A Community Comparison of Smith's Fen and Bryant's Bog in Northern Michigan

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Abstract

Human impact is causing peatland ecosystems to undergo negative large-scale changes in habitat. There are many organisms endemic to peatland environments; conservation of wetland ecosystems is crucial if we want to preserve these organisms. Smith's Fen and Bryant's Bog are two peatlands located in northern Michigan. We conducted a community comparison between the two sites, in which we looked at how their biotic and abiotic characteristics differed. We did two transects for vegetation and six for amphibians at each site. We also did dip netting for amphibians and macroinvertebrates, sampled for fishes, took water samples to look at nutrient content, and tested pH. We found that the bog had significantly more vegetation ($p = 0.0001$) and a higher diversity of macroinvertebrates than the fen. The bog was also more acidic than the fen. A majority of the vegetation included in our transects is only found in wetland habitats, causing the need for the preservation of such habitats in order for these organisms to survive.

Introduction

Wetlands are important and diverse ecosystems that vary based on abiotic factors, such as nutrient content and pH, as well as biotic factors, including vegetation biodiversity (Hájek *et al.* 2006). Peatlands are a type of wetland defined by the accumulation of organic peat material. Peatlands are helpful when studying relationships between communities of different organisms because there are many types of biota specific to them. Peatlands are also important to other ecosystems around them because they help supply them with filtered water (Lamentowicz *et al.* 2010). Peatlands serve as valuable water reservoirs, shelter, and feeding ground for many different types of wildlife (Gates 1942).

The two most common types of peatlands are fens and bogs. Fens are groundwater fed (minerotrophic), so the characteristics of their water depend on the water entering from the ground, as well as the underlying bedrock (Schwintzer and Tomberlin 1982). Bogs are rainwater fed (ombrotrophic), so their only source of nutrients and water is from precipitation (Mazerolle 2003). Water source can lead to differences in pH, conductivity, and nutrient availability, causing the biota present to be different between the two. Species of vegetation, amphibians, and macroinvertebrates found at either site will likely have adapted to the different features present (Hájek *et al.* 2006).

Differences in nutrients and vegetation are seen between fens and bogs. Fens tend to be more nutrient-rich and dominated by sedges (Lamentowicz *et al.* 2010), as well as having a more basic pH of >5.5 (Hájek *et al.* 2006). Bogs form when peat has accumulated so much that it creates a mat over a body of water. Since bogs are ombrotrophic, there is a lack of water circulation through them, resulting in slow decay of organic material (Gates 1942). These factors lead bogs to be nutrient poor and *Sphagnum* dominated. The

Sphagnum immobilizes nutrients and acidifies the water (Lamentowicz *et al.* 2010), causing bogs to have a more acidic pH of <5.0 (Hájek *et al.* 2006).

There are also differences in macroinvertebrates and amphibians between fens and bogs as a result of them adapting to different habitat characteristics. Vegetation structure and pH are important factors in determining abundance of these organisms in fens and bogs.

Cheboygan County is located in northern Michigan, USA, and contains most of the property of the University of Michigan Biological Station (UMBS). In 1982, approximately 15% (308 km^2) of the land area of the county was made up of wetlands (Schwintzer and Tomberlin). This number could potentially be decreased today due to the impact of humans (Koning 2005; Chagué-Goff *et al.* 2010). There are many bogs and fens within the UMBS property, and we are comparing two of them; Smith's Fen and Bryant's Bog are two peatlands between which we will be comparing vegetation, macroinvertebrates, presence or absence of amphibians and fish, and the chemistry to see how different they are and what makes them different.

Smith's Fen used to be classified as a bog because of its peat build-up, pH of 4, and separation from groundwater. However, fires in 1914 and 1916 destroyed much of the peat, and the mat became grounded. Vegetation started to bounce back after the fire, but there was a shift toward plants found in more nutrient-rich locations. The area experienced dry years around 1938, causing organic mud to reach the surface, and increasing the pH of the main pool to 7 (Gates 1942). Changes in vegetation and pH allowed Smith's Bog to become Smith's Fen.

Bryant's Bog is a kettle hole formed from a glacial deposit, and as a result it has a depth of 22 meters. It has a false bottom made of organic mud, and a thin floating mat (Gates 1942). It has maintained its bog status over the years because of low pH and by containing vegetation associated with acidic environments.

