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Classifying The Woody Vegetation Community Of Wade Ponds In Colleton County, South Carolina

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by

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Abstract

Wetland habitats are some of the most biodiverse ecosystems in the world, varying in both physical and biological characteristics. Geographically isolated wetlands are particularly important to the landscape due to their role in the hydrological cycle and as local centers for biodiversity. In parts of the coastal plain of South Carolina, there are geographically isolated wetlands found in concentrated groups with distinctive size, shape, and distribution. Despite their unique appearance and distribution, these wetlands have been scarcely researched or investigated. This project seeks to explore the plant communities that are contained within these ponds in order to understand their composition and to compare them to existing community classifications. The study area lies within a plot of managed pine forest and focuses on sixteen ponds within an area of about 1.5 square miles. The small scale and proximity of the study allows for ponds to be compared individually rather than throughout their entire range. Using a plotless sampling method, this study gathers data that is used to determine species composition

and various measures of diversity. This information is then used to describe the vegetative composition of the ponds, explore the variability between individual ponds, and attempt to determine the appropriate community classification of the ponds. It is hoped that this project will prove useful to expanding knowledge on the natural environment and informing management decisions regarding the protection of these rapidly disappearing natural areas.

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List of Abbreviations

AOI .... Area of Interest

DBH .... Diameter at Breast Height

GIW .... Geographically Isolated Wetland

WP .... Wade Pond

Chapter One: Introduction and Literature Review

Colleton County is located in the Coastal Plain of South Carolina. It is bordered by Bamberg County to the north, the Salkehatchie and Combahee rivers to the west, the Edisto River to the east, and the Atlantic Ocean to the south. With a land area of about 2,736 square kilometers, it is the fifth largest county in South Carolina. The county was first settled in 1663 and receives its name from Sir John Colleton, one of the original Lords Proprietors of the Province of Carolina (Rayner, 1984).

Economic activity in Colleton County has historically been reliant on agriculture. Lands that could be converted into cropland were used to produce cash crops, beginning with rice in 1680, indigo in 1739, and cotton from 1785-1813 (Rayner, 1984). Farming of crops and raising of livestock is still practiced today, but much of the agroeconomic activity in the county is in forest management. The forest industry in South Carolina is the largest provider of jobs and payroll in the state, bringing in about $17 billion annually (SCFC, 2014).

As is characteristic of the Coastal Plain, Colleton County exhibits little variation in topographic relief. With elevation only ranging from sea-level to 134 feet, the county is marked by gentle slopes and is poorly drained (Rayner, 1984). Vegetation is also typical of the Coastal Plain, with the landscape being dominated almost exclusively by pine flatwoods and swamps. Because of these features, small wetland depressions are extremely common (Rayner, 1984).

Because the forest products industry is vital to South Carolina’s economy, forest management can be expected to expand and increase in Colleton County. Efforts to increase usable land area for woodland or cropland will rely on altering surface drainage processes, which includes the ditching and draining of depressional wetlands (Rayner, 1984). These practices pose a threat to the ecological diversity and functionality of the landscape.

Geographically isolated wetlands, or GIWs, are particularly vulnerable to increasing human disturbances because of drainage practices carried out to make land more conducive to development or agriculture. This situation is exacerbated by their lack of regulatory protection. GIWs provide unique habitat for plant species that rely on acidic soils and periodic natural disturbance regimes, such as flooding and fires. These wetlands are also a valuable resource to wildlife. In addition to their biological impacts, GIWs provide several ecosystem services for humans, including carbon sequestration, sediment storage, nutrient transformation, and retention of floodwaters (Marton, 2015).

Rayner (1984) mentions the abundance of GIWs in Colleton County; otherwise, no reasonably accurate enumeration of GIWs has been made. Aerial imagery makes it easy to locate wetlands and observe their distribution. Satellite imagery from Google Earth displays various concentrations of round to elliptical wetlands in northern Colleton County, with hundreds of small ponds clustered in some places and nearly absent in others, making them very conspicuous (Figure 1.1). To distinguish wetlands of this distribution from other GIWs, they will herein be referred to as “wade ponds.”

Wade ponds, or WPs, are freshwater GIWs that are round/rounded-elliptical in shape, range in diameter from about 50-150 meters, are typically surrounded by pine forest, and occur in concentrations or clusters. Because of their unique appearance and distribution, it is possible that they may belong to a different natural community classification than other GIWs in the region. Although their appearance is somewhat reminiscent of Carolina Bays, they do not exhibit consistent orientation or other features that are indicative of Carolina bays. Additional research into these ponds is recommended for expanding knowledge on natural environments of South Carolina.

This project focused on woody plant community composition as the basis for determining the classification of WPs in northern Colleton County. Additionally, data collection from multiple WPs allowed for the comparison of species assemblages between individual ponds. Prior to conducting a field assessment, some preliminary research was necessary to infer what community description, if any, might apply to WPs. The observable characteristics of the ponds were used as criteria for identifying natural communities with similar traits from several different publications. Nelson (1986), Rayner (1984), Porcher and Rayner (2001), and Wharton (1977) define natural communities that occur in the Southeastern Coastal Plain.

Those communities that have similar traits to wade ponds were further explored.

