Returning Lost Heritage: A Study of the Suitability of the Maple River for the Re-Introduction of Arctic Grayling

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Abstract

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Intro:

The Arctic Grayling, *Thymallus Arcticus*, was once one of the dominant fish species in coldwater streams in the northern region of Michigan's Lower Peninsula. It was last seen in Michigan waters in 1936, and has since been listed as an extirpated species (DNR, 2017). Prior to the 1880s, grayling were the most abundant salmonid fish in the region; anglers reported being able to harvest them in such numbers that they filled buckets (DNR, 2017). The reasons for the decline of the Grayling are numerous; competition from larger introduced species such as the Brown and Rainbow trout, overfishing, and large-scale deforestation due to human logging are ascribed as being the primary reasons for the decline and fall of the michigan population of the Arctic Grayling (Danhoff, 2014). Of these causes mass deforestation on the part of the lumber industry is widely listed as being the most important reason for the decline of the Grayling; the removal of streamside forests led to siltation of their gravel spawning sites, increases in temperature due to the lack of shade cover, and the creation of log jams that clogged the pools that they typically live in (Danhoff, 2014). The Grayling still has stable populations in the Northwest Territories of Canada, and has undergone successful conservation and restocking efforts in some parts of their original range in Montana; this success has prompted the Michigan DNR to investigate possible re-introduction of the Arctic Grayling into some of their original habitats in the Lower Peninsula of Michigan.

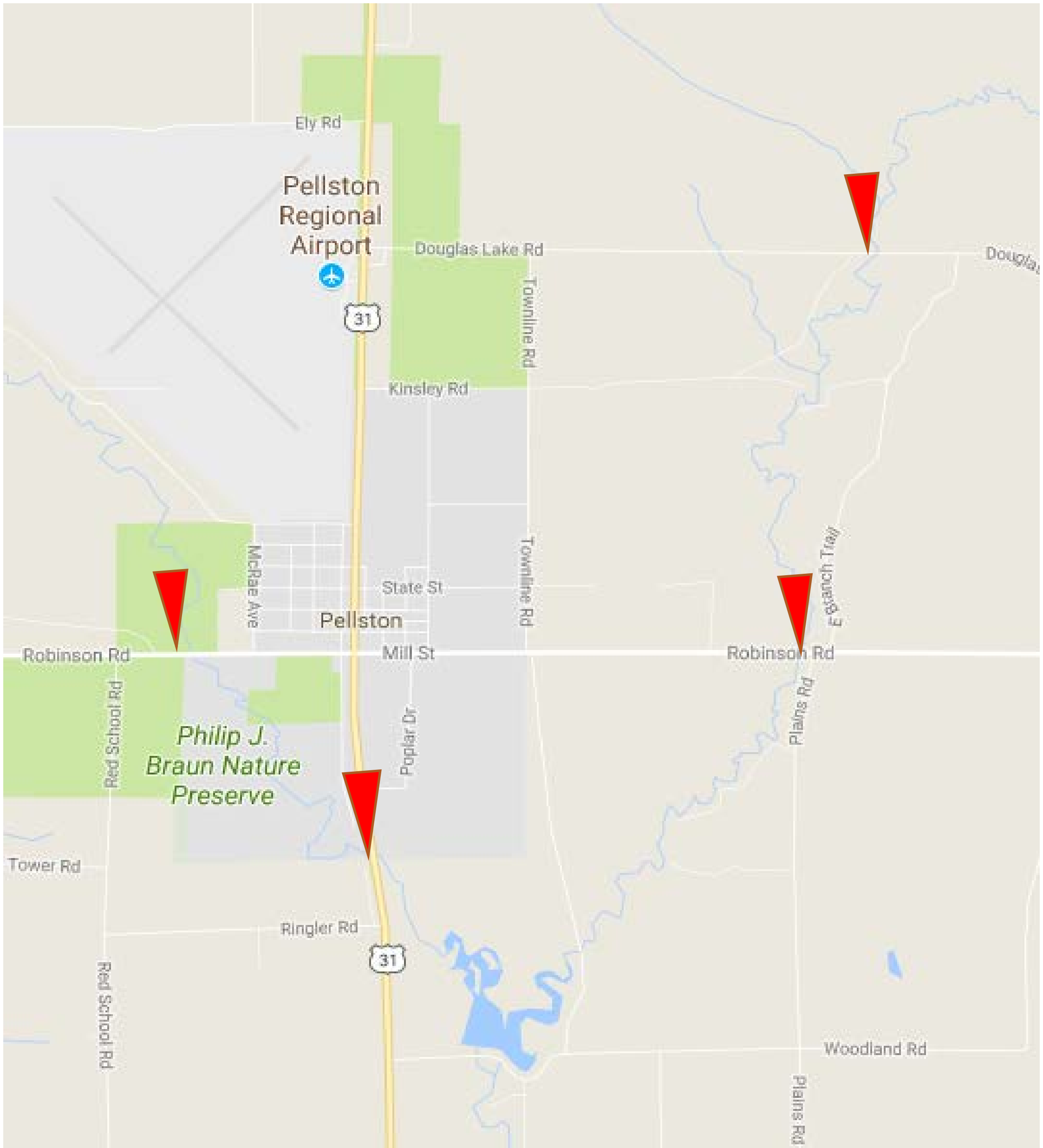
Grayling are members of the salmonid family; they are in the subset of this group called the char, which includes species such as Brook Trout, Lake Trout, and Arctic Char. . Like all Char, the Arctic Grayling needs cold water habitats. A general range of their needed temperature is between 2.7 and 22.0 degrees celsius, while the fry and young of the year require temperatures of between 4.5 and 17.5 degrees celsius (Danhoff et. al, 2017). The median tolerance limit, or the temperature at which 50% of a given sample of young grayling can survive is listed as 24.5 degrees celsius (Lhor, 1996). For grayling acclimated to 16 deg. C and 20 deg C, Lethal temperatures are listed as 23 and 25 degrees celsius (Lhor, 1996). They need a dissolved oxygen content of between 1.3 and 12.6 mg/L, and a water pH of between 5.9 and 8.5 (Danhoff et. al, 2017).

