Burt Lake Watershed Planning Project: Biological Management Plan

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Cooperative Agencies

Burt Lake Preservation Association

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University of Michigan Biological Station
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Michigan DNR
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Little Traverse Bay Bands of Odawa Indians – Natural Resource Department
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Sturgeon for Tomorrow
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Introduction

Lake management plans are used to maintain the health of freshwater bodies and interests of residents, as well as address environmental and ecological concerns. Management plans suggest ways in which to manage water quality and ecosystem health. Aquatic environments are threatened by the introduction of invasive species and process of eutrophication. Invasive species and eutrophication affect water quality by outcompeting native species and decreasing water quality respectively. Ecosystem health plays a role in the local economy. People spend money to vacation in a beautiful habitat, and poor ecosystem health can negatively affect ecotourism. Nevertheless, with growing anthropogenic concerns, lake management is becoming more necessary to implement.

Management of Burt Lake must encompass at least Burt Lake and its four main tributaries.: the Maple, Crooked, Sturgeon, and Indian River. Maintaining the health of the overall watershed is important because Burt Lake and the main tributaries connect a larger network of lakes and rivers, including Black Lake, the Black River, Mullet Lake, Douglas Lake, and the Cheboygan River. Each part of the watershed must be healthy. If, for example, the Crooked River is unclean, that unclean water is being emptied into Burt Lake, affecting overall health. In order to maintain the appearance and health of Burt Lake, our team identified four key aspects to focus on for the management plan: sturgeon, crayfish, plants, and algae.

Each component of the assessment encompasses a significant, and different, part of ecosystem health. If there is not a healthy population of native plants, then there is less likelihood for a healthy population of crayfish. Plants and detritus are a food source for crayfish species. If there is not a healthy population of crayfish, then there is a less likelihood for there to be a sustainable population of sturgeon because crayfish are an important component of a Lake Sturgeon's diet. Algae can be used as an indicator of water quality health. If there are large masses of algae, that could be an indicator of nutrient pollution, which would mean that the lake is not healthy enough to support a sustainable population of sturgeon or crayfish.

Assessment Goals

1. Lake Sturgeon: Is there suitable spawning habitat to host a sustainable Lake Sturgeon population?
2. Crayfish: Has there been a serious decline in the population of crayfish?
3. Plants: What invasive aquatic plants are present?
4. Algae: Are there any invasive species of algae present in the watershed?

Threats to Burt Lake Watershed Management

Sustainable Lake Sturgeon Population

In order to reintroduce a sustainable population of Lake Sturgeon to the Burt Lake Watershed, certain habitat conditions must be satisfied. Without specific habitat, the life stages of Lake Sturgeon cannot be completed successfully. There are five distinct life stages of a Lake Sturgeon: spawning adult, egg, larval, juvenile, and adult. For each of those life stages, Lake Sturgeon require specific substrate, temperature, dissolved oxygen, depth, food, and flow (Table 1-A). Without all ecological niches present in the same watershed, Lake Sturgeon cannot be self-sustaining. Additionally, invasive species pose a threat to sustainable Lake Sturgeon population. Species, like round goby, may complicate aquatic food webs by preying on sturgeon eggs and larval sturgeon, or conversely, provide a food source for adults. Invasive plant species may not host the proper food sources for Lake Sturgeon, or may crowd out the clear, open water, which sturgeon prefer.

Invasive Plants

Invasive plants are known to be problematic when introduced into a system because non-native plants can alter the natural ecology in a body of water. If a plant species is removed from its native system and placed into a foreign system, the usual predators of that plant are absent from the new environment, often leading to the out-competing of native species. The absence of natural predators and an increase in human activities may allow for invasive plants to proliferate. Fragmented plants can result from activities such as boating and raking, which allows many aquatic plant species to disperse and form new plants. New plants can establish dense mats of vegetation, ultimately affecting the structure of the ecosystem as plants are the cornerstone of the productivity in a watershed. Crayfish depend on plant species as a component of their diet. If the invasive species outcompetes the native plant species, crayfish populations may be affected.

Crayfish

Crayfish are a keystone species and are known to significantly alter their surroundings by being ecosystem engineers. For example, when crayfish are hunting for food, they can increase sand and gravel erosion by displacing sand grains between the gravel of stream riffles (Bernhard et al. 2000). Population and community structure at the benthos is also affected by crayfish activity (Bernhard et al. 2000). As previously stated, large sportfish and other animals depend on crayfish as a primary food source. Community structure is affected even greater when invasive species are introduced, such as the rusty crayfish. Rusty crayfish are native to the Ohio River Basin and are often used as bait. Fishermen will buy rusty crayfish to use in other watersheds, introducing the invasive species to a new environment. Invasive crayfish eat two to three times more than native crayfish species, often displacing native crayfish in home and food. While invasive crayfish may have a negative impact, the general presence of crayfish can be an indicator of high water quality as they require high oxygen content and clear waters to survive. Along with crayfish, algae can also be an indicator of good or poor water quality.

