# Ecosystem Profile Assessment of Biodiversity at Loyola University Retreat and Ecology Campus Summer 2014

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## Abstract:

An ecosystem profile assessment of biodiversity for four plots representing four distinct terrestrial ecotypes and three small calcareous ponds within the 98-acre property of Loyola's University Retreat and Ecology Campus (LUREC) were performed during June-mid August of 2014. Biodiversity testing protocols for the terrestrial ecosystems were based on those outlined in the "Ecosystem Profile Assessment of Biodiversity: Sampling Protocols and Procedures" of the U.S. Department of Interior and the National Park Service. Twenty biotic and abiotic protocols were selected. Species richness, Simpson Index of Diversity and the Shannon-Weiner's Biodiversity Index were calculated for each ecotype. We found that, overall; the buckthorn and fen plots were more diverse than the oak hickory and shrubland plots. Seven biotic protocols and six abiotic protocols were performed on the three ponds. We found that the third pond, as expected, was the most diverse of all three ponds. The results serve as baseline data for studying the effects of climate change on ecosystems located in the Northern Illinois region as well as for monitoring ongoing restoration efforts on the campus.

## Introduction:

A biodiversity assessment is a comprehensive analysis of an ecosystem including its flora, fauna and abiotic factors. Certain aspects of biodiversity within LUREC have been surveyed previously (plants by Dr. Roberta Lammers-Campbell, and Lepidoptera, birds, and vertebrates by Edgar Perez and Stephen Mitten; see Perez and Mitten (2012) for birds), but an overall property biodiversity analysis has not been completed. We conducted biodiversity profiles, which include composition, structure, function, and inter-relationships of biotic and abiotic components within a sample plot. We measured species richness and distribution of organisms in order to determine their ecological roles at four defined sites. We then combined this information with certain abiotic factors to create an overall ecosystem profile. The sampling protocols, as developed by Mahan et al (1998), can be used to answer general research questions. Our objectives in this project were to: 1) learn as much as possible about the main ecosystems at LUREC; 2) collect data/samples and identify organisms present within the plots; 3) describe composition and inter-relationships between biotic and abiotic elements of each habitat; 4) determine species richness and biodiversity of each ecosystem; 5) establish standardized protocols for future surveying of the same or new ecosystems at LUREC; and 6) promote future monitoring of these ecosystems. This research "provides a comprehensive description of species assemblages and community structure within an ecosystem" (Mahan et al.1998, p.10). LUREC's biodiversity is important as it shows us what is currently here and thus may also indicate the current health of each ecotype. We can then use this information in the future as we monitor changes over time within each ecosystem type that was sampled on the property so as to examine trends. The results can also serve as baseline data for studying the effects of climate change on ecosystems located in the Northern Illinois region as well as for monitoring ongoing restoration efforts on the campus.

Our assessment of the ecosystems began with a 20 x 20 m plot for each ecosystem. The four main ecosystems studied include a successional shrubland, an oak-hickory woodland, an invasive buckthorn-honeysuckle thicket, and a degraded calcareous fen. Often times, it is nearly impossible to document an entire ecosystem due to time, size, and labor restraints. Thus, sampling provides an adequate representation of an ecosystem's relationships and processes occurring on a larger scale. Since some species, like birds and bats, have larger, overlapping habitats greater than a 20 x 20m plot, it is necessary to perform modified protocols to better understand these species' role in the entire ecosystem. We accounted for this difference with supplemental mammal, herpetofaunal, and avian surveys.

A supplemental series of tests were conducted on the three small human constructed retention ponds on the property. Since this is an aquatic environment, different sampling protocols were conducted to obtain similar types of data as that of the terrestrial plots. We wanted to: 1) understand what organisms are present in each pond; 2) observe differences and changes of biotic and abiotic factors across each subsequent pond; 3) compare species richness and biodiversity of each pond; 4) identify reasons for the differences and changes across the ponds, if any; and 5) establish standardized protocols for future surveying of the ponds. The data from this accompanying project will be found at the end of each section within this paper.

**Study Area:**

LUREC is located at 2710 S. Country Club Road, Bull Valley, McHenry County, IL, and encompasses 98 acres (9.7 hectares) total. The property is located in Section 13, Township 44, North, Range 7, and East of the Third Meridian. LUREC, at its southeastern tip, is situated next to the Parker Fen, an Illinois Nature Preserve (Perez and Mitten, 2012).

Various ecosystems exist within the property, including a buckthorn/honeysuckle invaded oak-hickory woodland, a recreated prairie, a sedge meadow, a white pine grove, various shrub lands, a calcareous fen, three small retention ponds, a small lake, and two stream ditches that drain a wetland. Restoration efforts are currently under way in the prairie and the oak-hickory woodland. On the eastern side of the property, natural forests and wetlands have been overgrown by invasive buckthorn and honeysuckle. These invasive species have interrupted many of natural ecosystem processes and have made travel through these areas difficult. Restoration ecologists and volunteers have been working since January 2012 to remove these invasive species and restore native vegetation. Travel through this area was possible via trails created by past LUREC Interns and Restoration volunteers.

We surveyed four of the main habitat types found at LUREC: oak hickory woodland, shrubland, degraded calcareous fen wetland, and buckthorn-honeysuckle thicket. The 20 x 20 m plots were randomly chosen within the general ecosystem type areas and we used GPS to map the plots on ArcGIS. **Figure A** below shows each of our study plots on a general map of the LUREC property boundaries. **Figure B** below are photographs of all four plots (Shrubland, Oak Hickory, Buckthorn-Honeysuckle, Fen, respectively) from the center of the plot to the edges North, East, South, and West.

**Figure A.** *The blue square shows the shrubland plot. The red square shows the oak-hickory woodland plot. The green square shows the buckthorn-honeysuckle thicket plot. The purple square shows the calcareous fen plot. The grey circle shows the location of the three retention (trout) ponds.*

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Shrubland (looking North, East, South, and West)

Oak-hickory Forest (looking North, East, South, and West)

Buckthorn-honeysuckle thicket (looking North, East, South, and West)

Degraded fen wetlands (looking North, East, South, and West)

**Figure B.** *Photographs of all four plots (Shrubland, Oak Hickory, Buckthorn-Honeysuckle, Fen, respectively) from the center of the plot to the edges North, East, South, and West.*

**Methods:**

***Terrestrial Sampling***

Although modified to fit our situation, our sampling methods were based on those laid out in "Ecosystem Profile Assessment of Biodiversity: Sampling Protocols and Procedures" of the U.S. Department of Interior and the National Park Service (Mahan et al. 1998).

- ➢ ***Terrestrial Biotic***
- Herpetofaunal surveys: We overturned all movable objects such as downed logs and rocks within a 5m radius from the center point of the plot for ten minutes (See **Appendix A**). When a herptile was found, the diameter of the object under which it was found was recorded along with a photograph or notes if the photo was missed. The overturning of moveable objects was performed once in June and once in July. We also used chance photography during our research to record any herptiles found, even while performing other tests or while travelling to other plots.
- Macroinvertebrate surveys: All macroinvertebrates were stored in 95% ethanol unless otherwise noted. A stereoscope and various online sources and textual dichotomous keys: *Common Spiders of the Chicago Region (Balaban 2012), A Field Guide to the Insects of America north of Mexico (Borror et al. 1970), How to Know the Immature Insects (Chu 1949), Kaufman Field Guide to Insects of North America (Eaton et al. 2007),* and *Photographic Atlas of Entomology and Guide to Insect Identification (Castner 2000)* were utilized in order to identify the specimens collected unless otherwise noted (Mahan et al. 1998).
    - Beating Sheets: Researchers constructed a 1 x 1 m beating sheet using an old bed sheet and two 1-meter sticks tied in an X pattern to the corners to create a

square. Researchers then placed the sheet near vegetation at five random points within the plot (see **Appendix A**). We beat the plants 10 times with another meter stick to agitate invertebrates occupying the vegetation. Any invertebrates that fell onto the sheet were collected in jars of ethanol, identified, and counted. This sampling was conducted during shelter seeking time for invertebrates, which is in the early afternoon or early evening. We collected beating sheet samples twice, once in June and once in July.

- Sweeping: The purpose of this test is to collect flying invertebrates. The top of understory vegetation was swept at a rate of 30 seconds per point for 5 randomly selected points within each plot (see **Appendix A**). Invertebrates were collected using a sweep net (30.4 cm diameter) that was passed side to side in a figure-8 motion. The captured specimens were then placed into jars filled with 70% ethanol and subsequently identified and counted. We collected sweep net samples twice; once in June and once in July.
- Trunk Tree Traps: Trunk tree traps were constructed for the purpose of capturing tree-dwelling insects. These traps were constructed from a 2L soda bottle, an Erlenmeyer flask, circular clamps, nails, and a copious amount of duct tape. The 2L bottle was cut so that invertebrates crawling on tree bark could fall into the Erlenmeyer flask which had had 95% ethanol as a preservative. The top of the 2L bottle was nailed into the the trunk roughly 2 meters from the ground on a randomly selected tree (see **Appendix A**). Trunk tree traps were in place for 1 week and refilled with ethanol if necessary over that period. When the sampling period was over, traps were removed and invertebrates collected, identified, and counted. There were two sampling periods for this protocol, once in June and once in July.
- Light Traps: This test was designed to attract nocturnal invertebrates. Light traps were made from a 1.5 x 2m fitted bed sheet attached to two large wooden stakes. The LED light from a Samsung Galaxy s4 cell phone and two incandescent flashlights illuminated the sheet after 10:00pm, for a period of 10 minutes per plot. Invertebrates attracted to the light source and sheet were photographed and identified after those initial 10 minutes. Light traps were conducted near the edge of each test plot once in the month of June.
- Pitfall Traps: To capture insects that are most active on the habitat floor, we constructed pitfall traps. We collected invertebrates using 18-ounce plastic cups. The cups were placed within holes that were dug one week before the collection period began. The holes were dug at five randomly selected holes within and along the edges of the plots (see **Appendix A**). The drinking cups had two small drainage holes on the side of the cups to prevent flooding from rain events. The cups were filled approximately 3 ounces with a sea salt-water solution. Pitfalls were open for a 5 day period, inserted on Monday, checked and collected on Wednesday and collected and removed on Friday. Specimens were immediately transferred into 95% ethanol upon return to the laboratory. Pitfall traps were conducted once in June. Since the majority of the fen was inundated with water,

we decided not to conduct pitfall traps at this location since the test would be ineffective.

- Mammal Trail Cams: Trail cameras (Browning Trail Cam, Model BTC-5 and Plotwatcher Pro) were placed between 0.5 m and 1 m on a tree above the ground in the 4 plots for approximately one week each. The camera was placed on a random tree facing inside the plot. After one week, the data was removed from the camera and analyzed. These trail cams were placed only once in each plot during the two month testing period.
- Avian Surveys
    - Bird Counts: Point counts were conducted for 7 minute periods at the center of each plot beginning at 6:00am (see **Appendix A**). Researchers used Bushnell's 8 x 42 binoculars. There were two people counting birds and one person who recorded species type and number. All birds seen or heard within the plot during the seven minute time period were counted. Birds seen or heard while traveling to the center of plot along with those that flew over were recorded in a separate category called "incidentals". A one minute equilibrium time was observed before each point count began. These counts were performed at each plot once in June and once in July.
    - Owl Points: Specific owl sounds were played from the center of three out of four plots after one minute of silence in the beginning or when switching species (see **Appendix A**). Playback was for 15 seconds, with a 45 second pause, 4 times. Researchers maintained silent and still during this period. Playback was done for each previously seen species in the area, which includes Eastern Screech Owl and Great Horned Owl. This test was performed once in early June.

- Flora Surveys
    - Herbaceous Plants: Herbaceous plants were defined as grasses, sedges, rushes, ferns, and forbs. Cover of herbaceous plants was estimated to the nearest 5% within a 5 x 5 m plot around the center of the 20 x 20 m plot (see **Appendix A**). Herbaceous plants were identified with online sources and textual resources, primarily *Flora of North America: North of Mexico (2007)*. This test was conducted once in July.
    - Shrubs: Shrubs were defined as woody plants 0.5-1.4 m in height and less than 2.5 cm in diameter. Cover of shrubs was counted individually within a 10 x 10 m plot in the center of the 20 x 20 m plot (see **Appendix A**). Shrubs were identified with online sources and textual resources, primarily *A Field Guide to Trees and Shrubs: Northeastern and north-central United States and southeastern and south-central Canada (Petrides 1986)*. This test was conducted once in July.
    - Saplings: Saplings were defined as woody plants greater than 1.5 m in height and less than 11.4 cm in diameter. Saplings were counted individually within a 10 x 10 m plot in the center of the 20 x 20m plot, noting any browse or insect damage (see **Appendix A**). Saplings were identified in the field or with online sources and/or textual resources, primarily *A Field Guide to Trees and Shrubs: Northeastern and north-central United States and southeastern and south-central*

*Canada (Petrides 1986),* in the lab with photographs. This test was conducted once in July.

  - Overstory Trees: Overstory trees were defined as woody plants greater than 1.5 m in height and greater than 11.4 cm in diameter. Trees were counted within the entire 20 x 20 m plot (see **Appendix A**). Overstory tree identification was done using textual keys within the field, primarily *A Field Guide to Trees and Shrubs: Northeastern and north-central United States and southeastern and south-central Canada (Petrides 1986),* or using photographs and keys in the lab. This test was performed once in July.
  - Bryophytes: Bryophyte and lichen samples were collected from a 1 x 0.5m random point within the 20 x 20 m plot (see **Appendix A**). Substrate searched included live wood, dead wood, and rocks. The numbers of different species were recorded, as was exact species, if possible. Substrate type was also recorded. Samples were collected in jars and brought back to lab for analysis using textual and online resources: *Bryophytes: Illinois Bryhophytes (2006)*. This test was conducted once in June.

➢ ***Terrestrial Abiotic***

- Canopy Cover: Canopy cover was estimated by percentage from the four corners and at the center of the 20 x 20 m plot by estimating how much of our field of view when looking upward was covered by foliage and performed by the same viewer for each of the four plots. Percentages were estimated to the closest 10%. Each test was completed on days of full sun, once in June and once in July.
- Leaf Litter Samples: Leaf litter samples were collected by hand in approximately 0.25 x 0.25 m section at five random points within each ecosystem (see **Appendix A**). These samples were taken at the same location as soil cores. Samples were placed in plastic bags which were sealed and stored in a freezer at 5 degree Celsius for seven days. After this period, the samples were thawed and the weight was recorded. The samples were then dried using a scientific drying oven. The dry weight was recorded. This test was performed twice, once in June and once in July.
- Distance to Edge: A rangefinder (Bushnell Yardage Pro Sport 450) was used to calculate distance to edge (meaning the distance to the nearest edge created by a change in general habitat type (e.g., forest stand edge, stream, road)). One person took readings facing each cardinal direction from the midpoint of the center of the plot. The rangefinder was pointed at a habitat that was different than the ecosystem being studied. This value was recorded in yards as distance to edge. This test was conducted once per plot.
- Soil Chemistry: Soil cores were taken at the same place as leaf litter samples, which were five random points within each plot (see **Appendix A**). These cores were sampled using 12-inch soil corer. The middle six inches of each core of the five samples were collected in one plastic bag for each plot. The bags were brought back to the lab and frozen until analysis was performed. When this happened, bags were thawed and tested for pH, potassium (lb/acre), phosphorus (lb/acre), and nitrogen (lb/acre) using a soil macronutrient testing kit (LaMotte, Code 5928). Soil texture and type were also analyzed

and recorded (USDA Soil Texturing Field Flow Chart). A hand soil pH tester was also used to supplement our data (Kelway Soil Tester). Soil cores were sampled twice per plot, once in June and once in July.

- Water Chemistry: Water chemistry was measured only in the fen using a YSI Environmental tool (Model 556). This instrument gives data for temperature (degrees Celsius), electrolytic conductivity, or ion content (ms/cm^c), electrical resistance (Ω*cm), total dissolved solids (TDS, g/L), salinity (sal), dissolved oxygen (D.O., mg/L), pH, and reduction potential (ORP). The fen water quality was taken three times in one sampling and the results were averaged to give a single value. The test was performed twice in the fen, once in June and once in July when water was present.
- Elevation: We used a GPS (Garmin GPSmap 62s) to get an elevation calculation. Four samples were taken and averaged to get a final value. This test was performed once per plot.

***Aquatic Sampling***

All protocols were based on those performed by Loyola University Chicago's Biology Department's "Biotic and Abiotic Profile of Dufield Pond, Woodstock IL" (2013), as well as the "Ecosystem Profile Assessment of Biodiversity: Sampling Protocols and Procedures" of the U.S. Department of Interior and the National Park Service (Mahan et al. 1998).