Arctic Grayling are commonly associated with forested streams; in their former habitat in the Manistee river, they were often associated with forests of *Pinus Resinosa* and other conifers (Danhoff, 2014). Grayling prefer with 20-30% pools by area, and that have a current. In order to spawn, the Arctic Grayling requires streambeds with small stones; the optimal spawning substrata is 20% gravel and/or small pebbles (Danhoff, 2014).

Grayling are primarily insectivores that feed on drifting macroinvertebrates; adult grayling tend to be opportunistic feeders that eat any macroinvertebrate foolish or unfortunate enough to enter the water column. while the young of the year tend to be more specific, and prefer ephemeroptera (mayfly) nymphs and diptera pupae (Stewart et. al, 2007). Grayling are also capable of feeding on plankton; cladocera were a common prey of young grayling in one study conducted in a stream of the Great Slave Lake in Canada (Bishop, 1971). Grayling are also shown to form hierarchies where the dominant fish in a pool positions itself closest to the upstream limit of the pool as to optimize food choice (Huges, 1992). In Montana, the Grayling naturally share a range with the Brook Trout (*Salvenus Fontalius)*, which is found in many of the coldwater streams of Michigan.. However, the two species have been shown not to compete for food resources; when the two fish species are found in the same pool, grayling feed closer to the upstream limit of the pool, while the Brook Trout tend to stay in the calmer reach of the pool, and are more associated with woody cover (Magee,1994)

In order to assess the viability of sites on both branches of the Upper Maple River, this project will conduct quantitative assessments on the pH, Dissolved Oxygen Content (DOC), temperature, streambed type and embeddedness, and macroinvertebrates present in the river branches. The primary goal of this project is to conduct preliminary investigations into the biotic and abiotic conditions of the East and West Branch of the Upper Maple River. Although this study is not exhaustive, it may be used to facilitate further research into sites deemed promising by the results of the project.

Site Map:



Geographic Coordinates for Sites: Robinson Road West is 45.5511 N, 84.7966 W. US-31 West Is 45.5406 N, 84.7849 W. Coordinates for Robinson Road East is 45.5512 N, 84.7518 W; Coordinates for the Douglas Lake East are 45.5719 N, 84.7465 W

Methods:

We collected data from four sites: two on the East Maple river, and two on the West Maple River. The East Maple River sites were at the branch's crossing at Douglas Lake Road and Robinson Road; the West Maple River Sites were at the crossing with the US-31 highway and Robinson Road We measured 100 meters of stream at each site with meter tape, posted at the 0 meter and 100 meter marks, as well as every ten meters

We calculated river discharge for the transects at 0 and 100 meters (upstream and downstream). After the width is known, the depth will be measured at ten equally spaced intervals; after each depth is measured, the current velocity in meters per second will be measured for 60% of each depth. We measured the total discharge at each site by multiplying the rate of flow, width of each sample location (always one tenth of the width of the stream), and the depth at each place we measured current. At the downstream reach of every site, we will use a YSI meter to obtain temperature, pH, DOC, and conductivity. This data was obtained on August 3, 2017 with the idea that the recorded temperature values will be an accurate estimate of the yearly maximum temperature of the stream; we also calculated the average river maximum temperature of each river branch.

In order to assess the substrata of each site, we took samples for ten transects, starting at the 0, or downstream transect. At each transect, we measured the distance across, and used a 0.25 square meter quadrat to observe the substrata every two meters across the transect (for the West Maple River, Robinson Road site, we took quadrat data every meter) . Each time we used the transect, we visually observed the bottom composition, and estimated the percent cover of woody debris and mineral particles based on the Modified Wentworth Scale (citation needed); we also observed the embeddedness and periphyton index of each site. We calculated the average percent cover, embeddedness, and periphyton index of each site based on the observed data.