Algae

Algae are a normal part of a healthy aquatic ecosystem. Algae convert carbon dioxide to oxygen through photosynthesis, can help remove nutrients and pollutants from a body of water, and can play a role in stabilizing sediment (Wehr & Sheath, 2003). Importantly algae is the base of the food chain on which all aquatic organisms, including Lake Sturgeon, ultimately depend (Wehr & Sheath, 2003). Macroinvertebrates can consume algae, a primary producer, and Lake Sturgeon prey on macroinvertebrates. However, algae that is invasive or growing rapidly can be a nuisance, affecting the aesthetics and recreational use of a body of water. As aforementioned, large masses of algae can act as indicator of other problems in a freshwater system, such as nutrient pollution. Large mats of algae assimilate the nutrients from sources of point-source pollution, such as septic tanks. In order to sample for rapid algal growths and the other parameters above, we developed the following sampling protocol.

Sampling Protocol

Samples were collected from 32 different sites in Burt Lake from the southern basin, Sturgeon Bay, and Maple Bay (Table 1). At each of those 32 sites, the parameters of substrate, physical parameters, and plants were sampled when applicable. Samples were also collected in the four main tributaries of Burt Lake: The Indian River, Sturgeon River, Maple River, and Crooked River. At each river site, the substrate, physical water parameters, plants, flow, and algae were analyzed. In order to determine whether crayfish are present in Burt Lake, data was collected in the Maple Bay and Devoue Beach.

Lake Sturgeon

Sediment was taken at sampling sites on Burt Lake and the four main tributaries. Sediment was collected using an Eckman Grab. On Burt Lake the Eckman grab was placed over the side of the pontoon boat and lowered to the bottom of the lake. A steel messenger was placed on the rope that was sent down to close the Eckman grab. The Eckman grab is triggered, and then raised to the side of the boat. The sample was placed in a tub where the grab was opened and the sediment was released. The sediment was gathered and then placed in a sealed whirl-pack. The sampling process was also done on the four main tributaries that are connected to Burt Lake. Once collected the samples were brought back to the lab and placed in a refrigerator until analysis. When being analyzed the sediments were identified for texture, composition, and color, as Lake Sturgeon are dependent on having a specific texture and composition to survive. The texture was determined by using the ribbon test. From the texture, composition can be determined using a soil texture triangle. Hue was determined by using a Munsell color soil technique.

In order to assess necessary physical parameters for Lake Sturgeon, a multi-measurement device (Hydrolab) was used on Burt Lake at the sampling sites to collect, pH, dissolved oxygen, temperature, and turbidity. Light was also measured using a LiCor light meter to check levels of light penetration. The hydrolab was lowered every one meter until the hydrolab reached the bottom. At each meter pH, dissolved oxygen, temperature, and turbidity were measured. The light meter was lowered every one meter till eight meters or until the bottom was reached to determine light penetration. In the four main tributaries the multi-measurement device, and light meter was also used. In addition flow was also included in the data collection. A transect was set up at each sampling site, using flags to mark out 10 evenly spaced cells. In the middle of each cell, the Hydrolab will take temperature and turbidity at mid-depth. Dissolved oxygen, pH, and conductivity will also be taken, but only in cell number six, towards the middle of the transect. A meter stick was used to measure depth in each cell, and flow will be taken at 60% depth to capture the average flow through the cell. Discharge was calculated and compared to historic rates. In each cell light was also collected at the surface and at the bottom of the river.

Crayfish

The abundance of crayfish in Maple Bay of Burt Lake was sampled by the Bowling Green State University Laboratory for Sensory Ecology (LSE) from mid-June to August. The LSE collected crayfish by using steel nets and spotlights at night. The crayfish were collected from July 29 – July 30, 2016, identified by species, then collected for research purposes. In the southern basin of Burt lake at Devoe Beach, crayfish were captured using 3 modified minnow traps that were set for 24 hours. All crayfish collected were recorded, identified, and released.

Invasive Plants Species

Burt Lake and the four main tributaries were sampled for presence of invasive species using modified plant rakes attached to rope. On the boat in Burt Lake, the plant rake was thrown overboard four times: from the front, each side, and rear of the boat. Once at the bottom, the rake was pulled in slowly along the substrate to collect any present plants. When appropriate, plants were hand picked in the tributaries given that the water depth is shallow enough to walk through. Each unique species sampled was placed in a whirl-pack to be examined back at the lab. All samples were identified to genus and species utilising the dichotomous key in A Manual of Aquatic Plants by Norman C. Fassett back at the lab (Fassett, 1966).