➢ ***Aquatic Biotic***

- Macroinvertebrates: Macroinvertebrates were collected using a 12 x 6 in. fine mesh net with a 6 ft. long handle in order to collect specimens. One sample was taken from the limnetic zone and another from the benthic zone at three random locations of each pond, for a total of six samples per pond. All six samples were collected in a single jar for each pond. These samples were taken back to lab for analysis using a stereoscope and various textual and online identification resources: *Guide to Aquatic Invertebrates of the Upper Midwest (Bouchard et al. 2004), An Introduction to the Aquatic Insects of North America (Merritt, 2008), Key to Common Macroinvertabrates (2014)*. We recorded number of specimens to the taxonomic order to which they belong. This protocol was performed once in late July.
    - Dragonflies and damselflies were observed over the ponds and identified in the lab with the use of online sources and textual keys.
- Microinvertebrates:
    - Phytoplankton were collected using a plankton net trap. The trap was thrown once into the center of a pond and dragged into shore by the researcher. This was conducted one time for each pond. The contents of the net were then emptied into a jar for analysis. Only one sample was collected at a time to ensure that organisms were living when observed under the compound microscope. From the bottom of each jar, 10 drops were taken and one drop was placed on each slide. We observed each slide for five minutes and recorded all phytoplankton species seen within that time frame (filamentous, non-filamentous, or diatom). Online and textual sources were used to identify each type of phytoplankton: *Guide to Identification of Fresh Water Microorganisms (Walker et al. 2000)*.

- Zooplankton were collected using jars from each cardinal direction in the benthic zone one meter from the edge of the pond. Only one sample was taken at a time to ensure that all organisms were living when analyzed. Jars were brought into the lab for analysis under a compound microscope. From the bottom of each jar, 10 drops were taken and one drop was placed on each slide. We observed each slide for five minutes and recorded all zooplankton species seen within that time frame (protozoa [ciliates, heliozoans, flagellates, and amoebas], rotifers, roundworms, flatworms, cladocerans, copepods, ostracods, water mites, oligochaetes, gastrotricha, tardigrades, and insect larvae). Online and textual sources were used to identify each type of zooplankton: *Dichotomous Key for Protozoa (n.d.), A Guide to the Freshwater Calanoid and Cyclopoid Copepod Crustacea of Ontario (Smith et al. 1978), Guide to Identification of Fresh Water Microorganisms (Walker et al. 2000), An Illustrated Guide to the Identification of the Planktonic Crustacea of Lake Michigan (Torke, 1974), ,* and *Protoctista (a.k.a. Protists) (Duffie et al. 2012)*.
- Both tests were performed once at the end of July.

- <u>Vegetation:</u> Submerged underwater vegetation (SUV) in the ponds was identified recorded. This was conducted once at the beginning of August.
- <u>Herptiles:</u> Species types and number observed of herptiles were recorded for each pond. This test was performed each time we visited the ponds.
- <u>Avian Species:</u> Avian species were noted each time we visited the ponds.

➢ ***Aquatic Abiotic***

- <u>Turbidity:</u> A secchi disk was used to determine turbidity as close to center of the pond as possible. The disk was dropped from the surface of pond and slowly lowered via rope into the water until the black and white pattern was no longer visible to the researcher. The depth at which this occurred was recorded by measuring the length of the rope. Thus, turbidity was measured in centimeters. This was conducted once per pond at the end of July.
- <u>Area/Volume and Depth at Center:</u> Average length, width, and height were measured using a transect measuring tape, and area and volume were calculated with this data. The depth at center was calculated using slope method. This was calculated once per pond.
- <u>Bank Condition/Substrates:</u> Bank condition and substrates were analyzed visually. Descriptions were recorded once per pond at the end of July.
- <u>Canopy cover:</u> Canopy cover was estimated by percentage from the four cardinal directions at the edge and at the center of each pond. Percentages were estimated to the closest 10%. Each test was completed on a day of full sun, once at the end of July.
- <u>Water Chemistry:</u> The YSI tool (Model 556) was also used for pond analysis. We brought the probe to the center of the pond and dropped it to the bottom. Three samples were recorded when the values stabilized, and an average was taken. This instrument gives data for temperature (degrees Celsius), electrolytic conductivity, or ion content (ms/cm^c), electrical resistance (Ω*cm), total dissolved solids (TDS, g/L), salinity (sal), dissolved oxygen (D.O., mg/L), pH, and reduction potential (ORP). Each pond's water

quality was taken three times in one sampling and the results were averaged to give a single value. This test was performed once at each pond at the end of July.

- General Observations: General ecosystem observations of each pond were recorded whenever we visited to take samples.

**Results:**

Terrestrial Results

**FEN:**

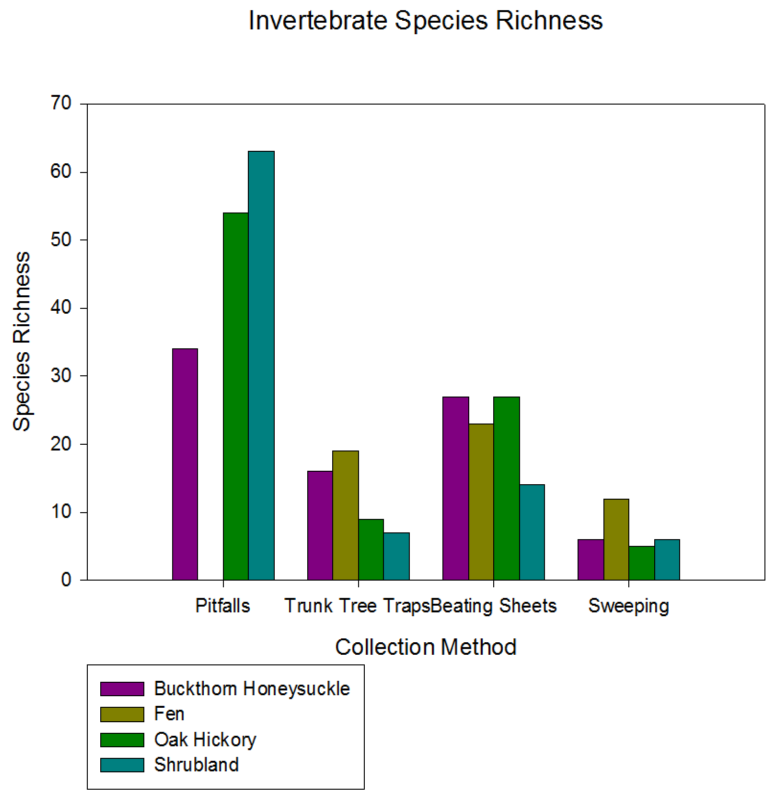
Using the Simpson Index of Diversity, we calculated the overall biodiversity (1-D) within the fen to be 0.9676. Likewise, using Shannon-Weiner's Biodiversity Index, we calculated overall biodiversity (H') at this location to be 4.051. Species richness for this plot habitat was calculated to be 90 overall (see **Appendix B**).

We found 4 different species of herptiles, including Western Chorus Frog (*Pseudacris triseriata*), Plains Leopard Frog (*Lithobates blairi*), American Toad (*Anaxyrus americanus*), and Eastern Milk Snake (*Lampropeltis triangulum triangulum*).

No images of vertebrates were captured on the trail camera at the fen.

For avian biodiversity, we recorded 19 different species of birds during the two month testing period. Overall, the most abundant bird species observed in this location was the Red-winged Blackbird (*Agelaius phoeniceus*). For a list of all the birds found here, please see **Appendix B**. *While owl point counts were performed, no species were observed because it was outside of the breeding season.*

Macroinvertebrates were collected using four tests in the fen. These tests collected flying insects (sweeping), insects dwelling in trees and in forbs (trunk tree traps and beating sheets), and nocturnal flying insects (light traps). We found a total of 53 different species in this ecosystem. The effectiveness of these tests varied, but **Figure C** below shows number of species found relating to each test for all four transects. The graph shows that the sweeping collected 12 species of insects, beating sheets with 23 species, and trunk tree traps with 19 species. Unfortunately, the light trap data was not collected because the camera lens could not magnify the macroinvertebrates adequately at night. A list of all macroinvertebrate species observed in the fen can be found in **Appendix B**.  Please note: due to the wet conditions of the fen, invertebrate pitfall trap samplings were unable to be performed.



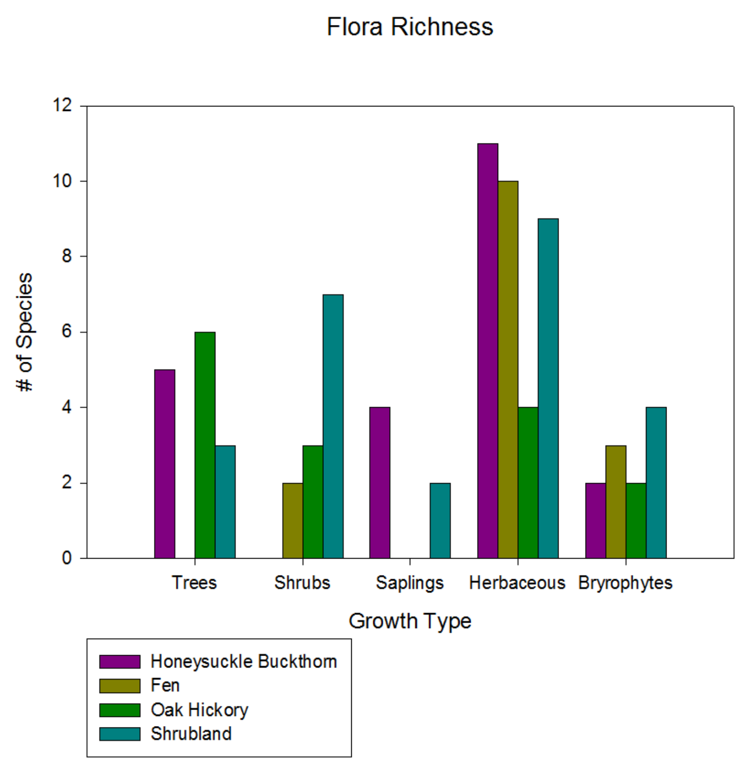




**Figure C.** *The top chart shows the number of different species of invertebrates for each test on the four plots. The bottom chart shows the number of different species of plants for each test on the four plots.*

Flora surveys provided a representation of the fen plant diversity. Flora types were separated into five categories: herbaceous plants, shrubs, saplings, overstory trees, and bryophytes. A total of 15 different species of flora were observed in the fen. **Figure C** above displays species richness of each type of flora found in the fen and the other three transects. The graph shows that there were 10 herbaceous plant species, 2 shrub species, 0 sapling species, 0 overstory tree species, and 3 bryophyte species.  A list of all flora noted in the fen can be found in **Appendix B**.

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**Figure D** below shows the abiotic factors that influence the fen ecosystem. We collected information for canopy cover, leaf litter, soil chemistry, distance to edge, and elevation. We were able also to conduct water chemistry analyses at this site because of the standing water. Throughout this entire plot, there was 0% canopy cover in all directions during both testing dates in June and July. Slightly more leaf litter was collected during June than in July, consisting of 29.17 grams of dead grasses compared to 20.49 grams of dead grasses, leaves, and live grasses in July. In relation to soil chemistry, the most prominent data collected was pH, which fluctuated from 7.2 to become slightly more acidic in July at 5.8 respectively. Potassium, Nitrogen and Phosphorous loads were all low in this location. In relation to water chemistry, dissolved oxygen content had the most significant data change between June and July, ranging from 3.922 (mg/L) to 0.35 (mg/L). In observance of distance to edge, various habitats were observed from the center of the plot. Roughly 118 meters to the north, oak woodland is the closest bordering habitat. To the east, marsh habitat lies at a distance of 22 meters. A buckthorn thicket is observed roughly 25 meters south of the test plot and 4 meters west of the test plot. The elevation of this test plot is about 254.5 meters.

| Abiotic Factors in Fen | | | | | |
|---|---|---|---|---|---|
| **Canopy cover** | | | | | |
| Direction | NE | SE | NW | SW | Center |
| June 12 % | 0 | 0 | 0 | 0 | 0 |
| July 10 % | 0 | 0 | 0 | 0 | 0 |
| **Leaf Litter** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Inital Weight (g) | 101.4 | 60.33 | | | |
| Dry Weight (g) | 29.17 | 20.49 | | | |
| Composition | dead grasses (100%) | dead grasses (95%), dead leaves (<1%), live grasses (<5%) | | | |
| **Soil Chemistry** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Texture/Type | peat | peat | | | |
| pH | 7.2 | 5.8 | | | |
| P (lb/a) | 30 | 20 | | | |
| K (lb/a) | <100 | <100 | | | |
| N (lb/a) | <10 | <10 | | | |
| **Water Chemsitry** | | | | | |
| Date | 6.19 | 7/11/2014 | | | |
| degrees C | 20.925 | 22.86 | | | |
| ms/cm^c | 1.049 | 1.123 | | | |
| Ω*cm | 1035.76 | 929.66 | | | |
| TDS (g/L) | 0.683 | 0.729 | | | |
| sal | 0.522 | 0.56 | | | |
| D.O. (mg/L) | 3.922 | 0.35 | | | |
| pH | 7.41 | 7.51 | | | |
| ORP | -137.275 | -138.8 | | | |
| **Distance to Edge** | | | | | |
| Direction | N | E | S | W | |
| Distance (yds) | 129 | 24 | 27 | 4 | |
| Type of Habitat | woodland | marsh | buckthorn thicket | buckthorn thicket | |
| Distance (m) | 117.9579558 | 21.94566619 | 24.68887446 | 4 | |
| **Elevation** | | | | | |
| Feet | 835 | | | | |
| Meters | 254.5079919 | | | | |

**Figure D.** *This table shows several abiotic samples that were collected from the fen. All data, except for distance to edge and elevation, were collected twice and both results are displayed.*

**Figure E** below shows all of the different types of organisms observed in the fen. Of all the organisms, we found 3 bryophyte species, 4 herptile species, 19 avian species, 53 macroinvertebrate species, and 12 plant species. Macroinvertebrates were the most abundant type of organism found.

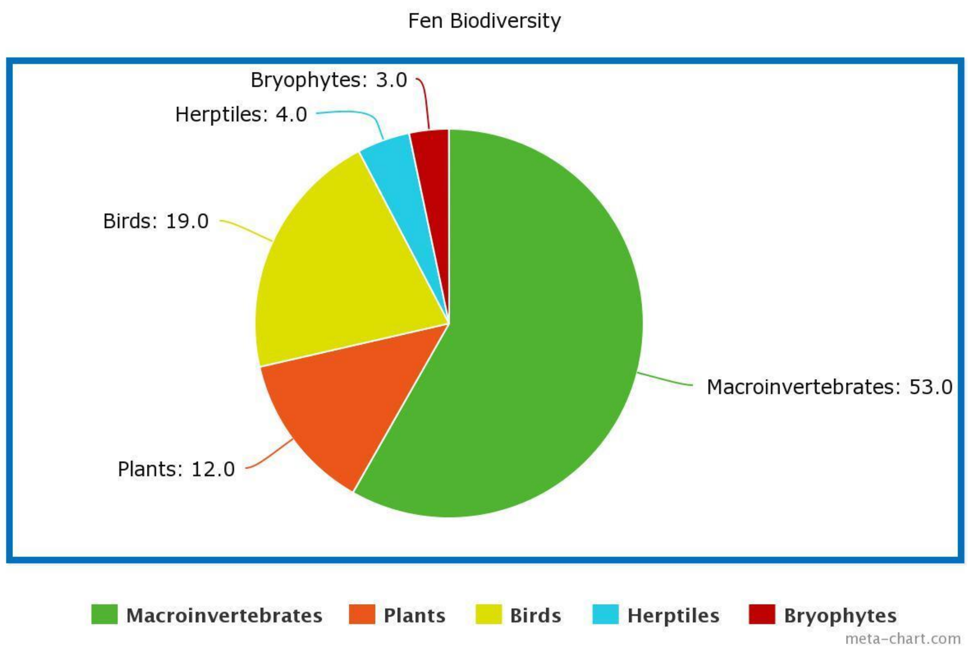



**Figure E.** *This chart compares the amount of each type of organism found in the fen.*

**BUCKTHORN-HONEYSUCKLE:**
Using the Simpson Index of Diversity, we calculated the overall biodiversity (1-D) within the buckthorn-honeysuckle thicket to be 0.9703. We used the Shannon-Weiner's Biodiversity Index and calculated overall biodiversity (H') at this location to be 4.221. Species richness at this location was calculated to be 124 overall (see **Appendix C**).

We found 2 different species of herptiles including the Northern Leopard Frog (*Lithobates pipiens*) and the American Toad (*Anaxyrus americanus*).

Using the trail camera, 8 species of mammals were observed. These mammals include Virginia Opossum (*Didelphis virginiana*), American Mink (*Neovison vison*), Eastern Cottontail (*Sylvilagus floridanus*), Eastern Chipmunk (*Tamias striatus*), Common Raccoon (*Procyon lotor*), and White-tailed Deer (*Odocoileus viginianus*). Unfortunately, some small mammals inadvertently fell into the invertebrate pitfall traps. These mammals include Western Harvest Mouse (*Reithrodontomys megalotis*) and Masked Shrew (*Sorex cinereus*).