Nelson (1986) provides an approximate range of natural communities in South Carolina. He defined 67 communities, providing brief descriptions of the type of environment, site description, location, vegetation, and other associated communities. Using Nelson’s classification, five communities were determined to have potential similarities to wade ponds: limestone sink, non-alluvial swamp forest, pond cypress pond, pond cypress savannah, and swamp tupelo pond.

Limestone sinks are very heterogeneous, exhibiting a canopy dominated by red maple and loblolly pine. The sub-canopy layer is more diverse, with several different shrub species listed. It is also noted that little knowledge is available on this particular environment at the time of publication. They are relatively rare and typically found in Berkeley, Calhoun, and Orangeburg Counties (Nelson, 1986).

Non-alluvial swamp forests are found throughout the Coastal Plain. They are poorly drained depressions that have a diverse list of canopy and sub-canopy species. The canopy is highly variable with the possible presence of swamp tupelo, pond cypress, sweetgum, red maple, pine spp. and oak spp. The subcanopy tends to be made up of shining fetterbush, titi, and buttonbush. Like limestone sinks, there is little other information on this community type (Nelson, 1986).

Pond cypress ponds can have a round-elliptical or irregular shape. They are typically found in the Sandhills and the Coastal Plain in South Carolina. The canopy is exclusively dominated by pond cypress and swamp tupelo, although the latter may be absent. The sub-canopy layer tends to consist of myrtle holly, buttonbush, and titi (Nelson, 1986).

Pond cypress savannahs have some similarities to pond cypress ponds but have more open canopies with a more diverse sub-canopy layer. Pond cypress is the dominant canopy species while swamp tupelo, red maple, and persimmon may also be present. Myrtle holly is the most common shrub species and may be accompanied by buttonbush, although not as frequent (Nelson 1986).

Swamp tupelo ponds are rounded or irregularly shaped depressions that are found throughout the Coastal Plain. Swamp tupelo and red maple are the dominant canopy species. Pond cypress can be present, but it is not a dominant species in this community. The sub-canopy layer consists of myrtle holly, fetterbush and shining fetterbush (Nelson, 1986).

Wharton (1977) discusses an inventory of communities in Georgia that can also be found in the Coastal Plain and other regions throughout the southeastern United States. The publication includes information on 100 different communities, including five that are more or less equivalent to those selected from Nelson (1986), although with different given names. Limesink, cypress dome, cypress savannah, and gum pond are communities that share similar traits with WPs and can be cross-compared with Nelson’s communities.

Limesinks tend to have a variety of plant communities from site to site. Wharton describes them as open canopied ponds that can consist of bay trees or pond cypress with few swamp tupelo trees. The sub-canopy layer is only described as being dominated by buttonbush (Wharton, 1977).

Cypress ponds, or cypress domes, are round wetland depressions that are dominated by pond cypress. Swamp tupelo is also common, but not as dominant as pond cypress. Other canopy species include slash pine and red maple.

Shrub species are common and mostly consist of shining fetterbush, wax myrtle, and button bush (Wharton, 1977).

Cypress savannahs are exclusively dominated by pond cypress trees. Swamp tupelo and red maple may be present, but are mostly found in a dwarf state and remain within the sub-canopy layer. Shrubs are generally absent from these wetlands (Wharton, 1977).

Gum ponds are dominated by swamp tupelo and lack pond cypress. Red maple, willow oak, sweetgum, and slash pine may be present around the rim of the pond but are not ubiquitous. The sub-canopy layer consists of gallberry and buttonbush, with the possibility of wax myrtle (Wharton, 1977).

Finally, Porcher and Rayner (2001) and Rayner (1984) also describe natural communities that occur in the Coastal Plain, but only three of their classes are equivalent to the communities described by Wharton and Nelson: sink holes, pond cypress-swamp tupelo upland swamps, and cypress savannahs.

Sink holes are small, deep depressions that are unique in appearance and formation. Plant communities within them are highly variable, with no distinct dominant species.

Some within Colleton County are dominated by sweetgum and swamp tupelo (Rayner, 1984).

Pond cypress-swamp gum upland swamps are dominated by either pond cypress or a balance between pond cypress and swamp tupelo. Pond pine is the most frequently occurring associate canopy species. There usually is not a shrub layer within the pond, but buttonbush, titi, cassena, and myrtle holly are common around the margin of the pond (Porcher and Rayner, 2001).

Pond cypress savannahs are dominated by pond cypress and have a fairly open canopy. Red maple and swamp tupelo may or may not be present. In the sub-canopy layer, there are few shrubs present. Myrtle holly and buttonbush may be sparsely present. In South Carolina, this community is mostly found within Francis Marion National Forest (Porcher and Rayner, 2001). Examples of this community are increasingly rare in other areas.

The information provided by this literature search is helpful in anticipating species that may be found within the wade ponds (Table 1.1). Each of these authors has a slightly different description for the same type of community because natural environments are complex. Nelson (1986) states that natural communities exist as continua rather than repetitive units. Cross-referencing multiple sources provides a more well-rounded classification for a community that can be used when attempting to define a community; here, the classifications are organized by author, community, and species (Table 1.2).

The purpose of this study is to expand upon the knowledge of natural environments in South Carolina, to provide a methodology for efficiently surveying and comparing multiple wetland sites, and to collect data that can be used to inform management decisions and conservation efforts. To determine the proper classification of WPs, multiple ponds within a concentration need to be sampled. The field study will consist of identifying a desirable area of interest (AOI), implementing a vegetation sampling method, and recording the data for later analysis. The next chapter discusses the AOI, the implementation of the point-quarter sampling method, and the results of the field study.

