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An Assessment of the pH of the Soil in the Tamarack Bog

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I. Abstract

The purpose of this research project was to assess the pH of the Tamarack bog. The research was conducted once a month, weather permitting, at the Tamarack bog at the Bath Nature Preserve in Akron Ohio. Data collection began on July 31st, 2019 ended October 2020 and was supplemented with pilot data collected in 2018. The pH was taken with a pH probe at specific sampling sites and transects that have been placed by Dr. Mitchell previously for other experiments. It was found that the Tamarack bog presented as a mosaic bog with features of a fen as well. The pH values ranged from 3.63 to 7.90 and while water level did not have a significant effect, surrounding vegetation, time of year, temperature and location within the bog all did.

II. Introduction

According to the Ohio Environmental Protection Agency (OEPA), Ohio has lost 90% of all wetlands since the 18th century primarily by methods such as ditching or dredging (Ohio EPA, 2016). This practice is still being used, but overall has slowed as research shows the importance of wetlands as environmental buffers. Wetlands effect the environment by regulating water flow, recharging groundwater, and providing flood control for delicate environments (Carter 1996). Wetlands also act as a natural water filter by retaining essential nutrients and removing toxins and pollutants (Miletti et al. 2005). The OEPA (2016) states that wetlands are home to "one-third of all endangered species" which further strengthens how important wetlands are (Ohio, 2016). The restoration of wetlands is an important project that many state governments have begun to protect the ecosystem and help reduce future costs associated with the negative impacts that come with destroying wetlands.

Wetlands can be classified into subcategories based on their hydrology, where fens are defined by their reliance on groundwater and bogs are influenced primarily by precipitation (Vitt et al. 1994). Fens can be further subdivided into a rich and a poor fen where rich fens primarily contain brown-moss, and poor fens are dominated by *Sphagnum* (Jassey et al. 2014). Furthermore, bogs and poor fens have pH that is less than 6 whereas rich fens have pH between 6 and 8 (Sjors and Gunnarsson 2002). The Tamarack bog is one of the few wetlands left in Ohio and is a subcategory of the bog wetland type which are freshwater wetlands that received more rainfall than is lost via evapotranspiration (Miletti et al. 2005). Despite its name, the Tamarack Bog behaves more like a fen it has been reported water enters the bog via the groundwater throughout the bog which is a defining characteristic of a fen (Vitt et al. 1994; Hartman & Mitchell 2016). The Tamarack bog has also been reported to have a pH pH ranging from 5.94 to 7.41 which was much greater than that of a typical bog and is more closely related to the pH of a rich fen (Miletti et al. 2005)

In 2013 researchers were granted permission to begin the restoration of the Tamarack bog which was ditched between 1963 and 1969 (Hartman & Mitchell 2016). The ditching 50 years ago altered the hydrology of the Tamarack bog and allowed many upland invasive species such

as (*Rhamnus frangula*) and multiflora rose (*Rosa multiflora*) to establish themselves in territory that was previously home to rare plant species such as pitcher plants (*Sarracenia purpurea*), leather leaf (*Chamaedaphne calyculata*) and the tamarack tree (*Larix laricina*) (Miletti et al. 2005). The abundance of *Sphagnum* moss in the Tamarack bog has previously led to acidic conditions that the rare deciduous conifer known as the tamarack tree (*Larix laricina*) were able to tolerate and thrive on before the ditching process began (Miletti et al. 2005). The Tamarack bog is categorized as a poor fen, but little is known about the variation in its pH.

The main factors that have been found to affect the soil pH in a wetland are the time of year, location in the area and the surrounding vegetation of the sampling location (Miletti et al. 2005; Zoltan 2008; Schot and Pieber 2011). Few studies examine how spatial and temporal variation in pH in a wetland, but one study by Schot and Pieber (2011) discusses both factors. Schot and Pieber (2011) found that within the wetland there were zones comprised of significantly different chemical concentrations such as calcium, sodium, potassium, iron, and the pH level within the soil. They also found that the temporal variation of the pH and other chemical concentrations were statistically significant and might relate to plant growth and bacterial processes that are temperature dependent (Schot and Pieber 2011). Schot and Pieber (2011) discussed that the pH was most likely affected by the quality of groundwater in the wetland they examined and how more polluted surface water might lead to different concentrations of pH and how the pH concentrations might exert a negative effect on the native species living in the bog. This paper assesses the vegetation, spatial and temporal patterns in the Tamarack Bog in the Bath Nature Preserve.