Algae

Algae were surveyed in the four main tributaries of the watershed. If present, samples of the algae found in significant masses were collected in a whirl-pack. Whirl-packs were placed in the water by hand and the alga gently collected inside. The algae samples were brought back to the lab for identification with a light microscope down to genus. The genus and location found were recorded. Conclusions were then drawn from all of the data collected.

Results

Lake Sturgeon Habitat

The assessment indicates that Burt Lake provides suitable adult Lake Sturgeon habitat. Several sites measured on Burt Lake had sandy, silty substrate, the necessary substrate adult Lake Sturgeon need to survive (Table 2-A). There is also a high concentration of dissolved oxygen in the Burt Lake watershed overall (Table 3-A). The data collected by the Michigan DNR in 2011 supports the conclusion that Burt Lake provides the right substrate and physical water conditions needed to survive. The Sturgeon River and the Indian River provide suitable spawning habitat for sexually mature Lake Sturgeon.
In both the Indian River and the Sturgeon River the correct substrate, flow, temperature, and depth were found. Flow on the Indian River was 0.205 m/s on average (Table 4,6-A). While not between the necessary 0.5 - 1.8m/s for flow, lower flow during the summer than what flow would be during the spring is normal. The snow and ice melts in the spring add an increased amount of flow to each tributary. Lake Sturgeon require temperature to be above 12 degrees Celsius. The average temperature in the Indian River was measured to be 23 degrees Celsius (Table 6-A). Like flow, temperature is expected to be different in the summer than in the spring. The average depth on the Indian River was 1.9 meters, greater than the minimum requirement of 0.5m. The Sturgeon River also meets the necessary spawning requirement with a gravel sandy bottom, average flow of 0.776 m/s, average temperature of 15.07 degrees Celsius, and average depth of 0.5m (Table 4,5-A). While both the Indian and the Sturgeon rivers provide excellent habitat for spawning and juvenile lake sturgeon, the Sturgeon River is best suited to host a sustainable sturgeon population. The Indian River flows out of Burt Lake into Mullett Lake, which means any fry hatched in the Indian River would drift into Mullett Lake.

The Crooked River and Maple River do not provide suitable spawning habitat. The Crooked River is too turbid for larval sturgeon to survive (Table 7-A). In addition, the substrate is mostly muck and detritus, decaying organic matter, an unsuitable substrate for sturgeon eggs and larvae. There is also low dissolved oxygen (Table 7-A). Unlike the other tributaries, the Maple River does not meet the depth requirements (Table 8-A). Where the Maple River meets Burt Lake, the depth is too shallow for Lake

Sturgeon to move upstream. The shallow depth can be attributed to the decreased flow from the Maple River dam. The dam is set to be removed in the near future, which could impact the flow and depth in the Maple River basin, also affecting the large crayfish population in the basin.

Crayfish

The crayfish data collected by the LSE support that a population of crayfish are present in Maple Bay and the north basin of Burt Lake. Approximately 730 crayfish were captured; both the invasive rusty crayfish (*Orconectes rusticus*) and native virile crayfish (*Orconectes virilis*) were captured. Ratios between the abundance of rusty and virile crayfish captured differed on different sampling days. The crayfish data collected from Devoue Beach and Maple Bay supports that crayfish are present in the south basin and north basin of Burt Lake. All of the crayfish collected in the South Basin were rusty crayfish (Figure 1-B).

Rusty crayfish are easily identifiable by the rust-colored spots on their sides. The Virilis Crayfish *(Orconectes virilis)* identified by their bright blue claws. Additionally, two other native crayfish are found in Burt Lake. The Devil Crayfish *(Cambarus diogenes)* identified by having a higher seated carapace and more robust claws compared to the other two; the Northern Clearwater Crayfish *(Orconectes propinquus)* is identified by a black stripe on their tail and smaller claws(Figure 2-B). Each species of crayfish depend on native plants as a food source, which is threatened by the presence of two invasive plant species.

Invasive Plants

Two species of invasive plants were discovered during the plant survey: Curly-leaf pondweed and Eurasian watermilfoil. Curly-leaf pondweed can be identified by tiny serrations along the leaf edge as well as its stiff, crinkled leaves. Commonly mistaken for the native clasping-leaf pondweed, the leaves of curly-leaf pondweed do not surround the stem. Also the Curly-leaf pondweed can tolerate water with cold temperatures, and so is the first weed to appear in the spring and dies off mid-summer. Eurasian watermilfoil is also commonly mistaken for a native plant, the Northern watermilfoil. The invasive Eurasian watermilfoil can be identified by the fact that the milfoil has greater than 12 leaflets on a single leaf, while the native Northern watermilfoil has less than 12 leaflets on a single leaf. Curly-leaf pondweed was found in the Indian River, while Eurasian watermilfoil was found in Burt Lake and the Crooked River (Figure 1C). Invasive plants may be an unwelcome part of an ecosystem, but the following algae are representative of a healthy ecosystem.