Since there are species of organisms specific to both locations (Hájek *et al.* 2006; Schwintzer and Tomberlin 1982), it is important to know what makes them different; with increased habitat destruction of wetlands, we need to know where species are endemic in order to prevent them from going extinct.

Materials and Methods

We measured percent coverage of vegetation in the two peatlands by evaluating two 10 meter transects at each site. At the fen, the first transect went from the north side, 10 meters toward the center, and the second transect went from the east side, 10 meters toward the center (**Figure 1**). At the bog, we measured 30 meters in from the road toward the center, making the first transect parallel to the road on the north side. The second transect was perpendicular to the middle of the first transect (**Figure 2**). The bog was smaller than the fen, and had an unstable mat with two pools of water, so we had to adjust how the transects were laid out at each site. Within each transect, we estimated percent cover of each species of plant using a meter squared quadrat every two meters along each transect, resulting in six quadrats per transect. We compared the average Shannon diversity index for the vegetation using a t-test to tell us if there was a significant difference in number and evenness of species between the fen and the bog. The diversity index for each of the 12 quadrats at each site was found; those numbers were averaged, and a t-test was performed to compare the two sites. We also combined the types of vegetation between the sites and divided them based on wetland indicator status to get a better idea of what could be found in certain habitats.

We collected macroinvertebrates from the sediment using dip nets. We took two dip net samples from each site in the same area in the main pool, put them in Whirl-Paks with ethanol, and took them back to the lab to be identified. We calculated the average abundances of macroinvertebrates at each site by averaging the two samples from each site together. We also calculated the Shannon diversity index and species richness for macroinvertebrates at each site by combining the data from both sampling locations.

We used an area constrained sampling method to determine salamander abundance along the perimeter of both the fen and the bog during the late morning. At the fen we used six 30 meter by 2 meter transects with 60 meters in between each transect (**Figure 1**). At the bog, we used six 30 meter by 2 meter transects with 10 meters in between each transect because of the smaller size of the bog (**Figure 2**). In each transect we looked under woody material and rocks for salamander species, recording how many we saw as well as how many items we turned over.