III. **Objectives**

The objectives of this study were to identify three key questions. 1) Does the pH of the bog change with time and if so, what are the patterns? 2) Is there a difference in pH based on the location of the sampling point within the bog? 3) Does pH differ among vegetation types?

IV. **Methodology**

a. *Location*

The area of interest was the Tamarack bog in the Bath Nature Preserve in Bath Township Ohio. In order to evaluate the pH of the Tamarack bog 56 locations in the 8.9-acre wetland were monitored monthly (Figure 1). Sampling points were placed by Dr. Mitchell in 2013 and were marked by a PVC pipe stuck into the ground with a tag marker on top. The PVC pipe was used because other materials might have altered the pH.

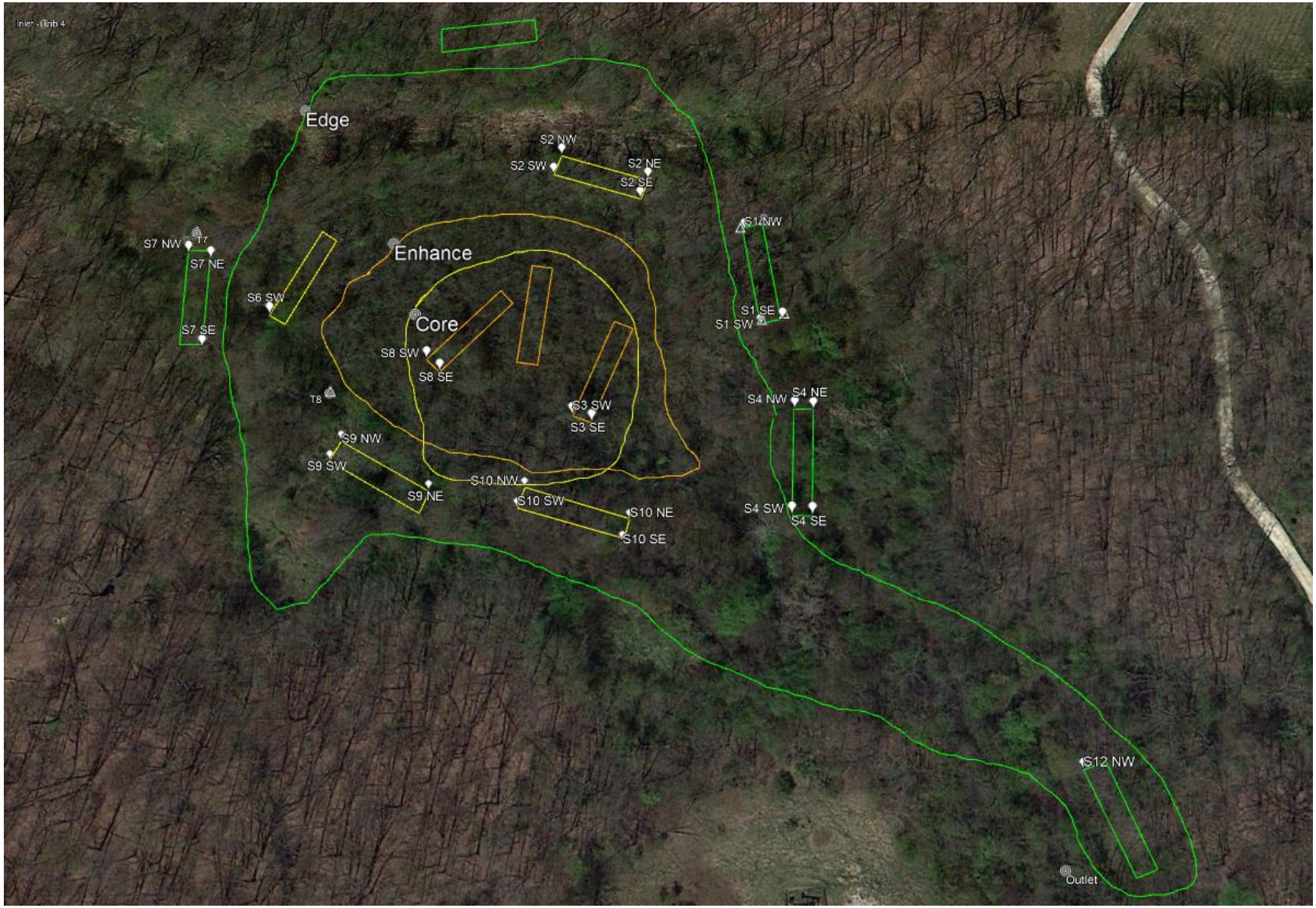

Figure 1. Location of the study points. Marked are the 26 testing locations, boundaries of the vegetation areas, as well as the water flow inlet and outlet of the Tamarack Bog.

b. *Data Collection*

Data collection occurred between July 2019 and October 2020. The data was recorded monthly, depending on weather conditions, at as many of the 56 sampling points as possible. Previous data was used for the months of May, December and October 2018, from other students working on a similar project. Due to safety concerns and vegetation density not all 56 sampling points could be evaluated every month. For final analysis, the 27 plots that had data from every month but one were used.

The pH, temperature and water level data were collected at each sampling point with a Hanna Instruments HI99121 Soil pH meter which was calibrated in a 10 pH solution. Tap water was used to keep the pH probe moist during data collection. The pH of the soil was taken within one meter of the sampling point of interest, and as close to the post as possible. The pH