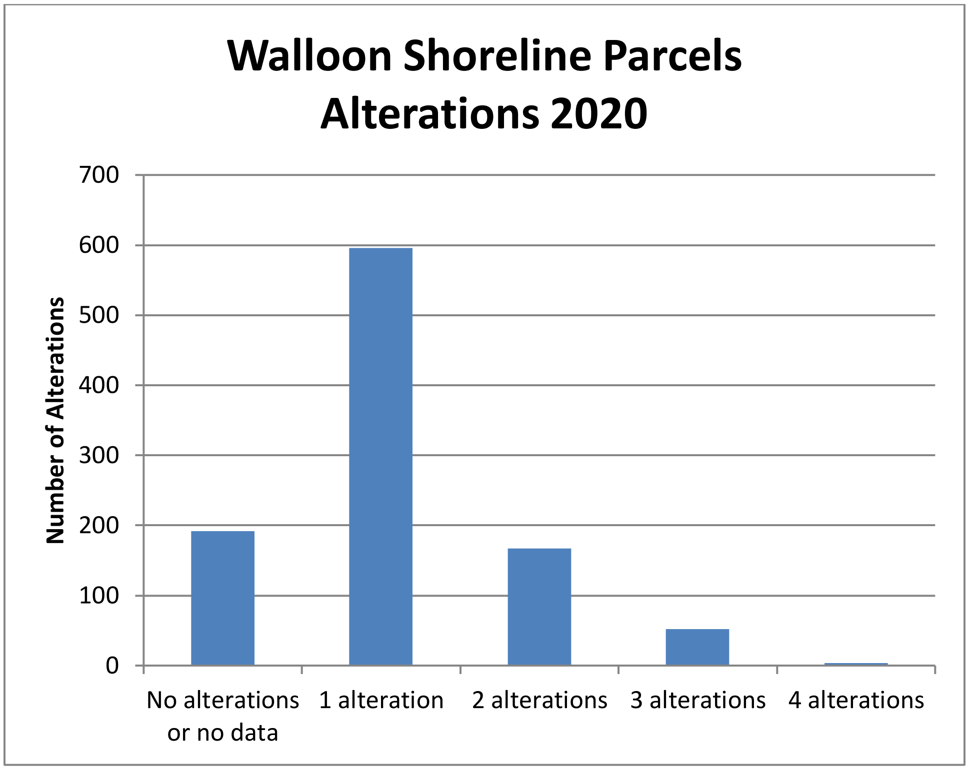


Figure 9. Number of alterations per parcel.

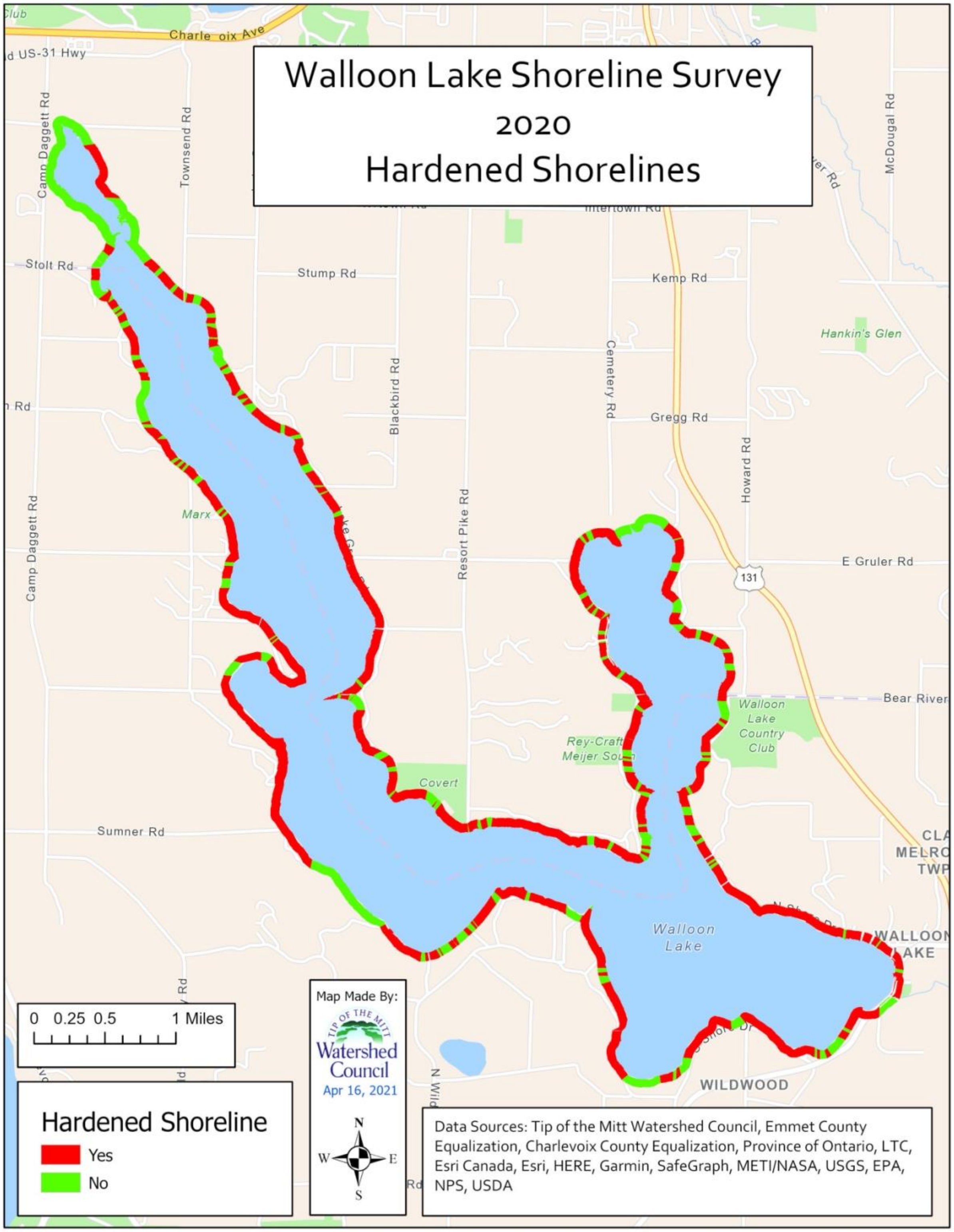


Figure 10. Hardened shorelines on Walloon Lake include all types of riprap and seawalls.