Algae

Five different genera of algae were identified: Spirogyra, Mougeotia, Vaucheria, Batrachospermum, and Chara (Table 1-D). Spirogyra and Mougeotia are filamentous green algae, Vaucheria is a filamentous yellow-green alga, Batrachospermum is a filamentous red alga, and Chara is a green macroalga (Wehr & Sheath, 2003). Small filaments of algae are not visible to the naked eye but long and aggregated filaments can form dense mats or floating clouds that are visible in the water. All identified algae are a part of the normal flora of aquatic habitats in Michigan and the presence of modest masses of algae is unlikely to be a sign of pollution or eutrophication (P. Kociolek, personal communication, July 25, 2016). The possibility that algae will bloom excessively and take over the lake is very unlikely.

Masses of Spirogyra and Mougeotia are grass-green in color, stringy, silky, and slimy to the touch (Kannan, Lenca 2013). Under a microscope, Spirogyra is distinctive as an unbranching filament of long cylindrical cells containing spiral-shaped chloroplasts, while Mougeotia is an unbranching filament of long, cylindrical cells containing ribbon-shaped chloroplasts. Spirogyra was collected in Maple Bay, and

Mougeotia in the Maple River Mouth. Vaucheria and Batrachospermum were each collected in the Indian River. Vaucheria forms a light to dark green felt-like mat while Batrachospermum appears as thick, dark masses (Wehr, Sheath 2003). Under a microscope, Vaucheria is distinctive as a long, bright green filament with no cross walls because the entire filament is a single cell. Batrachospermum can be identified by the whorled branches arising from the central filament. Vaucheria and Batrachospermum prefer to grow in cold water with a high oxygen content (P. Kociolek, personal communication, July 25, 2016). Because cool water with high oxygen content is usually quite clean, the presence of Vaucheria and Batrachospermum is a good sign for water quality in the Indian River (P. Kociolek, personal communication, July 25, 2016).

Chara was found at 6 sampling sites on Burt Lake and 2 sites each on the Crooked and Indian Rivers. Chara is a macroalga, meaning that an individual organism of the genus Chara forms a macroscopic structure that can be seen with the naked eye (Wehr, Sheath 2003). Although Chara may resemble a vascular aquatic plant, the algal structure is actually called a thallus in place of true stems and leaves (Wehr, Sheath 2003). Chara may be encountered rooted in the benthos or dislodged and floating, and may form low-growing dense mats or occur sparsely, depending on nutrient levels in the water (Rosen, St. Amand 2015). Chara can additionally be identified by its gritty texture and characteristic musky odor (MAPMS 2012). The presence of Chara is positive for Burt Lake and its tributaries because Chara provides several beneficial ecosystem services: filtering nutrients, stabilizing sediment, and providing a food source and habitat for other organisms (MDEQ 2012, Wehr & Sheath, 2003). Chara can occasionally cause problems in shallow water when growths reach the surface, as such tall growths can interfere with recreation (Wehr, Sheath 2003). This information explains what was found in the Burt Lake Watershed, the following are the recommendations for improving the health and quality of the watershed.

Recommendations for the Burt Lake Watershed

Management of Lake Sturgeon Habitat

Efforts on re-establishing a sustainable population of lake sturgeon should be focused on the Sturgeon River. While both the Indian and the Sturgeon Rivers offer suitable spawning habitat, the Sturgeon River flows into Burt Lake, meaning larval Lake Sturgeon will drift into Burt Lake. On the other hand, larval Lake Sturgeon in the Indian River will drift into Mullett Lake. Previous stocking of juvenile lake sturgeon has occurred, by the Michigan DNR, Sturgeon for Tomorrow, and the Little Traverse Bay Band of Odawa Indians. The Michigan DNR has a document regarding the introduction of Lake Sturgeon.

1. Streamside rearing facility: Juvenile Lake Sturgeon will develop the necessary homing mechanism to return to their natal stream, the Sturgeon River, when sexually mature if released from a streamside rearing facility, which rear lake sturgeon from eggs so larval sturgeon in Sturgeon River waters, so lake sturgeon can develop homing mechanisms.
2. Reusable reporting cards: Sturgeon for Tomorrow has a link on their website to record Lake Sturgeon sightings. However, the link is inconvenient and difficult to use. Reusable reporting cards allows for convenient reporting, which in-turn provides data on the time of year lake sturgeon enter tributaries to spawn, and specific spawning sites used. Data fro sightings can also be used to determine when restricted areas should be put in place to protect future sturgeon.
3. Designating spawning area: Adult Lake Sturgeon require a very specific habitat to spawn. Protecting an area and restricting entry will help protect spawning adult sturgeon, as well as increase survival rates of hatchlings.