For avian biodiversity, we recorded 14 different species of birds during the two month testing period. Overall, the most abundant bird species observed in the forest was the Grey Catbird (*Dumetella carolinensis*). For a list of all the birds found here, please see **Appendix C**. *As in the fen, owl point counts were performed, however testing was outside of the breeding season and no species were observed.*

Macroinvertebrates were collected using five tests in the buckthorn-honeysuckle thicket. These tests collected flying insects (sweeping), insects dwelling in trees and in forbs (trunk tree traps and beating sheets), ground dwelling insects (pitfall traps), and nocturnal flying insects (light traps). We found a total of 73 different species of macroinvertebrates in this ecosystem. The effectiveness of these tests varied, but **Figure C** above shows number of species found relating to each test compared to all three plots. The graph shows that the sweeping collected 6 species, beating sheets with 27 species, the pitfall traps with 34 species, and trunk tree traps with 16 species. Unfortunately, the light trap data was not collected because the camera lens could not magnify the macroinvertebrates adequately at night. A list of all invertebrate species observed in this plot can be found in **Appendix C**.

Flora surveys provided a representation of the buckthorn-honeysuckle thicket plant diversity. Flora types were separated into five categories: herbaceous plants, shrubs, saplings, overstory trees, and bryophytes. A total of 20 species of flora were noted in the buckthorn-honeysuckle thicket. **Figure C** above displays species richness of each type of flora found where these invasive plants have seemed to take over. The graph shows that there were 11 herbaceous plant species, 0 shrub species, 4 sapling species, 5 overstory tree species, and 2 bryophyte species. A list of all flora noted at this location can be found in **Appendix C**.

**Figure F** below shows the abiotic factors that influence the buckthorn-honeysuckle thicket's ecosystem. We collected information for canopy cover, leaf litter, soil chemistry, distance to edge, and elevation. Throughout this entire plot, canopy cover was most prominent in the southwest location of the plot, at 95%. Canopy cover also increased the most between the June and July testing dates in the northeast direction, fluctuating from 30% to 70%. Leaf litter collection was much more prominent during June than in July, consisting of 111.3 grams of dead leaves, plants, twigs, roots, bark and live mosses compared to 45.04 grams of dead grasses, barks, and sticks in July. In relation to soil chemistry, the most prominent data collected was phosphorous and nitrogen. Phosphorous load fluctuated from 25 lb/acre to 75 lb/acre between June and July. Nitrogen load decreased between June and July, going from 60 lb/acre to 15 lb/acre. Potassium load also increased from less than 100 lb/acre in June to 177 lb/acre in July. In observance of distance to edge, a similar habitat of woodland was observed in all cardinal directions, save for the trail that was observable to the west of the testing plot. The distance of each of these habitats from the center of the plot was difficult to measure due to the density of the thicket itself. The elevation of this test plot is about 260 meters.

| Abiotic Factors in Buckthorn | | | | | |
|---|---|---|---|---|---|
| **Canopy cover** | | | | | |
| Direction | NE | SE | NW | SW | Center |
| June 12 % | 30 | 10 | 20 | 95 | 10 |
| July 10 % | 70 | 10 | 30 | 95 | 40 |
| **Leaf Litter** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Inital Weight (g) | 164.127 | 87.92 | | | |
| Dry Weight (g) | 111.3 | 45.04 | | | |
| Composition | dead leaves (5%), twigs/sticks (75%), roots (<1%) dead plants (8%), live mosses (<1%), bark (10%) | dead grasses (20%), bark (55%), sticks (25%) | | | |
| **Soil Chemistry** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Texture/Type | peat/ sandy clay loam | peat/ sandy clay loam | | | |
| pH | 7.2 | 6 | | | |
| P (lb/a) | 25 | 75 | | | |
| K (lb/a) | <100 | 177 | | | |
| N (lb/a) | 60 | 15 | | | |
| **Distance to Edge** | | | | | |
| Direction | N | E | S | W | |
| Distance (yds) | ? | 3.27 | ? | ? | |
| Type of Habitat | woodland | woodland | woodland | trail | |
| Distance (m) | ? | 3 | ? | ? | |
| **Elevation** | | | | | |
| Feet | 854 | | | | |
| Meters | 260.2991917 | | | | |

**Figure F.** *This table shows various abiotic samples that were collected from the buckthorn-honeysuckle thicket. All data, except for distance to edge and elevation, were collected twice and both results are displayed. The "?" signify that no data was able to be collected with a rangefinder because of the density of the buckthorn surrounding the 20 x 20 m plot.*

**Figure G** below shows all of the different types of organisms observed in the buckthorn-honeysuckle plot. Of all the organisms, we found 2 bryophyte species, 4 herptile species, 14 avian species, 73 macroinvertebrate species, 8 mammal species, and 18 plant species. Macroinvertebrates were the most abundant type of organism found.

Buckthorn-Honeysuckle Biodiversity

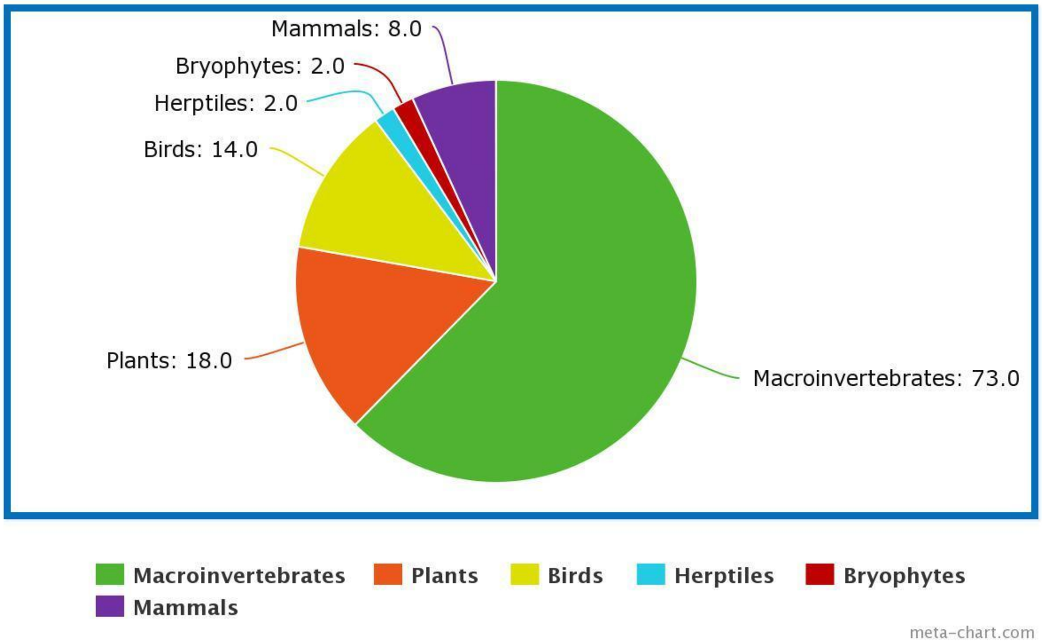



**Figure G.** *This chart compares the amount of each type of organism found in the buckthorn-honeysuckle plot.*

**OAK-HICKORY:**

Using the Simpson Index of Diversity, we calculated the overall biodiversity (1-D) within the oak-hickory forest to be 0.9402. We used the Shannon-Weiner's Biodiversity Index and calculated overall biodiversity (H') at this location to be 3.7630. Species richness for this forest was calculated to be 104 species overall (see **Appendix D**).

No herptiles were observed at this location.

While no data was captured from trail cameras, some small mammals happened to fall into our invertebrate pitfall traps. These included two Masked Shrews (*Sorex cinereus*) and a Deer Mouse (*Peromyscus maniculatus*).

For avian biodiversity, we recorded 8 different species of birds during the two month testing period. Overall, the most abundant bird species observed in the woodland was the White-breasted Nuthatch (*Sitta carolinensis*). For a list of all the birds found here, please see **Appendix D**. *As in the former two plots, owl point counts were performed, however testing was outside of the breeding season and no species were observed.*

Macroinvertebrates were collected using five tests in the oak-hickory woodland. These tests collected flying insects (sweeping), insects dwelling in trees and in forbs (trunk tree traps and beating sheets), ground dwelling insects (pitfall traps), and nocturnal flying insects (light traps). We found a total of 77 species in the woodland. The effectiveness of these tests varied, but **Figure C** above shows species richness relating to each test, as well as the other three ecosystems. The graph shows that the sweeping collected 5 species, beating sheets with 27 species, the pitfall traps with 54 species, and trunk tree traps with 9 species. Unfortunately, the light trap data was not collected because the camera lens could not magnify the macroinvertebrates adequately at night. A list of all invertebrate species observed in this plot can be found in **Appendix D**.

Flora surveys provided a representation of the oak-hickory woodland plant diversity. Flora types were separated into five categories: herbaceous plants, shrubs, saplings, overstory trees, and bryophytes. A total of 15 different species of flora were found in the oak-hickory woodland. **Figure C** above displays species richness of each type of flora found. The graph shows that there were 4 herbaceous plant species, 3 shrub species, 0 sapling species, 6 overstory tree species, and 2 bryophyte species. A list of all flora noted at this location can be found in **Appendix D**.

**Figure H** below shows the abiotic factors that influence the oak-hickory woodland ecosystem. We collected information for canopy cover, leaf litter, soil chemistry, distance to edge, and elevation. Throughout this entire plot, canopy cover generally increased between the June and July testing dates. The most prominent change occurred in the northwest corner of the plot; canopy cover fluctuated from 65% in June to 90% in July. Canopy cover also increased from 75% to 95% between June and July in the southwest corner of the test plot. Leaf litter collection decreased between June and July from 50.74 grams to 32.71 grams of dead leaves, sticks and bark. In relation to soil chemistry, pH remained slightly acidic (from 6.8 to 6.4) in both June and July. Phosphorous load increased from 20 lb/acre to 25 lb/acre between June and July. Nitrogen load increased between June and July, going from less than 10 lb/acre to 10 lb/acre. Potassium load remained less than 100 lb/acre in both testing months. In observance of distance to edge, various habitats were observed in all directions. Trail was observed in the east and west directions roughly 10 and 12 meters away respectively. To the north lies the edge of the forest while roughly 5 meters to the south is a hill. The elevation of this test plot is about 266 meters.

| Abiotic Factors in Oak Hickory | | | | | |
|---|---|---|---|---|---|
| **Canopy cover** | | | | | |
| Direction | NE | SE | NW | SW | Center |
| June 12 % | 85 | 95 | 65 | 75 | 55 |
| July 10 % | 85 | 90 | 90 | 95 | 65 |
| **Leaf Litter** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Inital Weight (g) | 86.441 | 63.27 | | | |
| Dry Weight (g) | 50.38 | 32.71 | | | |
| Composition | dead leaves (95%), twigs/sticks (3%), bark (2%) | dead leaves (90%), dead grasses (3%), sticks (7%) | | | |
| **Soil Chemistry** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Texture/Type | silty clay loam | silty clay loam | | | |
| pH | 6.8 | 6.4 | | | |
| P (lb/a) | 20 | 25 | | | |
| K (lb/a) | <100 | <100 | | | |
| N (lb/a) | <10 | 10 | | | |
| **Distance to Edge** | | | | | |
| Direction | N | E | S | W | |
| Distance (yds) | ? | 11 | 5 | 13 | |
| Type of Habitat | edge of forest | trail | hill | trail | |
| Distance (m) | ? | 10.09174312 | 4.587155963 | 11.9266055 | |
| **Elevation** | | | | | |
| Feet | 873 | | | | |
| Meters | 266.0903915 | | | | |

**Figure H.** *This table shows several abiotic samples that were cumulated from the oak-hickory forest. All data, except for distance to edge and elevation, were collected twice and the results from both dates are displayed. The "?" signify that no data was able to be collected with a rangefinder because of the density and vastness of the woodland.*

**Figure I** below shows all of the different types of organisms observed in the fen. Of all the organisms, we found 2 bryophyte species, 8 avian species, 77 macroinvertebrate species, 2 mammal species, and 13 plant species. Macroinvertebrates were the most abundant type of organism found.

Oak-Hickory Biodiversity

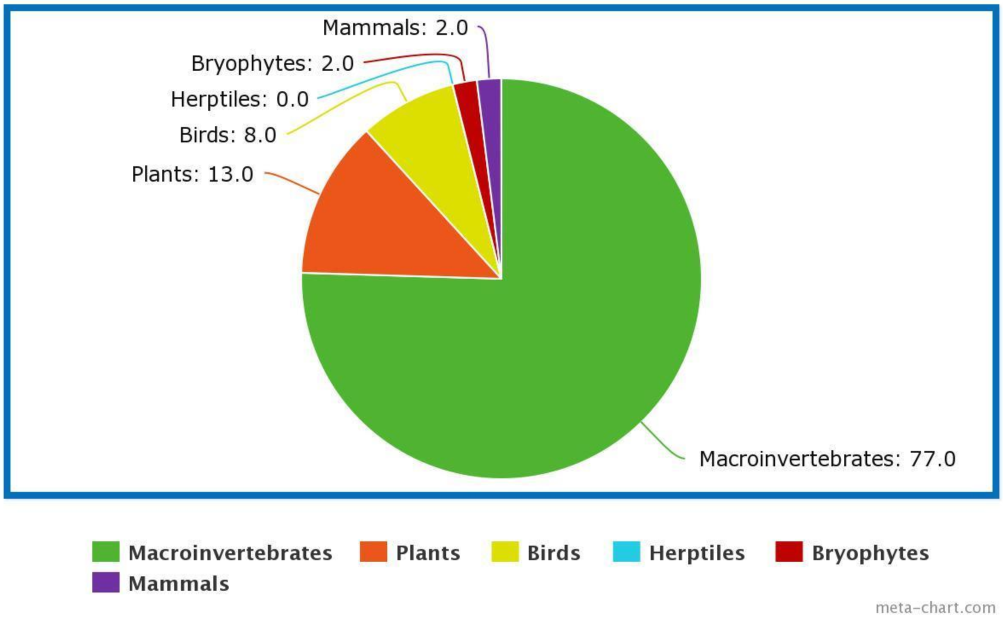



**Figure I.** *This chart compares the amount of each type of organism found in the oak-hickory woodland.*

**SHRUBLAND:**
Using the Simpson Index of Diversity, we calculated the overall biodiversity (1-D) within the shrubland to be 0.9551. We used the Shannon-Weiner's Biodiversity Index and calculated overall biodiversity (H') at this plot to be 3.855. Species richness for this plot was calculated to be 119 species overall (see **Appendix E**).

Unfortunately, no herptiles were observed at this location.
Using the trail camera, only 1 species of mammal was observed. The mammal was a White-tailed Deer (*Odocoileus viginianus)*.

For avian biodiversity, we recorded 12 different species of birds during the two month testing period. Overall, the most abundant bird species observed in the shrubland was the Grey Catbird (*Dumetella carolinensis*). For a list of all the birds found here, please see **Appendix E**. *As in the other three test plots, owl point counts were performed, however testing was outside of the breeding season and no species were observed.*

Macroinvertebrates were collected using five tests in this location. These tests collected flying insects (sweeping), insects dwelling in trees and in forbs (trunk tree traps and beating sheets), ground dwelling insects (pitfall traps), and nocturnal flying insects (light traps). We found a total of 84 different species of macroinvertebrates in this area. The effectiveness of these tests varied, but **Figure C** above shows species richness relating to each test and the other plots as well. The graph shows that the sweeping collected 6 species, beating sheets with 14 species, the pitfall traps with 63 species, and trunk tree traps with 7 species. Unfortunately, the light trap data was not collected because the camera lens could not magnify the macroinvertebrates adequately at night. A list of all invertebrate species observed in this plot can be found in **Appendix E**.

Flora was surveys provided a representation of the shrubland vegetative diversity. Flora types were separated into five categories: herbaceous plants, shrubs, saplings, overstory trees, and bryophytes. A total of 18 species of flora were noted in the shrubland plot. **Figure C** above shows the species richness of each type of flora found in the shrubland. The graph shows that there were 9 herbaceous plant species, 7 shrub species, 2 sapling species, 3 overstory tree species, and 4 bryophyte species.  A list of all flora noted at this location can be found in **Appendix E**.

