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Biodiversity of Insect Populations in the Springfield Bog Metropark in Summit County, Ohio: A Secondary Succession Site

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BIODIVERSITY OF INSECT POPULATIONS IN THE SPRINGFIELD BOG METROPARK IN SUMMIT COUNTY,OHIO

A secondary succession site

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Abstract:

An initiative has been taken up by many environmental agencies for the conservation and restoration of endangered wetland habitats. These unique ecosystems are being depleted of resources and acreage due to industrialization and extensive anthropogenic activities. Bogs are a unique subgroup that are diminishing worldwide. The Springfield Metropark Bog is a newly established conservation area in Summit County Ohio, in the United States. Insect populations were recorded over four seasons, starting in March 2015 and concluding in February 2016. Samples were taken from 3 different sites within the conserved habitat including field site, forested area, and a manufactured pond. Using a two-way ANOVA test to examine the dependent variables (families and individuals) in R statistical program, it was found that the significant difference in biodiversity of the habitats was between the pond and field. It appeared that seasonal changes had a greater effect on the growth and biodiversity than simply ecological succession over a time period. The overall analysis of families present and increases in their populations shows a trend in increasing biodiversity with many families important as bioindicators being observed in the study.

Introduction:

Bogs are ecological systems that are home to many insect species whose survival is dependent on their unique chemical and biological makeup for either a single life stage or their entire lifecycles. Bogs, also referred to as peatlands, are boreal systems meaning they have subarctic climates with latitudinal locations focused in the Northern Hemisphere (Johnson, 1943). The climatic conditions have effects on the characteristics of the chemical properties of the terrestrial and aquatic substrates as well as the rudimentary physical properties of the systems. Organisms living within the bog must be able to tolerate low pH levels contributed to by several different factors (Lyons, 1989). The rain in these areas can be slightly acidic for starters. This can be caused by lightening separating nitrogen oxides molecules which form solutions of nitric acids when combined with oxygen atoms (Koltuniewicz, 2014). More influential than the climatic features of the area is the geographical layout of the bog. There are numerous types of bogs, but the specific bog chosen for the survey was the Springfield Metropark Bog in Akron, Ohio. This park was established as the first “Watch Us Grow” project on January 5th, 2011 (Springfield Bog, 2015). Young’s Bog was established in glacial depressions along the Continental Divide. This bog is ombotrophic. The stagnant water located here is a carbon sink due to the cool seasonal temperatures and saturated soils decreasing the rate of decay. The carbon dioxide release from the decaying vegetation reacts with the water molecules forming carbonic acid (Welsch, n.d.). This acid decreases pH levels in the surrounding waters when hydrogen atoms are donated to the aqueous habitat (Klein, 2012). Another contributing factor to the pH levels are the sulfate-reducing bacteria found in wetland habitats (Kirchman, 2012). Surrounding Young’s bog is a large prairie that is host to a wide arrangement of prairie species that travel to and from the bog in search of food, shelter, and mates. The prairie undergoes yearly field burnings to support its growth. These burnings allow airborne particulates to be released into the bog during rain as well. Early land surveys in Ohio show the relationship between bogs and prairies along the continental divide (Springfield Bog, 2015).

The Metropark Bog is a recently created conservation and restoration area to rehabilitate the habitat and study the natural ecological succession of these ecosystems (Springfield Bog, 2015). Many insect species are primary and secondary pioneering species and offer valuable data for habitat evaluation. By surveying the species present in the prairie throughout the year, information can be collected on the health and biodiversity of the terrestrial and aquatic locations within the park. Insects are the link in the food chain between macroorganisms and microorganisms in every habitat. Many species are highly specialized in their ecological niche, and food webs would fall apart without their presence (Speight, 2009).

Methods:

Due to conservation efforts, surveying of the actual bog was not permissible. Data collection began in March 2015 and continued through February 2016. Observations were recorded once a month approximately 3-4 weeks apart depending on predicted weather conditions. Days chosen were chosen for selection of low precipitation amounts to prevent bias from inclement weather conditions. These monthly recordings allowed for repetitive collecting, resulting in three samplings per season, to give a better overall estimate. Climatic changes in Northeast Ohio can be drastic within a short time period, so instead of using climate indicators such as temperature or precipitation, the lunar cycle was used to determine the seasons. Table A below displays the given dates provided by the National Weather Service provided by The United States Naval Observatory (Earth's Seasons: Equinoxes, Solstices, Perihelion and Aphelion, 2015). Observations on the weather conditions and temperatures were recorded according to the National Weather Service for analysis of the data and to be used to explain any outliers in the sampling trends (National Weather Service Forecast Office, 2014). Collections dates were generally on the last Saturday of each month, with few exceptions due to restricting weather which could alter sample findings.