Table 1.1: Species identified in the literature that may be found within wade ponds. Listed alphabetically by scientific name with common name translation.

Potential Species	
Common Name	**Scientific Name**
Red maple	*Acer rubrum*
Hazel alder	*Alnus serrulata*
Buttonbush	*Cephalanthus occidentalis*
Titi	*Cyrilla racemiflora*
Persimmon	*Diospyros virginiana*
Cassena	*Ilex cassine*
Gallberry	*Ilex glabra*
Myrtle holly	*Ilex myrtifolia*
Fetterbush	*Leucothoe racemosa*
Sweetgum	*Liquidambar styraciflua*
Wax myrtle	*Myrica cerifera*
Swamp tupelo	*Nyssa biflora*
Slash pine	*Pinus elliottii*
Pond pine	*Pinus serotina*
Loblolly pine	*Pinus taeda*
Willow oak	*Quercus phellos*
Pond Cypress	*Taxodium ascendens*

Table 1.2: Community name and species description by author. Dominant species are listed first and associate species are in parenthesis.

Nelson		**Wharton**		**Porcher and Rayner**	
Limestone Sink		**Limesink**		**Sink Hole**	
Canopy: Variable (Red maple, loblolly pine)	Sub-Canopy: Variable species (Shining fetterbush, Wax Myrtle, Hazel alder)	Canopy: Variable tree species (Pond cypress, Swamp Tupelo)	Sub-Canopy: Buttonbush	Highly variable, non-distinct plant species	
Non-Alluvial Swamp Forest					
Canopy: Variable (Swamp Tupelo, Pond Cypress, Sweetgum, Loblolly Pine, Pond Pine, Oak, Red Maple)	Sub-Canopy: Shining fetterbush, Titi, Buttonbush, abundant vines				
Pond Cypress Pond		**Cypress Dome or Pond**		**Pond Cypress-Swamp Gum Upland Swamps**	
Canopy: Pond cypress (Swamp Tupelo)	Sub-Canopy: Myrtle Holly, Buttonbush, Titi	Canopy: Pond Cypress (Slash pine, swamp tupelo, red maple)	Sub-canopy: Shining fetterbush, Wax Myrtle, Buttonbush	Canopy: Pond Cypress, Pond Cypress/Swamp Tupelo (Pond Pine)	Sub-Canopy: Pondspice, Buttonbush, Cassena, Myrtle Holly
Pond Cypress Savannah		**Cypress Savannah**		**Pond Cypress Savannah**	
Canopy: Pond Cypress (Swamp Tupelo, Red Maple, Persimmon)	Sub-Canopy: Myrtle Holly, Buttonbush	Canopy: Pond Cypress (Swamp Tupelo, Red Maple	Sub-Canopy: Shrubs generally absent	Canopy: Pond Cypress (Red maple, swamp tupelo)	Sub-canopy: Myrtle Holly, Buttonbush
Swamp Tupelo Pond		**Gum Pond**			
Canopy: Swamp Tupelo, Red Maple (Pond Cypress)	Sub-Canopy: Myrtle Holly, Fetterbush, Shining fetterbush	Canopy: Swamp Tupelo (Sweetgum, Red Maple, Willow oak, and Slash Pine possible around edge)	Sub-Canopy: Buttonbush, Gallberry (Wax Myrtle)		