**Figure J** below shows the abiotic factors that influence the shrubland ecosystem. We collected information for canopy cover, leaf litter, soil chemistry, distance to edge, and elevation. Throughout this entire plot, canopy cover was generally 0%, except for the northeast corner, with 10% coverage between June and July and the center of the plot, which had 100% canopy cover during both June and July. Leaf litter collection remained relatively stable around 13 grams between June and July, with a collection of dead leaves, grasses, and live mosses. In relation to soil chemistry, pH remained slightly acidic (from 6.5 to 6.4) in both June and July. Phosphorous load decreased from 15 lb/acre to 10 lb/acre between June and July. Nitrogen load decreased between June and July, going from 10 lb/acre to less than 10 lb/acre. Potassium load also decreased from 100 lb/acre to less than 100 lb/acre between June and July. In observance of distance to edge, woodland habitat was observed in the north, east and south directions. Trail was observed in the west direction roughly 19 meters away. The elevation of this test plot is about 287 meters.

| Abiotic Factors in Shrubland | | | | | |
|---|---|---|---|---|---|
| **Canopy cover** | | | | | |
| Direction | NE | SE | NW | SW | Center |
| June 12 % | 10 | 0 | 0 | 0 | 100 |
| July 10 % | 10 | 0 | 0 | 0 | 100 |
| **Leaf Litter** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Inital Weight (g) | 21.24 | 27.1 | | | |
| Dry Weight (g) | 13.13 | 12.2 | | | |
| Composition | dead leaves (15%), dead grasses (80%), live mosses (5%) | dead grasses (80%), dead leaves (5%), live grasses (10%), sticks (2%), live leaves (1.5%), live mosses (1.5%) | | | |
| **Soil Chemistry** | | | | | |
| Date | 6/17/2014 | 7/15/2014 | | | |
| Texture/Type | clay loam | clay laom | | | |
| pH | 6.5 | 6.4 | | | |
| P (lb/a) | 15 | 10 | | | |
| K (lb/a) | 100 | <100 | | | |
| N (lb/a) | 10 | <10 | | | |
| **Distance to Edge** | | | | | |
| Direction | N | E | S | W | |
| Distance (yds) | 50 | 42 | 44 | 21 | |
| Type of Habitat | woodland | woodland | woodland | trail | |
| Distance (m) | 45.72013789 | 38.40491583 | 40.23372134 | 19.20245791 | |
| **Elevation** | | | | | |
| Feet | 942 | | | | |
| Meters | 287.1215908 | | | | |

**Figure J.** *This table shows various abiotic samples that were collected from the shrubland ecosystem. All data, except for distance to edge and elevation, were collected twice and data from both dates are displayed.*

**Figure K** below shows all of the different types of organisms observed in the fen. Of all the species, we found 4 bryophyte species, 12 avian species, 1 mammal species, 84 macroinvertebrate species, and 14 plant species. Macroinvertebrates were the most abundant type of organism found.

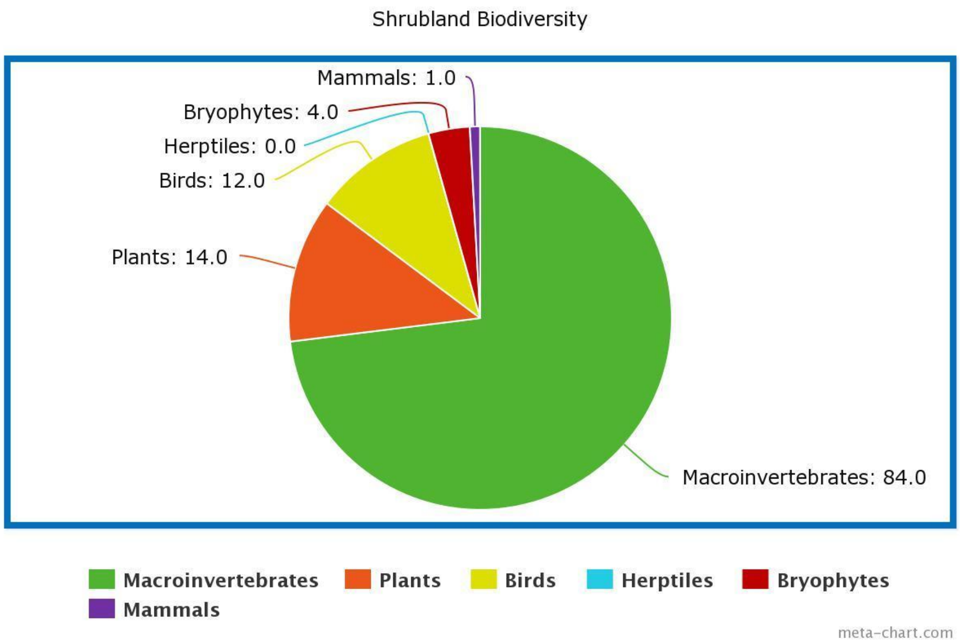



**Figure K.** *This chart compares the amount of each type of organism found in the shrubland.*

In order to get an idea of terrestrial biodiversity on the property, we successfully performed 12 different biotic protocols. This comprehensive collection of data has allowed us to calculate the Simpson Index of Diversity (SID), the Shannon-Weiner Index (SWI), and the Simpson Reciprocal Index (SRI). Below, **Figure L** shows the SWI, **Figure M** shows the SID, and **Figure N** shows SRI for all four plots.

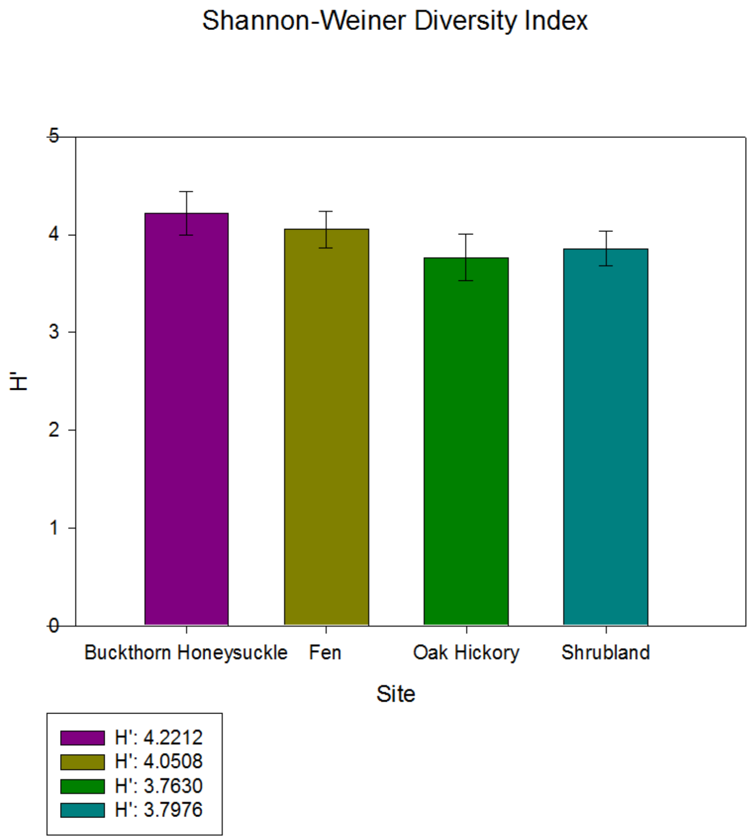



**Figure L.** *The Shannon-Weiner Biodiversity index was calculated for all four plots, and the results are shown above. According to this graph, the buckthorn-honeysuckle thicket displays the most diversity, followed by the fen, the shrubland, and the oak-hickory forest with the least amount of diversity. Bars represent 95% confidence intervals.*

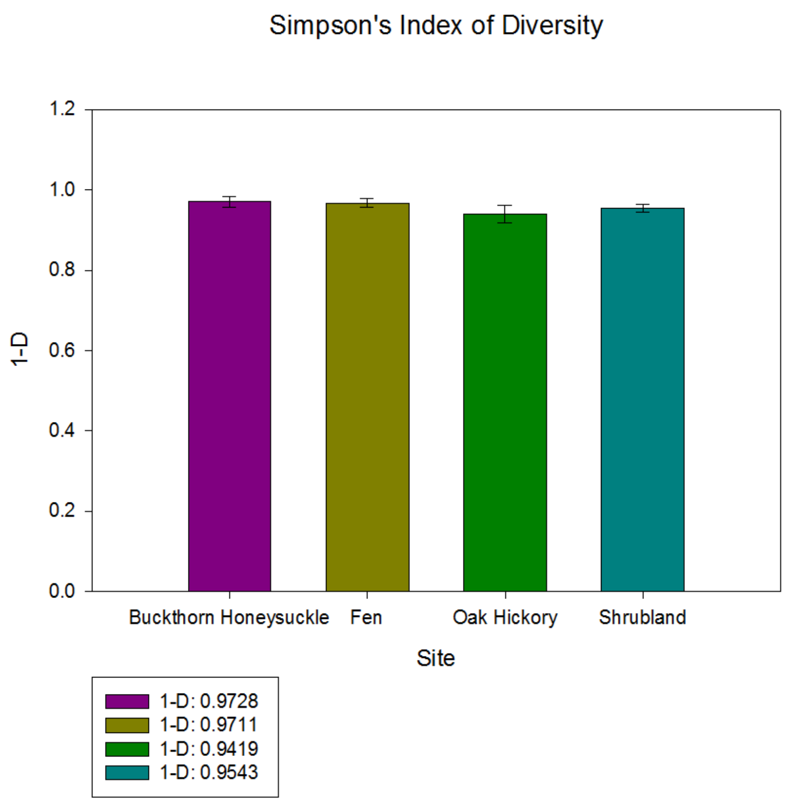



**Figure M.** *The Simpson's Biodiversity Index was calculated on all four plots. This graph shows that the buckthorn-honeysuckle thicket has the most diversity, followed by the fen, then the shrubland, and finally, the oak-hickory. Bars represent 95% confidence intervals.*

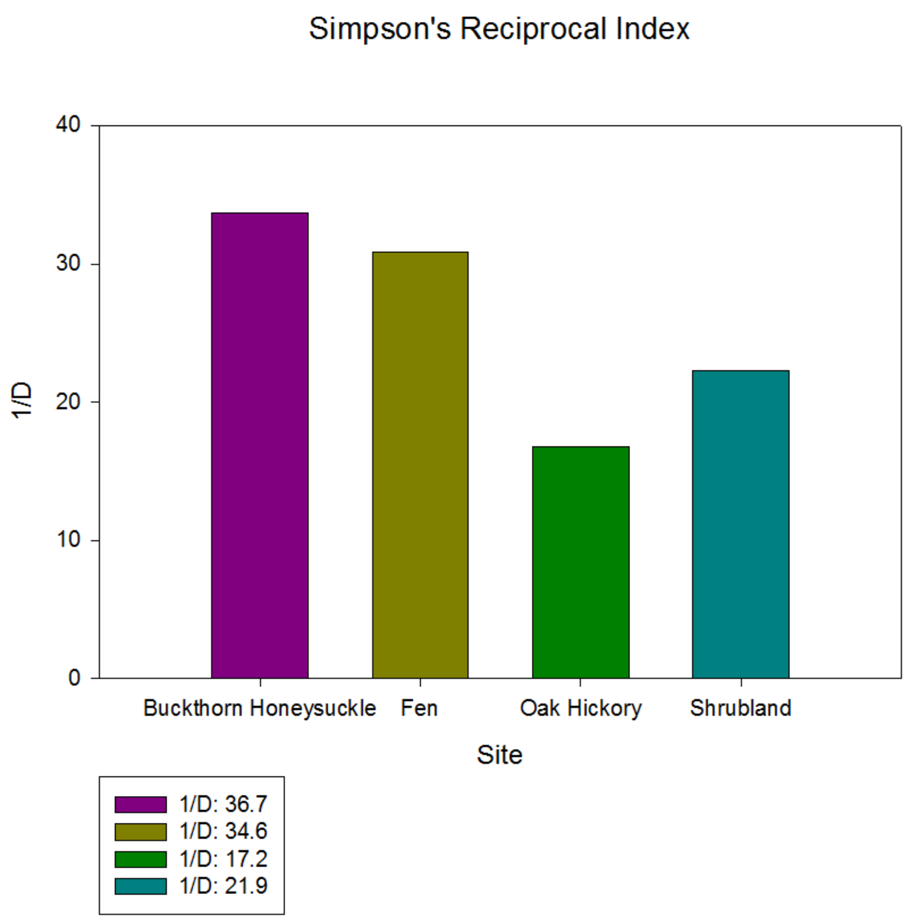



**Figure N.** *The significant differences found for SID are the same for SRI.*

<u>Aquatic Results</u>

**POND 1:**

Many biotic samples were collected to understand the organisms which inhabit the pond. A number of macroinvertebrate specimens were collected and classified as order. Eight different orders were found, including isopoda, amphipoda, diptera, gastropoda, hemiptera, tubificida, coleoptera, and araneae. See **Figure O** for a display of percentages. Overall, the most abundant order of specimens was coleoptera, and the least abundant orders were gastropoda, tubificida, and araneae. In addition, there was a dragonfly and a damselfly observed here: Common Green Darner (*Anax junius*) and Widow Skimmer (*Libellula luctuosa*).

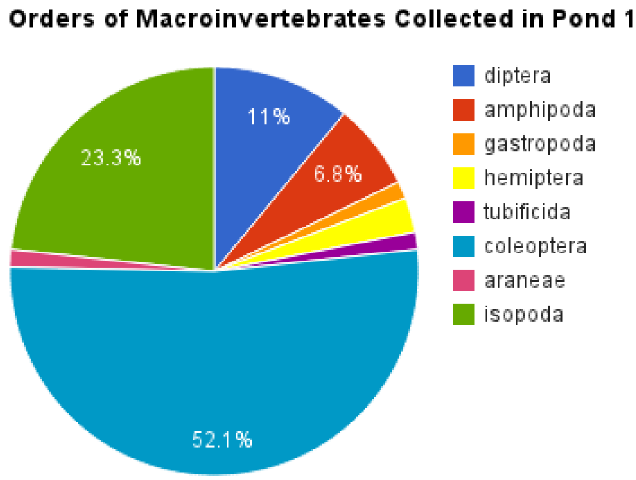
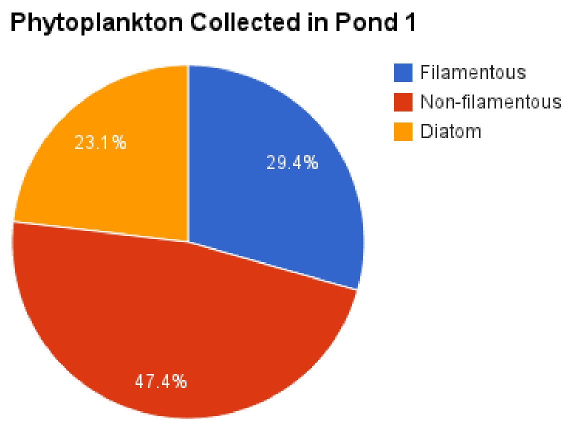



**Figure O.** *This chart represents a comparison of amount of different orders of macroinvertebrates found in the first pond.*

Zooplankton were collected and recorded by order. We classified phytoplankton as either filamentous, non-filamentous, or diatoms. All three were found to be present in Pond 1. The most abundant of these were non-filamentous plankton. Also in the pond, 14 different types of zooplankton were observed. These include heliozoans, ciliates, flagellates, amoebas, copepods, rotifers, roundworms, flatworms, water mites, cladocerans, gastrotrichs, ostracods, isopods, and mosquito larvae. **Figure P** shows a chart of microinvertebrate percentages found in this pond.



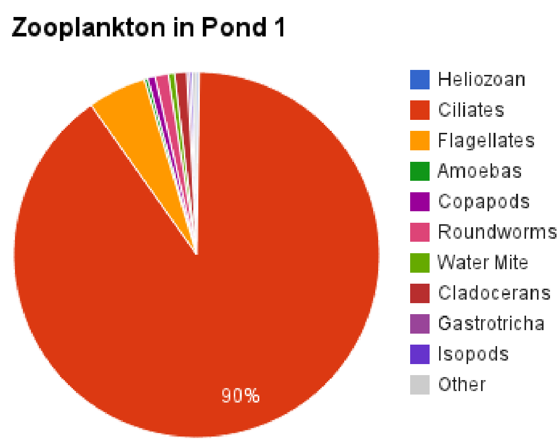




**Figure P.** *The two charts above represent both amounts of phytoplankton and amounts of zooplankton found in Pond 1. The "other" category in the Zooplankton chart includes rotifers, mosquito larvae, ostracods, flatworms.*

Five different types of vegetation were found growing in the pond. These include musk grass (*Chara spp.*), watercress (*Nasturtium officinale*), reed canary grass (*Phalaris arundinacea*), duckweed (Lemnaceae), and spike rush (*Eleocharis spp.*).

Two species of frogs were observed at this location: 18 Western Chorus Frogs (*Pseudacris triseriata*) and 1 American Bullfrog (*Lithobates catesbeianus*).

Two species of birds were observed over the pond: American Robin (*Turdus migratorius*) and American Goldfinch (*Carduelis Tristis*).