Table A: 2015 Equinoxes and Solstices

Event	Date
Spring Equinox	March 20th 2015
Summer Solstice	June 21st 2015
Fall Equinox	September 22nd 2015
Winter Solstice	December 21st 2015

Sampling locations were chosen for optimal diversity within the park. The sampling locations were chosen along the park trail that runs 2.8 km through the conservation area. The sites were located close to the trail to achieve similar exposures to anthropogenic disturbances. Only insects within the adult life stage were recorded. Location A was an open field. Techniques used for sampling were composed of 5-2’x2’ squares where manual observation was used for surveying and 2- 5'x5' flight interception traps (FIT) were installed the night before sampling. The manual surveying allowed for the sampling of the grasses and ground level insects while the FIT allowed sampling to be done for insects that were more apt to flight, as well as sampling of nocturnal species. The preservative used in the FIT was slightly diluted 70% alcohol with a mixture of dentatonium benzoate to deter other animals from getting into the traps. Location B was a small, slightly forested area located about 0.4km south of the park entrance. To collect forest species, a pitfall trap was used at the base of the tree to catch ground species. The container used was a 2 liter pop bottle with top cut off and a cover placed over it to cut back on leaf litter and other debris. The pitfall was installed each night before sampling to catch nocturnal species as well. To catch organisms living closer to the canopy, a 4'x5' beat sheet was used and the end of an entomology net to knock insects out of the overhanging branches. Data was also collected by plotting out a 1'x1' square on tree trunk. Location C is a newly created pond where data was collected in the riparian zone measuring out 30cm from shoreline to dry land, and traveling to approximately 60cm towards the center of the pond. Kick seining was use to cultivate insects living in the shallow water and in the soil sediments. Data was also recorded from insects resting on the water's surface as well as on aquatic and semi-aquatic foliage up to four inches above the pond surface.

Identification was established by using Kaufman's Field Guide to Insects of North America in the field (Kaufmann, 2007). Insects that could not be identified by the naked eye were collected and identified using Borror and Delong's Introduction to the Study of Insects, 7th Edition combined with microscopy when necessary (Triplehorn, 2005). Insects were identified down to family level to establish a better collage of occupied niches and diversity than order classification, but without the redundancy of such parameters which would come from genus identification.

Once data was collected, it was run through 2 separate two-way ANOVA (analysis of variance) test for each dependent variable. Assumptions were tested using the Shapiro-Wilkes test and diagnostic plots. An α value of p=0.05 was used for significance. Multiple comparison tests were performed on all variables that exhibited significant effects on the insect families found using the Tukey HSD test. All tests were performed using R and R Studio statistical programs version 3.2.2 and 00.99.489 respectfully.

RESULTS:

Sampling Results:

There were 85 total different families found within the survey, and 1663 total individuals. Listed in Table B is a breakdown of how many families and individuals were found according to season and site.

TABLE B

Springfield Metropark Bog Survey Data			
Site	Season	Families	Individuals
Field	Spring	47	315
Wooded	Spring	28	156
Pond	Spring	17	150
Field	Summer	42	436
Wooded	Summer	27	133
Pond	Summer	18	152
Field	Fall	12	90
Wooded	Fall	14	72
Pond	Fall	4	18
Field	Winter	13	60
Wooded	Winter	11	57
Pond	Winter	2	24

Recorded Temperature and Precipitation for Collection Dates

Table C shows the recorded dates and the correlating temperature and precipitation amounts for those dates.

TABLE C

Date	Temperature High in °C for day	Temperature Low in °C for day	Total precipitation for day in cm
March 19th 2015	8.33	0.00	0.1778
April 28th 2015	11.11	5.00	0.0000
May 26th 2015	30	21.11	0.2286
June 18th 2015	22.78	17.78	0.2032
July 14th 2015	27.22	21.11	0.0508
August 27th 2015	23.89	15	0.0000
September 16th 2015	25	15.56	0.0000
October 31st 2015	12.78	7.78	0.1270
November 28th 2015	7.22	3.33	0.0762
December 20th 2015	8.33	1.67	0.4826
January 31st 2016	16.11	8.89	0.0000
February 28th 2016	9.44	0.55	0.2286