We assessed the benthic macroinvertebrates by taking one sample at ten transects, starting from the downstream limit of each site. We collected macroinvertebrates from areas of one square meter by kicking up the substrata upstream of the net for two minutes. After the collection. We selected our collection positions based on the substrata of the site; most of our sites were on mixtures of particles ranging from sand to cobble; others were collected on woody debris or sand. To check for statistical differences between the rivers, we used T-tests (or MWU) to compare total macroinvertebrate abundance and percentage of EPT.

We set drift nets in the current at dawn, midday, and dusk at Robinson Road sites of the East and West Maple River. We set three nets at equal intervals across the downstream reach of each site. The nets stood in the current for one hour; we sorted them for 30 person minutes in enamel pans at the lab. We used T-test/MWU to assess total abundance and percent EPT per site.

Results:

Of the substrata types, sand, gravel, pebble,cobble, and woody debris were present in appreciable quantaties. The average percent cover for the Robinson Road West Maple river were 33.87% sand, 12.93% gravel, 12.59% pebble, 3.974% cobble, and 28.62% woody debris (Fig. 1-. 2); average embeddedness was 3.22, while average periphyton index was 0.33. The averages for cover on the West Maple River US-31 Site were 55.98% sand, 13.05% gravel, 7.80% pebble, 5.37% cobble, and 13.65% woody debris (Fig. 3-4); average embeddedness for the site was 2.56, while average periphyton index was 0.76. For the East Maple River Robinson Road site, the percent covers were 54.26% sand, 9.62% gravel, 9.44% pebble, 3.89% cobble (Fig. 5-6), and 7.41% woody debris; Embeddedness for the site averaged at 2.25, while average periphyton index was 1.30. For the East Maple River site at Douglas Lake Road, the average cover was 58.95% sand, 4.34% gravel, 6.32% pebble, 1.71% cobble, and 17.03% woody debris (Fig. 7-8). Embeddedness for the site was an average of 2.05; and had an average periphyton of 1.16.

Site	**Avg. % Sand**	**Avg. % Gravel**	**Avg. % Pebble**	**Avg. % Cobble**	**Avg. % Woody Debris**	**Avg. Embeddedness**	**Avg. Periphyton**
Robinson Road West	33.76	12.93	12.59	3.974	28.62	3.22	0.33
US-31 West	55.98	13.05	7.80	5.37	13.65	2.56	0.76
Robinson Road East	54.26	9.63	9.44	3.89	7.41	2.25	1.30
Douglas Lake Road East	58.95	4.34	6.32	1.71	17.02	2.05	1.16

The West Maple River Robinson Road site had total benthic macroinvertebrate density of 324 organisms per square meter; the population of EPT was estimated to be 56.79% (Fig 9-10). For the the US-31 site, the total number organisms per square meter was 405, and is roughly 79.75% EPT (Fig 11-12);observations would indicate that many of these are trichoptera. In the East Maple River, the Robinson Road site had 351, and EPT were estimated to compose 60.68%

(Fig 13-14) of this population. At the Douglas Lake Road site, the overall measured amount of insects was 327, and consisted of 49.85% EPT by volume (Fig 15-16).

Site	Total Macro Abundance	%EPT
Robinson Road West	324	56.79
US-31 West	405	79.75
Robinson Road East	351	60.68
Douglas Lake Road East	327	163

The insect per transect data for the benthos of each branch of the river were not normally distributed (P=.200 for West Maple River and P=.039 for the East Maple river). EPT sums per transect were normally distributed (P=0.018 for the West Maple River and P=0.005 for the East Maple River). The MWU test for site abundance showed no significant difference between rivers; Z=1.00, or absolutely confident that there is no significant difference between the branches. The T-test of the % EPT between rivers also showed no significant difference (T=0.448) between rivers.

The total number of drifting macroinvertebrates collected in the West Maple River was 140; for the East Maple River, it was 539. The percent EPT was 61.43 for the West Maple River and 27.83% for the East Maple River. None of the data were normally distributed; p=0.317 for both the distribution of the insect site sums and p=0.317 for for the %EPT. Statistically, there was a significant difference between both total drifting macroinvertebrate abundance and for %EPT in drift: Z=0.017 for both variables in MWU testing

River	Total Drifter Abundance	%EPT

West	140	61.43
East	539	27.83

Temperatures of the West Maple River were 16 degrees celsius for the Robinson Road site, and 15.1 degrees celsius at the US-31 site, making a river average of 15.55 degrees celsius for the river. The East Maple River Robinson Road site had a temperature of 19.3 degrees celsius and the East Maple River at Douglas Lake Road had a temperature of 21.4 degrees celsius, making an average river temperature of 20.35 degrees celsius. The Dissolved Oxygen Content was 8.55, 9.04, 7.00, and 7.56 mg/L for Robinson Road West, US-31 West, Robinson Road East, and Douglas Lake Road East, respectively. Conductivity for the West Robinson Site was 223.3 uS/C, 225.5 uS/C for the US-31 West Site, 184.3 uS/C for Robinson Road East, and 179.9 uS/C for the Douglas Lake East Site. The average discharge for the West Maple River Robinson Road site was 1.15 M^3/S; for the US-31 site, it was 1.31 M^3/S. The average discharge of the East Robinson Road site was 0.507 M^3/S; at the Douglas Lake Road site, it was 0.579 M^3/S. Site pH was 8.03, 8.05, 7.68, and 7.91 for the Robinson West, US-31, Robinson East, and Douglas Lake Road sites, respectively.