The abiotic factors that influence this pond can be found in **Figure Q** below. Data was collected for canopy cover, water chemistry, pond area and volume, depth at center, bank condition, substrate type, and turbidity. Canopy cover was most prominent on the north side of the pond, with 100% cover, while the east, south and west sides had only 35%, 10% and 30% canopy cover respectively. The area of this pond was measured at roughly 578.05 meters squared. The volume of Pond 1 was measured at 215.82 meters cubed, with a center depth of 1.18 meters. Primarily grasses surround the banks of Pond 1. The turbidity measured at 61 centimeters, with pond substrates consisting of algae, branches and grasses. The temperature for Pond 1 was 12.44 degrees Celsius. The pH was 7.04. Dissolved oxygen levels were also fairly prominent in this pond, measured at 12.04 mg/L.

| ***Abiotic Factors in Pond 1*** | | | | | |
|---|---|---|---|---|---|
| **Canopy Cover** | | | | | |
| Direction | N | E | S | W | Center |
| July 19 % | 100 | 35 | 10 | 30 | 0 |
| **Water Chemistry- 7/19/14** | | | | | |
| degrees C | 12.44 | | | | |
| ms/cm^c | 1.592 | | | | |
| Ω*cm | 1860.5 | | | | |
| TDS (g/L) | 0.689 | | | | |
| sal | 0.53 | | | | |
| D.O. (mg/L) | 12.04 | | | | |
| pH | 7.04 | | | | |
| ORP | -69.1 | | | | |
| | | | | | |
| **Pond Area (m^2)** | 578.05 | | | | |
| **Pond Volume (m^3)** | 215.82 | | | | |
| **Depth @ Center (m)** | 1.18 | | | | |
| **Bank Condition** | grasses | | | | |
| **Substrates** | algaes, branches, grasses | | | | |
| **Turbidity (cm)** | 61 | | | | |

**Figure Q.** *This table shows data collected for various abiotic tests that were performed for Pond 1. The water chemistry data was taken three times and the average value is displayed above.*

**POND 2:**

Many biotic samples were collected to understand the organisms which inhabit the pond. A number of macroinvertebrate specimens were collected and classified as order. Four different orders were found, including amphipoda, diptera, hemiptera, and coleoptera. See **Figure R** for a display of percentages. Overall, the most abundant order of specimens belonged to hemiptera. The least abundant order was amphipoda. In addition, there was one dragonfly and two damselflies observed here: Common Green Darner (*Anax junius*), Familiar Bluet (*Enallagma civile*), and Widow Skimmer (*Libellula luctuosa*).

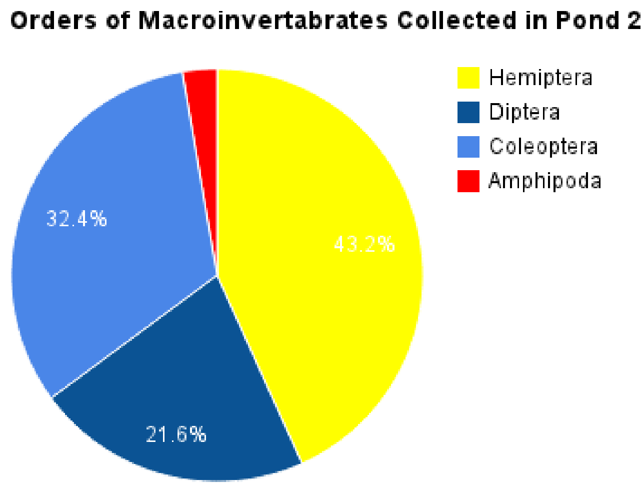



**Figure R.** *This chart represents a comparison of amount of different orders of macroinvertebrates found in the second pond.*

Zooplankton and phytoplankton were collected and recorded by order. We classified phytoplankton as either filamentous, non-filamentous, or diatoms. All three were present in Pond 2. The most abundant phytoplankton in this pond were non-filamentous algae. Also in the pond, 14 types of zooplankton were observed. These types of plankton include water mites, roundworms, flatworms, cladocerans, copepods, mosquito larvae, ciliates, heliozoans, flagellates, amoebas, rotifers, hydras, tardigrades, and gastrotrichs. **Figure S** shows charts of microinvertebrate percentages found in this pond.

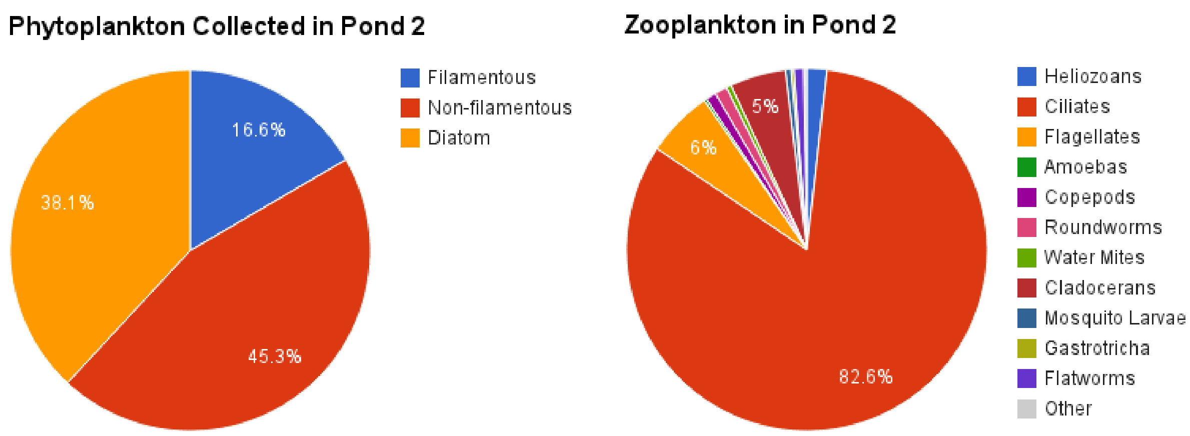



**Figure S.** *This chart represents a comparison of amount of different macroinvertebrates found in the second pond. The "other" category in the Zooplankton chart includes tardigrades, rotifers, and hydra.*

Two different types of vegetation were growing in the water. These include musk grass (*Chara spp/*) and Joe-Pie Weed (*Eutrochium purpureum*).

Only one species of frog was observed at this location: 2 Western Chorus Frogs (*Pseudacris triseriata*).

Two species of birds were observed over the pond: Green Heron (*Butorides virescens*) and American Goldfinch (*Carduelis tristis*).

The abiotic factors that influence this pond can be found in **Figure T** below. Data was collected for canopy cover, water chemistry, pond area and volume, depth at center, bank condition, substrate type, and turbidity. General observations were also recorded for this pond. Canopy cover was most prominent on the west, east and north sides of the pond, with 90%, 85% and 80% cover, respectively. Meanwhile the south end of the pond had 0% canopy cover. The area of this pond was measured at roughly 722.25 meters squared. The volume of Pond 2 was measured at 600.5 meters cubed, with a center depth of 2.4 meters. Primarily grasses and forbes surround the banks of Pond 2. The turbidity measured at 70 centimeters, with pond substrates consisting of algae and branches. The temperature of Pond 2 was 12.9 degrees Celsius. The pH was 7.43. It was also observed that this pond's water flow was stagnant, with a sudsy film present along the surface of the pond. Dissolved oxygen was slightly lower in Pond 2, with a measurement of 7.66 mg/L.

| Abiotic Factors in Pond 2 | | | | | |
|---|---|---|---|---|---|
| **Canopy Cover** | | | | | |
| Direction | N | E | S | W | Center |
| July 19 % | 80 | 85 | 0 | 90 | 0 |
| **Water Chemistry- 7/19/14** | | | | | |
| degrees C | 12.9 | | | | |
| ms/cm^c | 1.22 | | | | |
| Ω*cm | 1070.7 | | | | |
| TDS (g/L) | 0.791 | | | | |
| sal | 0.61 | | | | |
| D.O. (mg/L) | 7.66 | | | | |
| pH | 7.43 | | | | |
| ORP | -55.73 | | | | |
| | | | | | |
| **Pond Area (m^2)** | 722.25 | | | | |
| **Pond Volume (m^3)** | 600.5 | | | | |
| **Depth @ Center (m)** | 2.4 | | | | |
| **Bank Condition** | grasses, forbes | | | | |
| **Substrates** | algae, branches | | | | |
| **Turbidity (cm)** | 70 | | | | |
| **General Observations** | Pond flow is stagnant; sudsy film present along the surface of the pond | | | | |

**Figure T.** *This table shows data collected for various abiotic tests that were performed for Pond 2. The water chemistry data was taken three times and the average value is displayed above.*

**POND 3:**

Biotic samples were collected to learn about the organisms which inhabit the pond. A number of macroinvertebrate specimens were collected and classified by order. Nine different orders were found, including isopoda, amphipoda, diptera, hemiptera, coleoptera, basommatophora, hymenoptera, odonata, and unionoida. See **Figure U** for a display of percentages of each. Overall, the most abundant order of specimens was basommatophora, and the least abundant orders were diptera and odonata. In addition, there was one dragonfly and two damselflies observed here: Common Green Darner (*Anax junius*) and Widow Skimmer (*Libellula luctuosa*) and Familiar Bluet (*Enallagma civile)*.

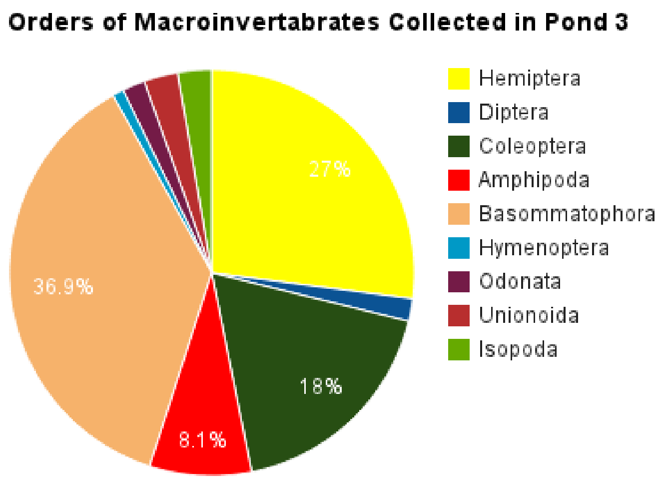
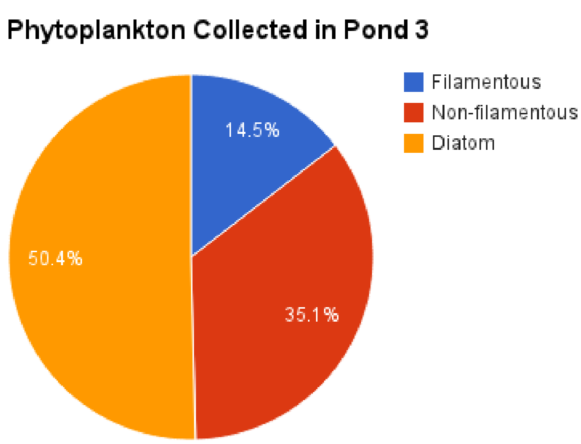



**Figure U.** *This chart represents a comparison of amount of different orders of macroinvertebrates found in the third pond.*

Zooplankton and phytoplankton were collected and recorded by order. We classified phytoplankton as either filamentous, non-filamentous, or diatoms. All three were present in Pond 1. The most abundant phytoplankton type were diatoms in this pond. Also in the pond, 16 different types of zooplankton were observed. These types of plankton include ciliates, heliozoans, flagellates, amoebas, copepods, rotifers, roundworms, water mites, cladocerans, flatworms, mosquito larvae, ostracods, gastrotrichs, tardigrades, oligochaetes, and caddisfly larvae. **Figure V** shows a chart of microinvertebrate percentages found in this pond.



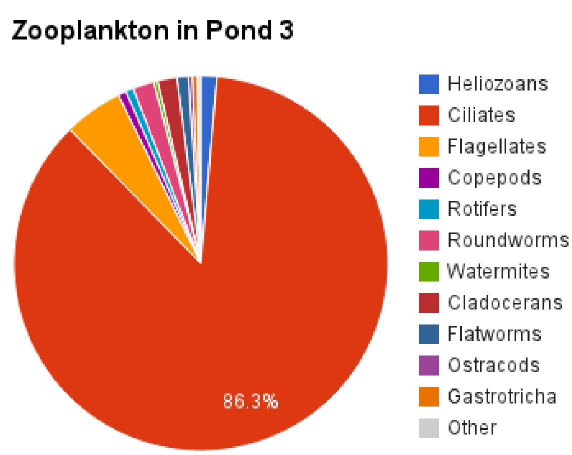




**Figure V.** *This chart represents a comparison of amount of different macroinvertebrates found in the third pond. The "other" in the Zooplankton chart category includes amoebas, mosquito larvae, tardigrades, oligochaetes, and caddisfly larvae.*

Nine types of vegetation were found to be growing in the water. These include musk grass (*Chara spp.*) , watercress (*Nasturtium officinale*), reed canary grass (*Phalaris arundinacea*), Narrowleaf Cattail (*Typha angustifolia*), Willow Herb (*Epilobium spp.*), Deadly Nightshade

(*Atropa belladonna*), duckweed (Lemnaceae), Joe-Pie Weed (*Eutrochium purpureum*), and spike rush (*Eleocharis spp.*).

One species of frog was observed at this location: 8 Western Chorus Frogs (*Pseudacris triseriata*).

Two species of birds were observed over the pond: Green Heron (*Butorides virescens*) and American Goldfinch (*Carduelis Tristis*). This is the same Green Heron that inhabits Pond 2.

The abiotic factors that influence this pond can be found in **Figure W** below. Data was collected for canopy cover, water chemistry, pond area and volume, depth at center, bank condition, substrate type, and turbidity. General observations were also include in the description of this pond. Canopy cover was generally low at Pond 3, but was most prominent on the west side of the pond, with 50% canopy cover. Meanwhile the south, east, and north sides of the pond had 40%, 20% and 20% canopy cover, respectively. The area of this pond was measured at roughly 2257.52 meters squared. The volume of Pond 3 was measured at 1042.22 meters cubed, with a center depth of 1.65 meters. Primarily grasses and forbs surround the banks of Pond 3. The turbidity measured at 1.04 centimeters, with pond substrates consisting of algae and branches. The temperature of Pond 3 was 14.15 degrees Celsius. The pH was 7.75. It was also observed that a small amount of sudsy film was seen on the pond surface - although less than Pond 2 - despite slightly higher pond flow. Dissolved oxygen was also slightly higher than in Pond 2, with a measurement of 12.08 mg/L.

| Abiotic Factors in Pond 3 | | | | | |
|---|---|---|---|---|---|
| Canopy Cover | | | | | |
| Direction | N | E | S | W | Center |
| July 19 % | 20 | 20 | 40 | 50 | 0 |
| Water Chemistry- 7/19/14 | | | | | |
| degrees C | 14.15 | | | | |
| ms/cm^c | 1.19 | | | | |
| Ω*cm | 1053.2 | | | | |
| TDS (g/L) | 0.779 | | | | |
| sal | 0.6 | | | | |
| D.O. (mg/L) | 12.08 | | | | |
| pH | 7.75 | | | | |
| ORP | -54.3 | | | | |
| | | | | | |
| **Pond Area (m^2)** | 2257.52 | | | | |
| **Pond Volume (m^3)** | 1042.22 | | | | |
| **Depth @ Center (m)** | 1.65 | | | | |
| **Bank Condition** | grasses, forbes | | | | |
| **Substrates** | algae, branches | | | | |
| **Turbidity (cm)** | 1.04 | | | | |
| **General Observations** | Slow water flow, some sudsy film on surface- less than Pond 2 | | | | |

**Figure W.** *This table shows data collected for various abiotic tests that were performed for Pond 3. The water chemistry data was taken three times and the average value is displayed above.*

Using the Simpson Index of Diversity, we calculated the overall biodiversity (1-D) within the first pond to be 0.521. Simpson's Reciprocal Index was calculated to be 1.919. We used the Shannon-Weiner's Biodiversity Index and calculated overall biodiversity (H') at this pond to be 1.229. Species richness for Pond 1 was calculated to be 34 species overall (see **Appendix F**).

We calculated the overall biodiversity (1-D) within the second pond to be 0.5829. Simpson's Reciprocal Index was calculated to by 1.7156. We used the Shannon-Weiner's Biodiversity Index and calculated overall biodiversity (H') at this pond to be 1.408. Species richness for Pond 2 was calculated to be 26 species overall (see **Appendix G**).

Finally, we calculated the overall biodiversity (1-D) within the third pond to be 066049. Simpson's Reciprocal Index was calculated to be 1.6532. We used the Shannon-Weiner's Biodiversity Index and calculated overall biodiversity (H') at this pond to be 1.463. Species richness for Pond 3 was calculated to be 40 species (see **Appendix H**).

All of these results can be seen in the figure below, **Figure X.** In addition, the species richness for each pond is displayed in **Figure Y**, with Pond 3 having the greatest richness.