4. Education and outreach: Posting fliers or signs can spread awareness to the general public about proper behavior to protect spawning sturgeon. Also, engaging with nonprofit and small interest groups will assist in engaging the public in citizen science.
5. Watch out for Lampricide: Work closely with the US Fish and Wildlife Service, as the USFWS regularly treats the Maple River and Sturgeon River with lampricides. However, the lampricide 3-trifluoromethyl- 4'-nitrophenol, used in sea lamprey treatment, has the potential to harm larval and juvenile Lake Sturgeon (Boogaard et al., 2003). The application of lampricide should not coincide with the spawning season or larval drift to decrease harm to Lake Sturgeon in the Burt Lake watershed.
6. Re-evaluate the Maple River: The Maple River dam is set to be removed in the near future, potentially affecting Lake Sturgeon's ability to move up the Maple River to spawn. The Maple River should be re-evaluated post-removal to determine whether the river would then be a viable spawning habitat.
7. Limit boat traffic: Larval drift for Lake Sturgeon occurs between 9:45PM and 3AM. Limiting boat traffic when larvae are in drift would increase survival rates of larval sturgeon, allowing for uninterrupted drift.
8. Dredge mouth of Sturgeon River: While larval sturgeon can survive in as little as 0.6m of water, dredging the mouth of the Sturgeon River would increase depth of the river. Dredging would also increase the safety of larval sturgeon residing in the mouth of the river.

Management of Crayfish

There is a healthy population of crayfish in Burt Lake, even with the presence on the invasive rusty crayfish.

1. Limit nonindigenous bait: One of the ways the rusty crayfish spreads in an area is through bait releases. Inform bait shop owners and resident users of the lake to limit their use of the rusty crayfish and other nonindigenous baits.
2. Lake Sturgeon: The crayfish is one of the staple foods of a Lake Sturgeon diet. There is a possibility that Lake Sturgeon will help control the population of the invasive rusty crayfish, however, there is uncertainty whether the Lake Sturgeon would preferentially eat the invasive species over native species. Continual surveys should be conducted because the crayfish move around the lake.

Management of Invasive Plant Species

The invasive plant species of Curly-leaf pondweed and Eurasian Watermilfoil were found in the Burt Lake watershed. With the threat of the invasive plant species of European Frogbit and Starry Stonewort in the area, prevention of the introduction and spread of invasives is important.

1. Education and outreach: Informing residents and visitors of the Burt Lake watershed of the current invasive species present will help to prevent the spread of invasive species. Ensure that people do not bring invasive species to the area.
2. Boat washing stations: Constructing boat washing stations in high-traffic areas such as the Maple River and Burt Lake State Parks will help to limit the introduction and spread of invasive species to the Burt Lake area.
3. Removal by herbicide: Herbicides are costly, but can be applied to Burt Lake to rid the lake of invasive species. However, herbicides rarely distinguish between invasive and native species, and may affect the native plant population.

4. Removal by hand: Invasive plant species can be removed by hand. With the correct identification, invasive plants should be taken out of the water, allowed to dry out, then disposed of into a trash receptacle.

Management of Algae

None of the algae identified in sampling of Burt Lake and its tributaries are invasive or occurred in excessive quantities indicative of a problem in the ecosystem. However, continuing to monitor algal growths is important, as the growths can be warning signs of potential future problems. Large blooms can affect the aesthetic and recreational use of the lake if not controlled.

1. Monitor possible point-source pollution: Algae clean watersheds by assimilating extra nutrients. Septic tanks, agriculture, and dumping can be sources of point-source nutrient pollution that may be aiding large algal growth.
2. Removal by hand: Algae is a normal component to an ecosystem, however if the presence of algae is unsettling to lake users, the algae can be removed by hand.

Appendix A: Lake Sturgeon

Table 1-A: The life stage requirements for Lake Sturgeon vary and what is required for growth. (MIDNR; Stone, 1900; Peterson et al., 2006; Hay-Chmielewski and Whelan, 1997; Thuemler, 1985; Choudhury et al., 1993).

Lake Sturgeon Life Stage Requirements				
	Spawning	**Larval**	**Juvenile**	**Adult**

Substrate	Rocky, Coarse Gravel	Pelagic, Rocky	Fine (Sand, Silt)/river mouth	Fine (Sand, Silt)
Temperature	12-21 C	11-16 C	19 C	<25 C
Dissolved Oxygen	N/A	.02g/body weight @ 10 C	1.9g/body weight @ 16 C	63g/body weight @ 20 C
Depth	0.6-12 m	0.6-12 m	>2 m	6-12 m
Food Source	N/A	Yolk Sac, Copepods	Invertebrates	Invertebrates, Mollusks
Flow	2.0- 2.8 ft/s	Not Specified		