Site	**Discharge (M^3/S)**	**Temperature (C)**	**Dissolved Oxygen (mg/L**	**Conductivity (uS/C)**	**pH**
Robinson West	1.15	16	8.55	223.3	8.03
US-31 West	1.31	15.1	9.04	225.5	8.05
Robinson East	0.507	19.3	7.00	184.3	7.68

Douglas Lake East	0.579	21.4	7.56	179.9	7.91

Discussions:

The Substrata for the West Maple River sites appear to have a sufficient portion of gravel and pebbles for grayling spawning. For the Robinson Road West Site, the gravel/pebble cover is around 25.52%; at the US-31 site, it was 20.85%; both are found slightly in excess of the 20% that is listed for the optimal percent cover for spawning (Danhoff, 2014). The East Maple River has lower percentages of gravel/pebble cover: for the Robinson East Site, the combined amounts of these particles was 19.07; for the Douglas Lake Road site had percent cover of 10.66% for gravel and pebble; so this indicates that in terms of spawning habitat, the East Maple River is likely inferior to the West Maple River in terms of spawning habitat.

In terms of macroinvertebrates, the West Maple river is likely better suited to the feeding needs of the young grayling, since it had significantly higher percentages of drifting EPT than the East Maple River drift, and benthic insect data did not significantly differ based on statistical Analysis. Ideal oxygen content is listed as being around 8.7-8.8 mg/L for streams in Montana that support healthy Grayling populations (Liknes and Gould, 1987). None of the stream sites we sampled had oxygen content much lower or higher than the ones, though the West Maple River content was higher than that of the East Maple River. Perhaps the most important factor that we sampled was the temperature readout.

The temperatures we recorded in the central channel of the downstream reaches for the West Maple River were less than 17 degrees celsius, while both of the East Maple Sites had temperatures in excess of 17 degrees. Based on this information, it is possible that side channels, backwaters, and tributary streams could grow too warm. Grayling are migratory fish that often seek out side channels and tributary streams; they might be trapped in water that warms past the lethal threshold in the event that water levels drop (West et. al, 2011). The colder West Maple river is less likely to have this problem, since both sites had temperatures less than 17 C when we measured them with the YSI, though some backwater pools or channels could grow too warm for the fish during times of low water.

Based on temperature, insect, and substrata data, we conclude that the East Maple River is not suited for the re-introduction of the Arctic Grayling, while the East Maple River holds promise based on the data we have collected. Before the DNR or other government agencies begin the stocking of Arctic Grayling in the West Branch of the Maple River, there are a number of other factors that must be taken into consideration before these attempts are made. The first would be the presence of non-native salmonids that were introduced for the purpose of sport fishing. The University of Michigan Biological Station Fishes Class found 1 Brown Trout (*Salmo Trutta)* in the US-31 site, and 1 at the West Robinson Road site when they went electrofishing. Since some studies seem to suggest that non-native salmonids drive out Grayling when they occur together, we recommend that the DNR conduct more electrofishing studies on the river, and halt any stocking of non native species in the event that these sites are selected for Grayling re-stocking (Liermann, 2015). An assessment of the channel morphology should be conducted, since the fish need pools to feed; studies might also be conducted on the planktonic communities in the water, since some zooplankton are visible to the young fish, and make good prey (Schmidt & O'Brien, 1982). Man-Made barriers, such as the wooden ones encountered at the Robinson Road site might disrupt their migration; so they should be removed. Finally, we recommend that more extensive data be collected for velocity, since this can affect the Grayling's feeding behaviors, and their line of focus when feeding (O'Brien & Showalter, 1993).

Acknowledgements:

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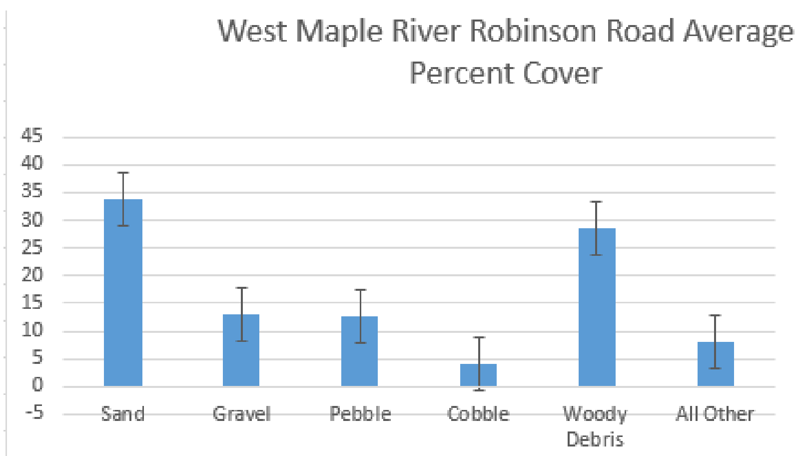
Figures:

Fig.1



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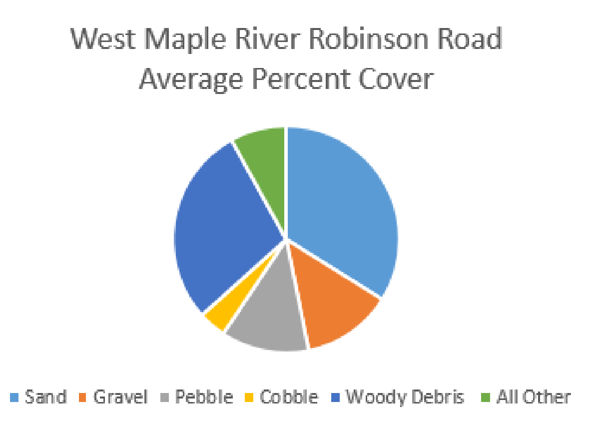

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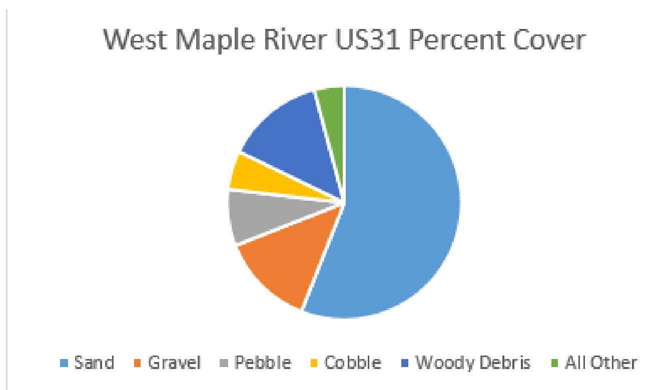

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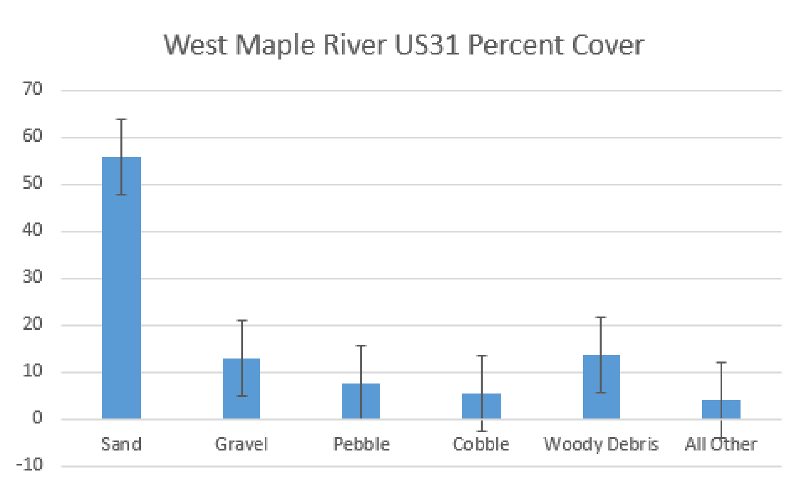

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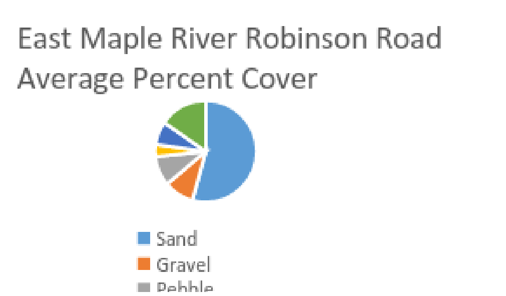

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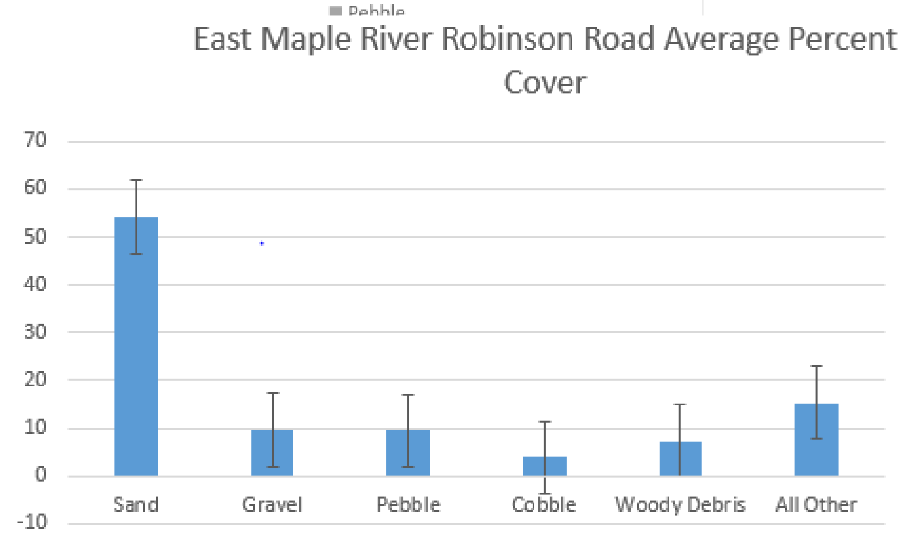