probe was inserted into the soil at a depth of one inch. If the soil was too dry a stick was used to poke a sufficient hole in the ground for the probe. If the soil was too dry for the stick, a sample was not taken at that location to keep the pH probe from breaking. The pH of standing water at each point was also taken on the occasions that the sampling point had water covering the area.

c. *Analysis*

To analyze the data the three questions were looked at separately. To identify patterns in vegetation type, the previously labeled vegetation areas were used to separate the data (Hartman and Mitchell 2013). Core, Edge, and Enhance describe the vegetation type. The Core refers to an area with alder swamp vegetation. Edge refers to an area with high quality wetland habitat that is adjacent to the Core and at the Edge of the wetland. The Enhancement area refers to marginal wetland habitat that has been dried out by ditching. Within the 27 sample points the area was distributed by 14 Edge, 12 Enhanced and two Core.

For each question of interest, the program JMP Pro 15 was used to run an ANOVA to compare the means of the different testing parameters.

V. **Results**

Over a two-year span, I measured the pH in the wetland 13 times at roughly bimonthly intervals, for a total for a total of 344 soil pH measurements at 27 different sampling points. Of all measurements, the values ranged from 3.63-7.90, had a mean of 5.78, and a standard deviation of 0.73. The temperature in Celsius was taken when possible, for a total of 315 measurements with a range of 25.6 C to 1.9 C, a mean of 15.25 C and a standard deviation of 7.37 C. The Tamarack bog presents characteristics of both a fen and a bog consistently at different locations as well as temporal patterns presenting a lower or higher mean pH at different times of the year.