Erosion was noted at 214 parcels in 2020 (Table 7). Only erosion that was observed to be caused by human practices was recorded. The majority of shoreline properties had minor erosion. Locations for erosion was scattered along Walloon Lake, but noticeably concentrated in Walloon Lake Village on the Foot Basin (Figure 11).

Table 7. Shoreline erosion results.

Erosion Category	2020 Properties	2020 Percent
Minor	123	57.5
Moderate	60	28.0
Severe	31	14.5
TOTAL	214	100

**Refers to percentage of properties with documented erosion*

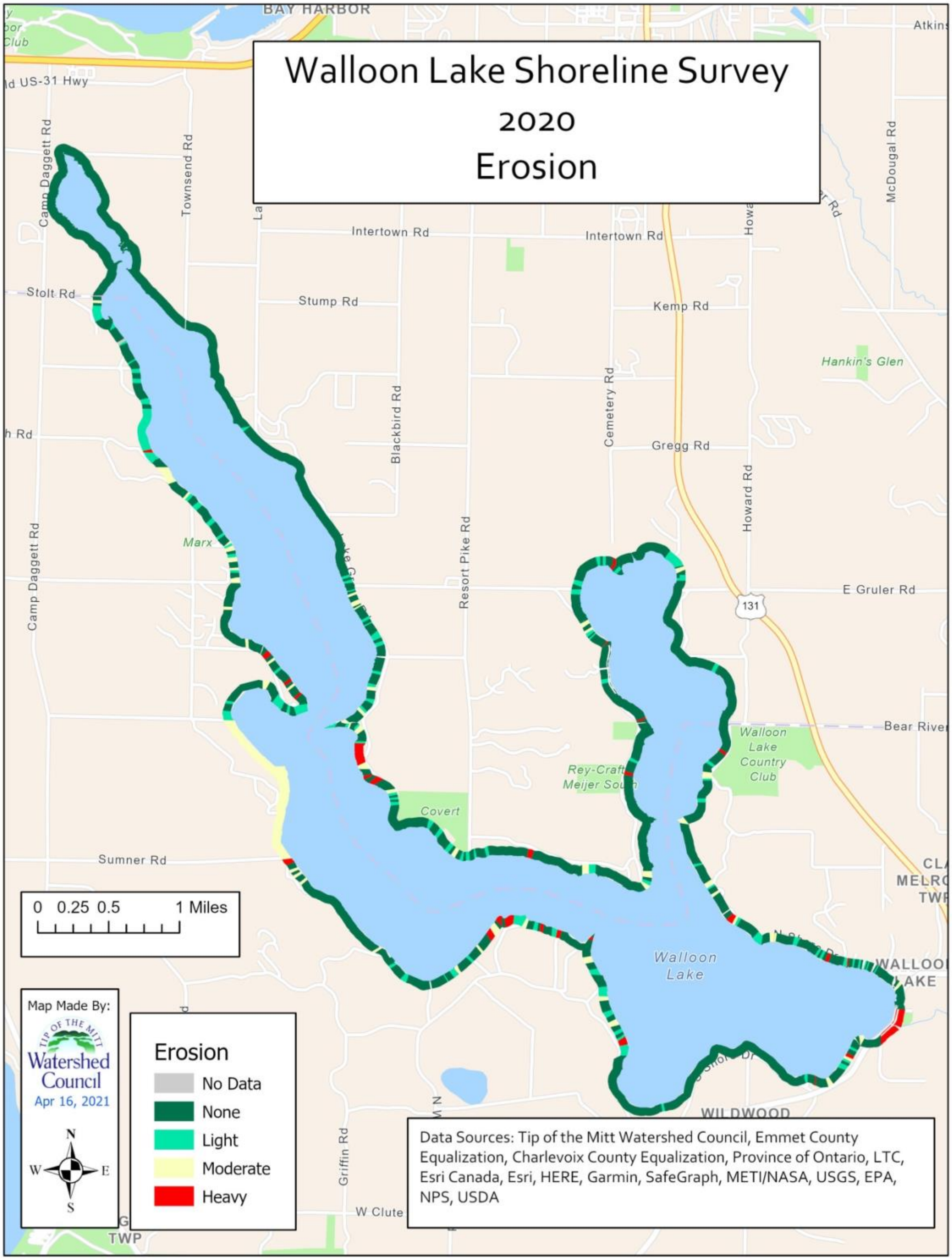


Figure 11. Shoreline erosion severity results for Walloon Lake

Walloon Lake is surrounded by five townships. Four have their own zoning (Bay, Evangeline, Melrose, and Resort). A fifth township, Bear Creek, relies on Emmet County zoning. Average results for greenbelts, heavy *Cladophora*, and heavy erosion were calculated for each township. Melrose Township had the worst overall average greenbelt score while Bay had the best. Both Melrose Township and Bear Creek had greenbelt scores that were lower than the whole lake's average. Resort Township had the most properties with heavy *Cladophora* and heavy erosion. Bear Creek had the least.

County	Township	Average Greenbelt Score	# properties with heavy *Cladophora*	# properties with heavy erosion	Total # properties
Charlevoix	Melrose	3.45	7	9	272
Emmet	Bear Creek	3.65	2	1	64
Emmet	Resort	4.14	10	11	417
Charlevoix	Evangeline	4.35	2	6	48
Charlevoix	Bay	4.49	3	5	211

DISCUSSION

Development of shoreline parcels negatively impacts a lake's water quality due to a multitude of factors. Among the most serious impacts are: 1) loss of vegetation that would otherwise absorb and filter pollutants in stormwater runoff as well as stabilize shoreline areas and prevent erosion, 2) increased impervious surface area such as roofs, driveways and roads, which leads to greater inputs of stormwater runoff and associated pollutants, and 3) waste and byproducts of human activity such as septic leachate, fertilizers and decomposing yard waste that potentially reach and contaminate the lake water. Clearly, there are many problems associated with development, but there are also many solutions for reducing or even entirely eliminating impacts.

Numerous best management practices have been developed that help minimize negative impacts to water quality and which can be utilized during, or retroactively after, the development of shoreline parcels. A buffer of diverse, native plants can be maintained along the shoreline to filter pollutants and reduce erosion. Impacts from stormwater generated from roofs, roads, and driveways can be reduced using rain barrels, rain gardens, grassy swales, and many other techniques. Leachate reaching the lake from septic systems can be minimized by pumping the septic tank regularly, having all components of the septic system inspected regularly, and replacing the septic system when necessary. Mulch can be composted far from the shoreline and fertilizers applied sparingly, if at all.