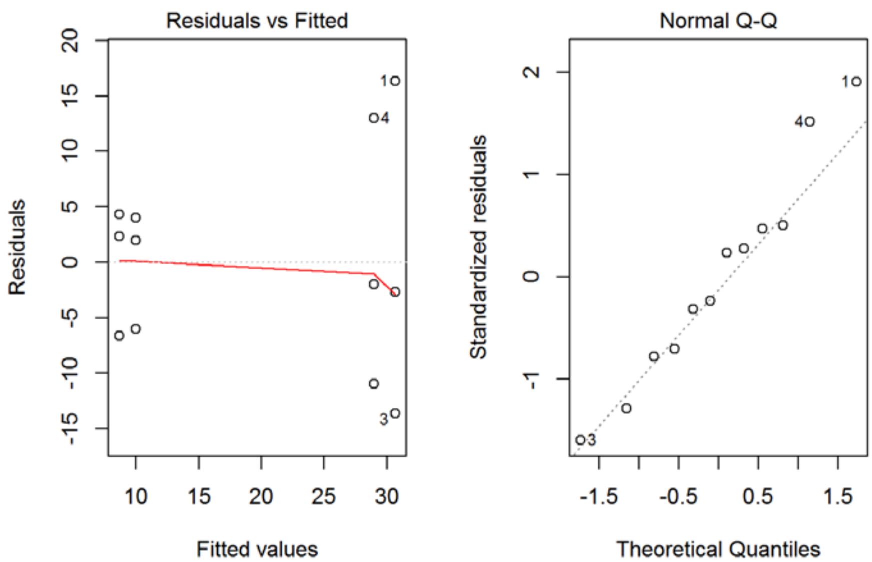
Statistical Analysis

***Tests for the Assumptions of ANOVA*:**

It was assumed for each of the assumption tests below that the observations recorded throughout this experiment are independent of one another.

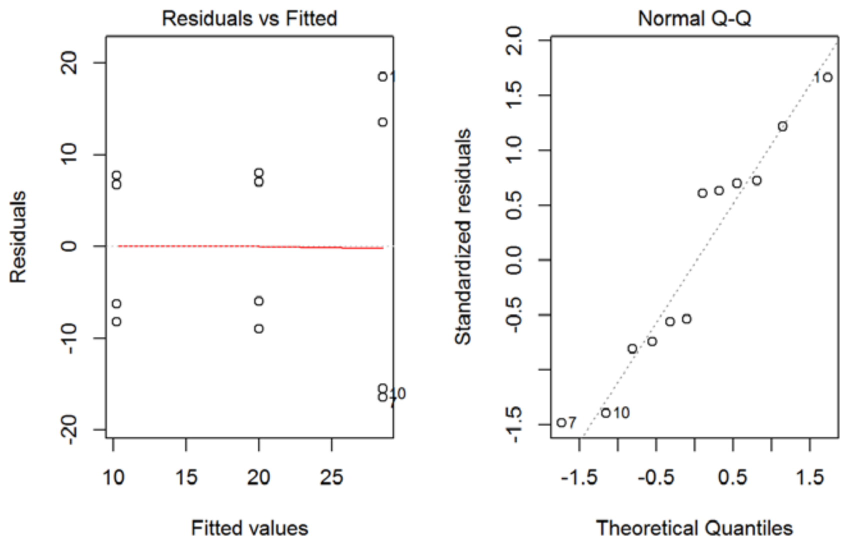
The α value set for these tests was placed at p= 0.05. The Shapiro-Wilks test for normality test was performed on both of the dependent variables, number of insect families present, and number of individuals present within the sampling locations. The null hypotheses variables season and site failed to be rejected, given a p value of 0.8744, and 0.2164, respectively for the season, and 0.3067 and 0.8746, respectively for the sites.

FIGURE1 Shapiro-Wilk Normality Plot for Family (Seasonal) Values



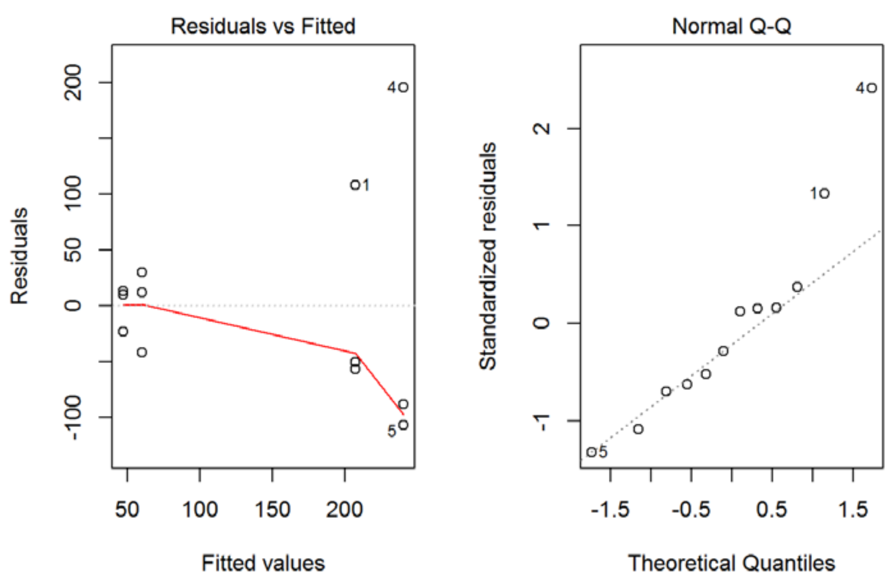
Diagnostic plots used to test the assumptions of ANOVA for the number of individuals of invertebrates present at the Springfield Bog Metro Park. The graph on the left shows the residual plot which tests for equal variance. As the red line does not follow closely to the dotted line, the residuals do not meet the assumption of equal variance. The graph on the right shows the NPP (normal probability plot) which tests for normal distribution. As the residuals/theoretical quantiles follows closely to the dotted 1:1 line, the residuals meet the assumption of normal distribution although there is some variations at the extremes.