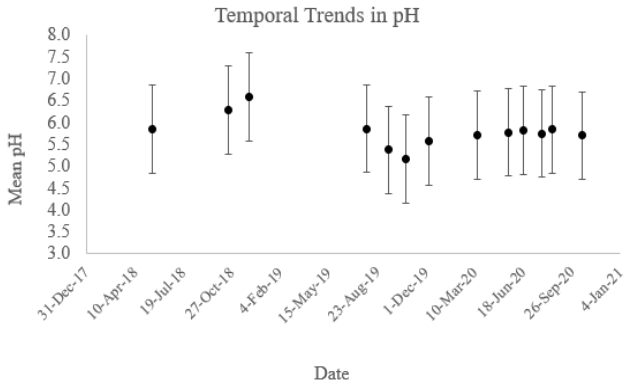

Figure 2. The temporal trends of the mean pH per month for the 27 sampling points from May 2018 to October 2020. Error bars represent standard deviation which ranged between 0.47 and 0.95.

a. Temporal Variation

The pH variation with each date of the testing period is detailed in Figure 2 and depicts some temporal variation between 2018 to 2020 with individual sampling points values ranging from 3.63 to 7.90 (Figure 2). The results of the ANOVA conclude that the pH did vary significantly among sampling dates (p-value<.0001) which was not likely attributed to chance (df=12, 331, F=6.9, P<0.0001).

b. Spatial Variation

Figure 3 shows that the locations in the Edge area have higher pH, whereas the Enhanced area has lower pH values. The standard deviations of each sampling point ranged between 0.2 and 0.65 and the means ranged between S7NE at 6.45 and S3SE at 4.59. The bottom half of the data consisted of primarily S1 and S4 locations (Enhancement area) which are in the same area of the bog and had the most acidic pH. The results of the ANOVA indicate that the location within the bog had a significant effect in the means of the sampling points (df=26, 317, F=21.0, P<.0001).

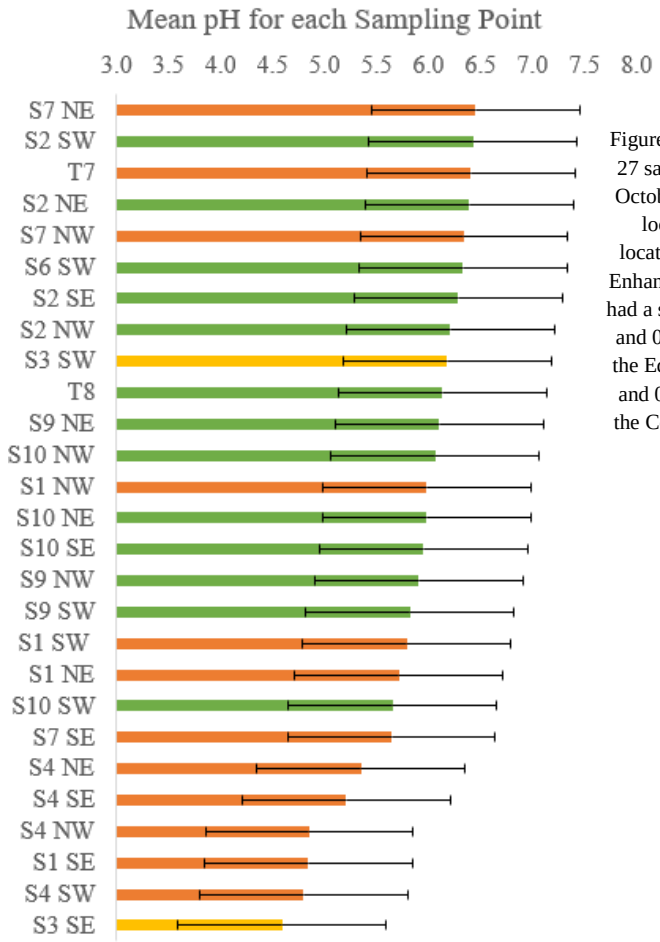

Figure 3. The mean pH of each of the 27 sample points from May 2018 to October 2020. Yellow bars are Core locations, green bars are Edge locations and orange bars represent Enhance locations. Enhance locations had a standard deviation between 0.24 and 0.53. The standard deviation of the Edge locations was between 0.31 and 0.71. The standard deviation of the Core locations was between 0.45 and 0.65.

c. pH variation among vegetation type

Figure 4 shows the temporal variation of each vegetation type which consistently shows that Edge has a higher pH value than the Core and Enhance. The Core tends to have lower pH values than both Enhance and Edge vegetation types. From Table 1, the descriptive statistics of the Core are lower for each category but the SD. The Edge tended to have higher pH values with a smaller SD between them (Table 1). These differences were found to be statistically significant (df=2, F=29.8, P<0.0001).