Results from the 2020 shoreline survey indicate that nutrient pollution, poor greenbelts, and shoreline alterations continue to pose a threat to the water quality and overall health of Walloon Lake. Nutrient pollution indicators were documented at nearly half of all shoreline properties; 30% of all shorelines exhibited greenbelts that were in poor condition; and 81% of all lakeshore properties had altered shorelines. Erosion was documented at 21% of properties, similar to the average for lakes in Northern Michigan.

Throughout the past two decades, shoreline surveys on Walloon Lake have documented development trends, both on land and at water's edge. The percentage of developed lakeshore properties (i.e., those with permanent structures or pavement installed) has increased from 83% in 2001 to 89% in 2016 and remained at 89% in 2020. The percentage of lakeshore properties with alterations has increased at a more rapid pace, from 66% in 2001 to 81% in 2020 (Figure 12).

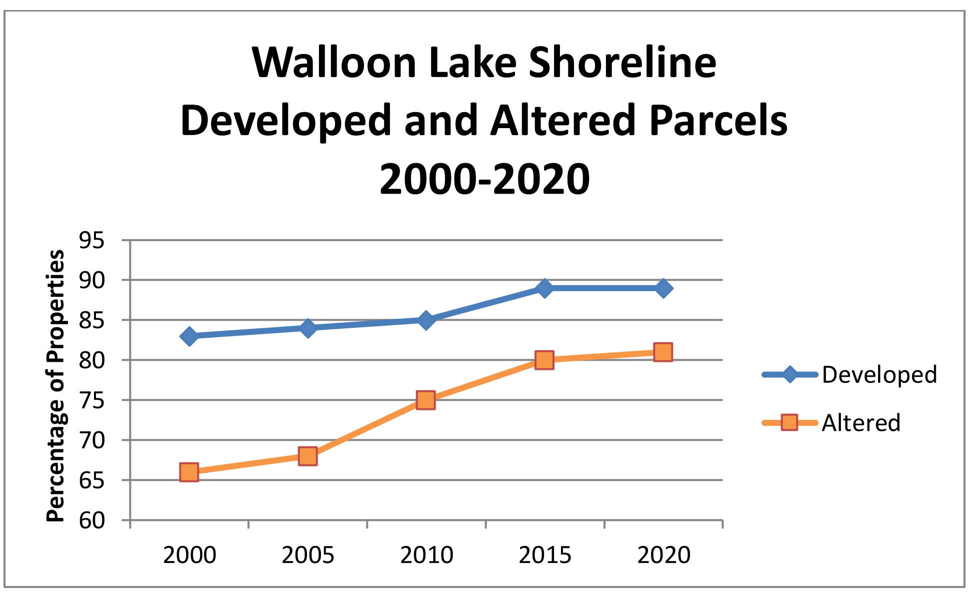


Figure 12. Increases in developed and altered shorelines on Walloon Lake

With regards to altered shorelines, 81% of all shoreline properties had some form of alteration (Figure 12). Large rocks or boulders were by far the most common type of alteration, found at 70.5% of all parcels (Table 8). In general, rocks of this size are not native to Walloon Lake. Oversized boulders can have negative impacts, including lakebed scour, shoreline erosion, and reduced habitat value. Seawalls are the most damaging type of shoreline alteration due to negative impacts that include loss of near-shore habitat, lakebed scour, and wave flanking. Seawalls were only found at 5% of properties. An additional eight properties were documented as having seawalls compared to 2016 and the number of properties with beach sanding stayed the same.

Table 8. Comparing alterations between 2016 and 2020.

Alteration Type	2016 Number of Parcels*	2016 Percent of Parcels With Alteration*	2020 Parcels	2020 Percent
Riprap (small)	212	20.6	291	26
Riprap (mixed big and small)	Combined with big boulder	Combined with big boulder	381	34
Riprap (big boulder)	718	69.7	113	10
Seawalls	52	5.0	60	5.39
Beach Sand	86	8.3	86	7.7
Unaltered	203	19.7	192	19

Comparisons with prior shoreline surveys show that there are more properties with *Cladophora* growth in 2020 compared to 2001; however, the number reached its peak in 2016 and has since decreased (Figure 13, Table 9).

Table 9). Changes since 2016 include more properties with heavy densities of *Cladophora*. Overall, algae has become less prolific throughout Walloon Lake, but the occurrence of localized heavy *Cladophora* blooms is becoming more common.

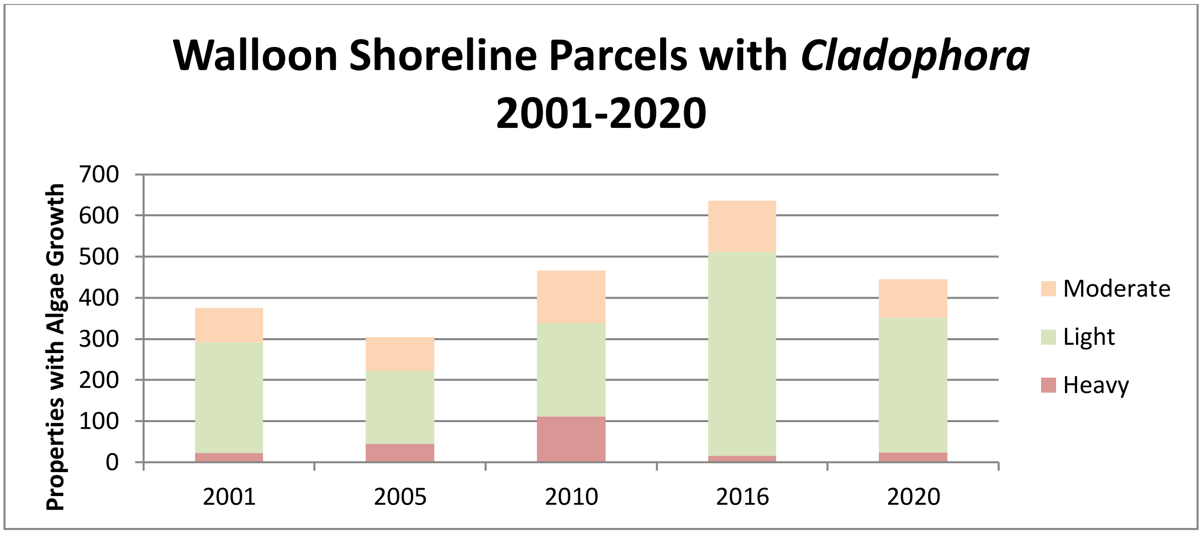


Figure 13. Comparing *Cladophora* occurrences on Walloon Lake from 2001-2020.