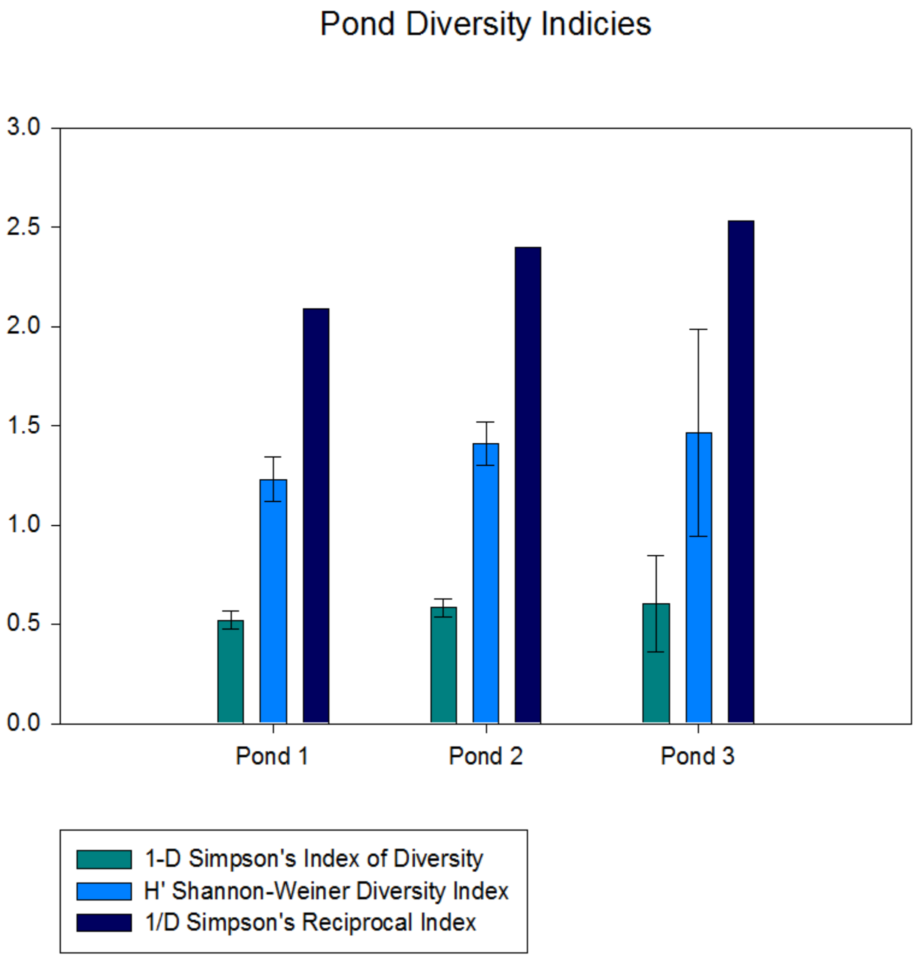



**Figure X.** *The above figure shows the three statistical tests performed on the data from all three ponds. Bars represent 95% confidence intervals.*

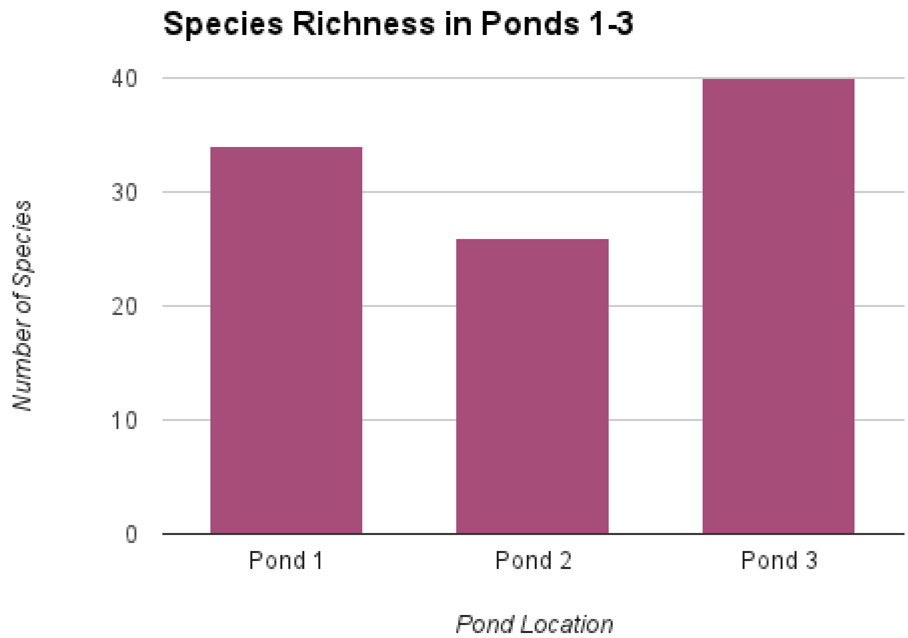



**Figure Y.** *This graphs shows that Pond 3 had the highest number of species, followed by Pond 1, and lastly Pond 2.*

**Discussion:**

Terrestrial Biodiversity

The SID shows us the probability that two individuals randomly selected from a sample will belong to different species. T-Tests were run to determine if diversity was significantly different between plots (T-Test p values can be found in **Appendix I**). Results have shown that the oak-hickory plot is significantly less diverse than the buckthorn-honeysuckle and fen according to both SWI and SID. The oak-hickory plot is less diverse than the shrubland, according to the SID. The T-Test for the SWI did not determine a significant difference for the shrubland and the oak-hickory.

T-Tests show that the fen plot is more diverse than the shrubland according to both SWI and SID. However, there were no significant differences in diversity between the buckthorn-honeysuckle and fen.

In addition, the shrubland is less diverse than the buckthorn-honeysuckle according to both the SID and SWI statistical analysis.

The SRI is essentially a magnification of SID, so the significant differences found for SID are the same for SRI.

The oak-hickory results were somewhat surprising but we believe that the plot within the oak-hickory forest was less diverse than the buckthorn-honeysuckle, shrubland and fen plots due to a lack of forest structural complexity. We believe that structurally diverse and well-developed forest habitats consisting of dense understory, midstory and canopy strata generally harbor more species than forests with simple structure. A forest with habitat complexity provides more niches and different types of nesting and foraging resources for more species (MacArthur and MacArthur 1961). In the oak-hickory test plot, a low number of plant species were observed, with many of the species present found to be invasive. This forest stand was also not very structurally diverse, with only canopy and understory layers observed. The combination of a lack of structural complexity and native plant species diversity is the likely cause of the plot's low diversity compared to the other three ecosystems tested.

The difference in diversity in the oak-hickory and shrubland may or may not be significant because of conflicting T-Test results from SID and SWI. This leads us to infer that the difference in diversity between these two plots is less than the difference in diversity between any other two plots.

We think the fen is more diverse than the shrubland because of the disturbance of intermittent flooding in the fen. This hydrologic disturbance may increase herbaceous plant diversity, which might lead to increased overall diversity. In contrast, the only disturbance to the shrubland is precipitation. In addition, the fen may be significantly more diverse than we calculated because we could not sample ground-dwelling invertebrates with pitfall traps because of the wet environment in the fen. In addition, habitats in the presence of water tend to have higher biodiversity than dry habitats.

It is possible that the buckthorn-honeysuckle is more diverse than the shrubland because of the structural diversity created by the high species richness of herbaceous plants, the sapling canopy created by the buckthorn and honeysuckle, as well as the presence of overstory trees. Since the buckthorn-honeysuckle area used to be a wetland, the hydrology and soil condition differs greatly from the shrubland and may promote higher biodiversity. In addition, the distance to edge for this plot was only 3 m from a different habitat, thus suggesting an edge effect and therefore a potential for higher biodiversity.

For abiotic factors, there was a significant change in pH from the dates tested. The pH decreased for each plot on the second date that it was sampled. This is because we changed testing kits for the second date. It was noted that the soil chemistry kit that we had originally been using LaMotte Soil Testing Kit (Code 5928) was not reliable and therefore we used the hand soil tester in the field (Kelway Soil Tester). The results for the buckthorn-honeysuckle plot and the fen changed significantly because the peat that exists as soil did not settle when we did the original soil test. The most reliable data is the results from July 15 in which we used the Kelway Soil Tester. Unfortunately, in addition to not being able to use the pH results from the LaMotte Soil Testing Kit (Code 5928), we do not believe the phosphorous (lb/a), potassium (lb/a) or nitrogen (lb/a) to be significant or reliable for each of the four terrestrial plots.

Using the most reliable pH data collected July 15th, the buckthorn-honeysuckle and fen plots have the lowest pH observed, as expected. The plot that was chosen within the buckthorn ecosystem used to be a portion of the calcareous fen prior to invasion. The buckthorn plot and the fen had lower pH (6 and 5.8 respectively) than the oak hickory and shrubland plots (both 6.4). Fens tend to be low in pH naturally, thus these results were expected.

There was also a change in the dissolved oxygen (DO) levels in the fen on the two dates that samples were taken. This is most likely because the water levels in the fen differ daily because of amount of precipitation. On June 19, the DO level was higher because there was more water (more precipitation). On July 11, the DO level was lower because there was less precipitation during that time period.

Across all four test plots, flora richness had a positive correlation with increasing leaf litter percent composition, with the exception of the shrubland plot. This plot demonstrated an anomaly of containing the highest species richness of all four test plots, despite also containing the lowest leaf litter composition. The general trend of higher species richness with higher leaf litter composition was expected across the four plots because more leaf litter contributes to more organic matter and nutrient availability in the soil. This then allows for more plant species which require a variety of nutrients and/or high-moderate nutrient amounts to survive successfully in a given habitat.

<u>Aquatic Biodiversity</u>
In order to understand biodiversity across the three ponds, 7 different biotic tests were carried out. From the data collected, the Simpson Index of Diversity (SID) and the Shannon-Weiner Biodiversity Index (SWI) were able to be calculated. **Figure X** shows these results, including the Simpson Reciprocal Index (SRI). **Figure Y** shows the species richness of all three ponds. Results showed that Pond 2 has less species than Pond 1, but Figure X illustrates that Pond 2 is more diverse than Pond 1. This may be due to the relative even distribution of species abundance numbers in Pond 2 versus, the huge abundance of one or two species in Pond 1.

According to T-Tests performed on the data, Pond 1 data was significantly less diverse than Pond 2 for both SWI and SID (T-Test p values can be found in **Appendix I**). However, there was no significant difference in data between Pond 1 and Pond 3 for both SWI and SID. A T-Test shows that Pond 2 data is significantly less diverse than Pond 3 for both SWI and SID as well. Again, the SRI is essentially a magnification of SID, so the significant differences found for SID are the same for SRI.

We believe that the reason Pond 1 is less diverse than Pond 2 is because Pond 1 is where water first enters the ecosystem from groundwater. Hence, the water lacks nutrients, which the subsequent ponds gain as photosynthesis and nitrogen fixation take place as the water moves through. This also may explain why we found more diversity in Pond 3 compared to Pond 2. (See diversity indices in **Figure X**).

There is an interesting result in for pH changes throughout the ponds that warrants discussion. We would expect to see that the pH decreases as the water flows from Pond 1 to Pond 3. We expect this because the water that flows into Pond 1 is from a calcareous fen, which are often neutral or alkaline. As the water flows, we expect the pH to become more acidic. Instead we see that the ponds become more basic. There may be a few explanations for this result. To obtain the values, the YSI tool was used at three samples were taken on one date and the numbers were averaged. More repetition of this method, especially on different dates, would have provided for more reliable results. In addition, the depth of the ponds increases from Pond 1 to Pond 3, and the pH was tested at the very bottom of the ponds. pH could be higher at greater depths for these ponds. However, we believe that simply more repetition at different areas of the ponds would provide significantly more reliable results.

There were correlations between pond biodiversity and present abiotic factors. First of all, as the volume of each pond increased, more biodiversity was observed. This was expected because higher volume suggests more potential habitat and specific niches for organisms to inhabit. Secondly, there tended to be more canopy cover (and thus less light) surrounding Ponds 1 & 2 compared to Pond 3. This was also expected because less canopy cover would allow for more photosynthetic organisms to thrive and in turn would promote more viable habitat for consumers. Thirdly, temperature increased as biodiversity increased. This was also expected because of the amount of light that penetrates each pond. Finally, total dissolved solids (TDS) showed a general increase across each pond. The amount of organic matter and biota increases with the ponds as the water travels from 1 to 3, so we expected to see an increase of TDS.

**Conclusion:** The above multi-taxon data coupled with abiotic measurements provides a description of the species assemblages and the community structure of the four ecosystem types chosen at the Loyola University Retreat and Ecology Campus using specific standardized protocols. Many resident organisms were excluded by the specific sampling protocols used. For instance, residence of smaller microhabitats or nocturnal species of bats and flying insects were missed. Nevertheless, we have provided necessary baseline data that hopefully future researchers and LUREC land managers can use alone or with other regional datasets to detect changes either due to 1) alterations from restoration activities or 2) climate change. We also hope that this research may be useful for predicting future trends as well.

**Acknowledgements:** Special thanks are extended to Dr. Roberta Lammers-Campbell for her assistance in plant identification and various textual resources. Thanks to David Treering for access to ArcGIS for our project. Thanks to Erin O'Connell for assistance with avian identification in the field. In particular, thanks to the wonderful staff at LUREC. Financial support was provided as a biodiversity internship by the Institute of Environmental Sustainability, Loyola University Chicago, and a grant from the Northern Trust.