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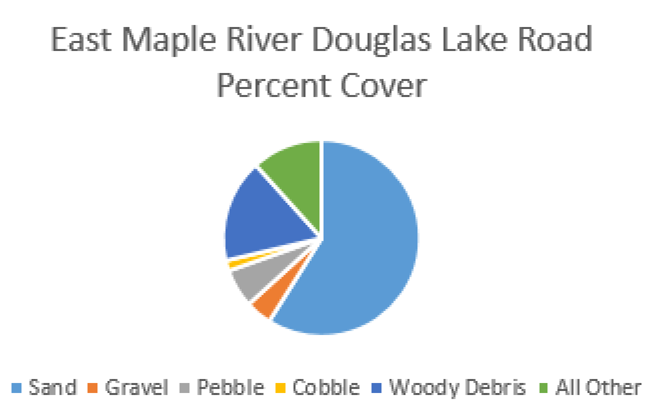

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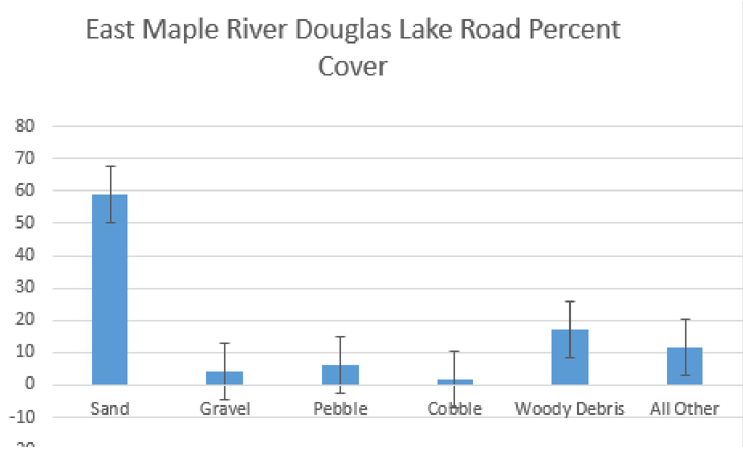

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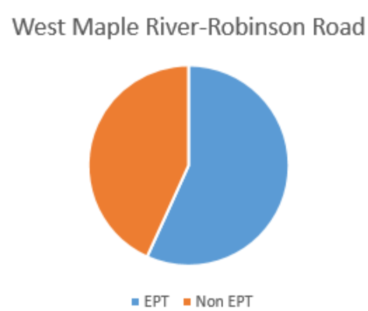

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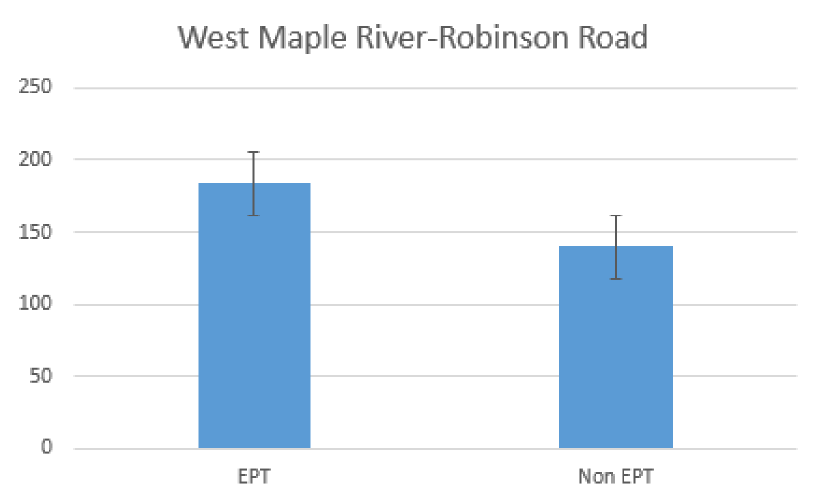
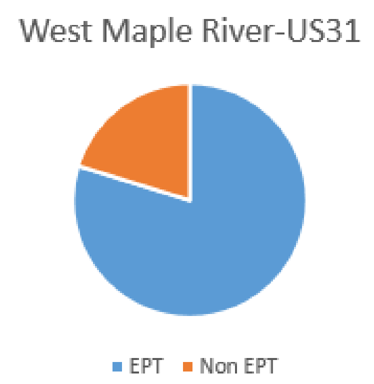