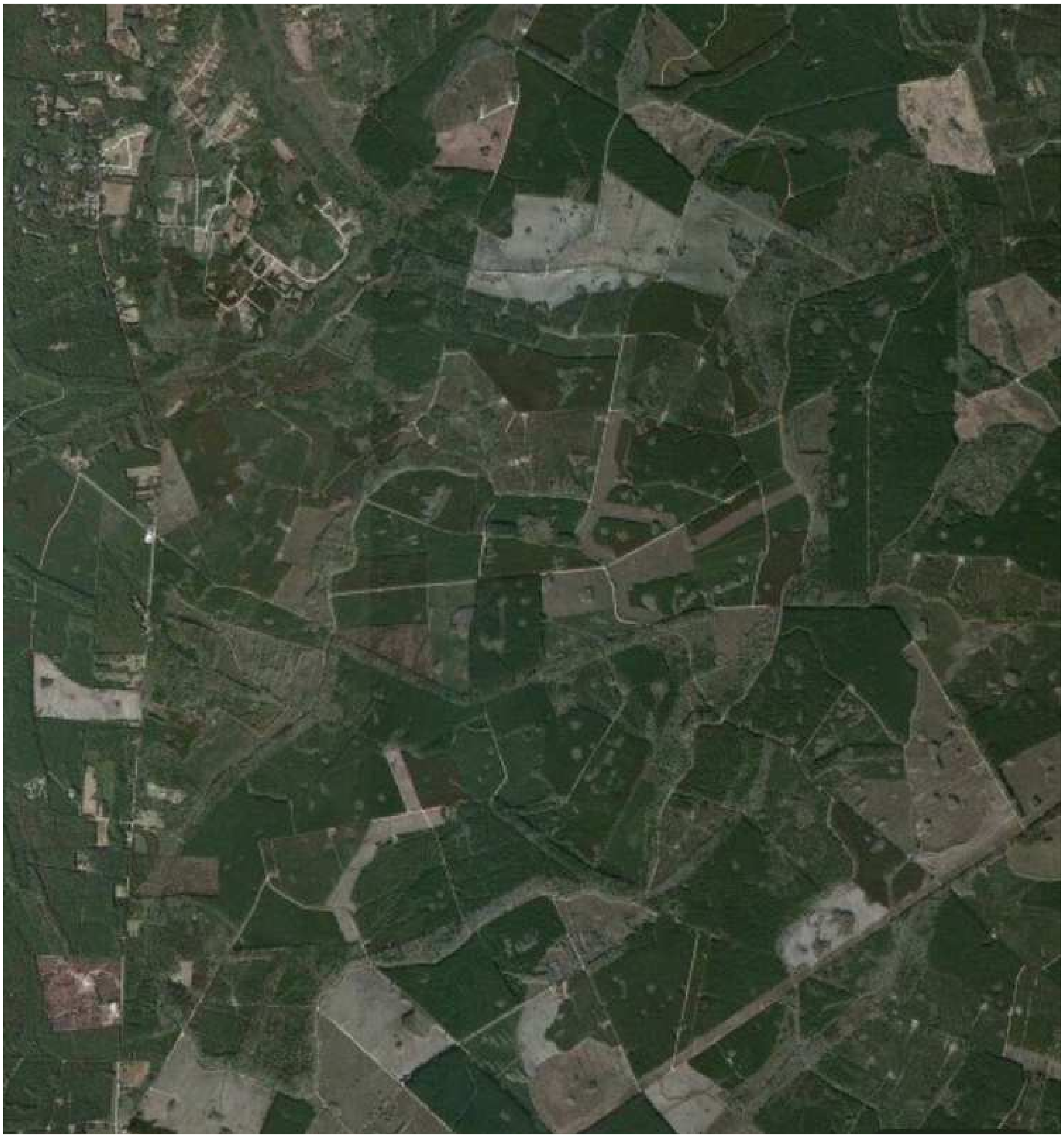

Figure 1.1: *Photograph from Google Earth showing a concentration of wade ponds in Colleton County, north of Walterboro*

Chapter Two: Survey and Analysis of Wade Ponds

2.1 Selecting the AOI

Wade ponds are almost exclusively found on private property across numerous parcels of land with different owners. Even if access were granted for most of the land area containing a concentration of WPs, a single parcel with a non-cooperative owner could hinder the integrity of the study. The AOI needs to contain several WPs, be within a reasonable travel distance from Columbia, and be accessible for intermittent visits over about a year’s time.

After scanning different patches of wade ponds and identifying property lines, a potential AOI was found in northern Colleton County. This particular concentration of wade ponds is fairly large, spanning about 150 square kilometers. Many of the ponds in this area are within the boundaries of property owned by Plum Creek Timber Company. Prior to ownership by Plum Creek, the land belonged to MeadWestvaco.

The site is easily accessible from state roads and highways, although it is behind locked gates. There are several logging roads traversing the property that provide more direct access to the wetlands. Plum Creek was contacted regarding the possibility of surveying the wetlands and therefore having the ability to enter the locked gate at the entrance of the property. Luckily, Dr. John Nelson had made an acquaintance with an SCDNR conservation officer, Ben Graham, during previous botanical field excursions in Colleton County. Officer Graham is the only SCDNR officer in the vicinity of the proposed AOI and had been tasked with patrolling the land owned by Plum Creek. Dr. Nelson contacted Officer Graham who obliged graciously with access to the AOI. Dates for each visit were selected in accordance with Officer Graham's schedule.

The AOI is located along the southern side of road SC 217 and west of its intersection with SC 61 (Figure 2.1). The area is approximately 4.5 square kilometers and contains about 30 wetland features. Of these features, sixteen were selected for sampling based on their shape. Focusing only on round to rounded-elliptic ponds imposes a control on any variability in composition that may occur as a result of shape.

2.2 Point-Quarter Sampling

There are several different methods used by ecologists to measure individuals present in a plant community. If the population is small and within a small land area, an entire count of each individual by plot sampling is practical and preferred. For larger populations, plotless sampling is an effective way of providing an estimate of the community where directly counting each individual is infeasible. Because of the number of WPs to be sampled and their large woody plant populations, a plotless sampling method would provide a way to efficiently gather data in a timely manner.

The point-quarter method is a plotless sampling method commonly used to collect data from forested areas when counting each individual tree is impractical (Cottam et al., 1953). Rather than setting up sample plots within a site, vegetation can be sampled along a transect. A transect line is a line pulled from one end to another through a stand of vegetation to be sampled; typically, along the long axis. The long axis is an imaginary line that bisects a pond along its longest length. A transect across the long axis is assumed to provide the best cross-section of pond depth and plant communities. Small pockets of plant assemblages may be present away from the transect line, as would be seen within Carolina bays. However, these are likely to be negligible when considering the plant community of the pond as a whole.

The location of sample points along a transect are determined by generating random numbers that represent a distance (in meters) from the beginning of the transect. Therefore, the list of random numbers must be in numerical order, representing a sequence of sample points. The difference between each number is the distance traveled from one sample point to the next. For example, if the random number generator gives the numbers one, three, and seven, then the first sample point will be one meter from the end of the transect line. The next sample point will be two meters farther at three meters from the end of the transect line. The third sample point will be four meters farther at seven meters from the start. This process is continued until a random number exceeds the length of the line.