Table 9. *Cladophora* density comparisons: 2001 to 2020.

Cladophora* Growth	**2001**		**2005**		**2010**		**2016**		**2020**	
	Properties	%	Properties	%	Properties	%	Properties	%	Properties	%
Light	270	26	177	17	228	22	496	48	327	32
Moderate	83	8	82	8	127	12	124	12	94	9
Heavy	22	2	45	4	111	11	16	2	24	2
TOTAL[ƚ]	375	36	304	29	466	45	636	62	445	44

** Note that the light growth includes "very light", moderate includes "light to moderate", and that heavy growth includes "moderate to heavy" and "very heavy".*

[ƚ] Percentage in the total is of all properties on the lake.

Recent changes in *Cladophora* on individual properties were evaluated by comparing densities assigned in 2016 to 2020. 37% of parcels had the same amount of *Cladophora* in 2020 as in 2016. 22% had more and 41% had less. Using a GIS analysis called "Find Hot Spots" clusters of parcels with the greatest change were identified. An increase of *Cladophora* density since 2016 was found in clusters located in the West Basin, Foot Basin, and in between the Foot Basin and Main Basin (north shore). Decreasing *Cladophora* clusters were located in the North Arm, Foot Basin, Eagle Island area, and in between the Foot Basin and Main basin (south shore) (Figure 14).

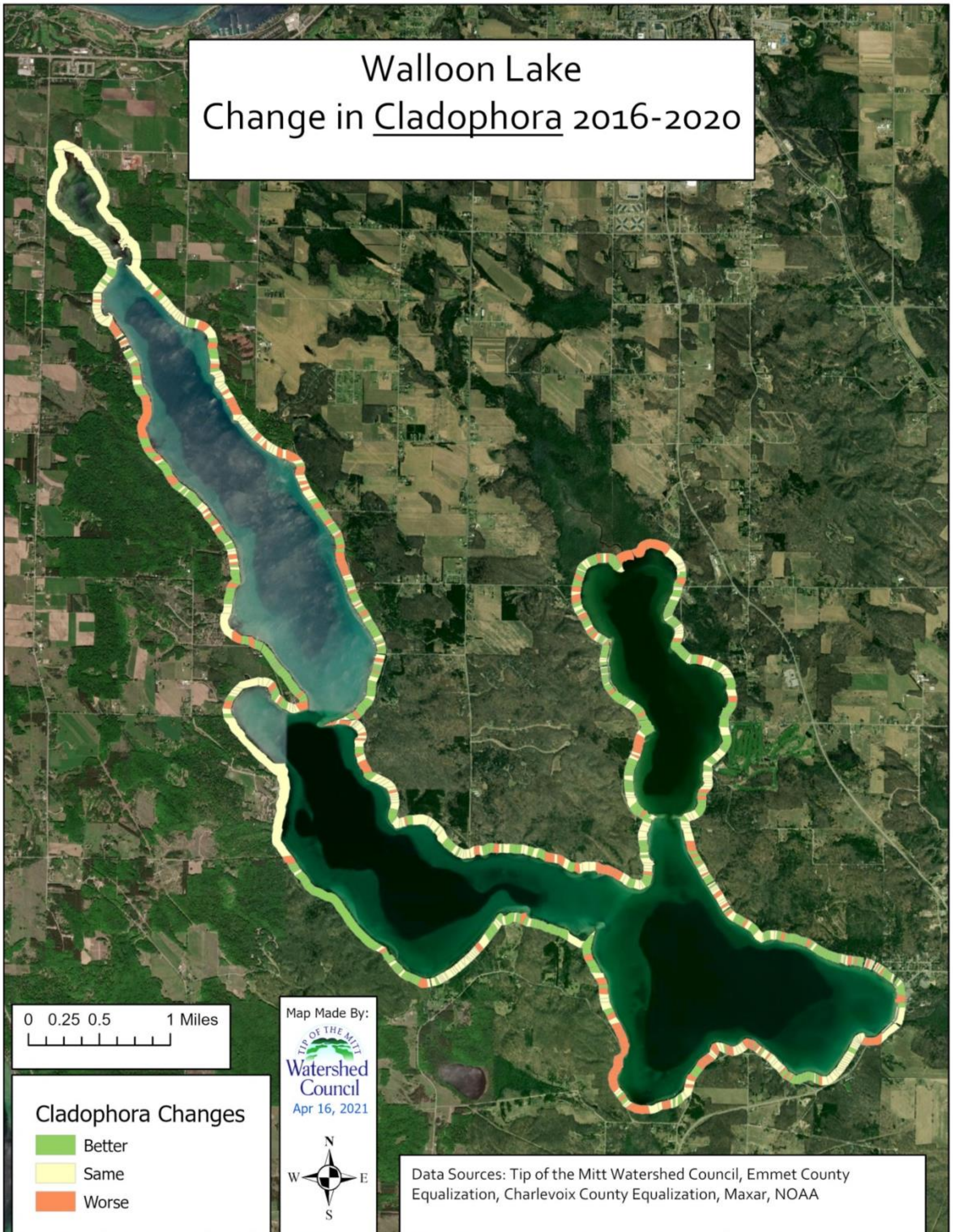


Figure 14. Changes in shoreline *Cladophora* 2016-2020.

In 2016, when 62% of all properties had some form of *Cladophora* growth, the presence of benthic algae was the norm for Walloon Lake. One factor could be the presence of zebra mussels, which can make conditions ripe for *Cladophora* growth. Zebra mussels can make nutrients available to *Cladophora*, which also lives on the waste from zebra mussels. A decrease in *Cladophora* may indicate fewer nutrients in near-shore areas, possibly caused by less zebra mussels.

Of the shoreline areas showing evidence of potential nutrient pollution, some of the heavier algae growth is undoubtedly associated with septic system leachate, agriculture, or other factors associated with development and human activities. There are numerous streams, springs, and seeps flowing into Walloon Lake at different points along the shoreline that may be delivering nutrients that naturally promote algal growth. Schoof's and Fineout Creeks are likely carrying nutrients that increase *Cladophora* algae as high nutrients were observed in water quality monitoring conducted in the streams in 2018 (Tip of the Mitt Watershed Council, 2018). Where human-caused nutrient pollution is occurring, the source has to be identified in order to address the problem. Although impeded by factors such as wind, wave action, currents, and groundwater paths, efforts by trained personnel to identify specific nutrient input sources on individual properties are often successful.