	Enhance	Edge	Core
Mean	5.6	6.1	5.4
Maximum	7.5	7.9	7.2
Minimum	4.0	5.0	3.6
Range	3.5	2.9	3.5
SD	0.8	0.5	1.0

Table 1: The mean, maximum, minimum, range and SD values for the Core, Edge. Enhance locations.

A heat map was generated in ARCGIS by graduate student Stuart Davis of the means of all 56 sampling points collected each month over the testing period. Some sampling points had data for all dates of collection while others, such as S3 NE and NW had only one date of collection. Figure 6 shows that the more basic sampling points are found in the Core and the more acidic sampling points are found on the surrounding Edge locations (Figure 6). The pattern shows that it gets progressively more basic going in towards the center of the wetland.

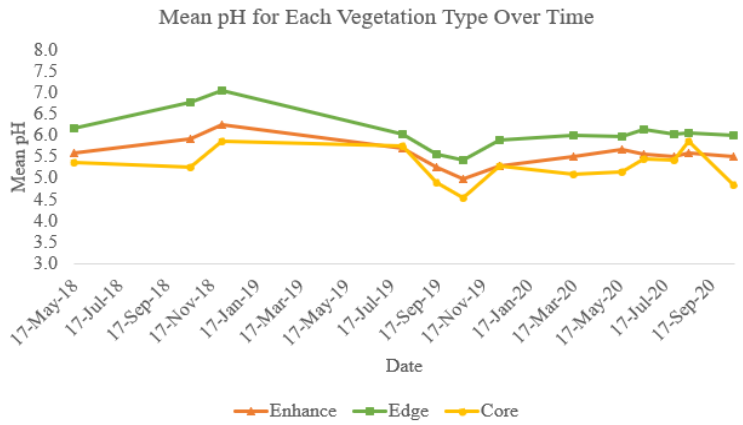

Figure 4: The mean temporal pH separated by vegetation type. Yellow represents Core locations which had a mean of 5.29 and a SD of 1.02. Green represents Edge locations which had a mean of 6.06 and a SD of 0.51. Orange represents Enhance locations which had a mean of 5.55 and a SD of 0.76.

d. Temperature

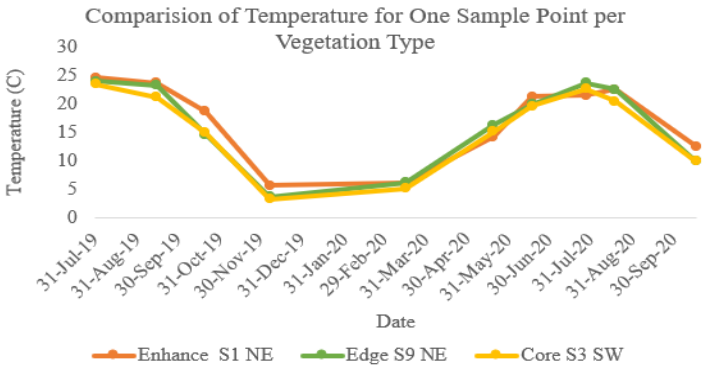

Figure 5: A comparison of the temperature data taken over the period of May 2018 to October 2020. Yellow represents core with the sampling point of S3 SW. Green represents edge and the sampling point S9 NE. Orange represents enhance and the sampling point S1 NE.

The temperature of the soil was measured while the pH data was taken. The mean temperature was 15.29 C with a minimum of 1.9 C and a maximum of 25.6 C. The temperature of the soil varied significantly among sites accounting for the date of the data (df=12, 302, F=16.4, prob>F=0.0001). Figure 7 represents the temperature data for each date which shows some dates having little variation and others having high variation.