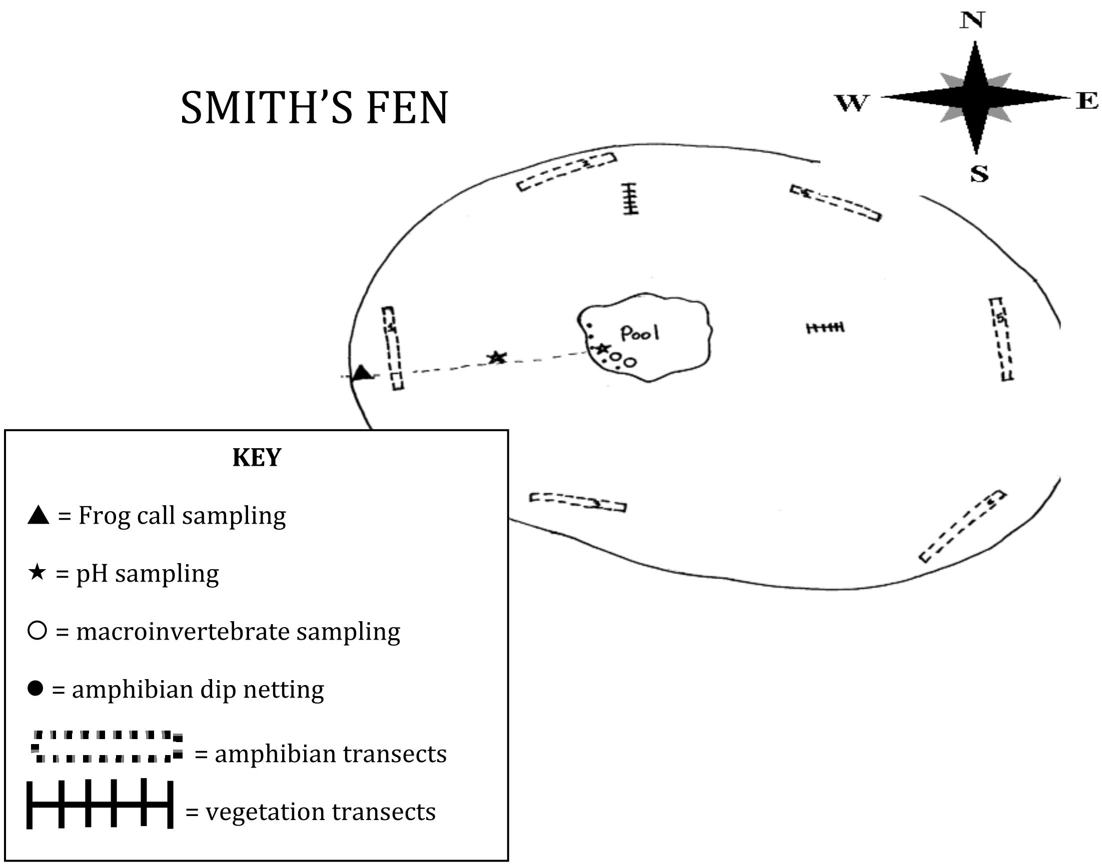

Figure 1: Map of Smith's Fen.

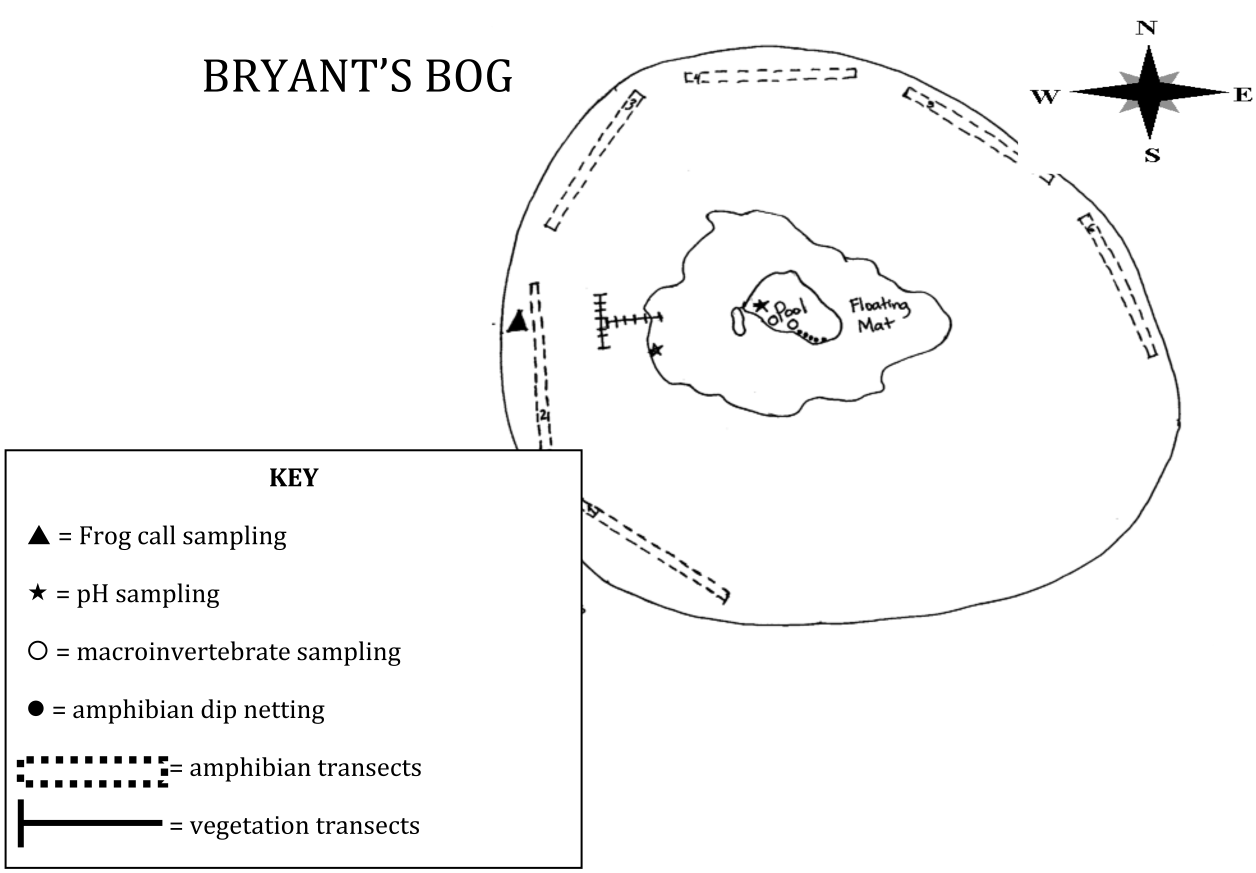

Figure 2: Map of Bryant's Bog.