FIGURE 2 Shapiro-Wilk Normality Plot of Family (Site) Values



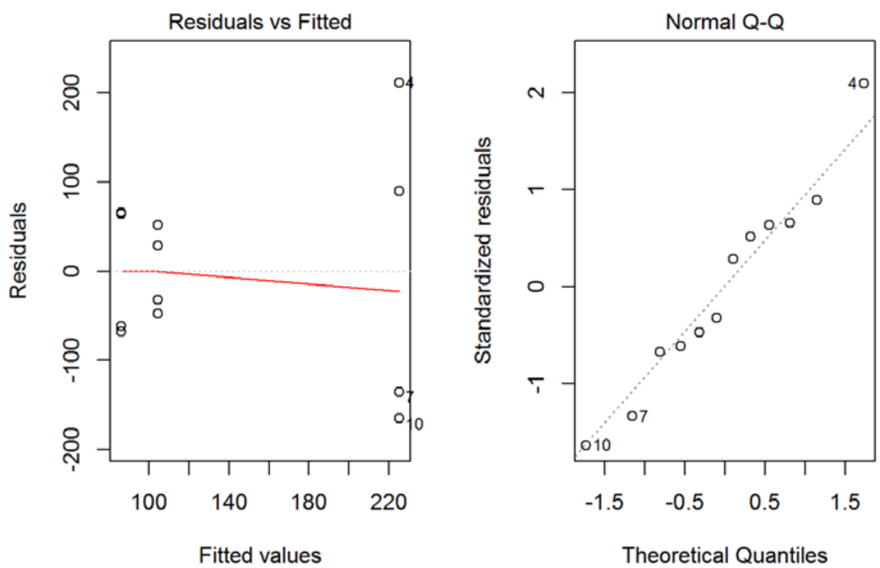
Diagnostic plots used to test the assumptions of ANOVA for the number of orders of invertebrates present at the Springfield Bog Metro Park. The graph on the left shows the residual plot which tests for equal variance. As the red line follows closely to the dotted line, the residuals meet the assumption of equal variance. The graph on the right shows the NPP (normal probability plot) which tests for normal distribution. As the residuals/theoretical quantiles follows closely to the dotted 1:1 line, the residuals meet the assumption of normal distribution.

FIGURE 3 Shapiro-Wilk Normality Plot for Individual (Season) Values



Diagnostic plots used to test the assumptions of ANOVA for the number of individuals of insects present per season. The graph on the left shows the residual plot which tests for equal variance. As the red line does not follow closely to the dotted line, the residuals do not meet the assumption of normal equal variance. The graph on the right shows the NPP, testing for normal distribution. The assumption of normal residuals/theoretical quantiles is not met because the graph skews left of the 1:1 line.

FIGURE 4 Shapiro-Wilk Normality Plot Individual (Site) Values



Diagnostic plots used to test the assumptions of ANOVA for the number of individuals of insects present per site. The graph on the left shows the residual plot which tests for equal variance. Again, the residuals do not meet the assumption of equal variance. In the NPP graph, testing for normal distribution, the assumption of normal residuals/theoretical quantiles is feasible, however there is oscillation of the data points across the 1:1 line with a single data plot skewing left at the farthest point.

To correct these abnormalities in the data sets, both dependent variables were transformed using log equations for each independent variable, producing Figures 5,6,7, and 8.. The results all failed to prove the null hypotheses having α values of $p=0.154$ for the families present and $p=0.5704$ for the individuals present within the Season, and $p=0.2328$ for the families present and $p=0.1154$ for the individuals present within the Site independent variable. Assumptions for equal variance could be seen as the data plots more closing follow the horizontal dotted line in the Residuals vs. Fitted graphs in all four figures as well as a closer correlation of the data points within the NPP graphs.

FIGURE 5 Log Transformation of Shapiro-Wilk Normality Plot Family (Season) Values