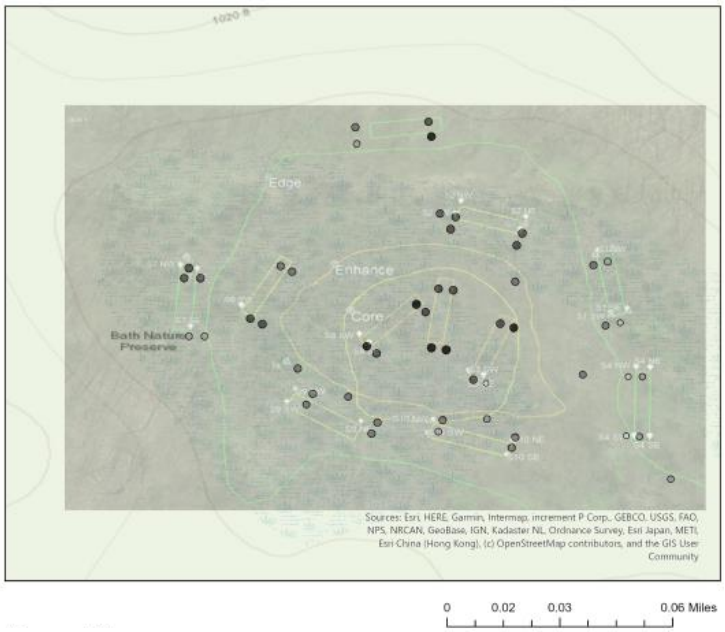

Figure 6: A heat map generated by Stuart Davis of all the data collected during May 2018-October 2020. Includes all 56 sampling points within the bog. Darker spots indicate higher pH and lighter spots represent lower pH. The green area represents edge area. The orange represents enhance area. The yellow represents core area.

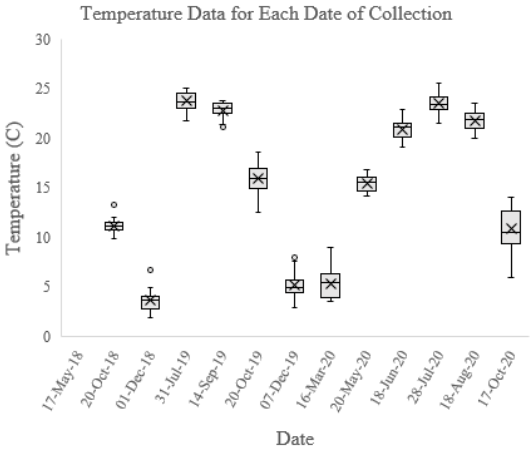

Figure 7: Temperature data taken in Celsius for all 56 sampling points between May 2018 to October 2020.

e. Water Level

The water level at the outlet of the Tamarack bog from May 2018-October 2020 ranged from 0mm to 762mm above the baseline, with a mean of 150mm and a SD of 250mm (Figure 8). There was no significant relationship between water level and pH during the testing period (df=1, F=2.0, prob>F= 0.1536).

Figure 9 compares the water pH and the soil pH of all 27 sampling sites for the sampling date of May 2020. The soil pH was found to have a mean of 5.77 with an SD of 0.57 and the wet pH was found to have a mean of 6.53 with an SD of 0.24. The lowest recorded wet pH was 5.62 and the highest was 6.85. The soil pH was found to have a minimum value of 4.09 and the maximum was 6.55.

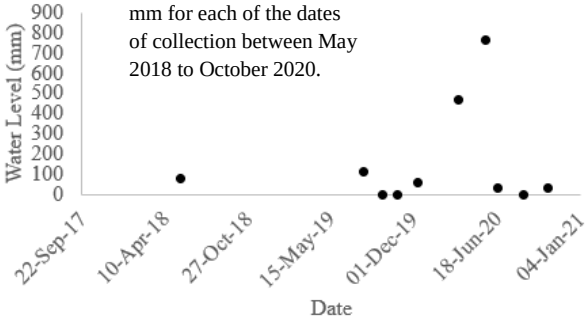

Figure 8: Water level in mm for each of the dates of collection between May 2018 to October 2020.