We also did dip netting for presence or absence of salamanders and tadpoles. Dip netting was done at each site for 10 minutes, by 2-minute intervals at 5 different locations around the main pool, using a 0.5-meter dip net sweep. We compared the average abundance of amphibians found using a t-test to see if there was a significant difference in the abundance of amphibians between the fen and the bog.

Audible frog sampling was done just after dark at the main entrance of both the fen and the bog for 10 minutes at a time for two evenings at each site. Species of frogs heard were tallied in order to identify which were present in the habitats.

Two minnow traps, baited with bread, were set for two days in the main pool of both locations to see if any fish species were present in either area.

We measured the nutrient levels of NO_3-N, NH_4-N, total phosphorus (TP), and PO_4-P, as well as the alkalinity, pH, and conductivity in the fen and the bog. We took a water sample from the main pool using an acid washed 250 mL Nalgene bottle at each site, rinsing it out three times before taking the sample, and had it tested for nutrients at Lake Side Lab. We also took a water sample from the main pool using a 1 L Nalgene bottle at each site and had it tested for alkalinity at Lake Side Lab as well. To measure the pH at the fen, we used a Fisher Scientific accumet portable AP10 pH meter and took one reading each at the main pool and on the pathway. pH at the bog was tested with the same pH meter at the main pool, as well as at the edge of the floating mat. Conductivity was measured using a YSI Incorporated conductivity meter submerged one foot in the main pool at each site.

Results

Vegetation

The fen and the bog differed in types and percentages of vegetation. The fen was dominated by leatherleaf (*Chamaedaphne calyculata*) and three-way sedge (*Dulichium arundinaceum*; **Figure 3**). The bog was dominated by moss (*Sphagnum* spp.) and grass (*Carex* spp.; **Figure 4**).

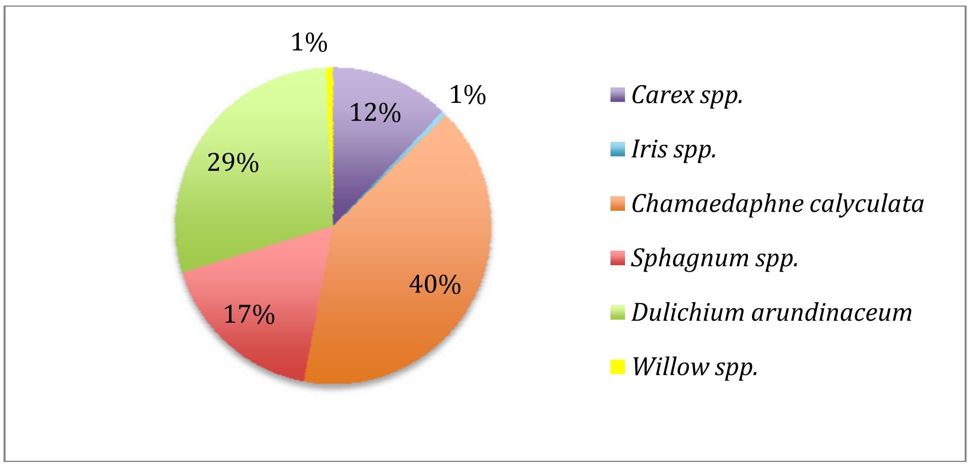

Figure 3: Smith's Fen vegetation is dominated by *Chamaedaphne calyculata* and *Dulichium arundinaceum*. Values indicate average percent cover over all quadrats (n=12).