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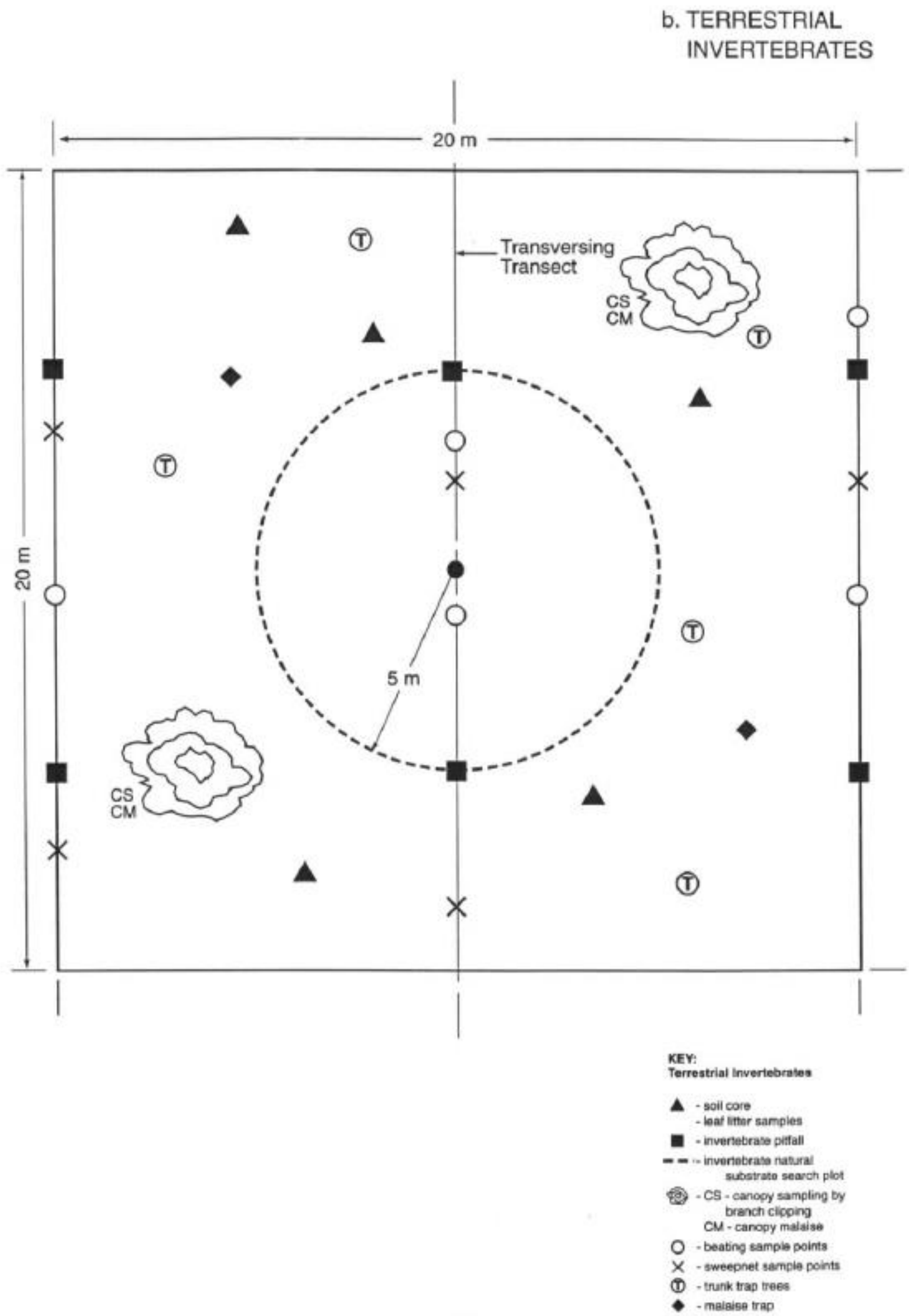
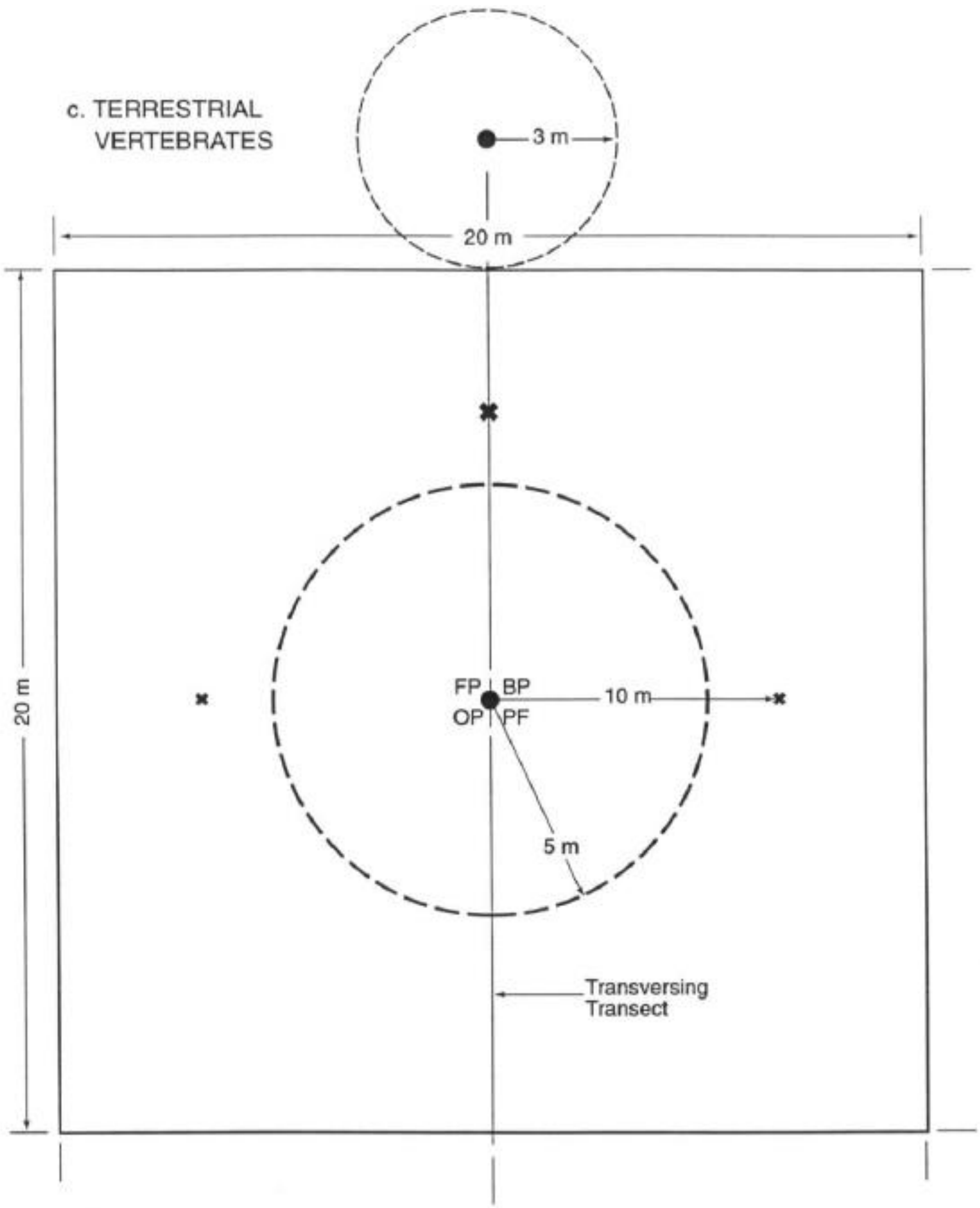
**Table of Contents: Appendices**

**Appendix A.** The following are mylar overlays of biodiversity profile plot design for sampling protocols for terrestrial invertebrates, vertebrates, and plants (Mahan 1998).

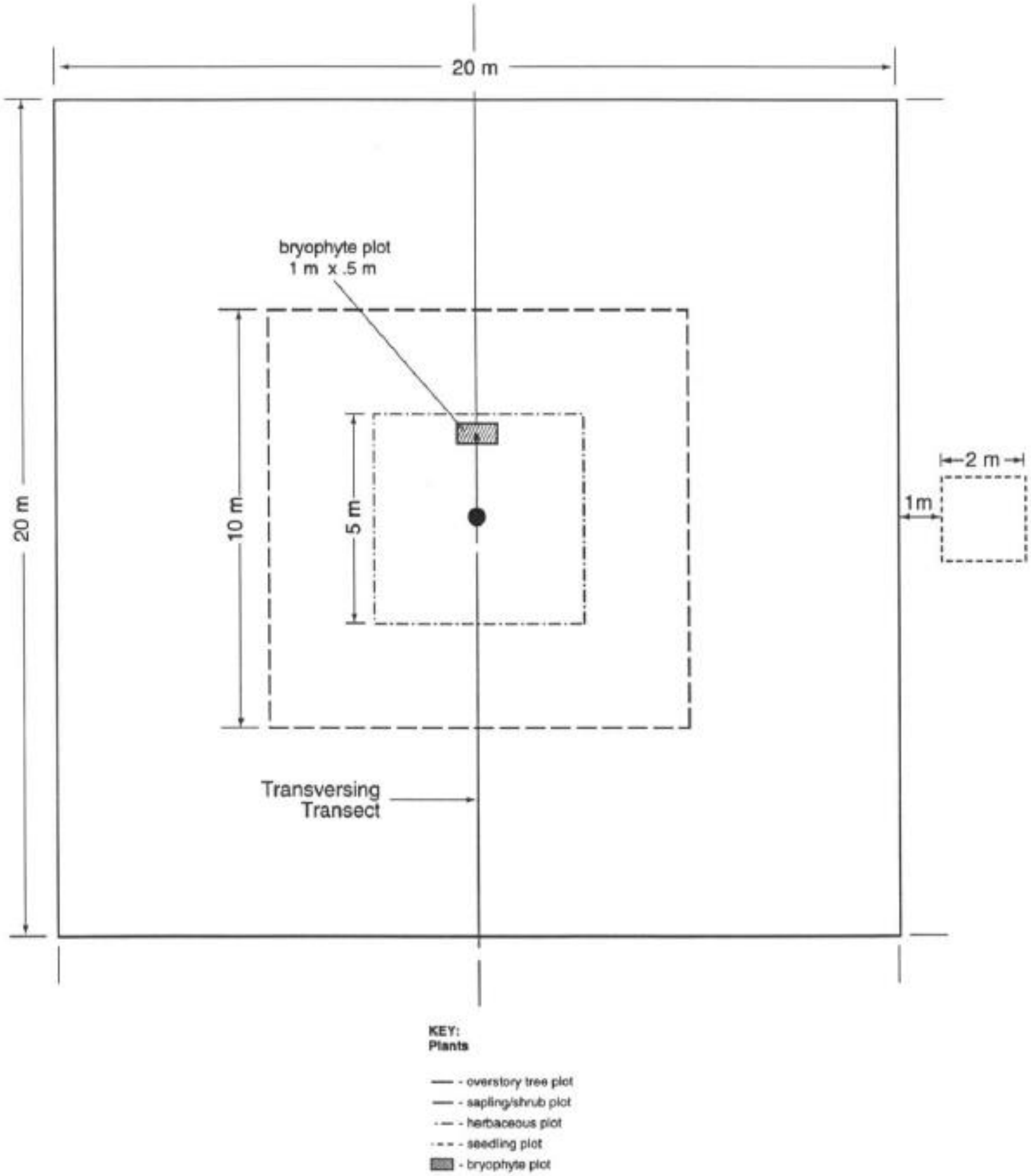





**KEY:**
**Terrestrial Vertebrates**

- ● OP - owl point
- ● PF - 1 gallon pitfall trap
- ● FP - tree frong point
- ● BP - bird point
- ▪ - small livetrap for mammals
- ✖ - large livetrap for mammals
- – — - deer pellet plot
- —— - amphibian natural substrate search plot

a. PLANTS


20 m
20 m
bryophyte plot
1 m x .5 m
10 m
5 m
2 m
1m
Transversing
Transect
KEY:
Plants
- overstory tree plot
- sapling/shrub plot
- herbaceous plot
- seedling plot
- bryophyte plot

**Appendix B.** The following table shows a list of all species found in the fen. If genus and species could not be identified, the organism was identified to family.

| Fen Species List | |
|---|---|
| Macroinvertebrates | |
| Common Name | Genus Species |
| Ant | Formicidae |
| Ant Mimic Spider | Castianeira longipalpis |
| Aphid | Aphididae |
| Black Fly | Simuliidae |
| Blunt-nosed Weevil | Curculionidae |
| Bostrichid Beetle | Bostrichidae |
| Brushfooted Butterfly | Nymphalidae |
| Chafers Beetle | Dichelonys spp. |
| Conifer Sawfly | Diprionidae |
| Crab Spider | Thomisidae |
| Cricket | Orthoptera |
| Daggerfly | Empididae |
| Darkling Beetle | Tenebrionidae |
| Dick Beetle | Elateridae |
| Green Stink Bug | Acrosternum hilare |
| Ground Spider | Gnaphosidae |
| Katydid | Tettigoniidae |
| Leaf Beetle | Chrysomelidae |
| Leafhopper | Cicadellidae |
| Longjawed Orbweaver | Tetragnatha spp. |
| Longlegged Fly | Dolichopodidae |
| Midge | Chironomidae |
| Mosquito | Culicidae spp. |
| Moth Fly | Psychodidae |
| Orb Weaver | Theridion spp. |
| Orb Weaver | Araneidae |
| Phantom Crane Fly | Ptychopteridae spp. |
| Planthopper | Fulgoroidae |
| Rove Beetle | Staphylinidae |
| Shorthorned Grasshopper | Acrididae |

| | |
|---|---|
| Snail | Gastropoda |
| Soldier Beetle | Cantharidae |
| Spotted Lady Beetle | Coleomegilla maculata |
| Stone Fly | Perlidae |
| Tachinid Fly | Tachinidae |
| Tethinid fly | Tethinidae spp. |
| Treehopper | Membracidae |
| Flora | |
| Common Name | Genus Species |
| Alleghany Bushy Moss | *Thamnobryum alleghaniese* |
| Arrowleaf | *Xanthosoma sagittifolium* |
| Bidens Beggar's Ticks | *Bidens frondosa* |
| Cattail | *Typha x glauca* |
| Common Elderberry | *Sambucus canadensis* |
| Duckweed | *Lemna minor* |
| Kentucky Bluegrass | *Poa pratensis* |
| Nightshade | *Circaea lutetiana* |
| Orange Jewelweed | *Impatiens capensis* |
| Red Bullrush | *Scirpus pendulus* |
| Reed Canary Grass | *Phalaris arundinacea* |
| Rice Cut Grass | *Leersia oryzoides* |
| Touching Star Moss | *Tortula ruralis* |
| Virginia knotweed | *Polygonum virginianum* |
| Avian Species | |
| Common Name | Genus Species |
| American Goldfinch | *Carduelis tristis* |
| American Robin | *Turdus migratorius* |
| Black capped chickadee | *Poecile atricapillus* |
| Blue Jay | *Cyanocitta cristata* |
| Brown Headed Cowbird | *Molothrus ater* |
| Cedar Waxwing | *Bombycilla cedrorum* |
| Chipping Sparrow | *Spizella passerina* |

| | |
|---|---|
| Common Yellowthroat | *Geothlypis trichas* |
| Grey Catbird | *Dumetella carolinensis* |
| Mourning Dove | *Zenaida macroura* |
| Northern Cardinal | *Cardinalis cardinalis* |
| Northern Wood Thrush | *Hylocichla mustelina* |
| Red-Winged Blackbird | *Agelaius phoeniceus* |
| Song Sparrow | *Melospiza melodia* |
| Tree Swallow | *Tachycineta bicolor* |
| Herptiles | |
| Common Name | Genus Species |
| American Toad | *Anaxyrus americanus* |
| Eastern Milk Snake | *Lampropeltis triangulum triangulum* |
| Plains Leopard Frog | *Plains Leopard Frog* |
| Western Chorus Frog | *Pseudacris triseriata* |

**Appendix C.** The following table shows a list of all species found in the buckthorn-honeysuckle. If genus and species could not be identified, the organism was identified to family.

| Buckthorn-Honeysuckle Species List | |
|---|---|
| Macroinvertebrates | |
| Common Name | Genus Species |
| Ant | Formicidae |
| Ant | *Lasius spp.* |
| Argid Sawfly | Argidae |
| Assassin Bug | Reduviidae |
| Black Carpenter Ant | *Camponotus pennsylvanicus* |
| Chafers Beetle | *Dichelonys spp.* |
| Clown Beetle | Histeridae |
| Cobweb Spider | Theridiidae |
| Common Earwig | Forficulidae |
| Common Sawfly | Tenthredinidae |
| Conifer Sawfly | Diprionidae |
| Crane Fly | Tipulidae |
| Darkling Beetle | Tenebrionidae |
| Earth-boring Dung Beetle | Geotrupidae |
| Elongate-bodied Springtail | Entomobryidae |
| Fire Ant | Solenopsis |
| Flower Fly | Syrphidae |
| Grey Garden Slug | Agriolimacidae |
| Ground Crab Spider | Thomisidae |
| Harvest Mite | Trombiculidae |
| Harvestman | Opiliones |
| Jumping Spider | Salticidae |
| Lady Beetle Larvae | Coccinelidae |
| Leaf-rolling Cricket | Gryllidae |
| Leafhopper | Cicadellidae |
| Lightning Bug | Lampyridae |
| Mayfly | Ephemeroptera |
| Membrane Winged Insect | Hymenoptera |
| Midge | Chironomidae |
| Millipede | Diplopoda |

| | |
|---|---|
| Mosquito | Culicidae |
| Nursery Web Spider | Pisauridae |
| Orb Weaver | Araneidae |
| Phantom Crane Fly | Ptychopteridae |
| Pillbug | Armadillidiidae |
| Pole-borer Beetle | *Neandra spp.* |
| Prowling Spider | Miturgidae |
| Robberfly | Asilidae |
| Rove Beetle | Staphylinidae |
| Skipper | Hesperiidae |
| Soldier Beetle | *Podabrus spp.* |
| Soldier Fly | Stratiomyidae |
| Sowbug | Oniscidae |
| Spittlebug | Cercopidae |
| Tooth-nosed Snout Weevil | Haplorhychites spp. |
| Treehopper | Membracidae |
| True Weevil | Curculionidae |
| Vinegar Fly | Drosophilidae |
| Water Boatman Nymph | Notonectidae |
| Willow Sawfuly | *Nematus ventralis* |
| Wolf Spider | Lycosidae |
| Flora | |
| Common Name | Genus Species |
| Alegghany Bushy Moss | *Thamnobryum alleghaniese* |
| Quaking Aspen | *Populus tremuloides* |
| Black Birch | *Betula nigra* |
| Box Elder | *Acer negundo* |
| Glossy Buckthorn | *Rhamnus frangula* |
| Common Cottonwood | *Populus deltoides* |
| Enchanter's Nightshade | *Circaea lutetiana* |
| White Snakeroot | Eupatorium Rugosum |
| Garlic Mustard | *Alliaria petiolata* |
| Giant Ragweed | *Ambrosia trifida* |

| | |
|---|---|
| Honeysuckle | *Lonicera maackii* |
| Oriental Bittersweet | *Celastrus orbiculatus* |
| Virginia knotweed | *Polygonum virginianum* |
| Stinging Nettle | *Urtica dioica* |
| Sugar Maple | *Acer saccharum* |
| White Mulberry | *Morus alba* |
| Woodsy Mnium Moss | *Mnium spp.* |
| Jack in the pulpit | *Arisaema triphyllum* |
| Orange Jewelweed | *Impatiens capensis* |
| Sweet Cecily | *Myrrhis odorata* |
| Avian Species | |
| Common Name | Genus Species |
| American Goldfinch | *Carduelis tristis* |
| American Robin | *Turdus migratorius* |
| Black-capped chickadee | *Poecile atricapillus* |
| Common Yellowthroat | *Geothlypis trichas* |
| Eastern Wood Pewee | *Contopus virens* |
| Grey Catbird | *Dumetella carolinensis* |
| Mourning Dove | *Zenaida macroura* |
| Northern Cardinal | *Cardinalis cardinalis* |
| Northern Flicker | *Colaptes auratus* |
| Northern Woodthrush | *Hylocichla mustelina* |
| Nuthatch | *Sitta carolinensis* |
| Red-Bellied Woodpecker | *Melanerpes carolinus* |
| Herptiles | |
| Common Name | Genus Species |
| American Toad | Anaxyrus americanus |
| Northern Leopard Frog | Lithobates pipiens |
| Mammals | |
| Common Name | Genus Species |
| Eastern Chipmunk | *Tamias striatus* |
| Eastern Cottontail | *Sylvilagus floridanus* |
| Masked Shrew | *Sorex cinereus* |
| Eastern Cottontail | *Sylvilagus floridanus* |
| Raccoon | *Procyon lotor* |
| Western Harvest Mouse | *Reithrodontomys megalotis* |
| White Tailed Deer | *Odocoileus virginianus* |