Results from the greenbelt assessment portion of the survey show an improving trend on Walloon Lake. Between 2001 and 2020, the number of properties with poor greenbelts decreased by 22% while properties with good greenbelts increased by 31% (Figure 15,
Table 10). It is important to note that the field methodologies were revised between 2001 and 2016. They now include additional parameters that factor into greenbelt ratings. Therefore, any direct comparisons between data sets in this time frame should consider this aspect.

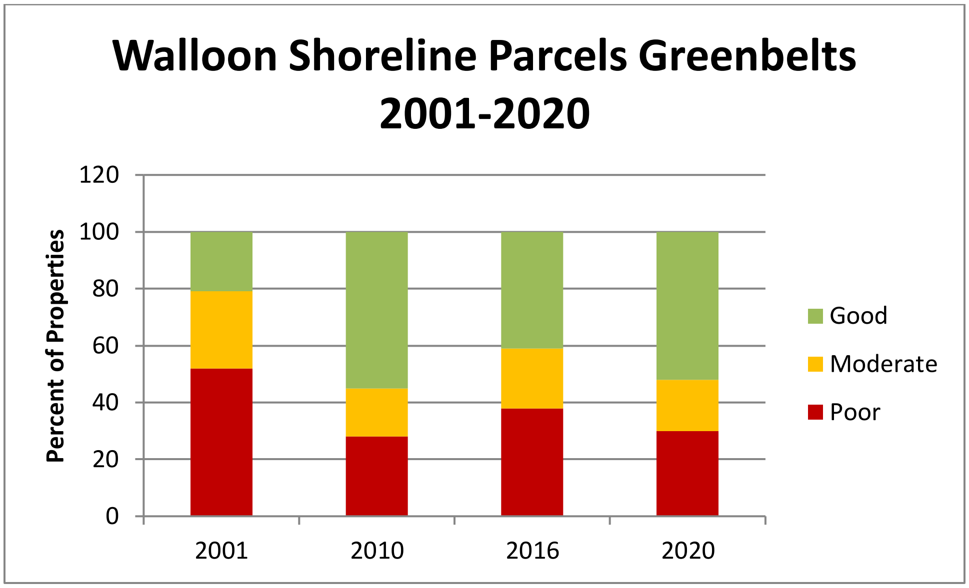


Figure 15. Comparing percentage of greenbelt scores on Walloon Lake from 2001 to 2020.

Table 10. Greenbelt rating comparisons: 2001 to 2020*.

Greenbelt Rating	2001 (%)	2010 (%)	2016 (%)	2020 (%)
Poor	52	28	38	30
Moderate	27	17	21	18
Good	21	55	41	52

**Greenbelts were not assessed for all properties in 2005.*

Shoreline survey greenbelt results fluctuate from year to year, based on a number of factors. Overall, greenbelt scores have improved on Walloon Lake since 2001. Development of new parcels often times correlates with a decrease in good greenbelt conditions, which was observed from 2010 to 2016 (
Table 10). Greenbelt scores increased from 2016 to 2020, possibly due to establishment of newly installed greenbelts in 2016 as well as improvements in greenbelts made across parcels. Parcels with no greenbelts increased 3% from 2016 to 2020. On the other end of the spectrum, parcels that received a perfect score increased 2% from since 2016. Similar to *Cladophora* conditions, the entire lake is improving while certain areas are getting worse. The majority of properties had greenbelt scores that

stayed the same (33%) or increased (42%) from 2016 to 2020 (Figure 16). This means more protection for Walloon Lake since 2016.

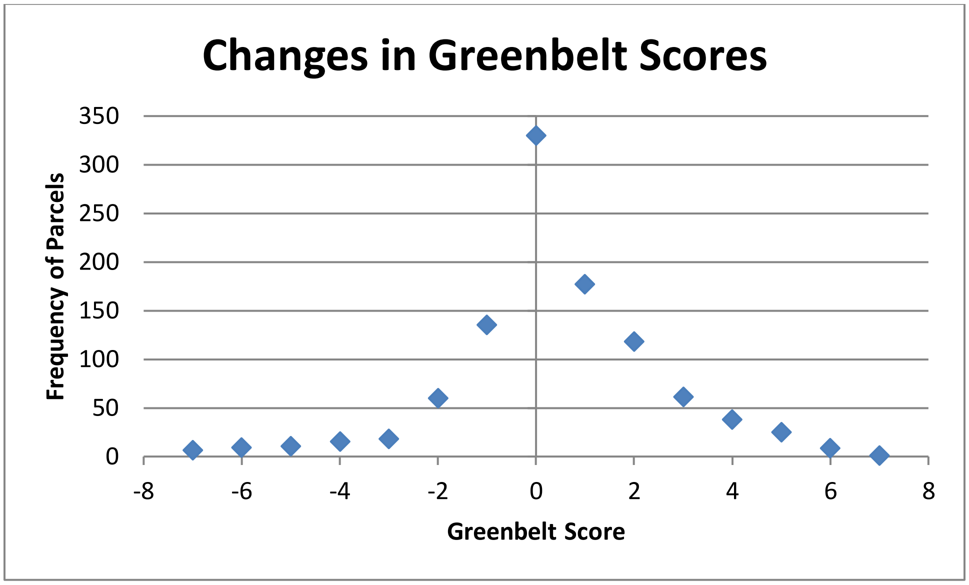


Figure 16. Changes in greenbelt scores from 2016-2020 on Walloon Lake's shoreline.