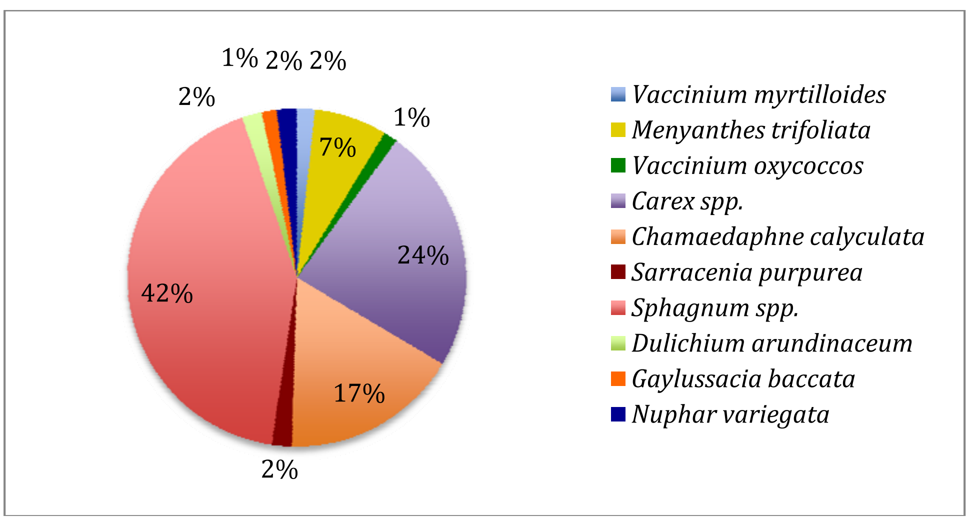

Figure 4: Bryant's Bog vegetation is dominated by *Sphagnum* spp. and *Carex* spp. Values indicate average percent cover over all quadrats (n=12).

The bog had more species evenly distributed than the fen, shown by calculating the average Shannon diversity index for each site (**Figure 5**).

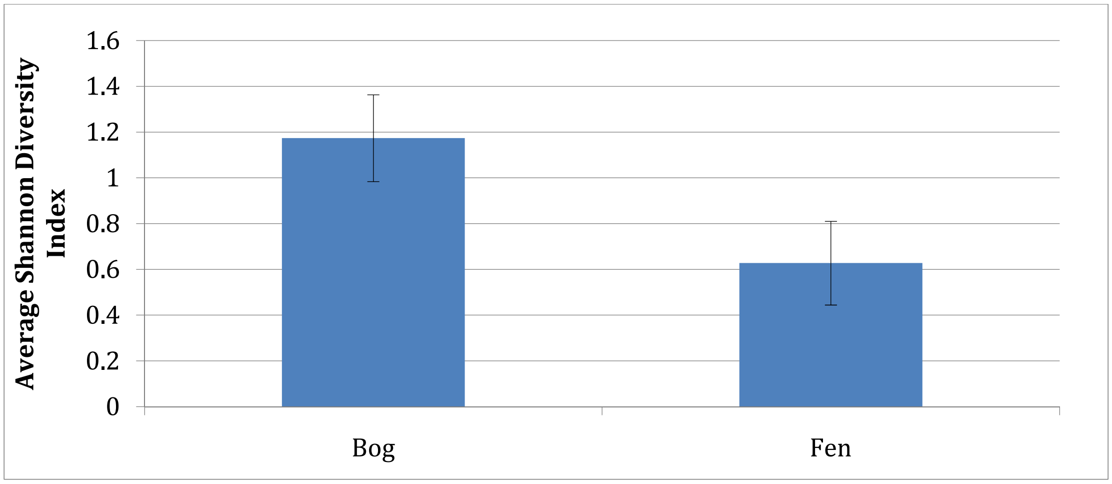

Figure 5: Bryant's Bog had greater species diversity than Smith's Fen. Error bars indicate one standard error.

There is a significant difference in the number and evenness of species of vegetation in the fen and the bog, found by calculating a t-test from the average Shannon diversity index. Using an α of 0.05, degrees of freedom of 22, and a t-statistic of 4.7042 gave us a significant two-tailed p-value of 0.0001.

A majority of plant species found between sites had obligate wetland status (**Figure 6**).