At each sample point, the surrounding area is divided into four quadrants. With the physical transect line providing one axis of division, a perpendicular line crossing the transect at the sample point creates the four quadrants. A meter stick or any other straight tool can be used to help visualize the divide, if needed. The quadrants are numbered conventionally, clockwise beginning with the top right quadrant. The orientation of the plane follows the transect line, with the progressing direction being the ‘top’ of the plane. Each quadrant will have any number of woody plants within it at varying distances from the sample point. The plant nearest the sample point in each quadrant will be recorded, equaling four plants per sample point.

The nearest plant in each quadrant was identified to species, creating a partial species list for each pond and allowing for inter-pond comparisons. The distance from the sample point to the tree and the diameter at breast height (DBH) was measured. These two metrics are used to calculate density and basal area. The total number of sample points in each pond are used to calculate species frequency. These values then determine the relative density, relative dominance, and relative frequency, and importance values (Cottam et al., 1953). The equations for each of these values is located on the ‘List of Equations’ page. Data collected for each plant was organized by sample point and quadrant number.

2.3 Surveying the Wade Ponds

The point-quarter sampling method was chosen to survey the wetlands because of its ability to provide a substantial amount of data from numerous ponds in a way that is practical and easily replicated. Although wade ponds are relatively small wetlands, they can have very dense vegetation, which makes plot-based sampling arduous and difficult to replicate.

The study included sixteen wade ponds sampled across nine site visits, spanning approximately eight months. Two ponds were sampled during seven of the visits, and only one pond was sampled during the other two visits. Each pond took between one and three hours to sample depending on the thickness of the vegetation. There was no particular order in sampling; each pond was selected at the onset of each visit from the remaining ponds within the study site. Certain criteria were implemented to control variables of pond shape and non-dominant or herbaceous plant species. Only ponds that were round to elliptical were chosen for sampling within the AOI; irregular ponds are assumed to be associated with stream activity and were rejected. The only plant species surveyed within the ponds were woody species with a DBH of at least three centimeters.

Prior to entering a pond, a list of random numbers was generated and written down in numerical order. This was accomplished using a random number generating application on a smartphone. In the settings, a range for the generated numbers was set and a toggle switch was selected that prevented numbers from being repeated. A range of 1-80 proved to be sufficient for most of the wade ponds in this study. For this range, between twenty and thirty numbers were generated. This ensured that a site was thoroughly sampled.

After choosing a pond, the global positioning system (GPS) on a smartphone was used to navigate to the nearest point of access along the gravel road. From the road, the GPS was used as a guide to ensure arrival at the pond because it was difficult at times to locate ponds within the dense pine plantation without assistance. Upon arrival, the shrubby fringe of the pond was excluded from the study. There were observable changes in vegetation between the pine plantation, the fringe of the pond, and the pond itself. Once the distinction was made between the fringe and the pond, the transect was started.

Flagging ribbon was tied around a tree nearest the end of the long axis and used to create the transect. Then the

GPS was used to determine the direction needed to pull the flagging ribbon. Dense thickets of shrubs or trees blocking the intended path created obstacles in some of the ponds. In this case, the flagging ribbon was threaded through or around the obstacle as straight as possible to create a more accurate transect along the long axis. After crossing a pond, the same observable change in vegetation between the pond and the fringe is used to determine where the transect will end. It should be noted that this end of the transect will herein be referred to as the 'origin' of the transect and the point where the ribbon was first tied will herein be referred to as the "finish."

Sampling was begun at the origin of the transect, with the distances represented by the series of numbers measured from this point. Continued sampling at each random point was conducted until a random number is reached that would extend beyond the finish of the transect. If the list of random numbers ended before finish was reached, more numbers were generated and sampled. This procedure was replicated within each pond throughout the study.

2.4 Statistical Methods

The species data were first used to calculate relative and absolute values for density, frequency, and dominance.

These values were then used to calculate importance values for each species per pond and several measures of diversity. The processed data was then used to generate ordinations to test for underlying patterns of difference between individual WPs.

Equations 1 and 2 were used to calculate relative density and the total density of all species, respectively. These values are needed before calculating absolute density, as shown by Equation 3. For these results, unit area was calculated for acreage. Since the field measurements are metric, unit area is equal to 4046.86 m^2/acre.

Next, frequency and relative frequency can be calculated to measure the occurrence of a species within a sample. The frequency of a species (Equation 4) is useful for determining the proportion of sample points a given species was found. This value needs to be calculated for each species within a pond before being able to find the relative frequency of a species. The relative frequency of a species is the proportion of its frequency value to the frequency values of all species within a given pond.

The dominance and relative dominance of each species can be calculated using the average basal area of each species. The dominance value of a species represents the influence of a species within a sample based on its proportion of the population and its biomass. A species can dominate either because it is the most abundant species or because it makes up most of the biomass. Relative dominance of a species is the proportion of its dominance value to the dominance of all other species within a pond; the sum of relative dominance values within a pond is equal to 1.

The importance value of a species measures the overall abundance a species within a pond. Because it is a sum of three measured proportions, the importance value is within a range of 0 to 3. These calculations were done for each species within all sixteen ponds to provide a complete analysis of all data.