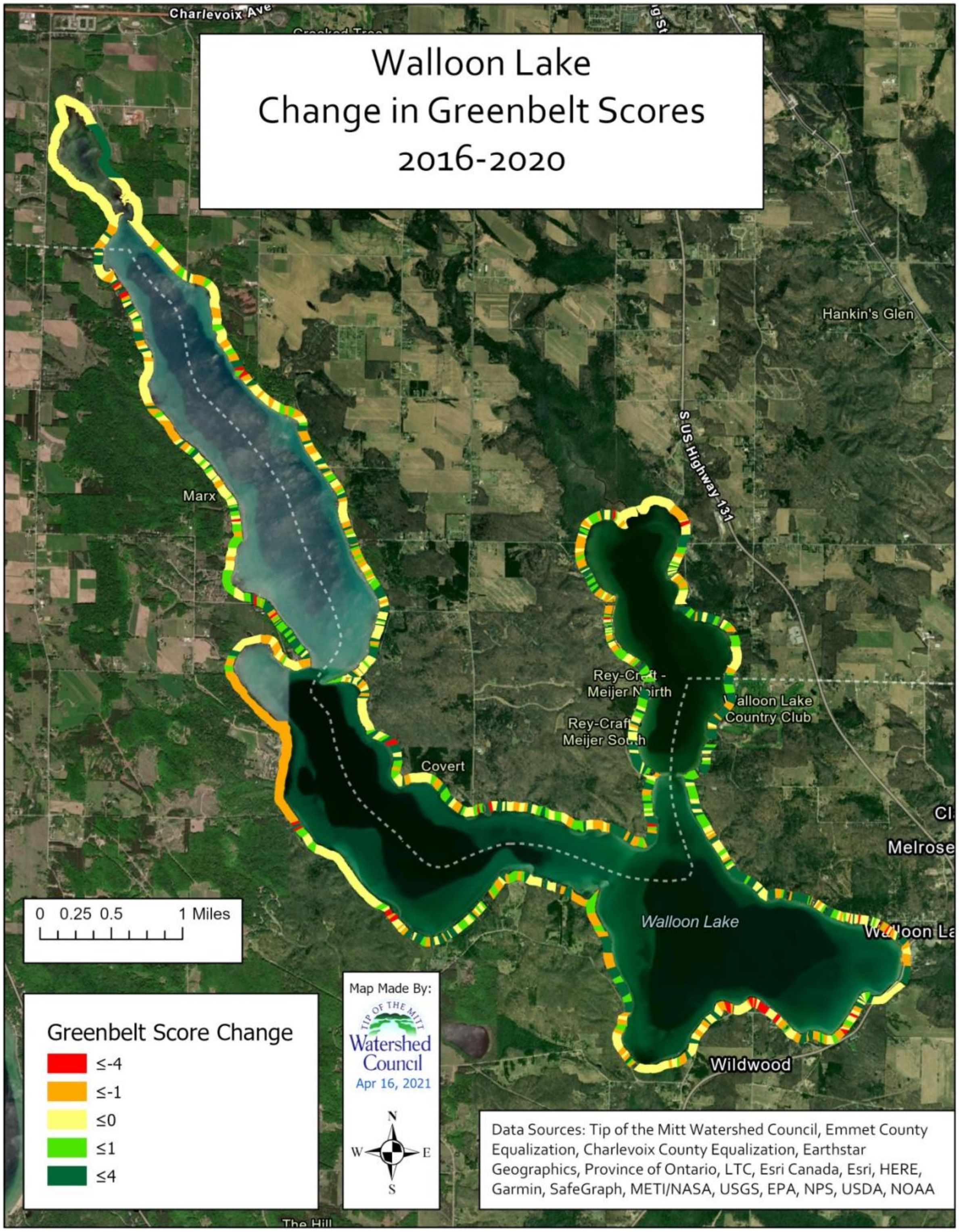


Figure 17. Changes in greenbelt scores at individual properties from 2016-2020.

Surveys started recording erosion beginning in 2010. Erosion has fluctuated, with a sharp rise between 2010 and 2016 and a sharp decline from 2016 to 2020 (Figure 18). The increase in erosion between 2010 and 2016 may be caused by increased development along Walloon Lake (Figure 12). Erosion may have decreased since then as new builds, yards, and greenbelts become established.

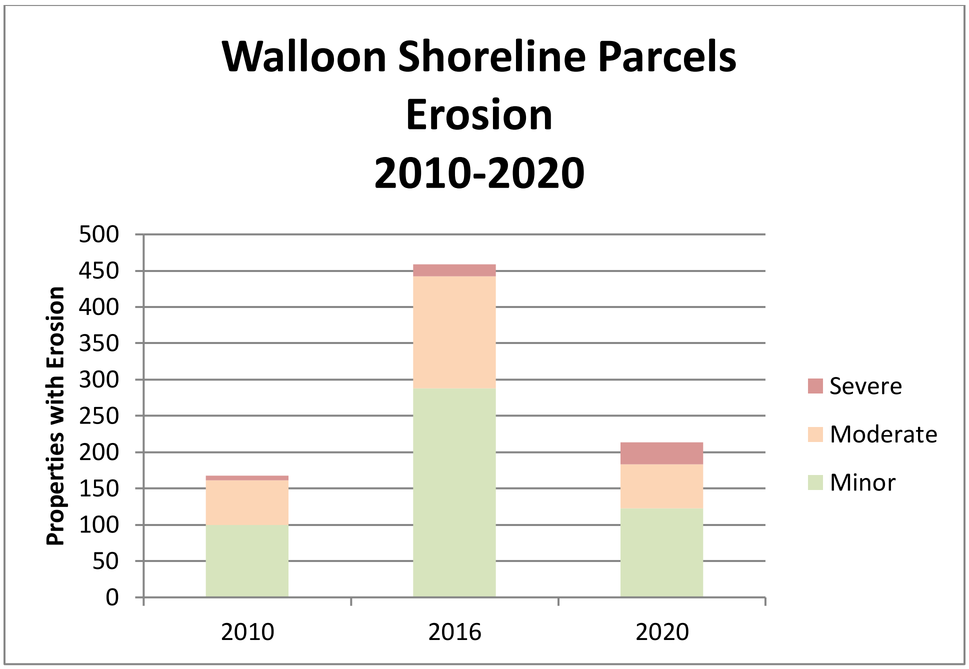


Figure 18. A comparison of erosion on shoreline properties from 2010-2020.

Table **11. Shoreline statistics on lakes in Northern Michigan**

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Beals Lake	2016	0%	0%	0%	17%	0%
Ben-Way Lake	2016	3%	0%	84%	47%	40%
Burt Lake	2009	47%	29%	4%	36%	46%
Bellaire Lake	2017	35%	1%	27%	30%	55%
Charlevoix, Lake	2018	37%	4%	34%	37%	62%
Clam Lake	2017	48%	5%	30%	51%	55%
Crooked Lake	2012	29%	26%	14%	51%	65%
Douglas Lake	2015	27%	6%	17%	53%	60%
Lake Charlevoix	2017	84%	2%	52%	30%	87%
Ellsworth Lake	2016	40%	14%	38%	24%	23%
Hanley Lake	2016	11%	0%	33%	19%	23%
Huffman Lake	2015	14%	0%	7%	57%	70%
Huron, Duncan Bay	2013	41%	2%	19%	45%	63%
Huron, Grass Bay	2013	0%	0%	4%	0%	8%
Intermediate Lake	2016	19%	9%	53%	63%	77%
Lance Lake	2014	19%	0%	12%	35%	31%
Larks Lake	2006	4%	0%	ND	12%	29%
Mullett Lake	2016	44%	6%	36%	59%	76%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Scotts Lake	2016	0%	0%	2%	18%	7%
Silver Lake	2014	3%	0%	70%	53%	65%
Skegemog Lake	2017	52%	5%	40%	46%	76%
St. Clair Lake	2016	4%	0%	13%	34%	21%
Six Mile Lake	2016	10%	24%	13%	41%	37%
Thayer Lake	2017	11%	1%	32%	16%	22%
Thumb Lake	2007	4%	0%	ND	ND	39%
Torch Lake	2017	39%	5%	26%	20%	ND
Walloon Lake	2020	44%	5%	21%	30%	81%
Wildwood Lake	2014	5%	0%	22%	45%	50%
Wilson	2016	27%	5%	29%	11%	14%
AVERAGE	NA	24%	6%	27%	36%	46%