Fig 11



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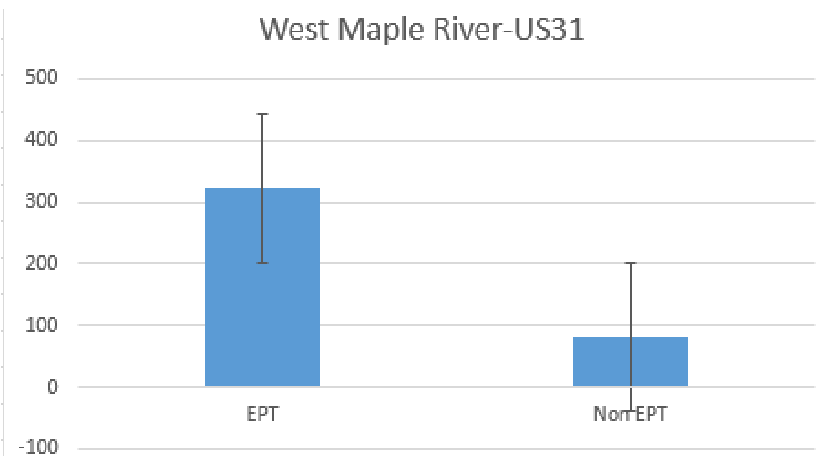

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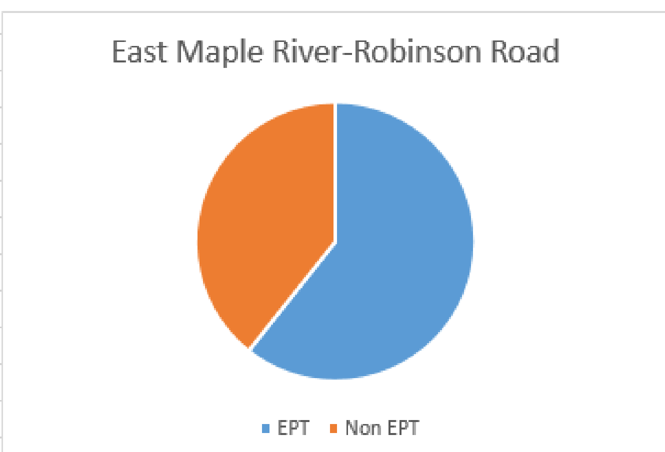

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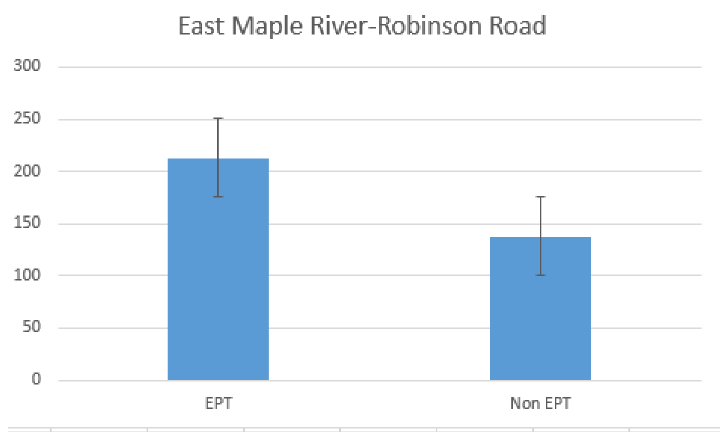

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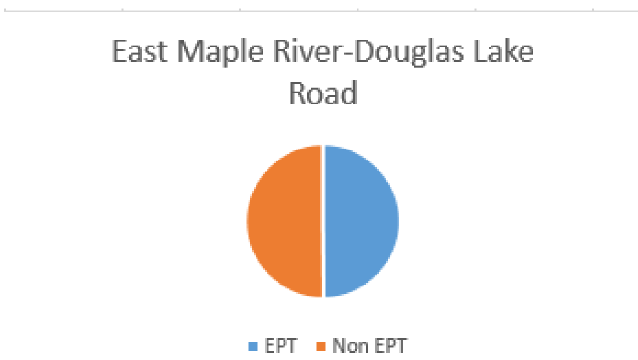

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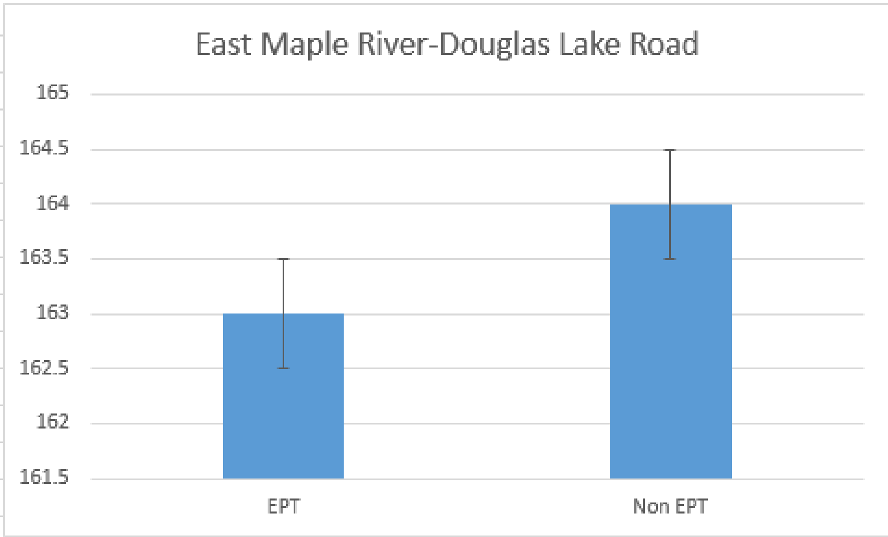