After completing these calculations, the results were organized into tables using Microsoft Excel with individual ponds listed as rows and plant species as columns. An individual table was made for each abundance measure and can be found in Appendix B. The processed data was then used to calculate various measures of diversity: Shannon-Wiener, Simpson’s, richness, and evenness (Appendix C). Measures of diversity provide additional information on the community composition of the ponds and were calculated to test for correlation with ordinations generated using PC-ORD.

PC-ORD is a software program used for statistical analysis of ecological communities (McCune & Grace, 2002). The program is used to generate ordinations, or graphical representations of data that are often used in ecology to describe patterns (McCune & Grace, 2002). McCune & Grace (2002) discusses different techniques for analyzing ecological data and suggests that nonmetric multidimensional scaling (NMS) is the most effective ordination method.

NMS is an ordination technique that attempts to display patterns that may be occurring within a dataset by locating the best position of n entities in a k dimensional mathematical space based on a dissimilarity matrix (Hart & Kupfer, 2011). Because this method entails fewer assumptions than other ordination methods, it is better equipped to analyze complex ecological data. The calculated values for abundance measures were entered using this method until an optimal ordination was found.

‘Stress’, which represents the departure from monotonicity in the relationship between distances within the data, is also calculated by the program (McCune & Grace, 2002). The closer the ordination points lie to a monotonic line, the better the ordination fits a patter in the data (McCune & Grace, 2002). If the stress value is high (>20), the ordination is not very useful. If stress is less than or equal to 20, then the ordination is assumed to provide an accurate representation of a pattern within the data (McCune & Grace, 2002).

After performing NMS ordinations with the abundance measures, it was determined that measures involving basal area of species would not be sufficient. These measures are sensitive and can create inaccuracies in data if not measured precisely, which the point-quarter sampling method lacks. The results of these analyses are discussed in the next section.

2.5 Results

Eleven species were recorded in the 16 sampled ponds (Table 2.1). These species can be described in terms of strata and dominance within the community; a species can be classified either as a dominant or associate occupying either the canopy or sub-canopy. Dominant species are defined as those that are the most abundant and determinant of the natural community. Associate species are defined as those that are less abundant and may possibly be absent from a given WP. The canopy species in WPs are large tree species that contribute to the canopy layer of the pond, and sub-canopy species are shrubs or small trees that grow far below the reach of the canopy. The constancy, or percentage of ponds in which a species was sampled, was calculated to display how common each species was throughout the study (Figure 2.2).

Swamp tupelo was the only dominant species found in the study, being the most common species in each pond and the only species occurring in all sixteen samples. Pond cypress was the most common associate species, occurring in 12 of the ponds. Other associate canopy species found were red maple, sweetgum, loblolly pine, persimmon, and water oak. Loblolly pine was the second most sampled associate canopy species, occurring in seven of 16 ponds. Red maple occurred in six ponds, sweetgum occurred in three ponds, and persimmon and water oak only occurred in one pond each.

Sub-canopy composition was variable, with no dominant species occurring within every sample. Some ponds had thick shrub layers, while others had only a few shrubs present. Fetterbush was the most common associate sub-canopy species, occurring in 11 of the 16 ponds. Other associate sub-canopy species were recorded much less frequently: myrtle holly occurred in three ponds, while wax myrtle and swamp bay only occurred in two ponds.

Species density provided the optimal NMS ordination, displaying an observable measure of difference between individual ponds. Some minor changes were made to the data prior to generating the ordination. Because of the high density values of swamp tupelo and pond cypress, the density values needed to be log-normalized. Without doing so, the data is overwhelmingly skewed towards uniformity despite the stark differences in associate species present throughout the ponds. Pond 3 was removed because it had a particularly unique assemblage of species, also skewing the results. Data for three species that occurred in fewer than three ponds (persimmon, water oak, and swamp bay) was also removed. These eliminations are common when creating ordinations and help make the results more distinguishable. Finally, the result was a usable ordination with fifteen WPs organized one-dimensionally with an NMS Axis 1 value range of about -1.64 to 2.22 and an acceptable stress value of 20.

It is difficult to quantify the ecological controls responsible for observable difference in pond composition due to the lack of measured environmental factors. Because of the focus on sampling vegetation, environmental data was not collected. However, the Natural Resources Conservation Service (NRCS) provides free soils data to the public. Using the online tools available, the soil data and corresponding map of the AOI are were gathered and can be found below in Appendix D. To test the effect that soil has on the observed difference in species density, each pond in the ordination was assigned the ID number of its soil type as represented in the NRCS soil report. The soil types were then assigned a color-code. This allows for comparison of soils and density within the same ordination. The NMS ordination combined with soil type for each pond is displayed below in Figure 2.3.

In the optimal NMS, the ponds were organized with the less diverse ponds having negative NMS Axis 1 values and more diverse with positive NMS Axis 1 values. All of the ponds with low NMS values were associated with soil types 50 and 51. Nearly all of the ponds at higher values were soil types 55 and 58, except for Pond 8, which had a high NMS Axis 1 value because it contained sweetgum, lacked pond cypress, and had a fairly low density of swamp tupelo. Its soil is listed as 50, but it borders (within a few meters) soil type 55. Therefore, soil does appear to affect the composition of WPs. Despite this correlation, it is particularly interesting that Pond 8 and Pond 13, the most different ponds within the ordination, have the same soil type.