(Figure 20). 5% of parcels on Walloon Lake are considered to have heavy algae, the same as Torch, Clam, Wilson, and Skegemog Lakes. The 2016 survey hypothesized that subsequent shoreline surveys would show more parcels with light *Cladophora*

algae due to zebra mussel infestation. The result was the opposite; parcels with light *Cladophora* decreased by 34% from 2016 to 2020. One explanation could be a rebound of natural conditions from the initial invasive of zebra mussels, which is also supported by water quality monitoring results since 2016. The number of properties on Walloon Lake with erosion is below the overall average for lakes within Northern Michigan. Walloon Lake's shoreline has a smaller percentage of properties with poor greenbelts compared to most other lakes in the region. Similar lakes include Lake Bellaire and Lake Charlevoix. The percent of properties with altered shoreline was high on Walloon Lake relative to other lakes in the region, only eclipsed by Lake Charlevoix **(**
Figure **19**).

Table 11. Shoreline statistics on lakes in Northern Michigan

Lake Name	Survey Date	*Cladophora**	Heavy Algae*	Erosion*	Poor Greenbelts*	Alterations*
Beals Lake	2016	0%	0%	0%	17%	0%
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Bellaire Lake	2017	35%	1%	27%	30%	55%
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Ellsworth Lake	2016	40%	14%	38%	24%	23%
Hanley Lake	2016	11%	0%	33%	19%	23%
Huffman Lake	2015	14%	0%	7%	57%	70%
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Lance Lake	2014	19%	0%	12%	35%	31%
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Mullett Lake	2016	44%	6%	36%	59%	76%
Pickerel Lake	2012	27%	33%	15%	52%	64%
Round Lake	2014	21%	0%	27%	44%	44%
Scotts Lake	2016	0%	0%	2%	18%	7%
Silver Lake	2014	3%	0%	70%	53%	65%
Skegemog Lake	2017	52%	5%	40%	46%	76%
St. Clair Lake	2016	4%	0%	13%	34%	21%
Six Mile Lake	2016	10%	24%	13%	41%	37%
Thayer Lake	2017	11%	1%	32%	16%	22%
Thumb Lake	2007	4%	0%	ND	ND	39%
Torch Lake	2017	39%	5%	26%	20%	ND
Walloon Lake	2020	44%	5%	21%	30%	81%
Wildwood Lake	2014	5%	0%	22%	45%	50%
Wilson	2016	27%	5%	29%	11%	14%
AVERAGE	NA	24%	6%	27%	36%	46%

**Percentages are in relation to number of parcels on the lake shore, except for "heavy algae", which is the percent of only parcels that had Cladophora growth. Erosion is the percentage of parcels with moderate to severe erosion and poor greenbelts include those in the poor or very poor categories. ND=no data.*

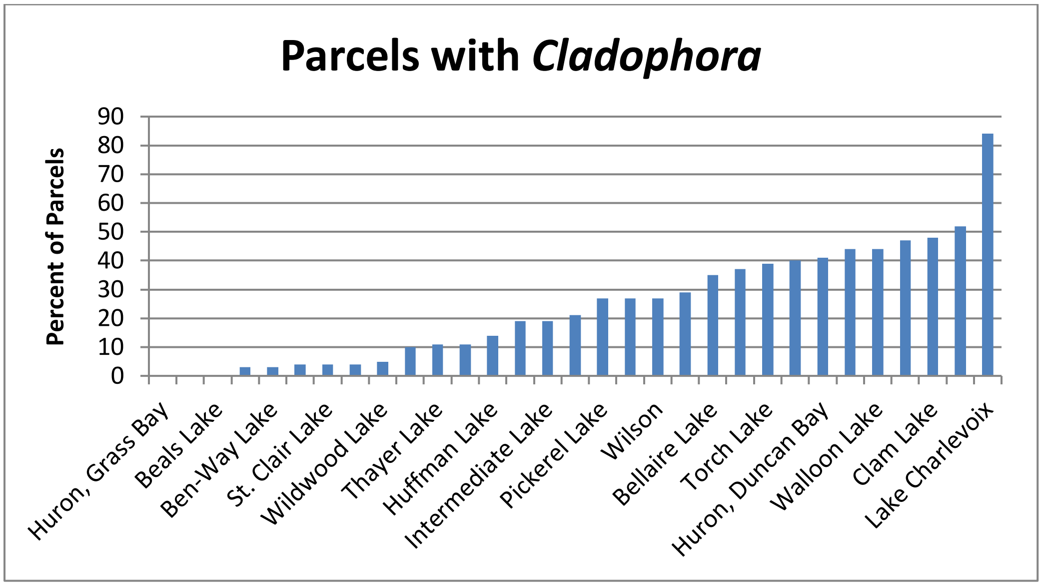

Figure 19. Comparison of *Cladophora* results between different lake shoreline surveys.