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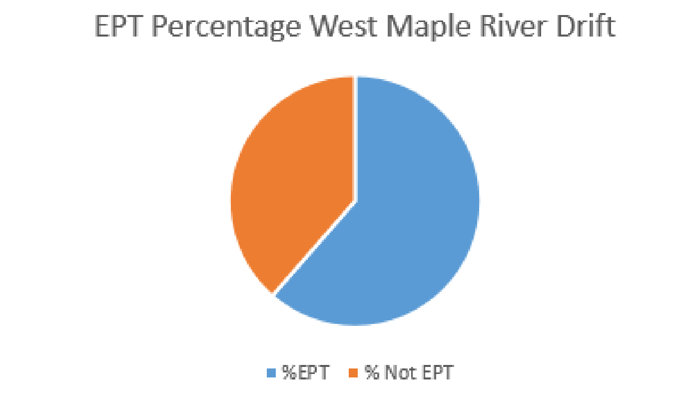

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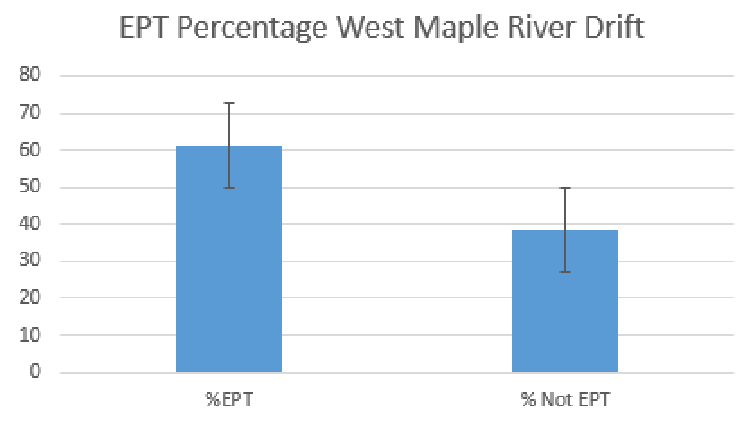

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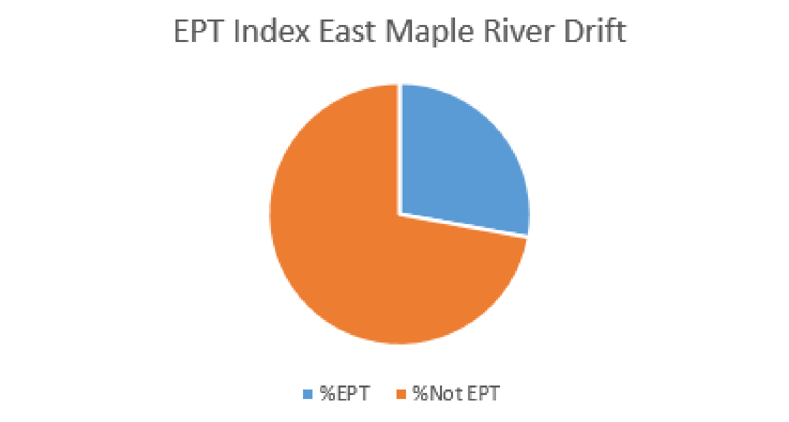
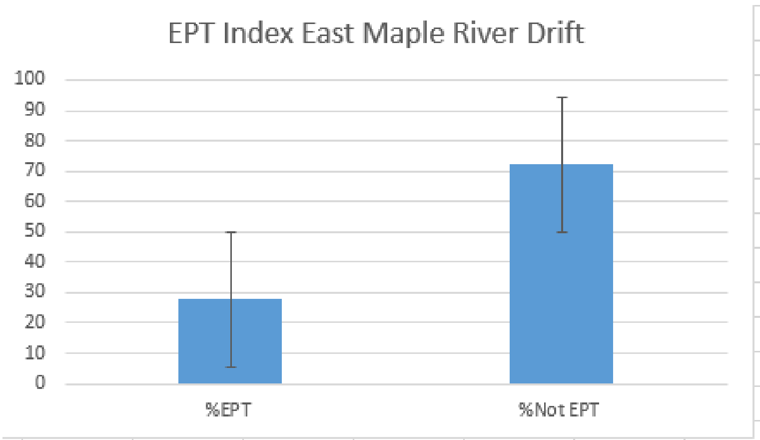


Figure 20


EPT Index East Maple River Drift
100
90
80
70
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50
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20
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