Table 2-A: Raw data of sediment sampling conducted in Burt Lake

Site	Location	Sediment Type	Color (Munsell)	Notes
Burt Lake 1	N 45° 24.570 W 084° 37.896	Clay loam	2.5YR 2.5/1	Sulfuric
BL 2	N 45° 24.441 W 084° 37.820	Sandy clay loam	2.5YR 2.5/1	Decaying terrestrial leaves
BL 3	N 45° 24.412 W 084° 37.646	Sandy loam	2.5YR 5/2	
BL 4	N 45° 24.248 W 084° 38.347	Silty clay	7.5YR 5/1	
BL 5	N 45° 24.211 W 084° 38.345	Sandy clay loam	2.5YR 5/1	
BL 6	N 45° 24.165 W 084° 39.050	Sandy clay	10YR 5/1	
BL 7	N 45° 24.427 W 084° 39.749	Clay	2.5Y 5/2	
BL 8	N 45° 27.778 W 084° 38.274	Sandy clay	2.5Y 4/2	
BL 9	N 45° 27.605 W 084° 38.241	N/A	N/A	Water too choppy for Eckman Grab
BL 10	N 45° 24.798 W 084° 37.410	Silty clay loam	10YR 3/1	Decaying organic matter
BL 11	N 45° 24.669 W 084° 37.576	Silty clay loam	10YR 3/1	Decaying organic matter
BL 12	N 45° 24.521	Silt loam	5YR 2.5/1	Sulfuric

	W 084° 37.473			
BL 13	N 45° 28.285 W 084° 43.391	Silty clay	2.5YR 3/1	
BL 14	N 45° 28.258 W 084° 43.513	Silty clay	5YR 4/1	Decaying terrestrial leaves
BL 15	N 45° 28.287 W 084° 43.176	Sandy clay	7.5YR 4/2	Broken up shell pieces
BL 16	N 45° 28.996 W 084° 42.495	Clay loam	7.5YR 3/1	Aquatic plant material
BL 17	N 45° 28.983 W 084° 42.666	Sandy clay	10YR 4/2	Aquatic plant material
BL 18	N 45° 29.005 W 084° 42.610	Sandy loam	2.5Y 3/2	Decaying terrestrial leaves
BL 19	N 45° 24.144 W 084° 38.066	Sandy clay loam	2.5Y 4/2	
BL 20	N 45° 24.166 W 084° 38.103	Silty clay	10YR 4/1	
BL 21	N 45° 24.067 W 084° 38.540	Clay loam	2.5Y 5/2	
BL 22	N 45° 24.087 W 084° 39.245	Sandy clay	2.5Y 4/0	Aquatic plant material
BL 23	N 45° 24.253 W 084° 39.554	Sand	7.5YR 4/2	
BL 24	N 45° 24.392 W 084° 39.554	Sandy clay loam	7.5YR 4/2	
BL 25	N 45° 25.107 W 084° 38.133	Clay	2.5YR 4/0	Aquatic plant material
BL 26	N/A	N/A	N/A	
BL 27	N/A	N/A	N/A	Rock, gravel
BL 28	N 45° 24.326 W 084° 37.295	Loamy sand	2.5Y 5/2	
BL 29	N 45° 25.548 W 084° 38.331	Sandy clay	2.5Y 5/4	
BL 30	N 45° 26.228	Silty clay	2.5Y 5/4	

	W 084° 38.408			
BL 31	N 45° 28.041 W 084° 42.205	Silty clay	2.5Y 4/2	Aquatic plant material
BL 32	N 45° 29.007 W 084° 42.082	Silty clay	2.5Y 4/2	

Table 3-A: Physical Habitat Parameters of Burt Lake

Site	Average Temp (°C)	Average Turbidity (FNU)	Average Dissolved Oxygen (mg/L)
BL 1	21.74	5.37	8.10
BL 2	22.38	5.25	8.30
BL 3	17.41	11.5	8.33
BL 4	22.36	4.76	8.28
BL 5	22.66	4.62	8.22
BL 6	22.47	4.28	8.22
BL 7	22.38	3.19	8.31
BL 8	23.01	0.51	8.13
BL 9	23.04	2.41	8.07
BL 10	22.30	2.18	8.05
BL 11	22.29	1.23	8.06
BL 12	21.68	2.45	7.85
BL 13	16.70	7.22	5.63
BL 14	17.76	7.73	7.70
BL 15	18.53	7.01	5.66
BL 16	21.46	8.05	3.19