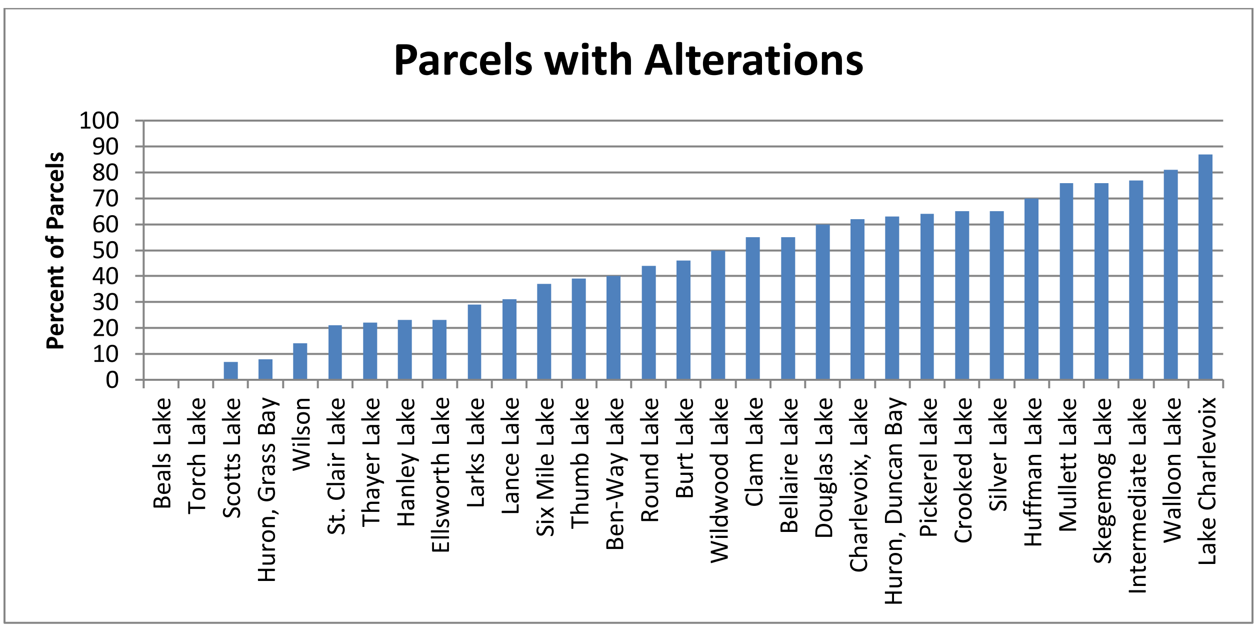

Figure 20. Comparison of alterations between different lake shoreline surveys.

Although the overall number of properties experiencing erosion has decreased since 2015, the percentage of properties with severe erosion increased by 10 percentage points. Many properties with patches of lawn at water's edge experience a minor undercutting caused by waves and ice shove. Properties with artificial beach sand usually experience some loss of sand into the lake, evidenced by small erosional rills leading into the lake. Although not catastrophic, these types of minor erosion do have the ability to degrade the water and habitat quality of Walloon Lake. While wind-generated waves can cause erosion, it is believed that the large powerful boats common to Walloon Lake are responsible for exacerbating erosion.

Scores for shoreline parameters were compared to an ordinance review publication produced by the Watershed Council for Charlevoix County in 2011 and Emmet County in 2013. In the Local Ordinance Gaps Analysis document for each county, townships and county zoning were scored based on their ability to protect water and wetlands across nine "Critical Elements:" master plan, basic zoning, shorelines, impervious surfaces and stormwater management, soil erosion and sediment control, sewer/septic, wetlands, groundwater and wellhead protection, and other (includes floodplains, steep slopes, and critical dunes). While no statistical correlation appeared between scores given in the gaps analysis and current shoreline conditions, a few connections exist:

- The majority of townships with their own zoning had high quality shorelines.
- Melrose Township had the lowest master plan and impervious scores, which may contribute to low greenbelt scores.
- Resort Township had the lowest scores for zoning and shorelines, which may contribute to its higher frequency of heavy *Cladophora* and erosion.
- Bay Township had the highest scores for master planning, shorelines, and stormwater management, which may contribute to it having the highest greenbelt score.

Drone imagery was collected on the North Arm only. The drone requires calmer winds than a kayak survey does. It also requires work to be done midday to avoid shadows, whereas kayak surveys can be done at any point during daylight hours. Collecting imagery via still requires two people, as one must operate the drone and the other must keep the drone within sight at all times.

Drone images were used to score properties in ArcGIS Pro by comparing pictures to property descriptions, parcel outlines, and features on aerial maps. Scoring properties with drone imagery resulted in no data syncing errors and almost no post-processing. While shorelines were easily seen using the drone imagery, the relative size of objects (e.g. rock vs. riprap) on the shoreline was more difficult to determine than when conducting shoreline surveys via kayak. Greenbelts and property descriptions were easier to score because the drone's height allowed the surveyor to see greenbelt depths and houses that were far from the shoreline.

Everything below the water's surface was more difficult to score because of the water's reflection. Substrate, submergent plants, and *Cladophora* were difficult to score using aerial images. Abundant *Cladophora* was easily seen in images. Likely only very light to light patches of *Cladophora* were missed and the drone would catch areas of moderate to very heavy *Cladophora*.

More time is required to evaluate the difference in time required between the two methods. More analysis is needed to determine the statistical difference in drone vs. kayak surveys.

This survey showed both improvements and detriments in shoreline practices to water quality. Improvements included better greenbelts, less erosion, and less *Cladophora* overall. Development has also slowed since 2016. Detriments included more hardening and an increasing number of properties with no greenbelts and heavier *Cladophora*. Likely education and outreach efforts by WLAC and the Watershed Council are reaching some property owners and having an effect on improving their shoreline impacts. It may be too early to relate changes in shoreline impacts to water quality as an increase and nutrients and decrease in water clarity could be explained by zebra mussel activity. Trends in water quality will be compared to shoreline data over the next few years to further understand changes occurring on Walloon Lake.

RECOMMENDATIONS

The full value of a shoreline survey is only achieved when the information is used to educate riparian property owners about preserving water quality, and to help them rectify any problem situations. The following are recommended follow-up actions:

1. Keep the specific results of the survey confidential (e.g., do not publish a list of sites where *Cladophora* algae were found) as some property owners may be sensitive to publicizing information regarding their property.
2. Send a *general* summary of the survey results to all shoreline residents.
3. Make results available online through an ESRI StoryMap or WebApp.
4. Share results and a summary in the WLAC and Watershed Council newsletters.
5. Present findings to the Little Traverse Bay Watershed Advisory Committee.
6. Submit a monitoring request to the Michigan Department of Environment, Great Lakes, and Energy's Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters for Schoof's and Fineout Creek.
7. Evaluate Walloon Lake's susceptibility to harmful algal blooms with assistance from the Michigan Department of Environment, Great Lakes, and Energy.
8. Encourage land owners to sign up and take a self-assessment for MI Shoreland Stewards.
9. Promote and encourage landscape contractors and designers to attend bioengineering workshops held by the Watershed Council.
10. Consider using the drone for future surveys and analyze time efficiencies gained.
11. Stay up to date on new drone technologies and enhance images of water with polarized filters.
12. Repeat some version of the survey periodically (ideally every 5-10 years).
13. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake and Stream Monitoring programs by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating water quality and determining trends. WLAC is encouraged to continue supplying volunteer help and volunteers should attend training sessions held by the Watershed Council to

ensure that a complete set of quality data is being collected each year.

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