**Appendix D.** The following table shows a list of all species found in the oak-hickory woodland. If genus and species could not be identified, the organism was identified to family.

| Oak-Hickory Species List | |
|---|---|
| Macroinvertebrates | |
| Common Name | Genus Species |
| Ant | Formicidae |
| Bark Lice | Psocidae |
| Beefly | Bombyliidae |
| Black Carpenter Ant | *Camponotus pennsylvanicus* |
| Black Fly | Bibionidae |
| Braconid Wasp | Braconidae |
| Carrion Beetle | Silphidae |
| Caterpillar | Lepidoptera |
| Chafers Beetle | *Dichelonys spp.* |
| Checkered Beetle | Cleridae |
| Cobweb Spider | *Enoplognatha ovata* |
| Common House Spider | *Parasteatoda tepidariorum* |
| Crab Spider | Thomisidae |
| Cricket | Gryllidae |
| Earth-boring Dung Beetle | Geotrupidae |
| Earth-boring Scarab | *Geotrupus spp.* |
| Fall Webwworm Larva | *Hyphantria cunea* |
| Funnel Web Spider | Agelenidae |
| Grey Garden Slug | *Deroceras reticulatum* |
| Ground Beetle | *Harpalus pennsylvanicus* |
| Ground Beetle | *Poecilus chalcites* |
| Ground Spider | Gnaphosidae |
| Harvest Mite | Trombiculidae |
| Harvestman | Opiliones |
| Lonchaeid Fly | Lonchaeidae |
| Midge | Chironomidae |
| Millipede | Diplopoda |
| Mosquito | Culicidae |
| Orb Weaver | Araneidae |
| Plant Bug | Miridae |

| | |
|---|---|
| Psyllid | Psyllidae |
| Robber Fly | *Diogmites spp.* |
| Rove Beetle | Staphylinidae |
| Scarab Beetle | Scarabaeidae |
| Slug | Gastropoda |
| Sowbug | Oniscidae |
| Spittlebug | Cercopoidea |
| Springtail | Isotomidae |
| Springtail | Entomobryidae |
| Stone Fly | Perlidae |
| Tachinid Fly | Tachinidae |
| Treehopper | Membracidae |
| Treehopper Nymph | Membracidae |
| True Bug | *Zelus Luridus* |
| True Cricket Nymph | Gryllidae |
| Velvet Mite | Trombidiidae |
| Vinegar Fly | Drosophilidae |
| Winged Ant | Formicidae |
| Wolf Spider | Lycosidae |
| Worm | Megadrilacea |
| Flora | |
| Common Name | Genus Species |
| Black Cherry | *Prunus serotina* |
| Box Elder | *Acer negundo* |
| Enchanter's Nightshade | *Circaea lutetiana* |
| False Solomon's Seal | *Smilacina racemosa* |
| Gooseberry | *Ribes uva-crispa* |
| Honeysuckle | *Lonicera maackii* |
| Japanese Barberry | *Berberis thunbergii* |
| Mayapple | *Podophyllum peltatum* |
| Red Oak | *Quercus rubra* |
| Sugar Maple | *Acer saccharum* |
| White Oak | *Quercus alba* |

| | |
|---|---|
| White/Burr Oak | *Quercus x bebbiana* |
| Avian Species | |
| Common Name | Genus Species |
| American Robin | *Turdus migratorius* |
| Eastern Wood Pewee | *Contopus virens* |
| Grey Catbird | *Dumetella carolinensis* |
| House Wren | *Troglodytes aedon* |
| Northern Flicker | *Colaptes auratus* |
| Red-eyed Vireo | *Vireo olivaceus* |
| White-Breasted Nuthatch | *Sitta carolinensis* |
| Mammals | |
| Common Name | Genus Species |
| Deer Mouse | *Peromyscus maniculatus* |
| Masked Shrew | *Sorex cinereus* |

**Appendix E.** The following table shows a list of all species found in the shrubland. If genus and species could not be identified, the organism was identified to family.

| Shrubland Species List | |
|---|---|
| Macroinvertebrates | |
| Common Name | Genus Species |
| Ant | *Componotus spp.* |
| Ant | *Formica spp.* |
| Aphid | Psyllidae |
| Beefly | Bombyliidae |
| Broad-nosed Weevil | *Sciaphilus Asperatus* |
| Camel Cricket | Gryllidae/Rhaphidophoridae |
| Caterpillar | Lepodoptera |
| Centipede | Chilopoda |
| Chafers Beetle | *Dichelonys spp.* |
| Clown Beetle | *Platysoma spp.* |
| Cobweb Spider | Theridiidae |
| Crab Spider | Thomisidae |
| Darkling Beetle | Tenebrionidae |
| Dogbane leaf beetle | *Chrysochus auratus* |
| Dwarf Spider | Linyphiidae |
| Ebony Bug | Thyreocoridae |
| Field Cricket | *Gryllus spp.* |
| Flowerfly | Syrphidae |
| Fruitfly | Tephritidae |
| Grey Garden Slug | Agriolimacidae |
| Ground Beetle | Carabidae |
| Ground Crab Spider 1 | *Xysticus spp.* |
| Ground Cricket | Gryllidae/Nemobiinae |
| Ground Spider | Gnaphosidae |
| Harvest Mite | Trombiculidae |
| Harvestman | Opiliones |
| Honeybee | *Apis spp.* |
| Ichneumon Wasp | Ichneumonidae |
| Jumping Bristletail | Microcoryphia |
| June Beetle | *Phyllophaga spp.* |

| | |
|---|---|
| Leafhopper | Cicadellidae |
| Longlegged Fly | *Condylostylus spp.* |
| Midge | Chironomidae |
| Millipede | Diplopoda |
| Mosquito | Culicidae |
| Plant Bug | Miridae |
| Prowling Spider | Miturgidae |
| Rabid Wolf Spider | *Rabidosa rabida* |
| Robberfly | *Diogmites spp.* |
| Roesel's bush-cricket | *Metrioptera roeseli* |
| Shorthorned Grasshopper | Acrididae |
| Six-Spotted Tiger Beetle | *Cicindela sexguttata* |
| Soldier Beetle | Cantharidae |
| Sowbug | Oniscidae |
| Spittlebug | Arcopidae |
| Spittlebug | Cercopidae |
| Spur-throated grasshpper | *Melanoplus sanguinipes* |
| Stink Bug | Pentatomidae |
| Sweat Bee | Halicitidae |
| Sweat Bee | *Lasioglossum spp.* |
| Tree Cricket | Gryllidae |
| Treehopper | Membracidae |
| True Bug | Hemiptera |
| True Weevil | Curculionidae |
| Wandering Glider | *Pantala Flavescens* |
| Winged Ant | Formicidae |
| Wolf Spider | Lycosidae |
| Woodlouse hunter | *Dydera Crocata* |
| Yellowjacket Wasp | *Vespula maculifrons* |
| Flora | |
| Common Name | Genus Species |
| Alleghany Bushy Moss | *Thamnobryum alleghaniese* |
| American Elm | *Ulmus americana* |

| | |
|---|---|
| Autumn Olive | *Elaeagnus umbellata* |
| Black Raspberry | *Rubus occidentalis* |
| Common Elderberry | *Sambucus canadensis* |
| Fleabane | *Erigeron spp.* |
| Frost Grape | *Vitis vulpina* |
| Glossy Buckthorn | *Rhamnus frangula* |
| Goldenrod | *Solidago spp.* |
| Hawkweed | *Hieracium spp.* |
| Hungarian Broam | *Bromus inermis* |
| Juniper Moss | *Polytrichum juniperinum* |
| Kentucky Bluegrass | *Poa pratensis* |
| Multiflora Rose | *Rosa multiflora* |
| Red Cedar | *Juniperus virginiana* |
| Red Clover | *Trifolium incarnatum* |
| Siberian Elm | *Ulmus pumila* |
| Sugar Maple | *Acer saccharum* |
| Sulphur cinquefoil | *Potentilla recta* |
| White Ash | *Fraxinus americana* |
| White Spruce | *Picea pungens* |
| Woodsy Mnium Moss | *Mnium spp.* |
| Yarrow | *Achillea millefolium* |
| Avian Species | |
| Common Name | Genus Species |
| American Goldfinch | *Carduelis tristis* |
| Brown Headed Cowbird | *Molothrus ater* |
| Chipping Sparrow | *Spizella passerina* |
| Eastern Towhee | *Pipilo erythrophthalmus* |
| Field Sparrow | *Spizella pusilla* |
| Grey Catbird | *Dumetella carolinensis* |
| House Finch | *Haemorhous mexicanus* |
| Northern Cardinal | *Cardinalis cardinalis* |
| Ruby-Throated Hummingbird | *Archilochus colubris* |
| Song Sparrow | *Melospiza melodia* |
| Yellow Warbler | *Setophaga petechia* |
| Mammals | |
| Common Name | Genus Species |
| White-tailed Deer | Odocoileus virginianus |

**Appendix F.** The following table shows a list of all species found in Pond 1. If genus and species could not be identified, the organism was identified to family or order.

| Pond 1 Species List | |
|---|---|
| Macroinvertebrates | |
| Common Name | Genus Species |
| Amphipod | Amphipoda |
| Beetle | Coleoptera |
| Common Green Darner | *Anax junius* |
| Isopods | Isopoda |
| Mosquito Larvae | Culicidae |
| Snails/Slugs | Gastropoda |
| Spiders | Araneae |
| True Bug | Hemiptera |
| True Fly | Diptera |
| Widow Skimmer | *Libellula luctuosa* |
| Worms | Tubificida |
| Flora | |
| Common Name | Genus Species |
| American Bullfrog | *Lithobates catesbeianus* |
| Common Name | Genus Species |
| Duckweed | *Lemnaceae* |
| Musk-grass | *Chara* |
| Reed Canary Grass | *Phalaris arundinacea* |
| Spike Rush | *Eleocharis* |
| Watercress | *Nasturtium officinale* |
| Western Chorus Frog | *Pseudacris triseriata* |
| Avian Species | |
| Common Name | Genus Species |
| American Goldfinch | *Carduelis Tristis* |
| American Robin | *Turdus migratorius* |
| Zooplankton | |
| Common Name | Genus Species |
| Amoebas | Amoebozoa |
| Ciliates | Ciliophora |
| Cladocerans | Cladocera |

| | |
|---|---|
| Copopods | Copepoda |
| Flagellates | Flegalleta |
| Flatworms | Platyhelminthes |
| Gastrotrichs | Gastrotricha |
| Heliozoan | Heliozoa |
| Ostracods | Ostracoda |
| Rotifers | Rotifera |
| Roundworms | Nematoda |
| Watermite | Acarina |
| Phytoplankton | |
| Common Name | Genus Species |
| Filamentous Algae | |
| Nonfilamentous Algae | |
| Diatoms | |

**Appendix G.** The following table shows a list of all species found in Pond 2. If genus and species could not be identified, the organism was identified to family or order.

| Pond 2 Species List | |
|---|---|
| Macroinvertabrates | |
| Common Name | Genus Species |
| True Bug | Hemiptera |
| True Fly | Diptera |
| Beetle | Coleoptera |
| Amphipod | Amphipoda |
| Flora | |
| Common Name | Genus Species |
| Musk-grass | *Chara* |
| Joe-Pieweed | *Eutrochium purpureum* |
| Herptiles | |
| Common Name | Genus Species |
| Western Chorus Frog | *Pseudacris triseriata* |
| Avian Species | |
| Common Name | Genus Species |
| Green Heron | *Butorides virescens* |
| American Goldfinch | *Carduelis tristus* |
| Zooplankton | |
| Common Name | Genus Species |
| Heliozoan | Heliozoa |
| Ciliates | Ciliophora |
| Flagellates | Flegalleta |
| Amoebas | Amoebozoa |
| Copopods | Copepoda |
| Rotifers | Rotifera |
| Roundworms | Nematoda |
| Watermite | Acarina |
| Cladocerans | Cladocera |
| Flatworms | Platyhelminthes |
| Gastrotricha | Ostracoda |
| Mosquito Larvae | Gastrotricha |
| Tardigrade | Tardigrada |
| Hydra | Cnidaria |
| Phytoplankton | |
| Common Name | Genus Species |
| Filamentous Algae | |
| Nonfilamentous Algae | |
| Diatoms | |

**Appendix H.** The following table shows a list of all species found in Pond 3. If genus and species could not be identified, the organism was identified to family or order.

| Pond 3 Species List | |
|---|---|
| Macroinvertabrates | |
| Common Name | Genus Species |
| True Bug | Hemiptera |
| True Fly | Diptera |
| Beetle | Coleoptera |
| Caddisfly Larva | Amphipoda |
| Mosquito Larvae | Culicidae |
| Aquatic Snail | Basommatophora |
| Membrane Winged Insect | Hymenoptera |
| Dragonflies/Damselflies | Odonata |
| Freshwater Mussel | Unionoida |
| Aquatic Isopod | Isoptera |
| Flora | |
| Common Name | Genus Species |
| Musk Grass | *Chara* |
| Watercress | *Nasturtium officinale* |
| Reed Canary Grass | *Phalaris arundinacea* |
| Narrowleaf Cattail | *Typha angustifolia* |
| Willow Herb | *Epilobium* |
| Deadly Nightshade | *Atropa belladonna* |
| Duckweed | *Lemnaceae* |
| Joe Pie-weed | *Eutrochium purpureum* |
| Spike Rush | *Eleocharis* |
| Herptile | |
| Common Name | Genus Species |
| Western Chorus Frog | *Pseudacris triseriata* |
| Avian Species | |
| Common Name | Genus Species |
| Green Heron | *Butorides virescens* |
| American Goldfinch | *Carduelis tristis* |
| Zooplankton | |
| Common Name | Genus Species |

| | |
|---|---|
| Heliozoan | Heliozoa |
| Ciliates | Ciliophora |
| Flagellates | Flegalleta |
| Amoebas | Amoebozoa |
| Copopods | Copepoda |
| Rotifers | Rotifera |
| Roundworms | Nematoda |
| Watermite | Acarina |
| Cladocerans | Cladocera |
| Flatworms | Platyhelminthes |
| Ostracods | Ostracoda |
| Tardigrade | Tardigrada |
| Oligochaetes | Oligochaeta |
| Gastrotricha | Gastrotricha |
| Phytoplankton | |
| Common Name | Genus Species |
| Filamentous Algae | |
| Nonfilamentous Algae | |
| Diatoms | |

**Appendix I.** The following tables show the T-Test p-values for both terrestrial and aquatic data that determined if the results were significantly different.

| Terrestrial T-Test p-values | | | | |
|---|---|---|---|---|
| | Fen | Buckthorn | Buckthorn | Oak Hickory |
| H' | 4.2212 | 4.0508 | 4.2212 | 3.763 |
| Hp | 0.087762 | | 1.85E-06 | |
| D | 0.029678 | 0.032374 | 0.029678 | 0.059786 |
| Dp | 0.63051 | | 1.06E-05 | |
| | Buckthorn | Shrub | Fen | Oak Hickory |
| H' | 4.2212 | 3.855 | 4.0508 | 3.763 |
| Hp | 2.36E-05 | | 0.0041682 | |
| D | 0.029678 | 0.044927 | 0.032374 | 0.059786 |
| Dp | 0.000829 | | 0.000218 | |
| | Fen | Shrub | Oak Hickory | Shrub |
| H' | 4.0508 | 3.855 | 3.763 | 3.855 |
| Hp | 0.032343 | | 0.28878 | |
| D | 0.032374 | 0.044927 | 0.059786 | 0.044927 |
| Dp | 0.020047 | | 0.024953 | |

| Pond T-Test p-values | | |
|---|---|---|
| | Pond 1 | Pond 2 |
| H' | 1.2291 | 1.4079 |
| Hp | 1.08E-05 | |
| D | 0.47905 | 0.41711 |
| Dp | 1.93E-04 | |
| | Pond 1 | Pond 3 |
| H' | 1.2291 | 1.2516 |
| Hp | 0.55643 | |
| D | 0.47905 | 0.49616 |
| Dp | 0.27966 | |
| | Pond 2 | Pond 3 |
| H' | 1.4079 | 1.2516 |
| Hp | 3.93E-05 | |
| D | 0.41711 | 0.49616 |
| Dp | 2.13E-07 | |