BL 17	17.30	7.61	6.30
BL 18	21.50	8.21	4.12

Table 4-A: Raw data of sediment sampling conducted in the four main tributaries

Site	Location	Sediment Type	Hue	Notes
Sturgeon River 1	N 45° 23.216 W 084° 37.007	Sandy loam	10YR 4/4	Gravel
SR 2	N 45° 22.313 W 084° 37.434	Loamy sand	10YR 5/3	Gravel
SR 3	N 45° 24.353 W 084° 37.565	Sandy clay loam	10YR 3/1	Decaying organic matter
Indian River 1	N 45° 24.607 W 084° 37.171	Silty clay	10YR 2/1	Decaying organic matter and terrestrial leaves
IR 2	N 45° 24.580 W 084° 36.236	Clay loam	10YR 4/2	Aquatic plant material
IR 3	N 45° 25.082 W 084° 36.146	Sandy clay	10YR 2/2	Aquatic plant material
Crooked River 1	N 45° 26.643 W 084° 47.044	N/A	N/A	All Chara
CR 2	N 45° 28.002 W 084° 45.761	Loamy sand	2.5Y 4/4	Aquatic plant material
CR 3	N 45° 28.141 W 084° 43.402	Sandy clay	10YR 2/2	Aquatic plant material
Maple River 1	N 45° 28.896 W 084° 42.706	Loam	5YR 3/2	

Table 5-A: Habitat assessment and locations of the Sturgeon River

Site	Average Depth (m)	Dissolved Oxygen (mg/L)	pH	Conductivity (uS/cm)	Average Temperature (°C)	Average Light (%)	Discharge (L/s)

SR 1	.214	9.02	8.26	416.80	15.62	44.89	4191.87
SR 2	.615	9.23	8.26	407.20	15.19	31.87	7346.41
SR 3	1.00	8.27	8.27	424.50	17.68	29.41	4954.51

Table 6-A: Habitat assessment and locations of the Indian River.

Site	Average Depth (m)	Dissolved Oxygen (mg/L)	pH	Conductivity (uS/cm)	Average Temperature (°C)	Average Light (%)	Discharge (L/s)
IR 1	1.47	8.00	8.45	332.20	23.94	30.22	5807.97
IR 2	1.49	7.90	8.40	334.00	23.20	24.71	13993.63
IR 3	1.32	8.21	8.40	333.80	23.21	30.14	11860.33

Table 7-A: Habitat assessment and locations of the Crooked River.

Site	Average Depth (m)	Dissolved Oxygen (mg/L)	pH	Conductivity (uS/cm)	Average Temperature (°C)	Average Light (%)	Discharge (L/s)
CR 1	1.15	7.46	8.22	309.30	24.15	1.31	281.98
CR 2	1.00	7.21	7.96	317.60	24.81	11.76	2992.77
CR 3	1.66	5.38	7.75	328.90	23.71	17.13	492.65

Table 8-A: Habitat assessment and locations of the Maple River.

Site	Average depth (m)	Dissolved Oxygen (mg/L)	pH	Conductivity (uS/cm)	Average Temperature (°C)	Average Light (%)	Discharge (L/s)
MR 1	.45	4.85	7.52	342.50	19.83	25.93	11.37