It is also possible that there is a correlation between flood regime and composition. Because of the clear gradient of associate species, with ponds dominated by wetland obligates (fetterbush, swamp bay, and pond cypress) to the left and ponds with more transitional species (sweetgum and red maple) to the right, it can be inferred that flood duration or stage decreases from left to right along the x-axis. However, this cannot be tested with the data gathered by this project.

An additional layer of analysis of the differences between individual ponds involves species-specific versions of the NMS ordination. Separate figures for myrtle holly, loblolly pine, and fetterbush were generated to illustrate which pond and soil type contained the particular species. Myrtle holly only occurs in ponds that have higher NMS values and soil type 55 (Figure 2.4). Therefore, it appears the presence of myrtle holly is more dependent on soil than other environmental factors, such as hydroperiod and flood stage. Loblolly pine only occurs in ponds with NMS values near 0 and above, although not in every pond in this range (Figure 2.5). Loblolly pine is also found in all four soil types, meaning it is much less soil dependent than myrtle holly. Other environmental factors must have a greater effect on this species. Figure 2.6 shows the presence of fetterbush along the ordination. The results for this species are opposite those of loblolly pine; only occurring in ponds with NMS Axis 1 values near 0 and below. Fetterbush also occurs in ponds with all four different soil types. Like loblolly pine, fetterbush is not as dependent on soil type as myrtle holly seems to be.

Additionally, the NMS Axis 1 values were plotted against the various diversity measures. The only significant relationship was that NMS Axis 1 had a positive correlation with species richness, with an R^2 value of 0.6098 (Figure 2.7). Since ponds with higher Axis 1 values had greater diversity in species density, it makes sense that these ponds also contained more species than ponds with lower Axis 1 values.

Visualizing the results of the ordination in the scope of the AOI allows for inter-pond comparison between NMS Axis 1 values and location. A map was generated with each pond color-coded by NMS value (Figure 2.8). The colors were assigned along a color bar legend, with low NMS values having cool colors and high NMS values having warm colors. There does not appear to be a strong relationship between NMS Axis 1 value and pond location. Some ponds, such as Ponds 7, 10, and 14 are very close together and have very similar NMS Axis 1 values, but the same trend is not present throughout the AOI.

The quantitative results discussed above provided information from each sampled pond and a means of comparing WPs as individuals. There is some variability in species composition, but overall the ponds are similar enough to be described and classified as a single community. Therefore, in the next section, WPs are discussed on a larger scale to qualitatively assess the community of WPs and attempt to determine their proper classification.

2.6 Discussion

The results from this study provided a list of species, information on the occurrence of species both within individual ponds and the AOI as a whole, and an ordination illustrating difference in community composition across individual ponds. This information can be used to describe the community exhibited by this sample of WPs which can then be cross-referenced with the community descriptions of Nelson (1986), Wharton (1977), Porcher and Rayner (2001), and Rayner (1984). WPs may belong to one of the existing community descriptions, or they may be different enough to require their own sub-classification.

Wade ponds are rounded/elliptical depressions that are found in clustered concentrations throughout the Coastal Plain. Swamp tupelo is the dominant canopy species. Pond cypress is very common, although it is never as abundant as swamp tupelo and may be entirely absent. Other associate canopy species include loblolly pine, red maple, and sweetgum. Persimmon and oak spp. are possible, although rarely are present. The shrub layer is highly variable, with fetterbush being the most common sub-canopy species. Myrtle holly, wax myrtle, and sweet bay may also occur.

Of the communities described in the introduction, only Nelson’s swamp tupelo ponds (STPs) and Wharton’s gum ponds (GPs) are dominated by swamp tupelo. The dominance of swamp tupelo in WPs makes them candidates for these communities. However, Nelson states that red maple is a fairly dominant species within STPs while only occurring in six WPs. Wharton defines GPs as having no pond cypress in them at all. Pond cypress was found in most of the WPs that were sampled, being the second most common species present. The sub-canopy of STPs is very similar to that of WPs. However, GPs are described as being dominated by buttonbush and gallberry which are not present in WPs. Other than being dominated exclusively by swamp tupelo, WPs also share many similarities of shape, size, and species with the cypress pond community descriptions of Nelson (1986) and Wharton (1977).

Nelson (1986) and Wharton (1977) each mention the importance of fire regimes in maintaining pond cypress ponds and savannahs. When describing the dynamics of the pond cypress pond community, Nelson states that the absence of fire may eventually lead to domination by swamp tupelo. Wharton states that fires occur frequent in cypress savannahs, preventing the establishment of shrubs and hardwood trees. With the AOI lying totally within managed timber forest, fires are certainly suppressed and presumably have been for some time. It would be reasonable to believe that WPs may exhibit a transitional community; perhaps they were once pond cypress ponds, but succession due to anthropogenic factors is in the process of establishing a swamp tupelo pond.

Determining the proper classification for a community is difficult when the community in question has marked dissimilarities with several classifications. Nelson (1986) speaks on this dilemma stating that when there is strict adherence to a particular definition, “the tendency is for all of nature to be viewed as a myriad of unique communities, only differing in unrealistically fine detail.” Furthermore, Nelson (1986) states that a nationwide classification system would be ideal to combat this issue of classifying communities.