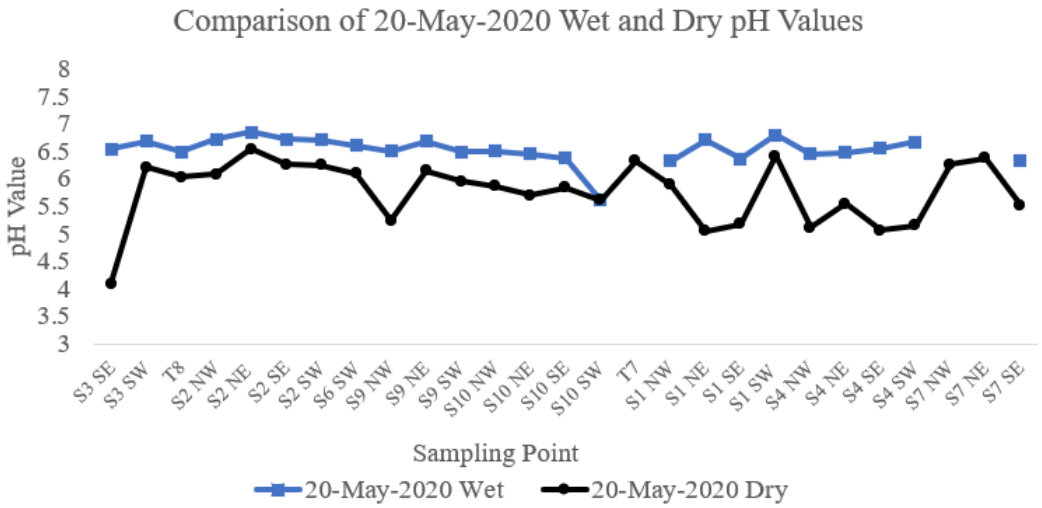

Figure 9: Comparison of water and soil pH values at each of the 27 sampling points for 20-May-2020. The sampling points are organized by area type in the following order: Core (2), Edge (13) and Enhance (12). The mean pH value for the water samples was 6.53 with a SD of 0.24 and the mean for the soil samples was 5.77 with a SD of 0.57.

VI. **Discussion**

Most peat-based wetlands are primarily characterized by being either a bog or fen, however, based on the pH, the Tamarack bog is a mosaic bog with some areas exhibiting classic signs of a fen and others a bog. When looking at all the pH data collected from the 56 sampling points between May 2018 and October 2020, Figure 6 illustrates the heterogenous pH of the Tamarack bog with majority of the less acidic locations in the Core area and the acidic locations primarily found towards the east Edge and Enhanced locations. Focusing primarily on the 27 included sampling points, the same pattern continues (Figure 3). The pH mosaic of the Tamarack bog is reflected in the spatial and temporal vegetation and also patterns were assessed based on the surrounding vegetation and all three variables were statistically significant. Similar patters have been found in other wetlands with a focus on the biotic and abiotic factors such as microbe presence or shading effects (Zoltan 2008). Zoltan (2008) reported, in one mosaic wetland, that the spatial and temporal patterns were related to topography, vegetation and temperature patterns effecting the pH via shading and reduction of radiation and eradiation. Temporal and spatial patterns were found to have significance which could be because of temperature on the surrounding plants allowing them to take up more nutrients during warmer times of the day (Zoltan 2008).

Miletti et al. (2005) analyzed the hydrology of the same Tamarack bog at Bath Nature Preserve in 2005 and, while they took the pH of different points, they found that the range of pH was between 5.94 to 7.41 in 2005 after monitoring three points for seven months. Currently, the Tamarack bog has a pH range of 3.63 to 7.90 which is lower than in 2005. While the maximum has increased by 0.49 the minimum has decreased by 2.31 majority of the area is still acidic. However, since Miletti et al. only had a total of 21 sampling points in different locations, the difference is not very significant, but it is worth noting. Since the Tamarack bog seems to be a mosaic, it can be identified as a poor fen or a bog which can be diagnosed as healthy when the pH is below 5.5 (Vitt et al. 1994). The conditions in the Tamarack bog have improved since 2005, but the pH has increased in some locations and it is important to identify these areas and increase restoration efforts in those locations.