Appendix B: Crayfish

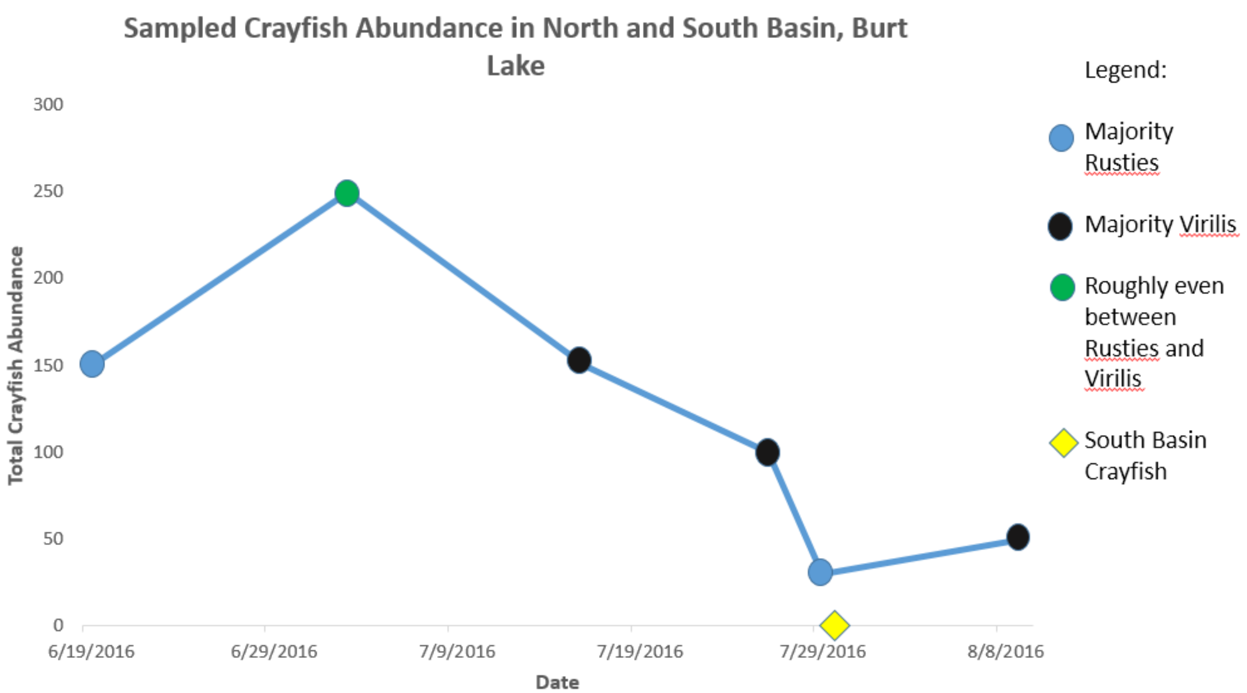

Figure 1-B: Sampled crayfish abundance in the North and South Basin of Burt Lake. All crayfish sampled in the Southern Basin were Rusty Crayfish.

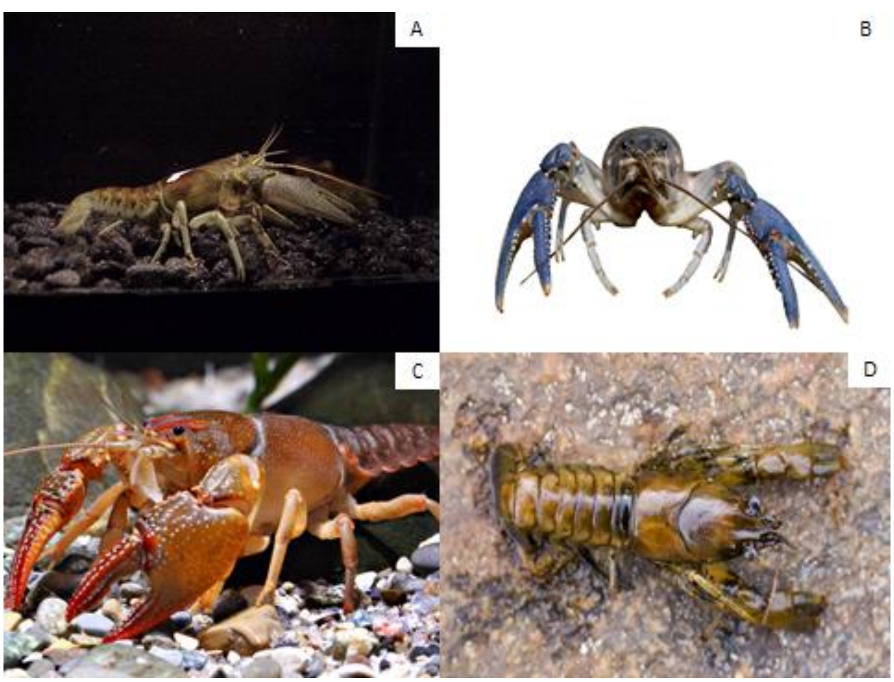

Figure 2-B: Photos of crayfish A) Rusty Crayfish, B) Virilis Crayfish, C) Devil Crayfish, D) Northern Clearwater Crayfish.

Appendix C: Invasive Plants

Table 1-C: Invasive plants found in Burt Lake and its tributaries

Eurasian watermilfoil	Site #
Burt Lake	1
Burt Lake	5
Burt Lake	7
Crooked River	1
Crooked River	3
Curly-leaf pondweed	Site #
Indian River	1
Indian River	3

Appendix D: Algae

Table 1-D: Algae Identified in Burt Lake and its Tributaries

Alga	Site Collected	Identifying Characteristics	Significance
Spirogyra	MR 1	Macroscopic: Grass-green color, long stringy filaments, slimy/soapy texture, sometimes trapped air bubbles Microscopic: Spiral- shaped chloroplast	Normal native algal flora, no excessive growth observed
Mougeotia	MR 1	Macroscopic: Grass-green color, long stringy filaments, slimy/soapy texture, sometimes trapped air bubbles Microscopic: Ribbon-shaped chloroplast containing starch granules	Normal native algal flora, no excessive growth observed
Vaucheria	IR 1	Macroscopic: light to dark green felt-like mat Microscopic: Long, bright green branching filament with no cross walls	Normal native algal flora, indicator of high water quality, no excessive growth observed
Batrachospermum	IR 3	Macroscopic: thick dark masses Microscopic: green branching filament, branches whorl around central axis	Normal native algal flora, indicator of high water quality, no excessive growth observed
Chara	BL: 1, 3, 4, 9, 13, 14 IR: 2, 3 CR: 1,2	Rooted or dislodged and floating, resembles aquatic plant, whorls of narrow leaf-like structures around hollow stem	Normal native algal flora, many benefits in aquatic ecosystems, no excessive growth observed

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