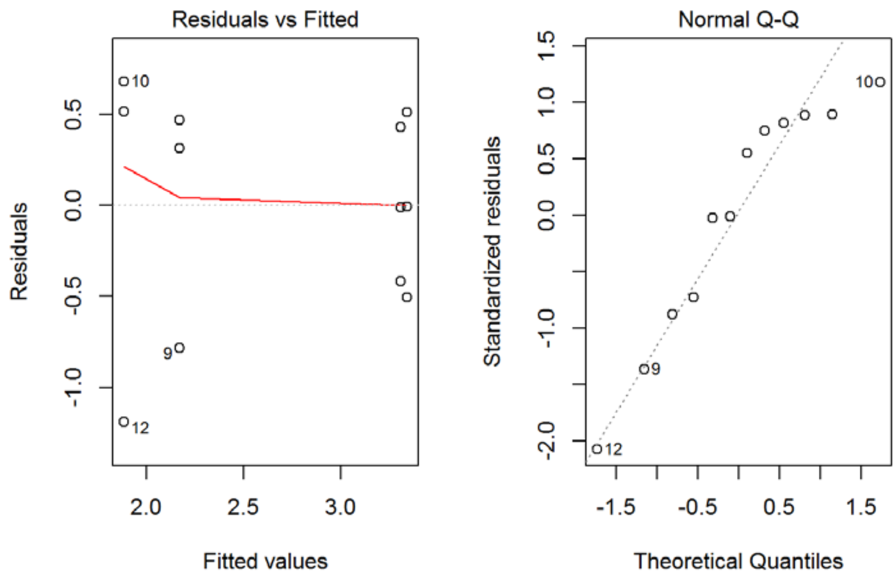


FIGURE 6 Log Transformation of Shapiro-Wilk Normality Plot Family (Site) Values

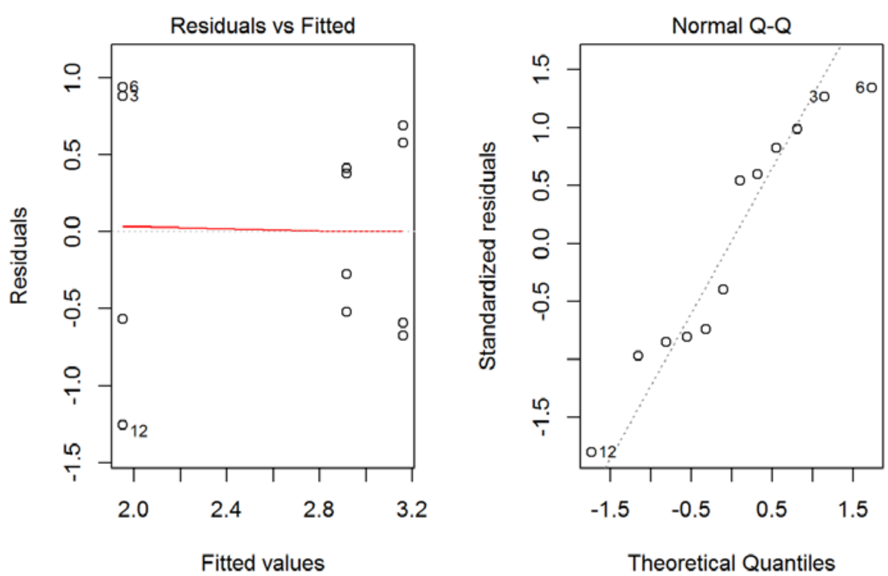


FIGURE 7 Log Transformation of Shapiro-Wilk Normality Plot Individual (Season) Values

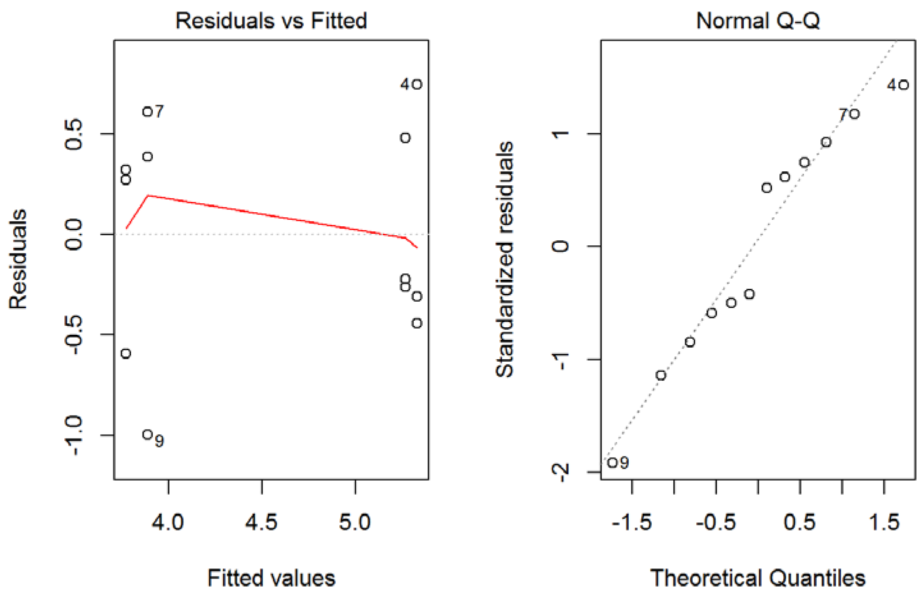
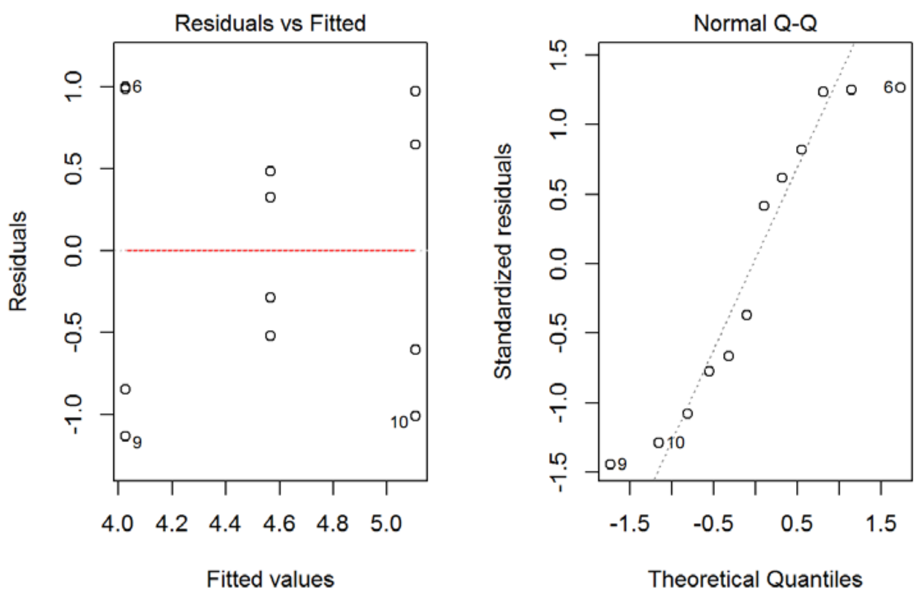