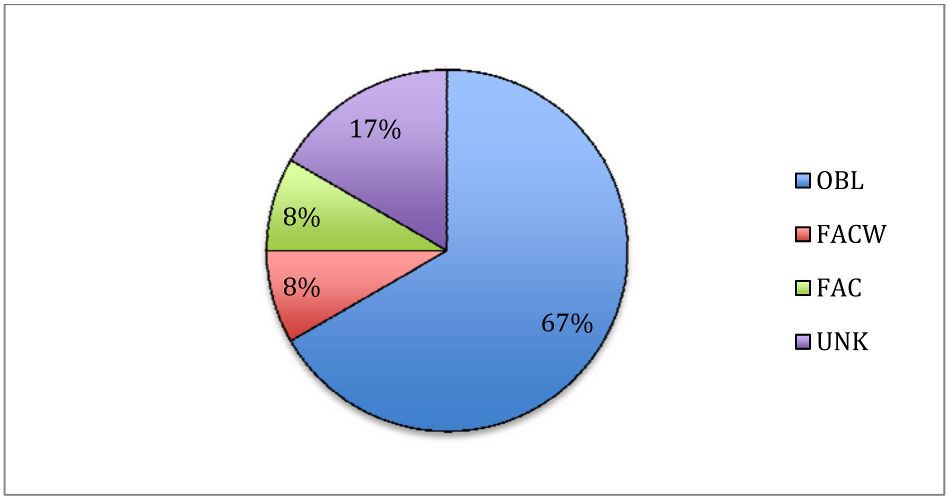

Figure 6: Percentages of which vegetation based on wetland indicator status (OBL=Obligate wetland, FACW=Facultative wetland, usually occurring in wetlands, FAC=Facultative, equally likely to occur within or outside of a wetland, UNK=Insufficient information to determine status; Chadde 2002).

Trees located around the fen include paper birch (*Betula papyrifera),* maple (Acer), red pine (*Pinus resinosa*), white pine (*Pinus strobus*), quaking aspen (*Populus tremuloides*), and northern red oak (*Quercus rubra*; Chadde 2002). Herbaceous plants that were not included in our transects but we observed include marsh cinquefoil (*Comarum palustre*) and St. John's wort (*Hypericum perforatum L.*; Newmaster 1997).

Trees located around the bog include hemlock (*Conium*), tamarack (*Larix laricina*), black spruce (*Picea mariana*), red pine (*Pinus resinosa*), white pine (*Pinus strobus*), and quaking aspen (*Populus tremuloides*; Chadde 2002). Herbaceous plants located around the bog, not included in our transects consisted of wintergreen (*Gaultheria procumbens*), starflower (*Trientalis borealis*), and royal fern (*Osmunda regalis*; Newmaster 1997).

Macroinvertebrates

We calculated the average catch per unit effort (CPUE) for macroinvertebrates at both locations. *Sphaeriidae* was the most abundant organism caught at the fen, with an average of 5 caught per 0.5-meter dip net sweep. *Libellulidae* and *Gyrinidae* were the two most abundant organisms caught at the bog, with 2.5 caught per 0.5-meter dip net sweep (**Figure 7**).

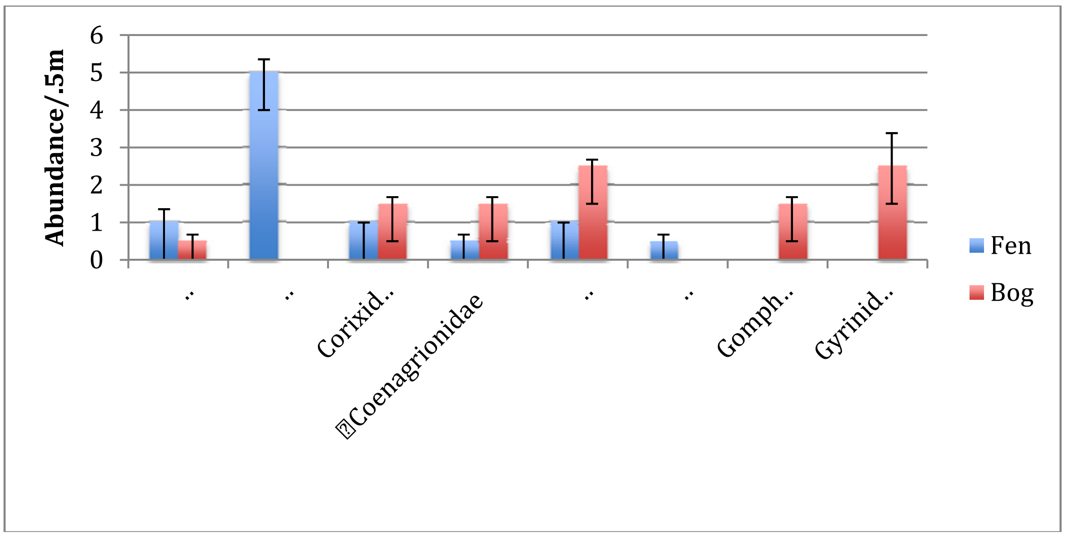

Figure 7: Average CPUE for macroinvertebrates at Smith's Fen and Bryant's Bog. Error bars indicate one standard error.

Smith's Fen and Bryant's Bog had an equal number of macroinvertebrate species present; however, the bog had them more evenly distributed than the fen, shown by calculating the average Shannon diversity index for each site.

Amphibians and Fish

The bog had a higher abundance of amphibians than the fen (**Figure 8**).