Does the pH of the bog change with time and if so, what are the patterns?

The pH of the bog over the period of May 2018 to October 2020 showed statistically significant seasonal variation. The Tamarack bog showed the most acidic pH around September-October and a cycle of being more alkaline in the time around December to July. This patter follows the period of wet and dry cycles in Ohio with the late summer months and early winter months being the driest and the late winter and early summer being the wettest.

One area of special interest was during May 2020, when the bog was flooded and the pH of the water at each location was taken as well as the pH of the soil. The results indicate that the water pH was almost completely identical across all the sampling points, but that the submerged soil had variation that was comparable to months with no high level surface water (Figure 8). This was surprising as it was suspected that the water flow would have influenced the pH due to waters importance on the definition of a bog or fen. Not only that, but the constant availability of water covering the soil that had a different pH was suspected to have altered the pH. The wet samples had little variation (SD=0.24, Range=1.23) whereas the soil pH had a larger SD and a wider range (SD=0.57, Range=2.46). While in this study the water level had no statistically significant effect on pH, it is still important to understand how flooding and water level might affect the hydrology of a bog or fen.

Does pH vary among sampling points?

The pH was found to vary significantly among location within the Tamarack bog. Overall, all of the sampling point means had a pH below 7, 21 of the sampling points had a mean between 5.50-7 and six sampling points had a mean under 5.49. However, some sampling points were much more acidic than others such as S1SE, S4NW, and S4NW. As can be seen from Figure 6, the locations on the north east side of the bog were found to have lower mean pHs. The two locations from S7 had a mean around 6.5 pH which was higher than the rest. Another cause of this could be that S7 is found on the outskirts of the bog but is closer to the stream that goes through the bog. One cause of this could be the these locations are further away from the stream that goes through the Tamarack bog, and while flooded water was found to not have a significant difference, water flow and the nutrient composition of water has been shown to affect the pH of the surrounding area (Papagiorgio 2019). Water can be comprised of a pollutant such as pool water, sewage water, storm drain water as well as chemicals used to treat grass which can seep into the soil surrounding a stream in a wetland (Papogiorgio 2019). Future studies should examine the hydrology of the stream in the Tamarack bog to determine if it could affect the pH of the soil surrounding it.

Does the pH vary with different surrounding vegetation?

The three vegetation types were examined annually and by location within the testing area. Annually, the Core, Edge and Enhanced all followed similar patterns to the temporal analysis, however, based on figure 4 and the 27 sample points, the Edge was the least acidic and the Core was the most basic. However, the heat map in Figure 8 (contains data from all 56 sampling points and collection dates), and in this illustration the Core is the least acidic. This discrepancy could be due to the Core location only containing two sampling points that were used in the final analysis. .

The analysis of the 27 sampling points only included two Core locations which provides less certainty when generalizing the Core locations and when the Core was excluded, the Enhanced area was the most acidic area. The Enhanced area contains marginal wetland habitats that have been dried out by ditching. It was surprising to learn that the area that contains the most high-quality wetland, Edge, was the least acidic as vegetation found there, such as Sphagnum moss, has been found to correlate with a more acidic pH in other wetlands (Vitt et al. 1994).

Conclusions

The Tamarack bog should no longer be solely characterized as a bog, but its definition should be expanded to include the mosaic. Spatially, the Tamarack bog has patterns where some locations are consistently more acidic than others. The temporal patterns are very similar and there are times of the year where the Tamarack bog has a less acidic pH (the dry season). Monitoring the pH and the hydrology of the stream within the Tamarack bog could help give valuable insight to researchers interested in restoring the Tamarack Bog.

VII. **Work Cited**

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