FIGURE 8 Log Transformation of Shapiro-Wilk Normality Plot Individual (Site) Values



Box Plot Demonstrating the Number of Insect Families Present According to Season (Figure 9) and Site (Figure 10)

FIGURE 9 Total number of families found in each of the four seasons

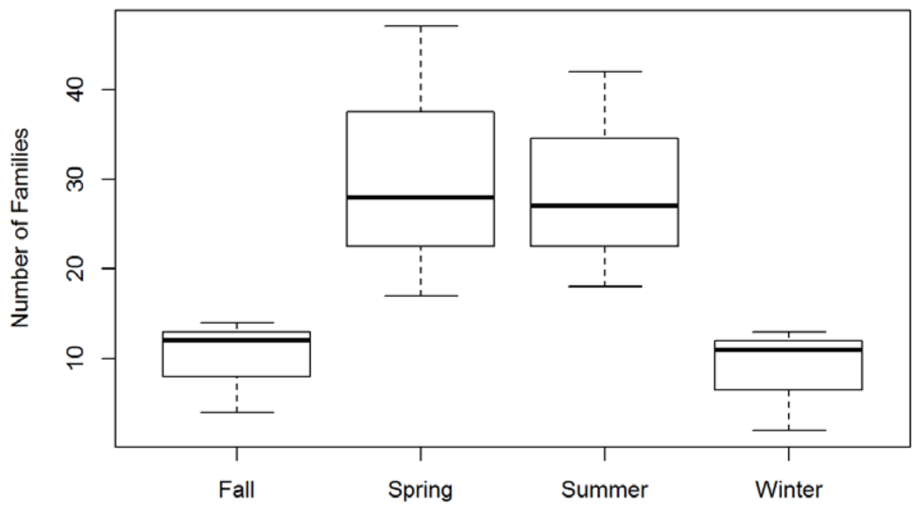
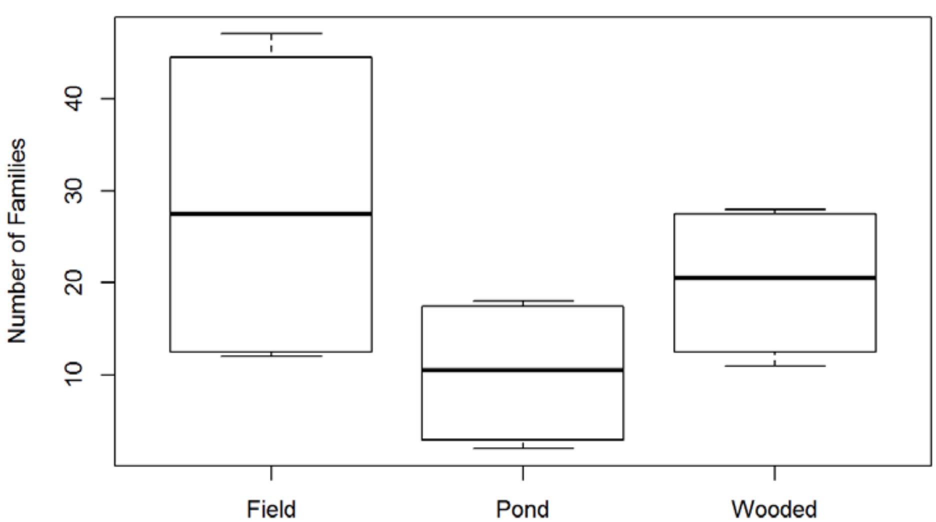