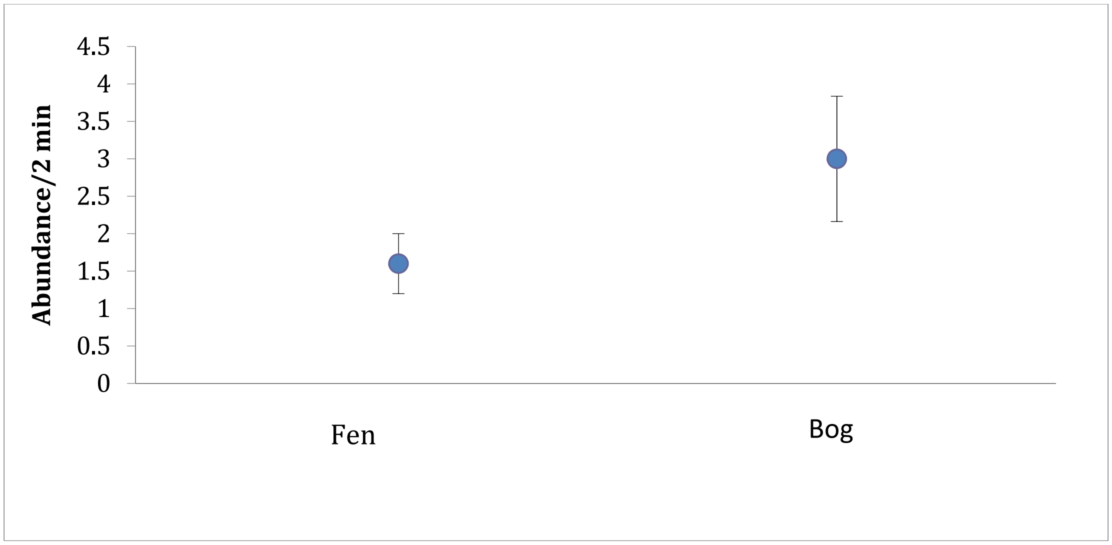

Figure 8: Average CPUE for amphibians per 2 minute dip netting time in the fen and the bog. Error bars indicate one standard error.

Using a t-test with an α of 0.05, degrees of freedom of 8, and a t-statistic of -1.5097, we got a two-tailed p-value of 0.1696, which indicated that there was not a significant difference in the average abundance of amphibians between the fen and the bog.

Thirteen items were turned over at Smith's fen, and forty-two items were turned over at the bog when surveying salamander transects. No salamanders were found in any transects at either site.

We did not hear any frogs on the two nights we went audible frog sampling at the fen, but at the bog, we heard one green frog (*Rana clamitans*) each night for two nights.

No fish were captured in the two minnow traps we set out for two days at each site.

Abiota

Table 3 shows that levels of NO_3-N, TP, and PO_4-P were relatively similar between sites. However, NH_4-N was much higher for the bog. Alkalinity levels were different, mainly because none was detected in Bryant's Bog, and conductivity was similar between the two sites. The pH levels reported in the table are an average of the two measurements taken at eat site.

Nutrient Data		
Nutrient	**Smith's Fen**	**Bryant's Bog**
NO_3-N (ug N/L)	2.2	2.6
NH_4-N (ug N/L)	27.9	46.1
TP (ug P/L)	70.5	65.7
PO_4-P (ug P/L)	3.7	2.4
Alkalinity (mg $CaCO_3$/L)	6.6	*ND
pH (SU)	5.6	4.4
Conductivity (mμ)	33.8	37.1

*ND= None detected

Table 3: Conductivity and most nutrient levels were similar between Smith's Fen and Bryant's Bog, except for NH_4-N being much higher for the bog; alkalinity was not detected in the bog, and pH was more basic for the fen and more acidic for the bog.

Discussion

Smith's Fen and Bryant's Bog have similar and different characteristics, the most significant being the vegetation. The bog had a significantly higher diversity in vegetation type and evenness than the fen. Normally, diversity decreases when going along a fen-bog gradient (Heino 2000). However, we found the opposite. Small changes in water level can have a strong effect on the growth and survival of certain plant species (Schwintzer and Tomberlin 1982), which could lead to an increase in richness and diversity of a species. This region experienced some of the highest precipitation levels it ever has during the month of June 2010 (VandeKoppel personal comm.), which leads us to believe that water level could be a major factor in the differences in species diversity between the fen and the bog. Hájek *et al.* (2006) also talked about how bog plants, specifically of the *Vacciniaceae* and *Shagnaceae* families, need to be adapted to grow in environments that are acidic and extremely low in nutrients. A majority of the plants we found are obligate wetland species, meaning they almost always occur in wetlands as opposed to other environments (Chadde 2002).