FIGURE 10 Total number of families found at each sampling location



Box Plot Demonstrating the Number of Insects Individuals Present According to Season (Figure 11) and Site (Figure 12)

FIGURE 11 Total number of individuals found in each of the four seasons

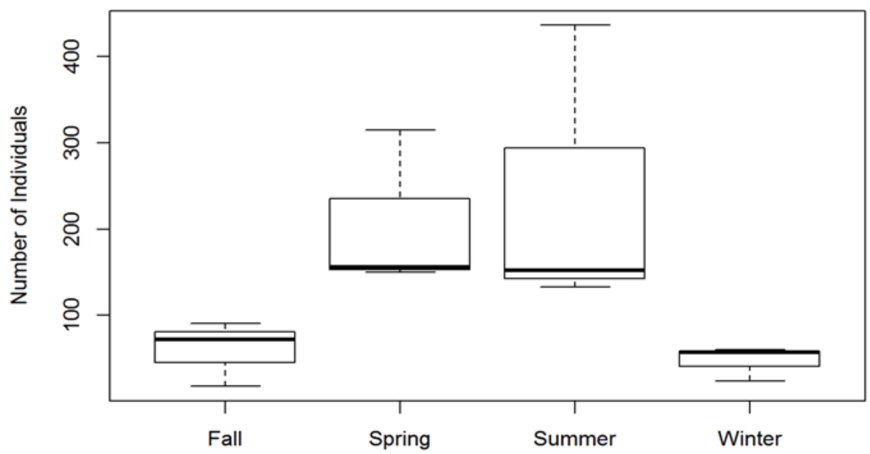
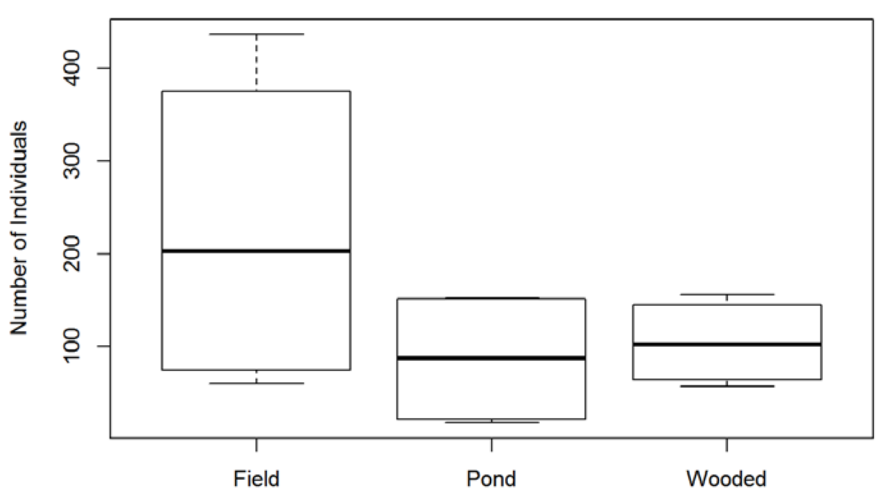


FIGURE 12 Total number of individuals found in each of the 3 sampling locations



Discussion:

Based off of the data presented, there were no significant differences between the season/site where the samples were recorded and the mean number of families/individuals found. There was, however, a significant difference between the average number of families present, and well as individuals present within a location site. Site A, the field, was by far, more heavily populated for both dependent variables. Summer also had a profound effect on the number of families and individuals sampled. Since there was no interaction between the seasons or the sites, it is safe to assume that biodiversity is slowly increasing within the systems. One would expect to find a much higher average within the summer months than within the winter months. Even though there was a difference, no significant interaction between the two suggests that biodiversity is steadily increasing since winter was the last of the seasons surveyed throughout the year. It would be safe to assume that actual species present changes throughout the seasons. Thusly, an overall increase was observed from Spring to Summer, then a slight decline into Fall and then Winter. This is expected as seasonal temperatures decrease exponentially into fall and Winter. The overall diversity still seems to remain however. Although population sizes decrease greatly January-March, there are still a significant amount of families present. If biodiversity were stagnant, one would expect the overall winter families to drop off more rapidly than observed. This lack of seasonal changes also lead to the conclusion that limiting factors such as food and shelter resources do not have a large impact on a seasonal basis and are readily available to support the family diversity within these months.

There was an overall trend of more families and individuals being present within the field location, however, there was an increase in the range of individuals present from spring to summer, with a decrease in range of families present. This does not necessarily mean that there was a decrease in overall diversity, but that population sizes may have been increasing within the families. Spring had a much larger range of families than individuals which may have led to the boom of individuals in the summer months. The small range in individuals, but larger range of families present in the winter months also demonstrates an increase in biodiversity since even though population sizes decrease, the decrease in range of families present is not as pronounced.

Insects important for bio indication of the biodiversity of a system were reported in the samplings. Collembola are considered to be a highly diversified order, both taxonomically and ecologically. It is no surprise that several families were found. Families such as Cercopidae, Membracidae, and Formicidae have extremely high ecological fidelity, along with many Lepidopteran families present which demonstrate a close relationship with habitats as well (Stewart, 2007). There were families such as Asilidae which are fairly widespread and easy to find in field settings, however, some species of Elateridae and Cerambycidae are highly endemic to locations. Specimens were not identified to species, so gravity of their presence cannot be concluded. Formicidae are one of the most influential families for determining the biodiversity of s system because they are well studied, easy to find in large numbers yet sedentary to a location, and functionally important within the ecosystem (Gullan, 2004). Other hymenopterans are important within the ecosystem as well along with other pollinating families which were recorded in the field site. They included lepidopterans such as Nymphalidae and Hesperiidae, along with hymenopterans such as Apidae, which are highly influential to ecosystems not only for their pollinating habits, but they honey production as well (Gullan, 2004). Some decomposers such as Sarcophagidae were present on decaying matter within the system. Their presence should be studied further to see if they have any effects on the role this bog has in nutrient cycling. Since bogs are generally stagnant carbon sinks, their presence may alter our perception of the cycling of nutrients within these systems. Many predatorial families of Odonata were found soaring over the pond and through the field. Aside from the truly aquatic insects, most major predators were found in the field, including the dragonflies/damselflies and mantids. This may be due to the lack over hanging branches which could obstruct site of prey.

One major abiotic factor to note is the unusually warm weather that was recorded throughout the year. Most years produce more now with colder temperature plummeting well below 0°C. This year's abnormal weather conditions may have contributed to such high population sizes of Dipterans and Hemipterans during breeding seasons. Since insects are poikilothermic, the warmer weather may have increased longevity and reproductive abilities along with deter predators from hunting in the warmer parts of the day that they were not accustomed to. There may have been biases since samplings took place in morning hours or at dusk when more insects were likely to be active, but also discriminated against the nocturnal or strictly diurnal families. The sampling sizes were considerably small and would give better focus and dilation of the biodiversity if the experiment was conducted over multiple years to compare seasonal changes against one another.

Overall, there was a noted increase in biodiversity of the insects within the park. As the seasons progressed, the number of families progressed, as well as the total of individuals. Further studies may isolate important bio indicators, especially aquatic ones, and further examine the impact that is suggested by their presence within the ecosystem. Lepidopterans are a vital part of the field ecology and could potentially be used to examine their biodiversity alone, comparing it to other systems where lepidopteran migration is influential. The role that the bog plays in the traveling patterns of migrating species may also be analyzed by families present. Surveys after the field burnings may be compared to these findings to see what insects are important to the initial succession of the habitat and to observe growth rates in the diversity of short time periods. On a long term scale, future studies at 10, 15, or even more years could be conducted and compared against this study top observe any increases in family diversity, population sizes, or any anomalies that may occur. This data, combined with soil quality information or nutrient cycling could give further insight on the insects' role in habitat conservation and ecological biodiversity.

Works Cited

Earth's Seasons: Equinoxes, Solstices, Perihelion and Aphelion. (2015, September 21). Retrieved from Naval Oceanography Portal: http://aa.usno.navy.mil/data/docs/EarthSeasons.php

Gullan, P. a. (2004). *The Insects: An Outline of Entomology.* London: Blackwell Publishing.

Johnson, C. W. (1943). *Bogs of the Northeast.* London: University Press of New England.

Kaufmann, K. a. (2007). *Kaufman Field Guide to Insects of North America.* New York: Houghton-Mifflin Co.

Kirchman, D. L. (2012). *Processes in microbial ecology.* New York: Oxford University Press.

Klein, D. R. (2012). *Organic Chemistry.* Hoboken: John Wiley & Sons Inc.

Koltuniewicz, D. A. (2014). *Sustainable Process Engineering: Prospects and Opportunities.* Poland: Walter de Gruyter GmbN & Co.

Lyons, J. a. (1989). *Walking the Wetlands.* New York: John Wiley & Sons Inc.

National Weather Service Forecast Office. (2014, December 18). Retrieved from National Weather Service: http://w2.weather.gov/climate/index.php?wfo=cle

Speight, M. R. (2009). *Ecology of Insects.* Hoboken: John Wiley & Sons.

Springfield Bog. (2015). Retrieved from Summit County Metroparks: http://www.summitmetroparks.org/ParksAndTrails/Springfield-Bog.aspx

Stewart, A. T. (2007). *Insect Conservation Biology.* London: Biddles Ltd.

Triplehorn, C. A. (2005). *Borror and Delong's Introduction of the Study of Insects.* Belmont: Brrok/Cole Cengage Learning.

Welsch, D. J. (n.d.). *Organic Soil Wetlands*. Retrieved from Forrested Wetlands: http://www.na.fs.us/spfo/pubs/n_resource/wetlands/wetlands9_organic.htm