Macroinvertebrates differed slightly between locations. Average CPUE for *Sphaeriidae* was the highest for the fen. While sampling fens in Europe with similar pH and vegetation as Smith's Fen, Hájek *et al.* (2006) found Mollusca, suggesting that they are common in fen habitats. No *Sphaeriidae* were found in the bog because of the lack of $CaCO_3$ that they need to make their shells. However, Bryant's Bog had more taxa with higher CPUEs than Smith's Fen. Heino (2000) observed that pH did not seem to play as big of a role in communities of macroinvertebrates as did the size of the lake and the habitat structure. Smith's Fen is bigger, but Bryant's Bog has a more diverse habitat, leading us to assume that that is why it has higher average CPUEs for more taxa. The fen and the bog had the same species richness for macroinvertebrates; however, the bog had a higher diversity, meaning that the species distribution was more even in the bog.

The activity of amphibians depends a lot on the climatic variables, which effect how wet the ground is. Salamanders prefer warmer, wetter areas (Mazerolle 2003), and since we sampled around the perimeter at both sites, the ground might have been too dry for salamanders to be there.

Even though none were found in the transects, we did dip netting for amphibians at the main pool at each site to make sure nothing was missed. We found tadpoles and salamanders while dip netting, with the bog having a higher average CPUE per two minutes of dip netting than the fen. Karns (1992) found that acidic pH in bogs makes it harder for organisms to regulate their sodium and chloride levels because of the more complex water chemistry, but the article also talks about amphibians being differentially tolerant of bog water. This finding leads us to assume that the amphibians we found in the bog have adapted to living in acidic, low nutrient water. Mazerolle (2003) observed that the low pH of bogs had a positive effect of the abundance of amphibians and green frogs, which is why we believe we heard green frogs at the bog and not the fen.

The low pH in bogs causes them to be devoid of fish (Mazerolle *et al.* 2006). Smith's Fen has a higher pH, but there is little water circulation, leading us to assume that fish are not able to survive in that environment.

Many of the differences between Smith's Fen and Bryant's Bog have been linked to differences in abiotic factors between the two. Nutrient levels and pH are two of the main abiotic factors driving these differences. Wetlands are considered nutrient sinks, as well as efficient systems that filter out excess nitrogen (N) and phosphorus (P) in order to reduce eutrophication downstream (Richardson and Marshall 1986). PO_4-P and TP levels were slightly higher for the fen, but NO_3-N and conductivity were slightly higher and NH_4-N was a lot higher in the bog. Hájek *et al.* (2002) noted that many *Sphagnum* sites with an approximate pH of 5 have good conditions for ammonifying bacteria. The acidity of the water caused the bog to have no detectible alkalinity.

At Smith's Fen, we took the pH in the main pool (6.09) and along the path on the way out of the fen (5.11) to get an idea of how the pH changed moving away from the pool. The main pool is the area connected to groundwater, causing it to be more basic. However, as you move away from the main pool, the water we sampled was more likely to be from rain, causing it to be more acidic. At Bryant's bog, we took the pH in the main pool as well (4.16) and at the edge of the floating mat (4.57). We expected the main pool to be more acidic because it is rainwater fed (Lamentowicz *et al.* 2010), and active decomposition of the exposed peat releases acid into the system (Chagué-Goff *et al.* 2010). However, this peat is being broken down and harvested because of increased human activity (Gates 1942; Hájek *et al.* 2002; Koning 2005; Chagué-Goff *et al.* 2010).

As human populations expand, wetlands and peatlands suffer more and more due to drainage for increased agriculture and urbanization, changes in climate that affect precipitation, and trampling of vegetation when people visit them (Koning 2005). Peatlands are important ecosystems in themselves because they act as filters, nutrient sinks, and havens for many organisms; but they are also important for surrounding ecosystems because they help reduce the eutrophication of aquatic ecosystems located downstream from them (Richardson and Marshall1986). There are many plant species that are endemic to wetlands. With increases in the destruction of the of wetland habitats, we are likely to see decreases in obligate wetland species, leading to the loss of many types of vegetation. We need to preserve these habitats if we do not want to lose the species they contain.

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