The US National Vegetation Classification (NVC) is an organizational framework for documentation, inventory, monitoring, and study of vegetation in the United States (USNVC, 2018). Developed by NatureServe, the Ecological Society of America, and federal agencies, the NVC was first recognized by the Federal Geographic Data Committee in 1998 and has since evolved as a national-level standard for classifying communities. Vegetation communities are organized into an eight-level hierarchy: class, subclass, formation, division, macrogroup, group, alliance, and association.

Dividing communities in this manner is helpful in recognizing variation among different examples of a single community type while still maintaining structural integrity necessary for classifying the natural environment. If Nelson’s STPs or Wharton’s GPs were to be entered into the NVC, they would belong to the ‘alliance’ level in the hierarchy.

The Swamp Tupelo Swamp Forest Alliance is defined as forests that are codominated by swamp tupelo and red maple, with variance in other canopy species as well as sub-canopy species (USNVC, 2018). This classification is further broken down into six ‘associations.’ The associations are much more specific and have a variety of species compositions that are not necessarily mentioned in their alliance definition. However, none of these associations mention the presence of pond cypress. Several communities within the pond cypress alliances mention the presence of swamp tupelo, but WPs would not fit into those alliances.

Attempting to determine the appropriate classification for WPs by combing through the details of definitions from varying authors seems trivial and unnecessary. However, the USNVC provides a framework that is conducive to such determinations. Therefore, perhaps WPs could be a new community classification, as an association of the Swamp Tupelo Swamp Forest Alliance. According to the website, the ESA Vegetation Panel manages formal reviews at each level of the NVC with open access for anyone interested in submitting a proposal.

For such a proposal to occur, let alone be granted, this study will need to be expanded. The methods used for the field survey could be expanded to include environmental parameters. Soil samples, hydroperiods, and other factors could be included to better understand these GIWs and their hydrology. Similar NMS ordinations could be generated to analyze any compositional differences that may exist between WPs in this AOI and WPs from other areas. The AOI contains only a small sample of this concentration of WPs in Colleton County. Wade ponds in other counties would be useful in determining if the community described in this study applies to all concentrations of WPs.

Upon further scanning on Google Earth, concentrations of rounded wetland depressions similar to those in this study can be seen in other counties in South Carolina’s Coastal Plain. West and southwest of Lake Moultrie, hundreds of these ponds can be seen spanning the majority of Berkeley County. The concentration suddenly halts near the border of Dorchester County, like the concentration in northeastern Colleton County where this study took place.

Northeast of Berkeley County, a small concentration can be seen just across the border into Williamsburg County, along with another large concentration in between the Black River and Black Mingo Creek. These features seem absent farther northeast from here into Horry County and North Carolina. Northwestern Colleton County does not appear to have any WPs, but there is another cluster in southeastern Colleton County and western Charleston County. Perhaps the westernmost concentration is in Hampton County, east of Fechtig and north of Early Branch. Beyond this concentration, no concentrations are apparent into Jasper County and Georgia.

It should be pointed out that the clusters of WPs occur seemingly in the same range as Carolina Bays. Although this may be simply coincidence; not every GIW in the Coastal Plain of South Carolina has a relationship to Carolina Bays. However, wade ponds have a conspicuous distribution and presumably a unique formation process that is different from that of limestone sinks, pond cypress ponds, or other GIWs. Perhaps as these ponds are studied further, a connection may be made between WPs and Carolina Bays.

The information provided within this document is valuable to wetland research and to the inventory of natural communities of South Carolina. Hopefully, this project will prove useful as a reference for further research into other concentrations of WPs or other GIWs. These wetland features are important to society, ecology, and the overall biodiversity of the landscape.

Equation 1: Relative density of a species

$$\text{relative density} = \frac{\text{individuals of a species}}{\text{total individuals of all species}} \times 100$$

Equation 2: Total density of all species

$$\text{Total density of all species} = \frac{\text{unit area}}{(\text{mean point-to-plant distance})^2}$$

Equation 3: Density of a species

$$\text{Density} = \frac{\text{relative density of a species}}{100} \times \text{total density of all species}$$

Equation 4: Frequency of a species.

$$\text{Frequency} = \frac{\text{number of points at which a species occurs}}{\text{total number of points sampled}}$$

Equation 5: Relative frequency of a species.

$$\text{Relative Frequency} = \frac{\text{frequency value for a species}}{\text{total of frequency values for all species}} \times 100$$

Equation 6: Average basal area of a species.

$$\text{average basal area} = \frac{(BA_1 + BA_2 + \ldots BA_n)}{n}$$

Equation 7: Dominance of a species

$$\text{dominance} = \text{density of species} \times \text{average basal area of species}$$

Equation 8: Relative dominance of a species

$$\text{relative dominance} = \frac{\text{dominance of a species}}{\text{total dominance for all species}} \times 100$$

Equation 9: Importance value of a species

$$\text{importance value} = \text{relative density} + \text{relative frequency} + \text{relative dominance}$$

Table 2.1: List of woody plant species found in wade ponds, listed with their scientific name, description, common name, and conventional abbreviation.

Common Name	Scientific Name	Description	Abbreviation
Swamp Tupelo	*Nyssa biflora* Walter	Dominant Canopy	Nys_bif
Pond Cypress	*Taxodium ascendens* Brongn.	Associate Canopy	Tax_asc
Sweetgum	*Liquidambar styraciflua* L.	Associate Canopy	Liq_sty
Red Maple	*Acer rubrum* L.	Associate Canopy	Ace_rub
Loblolly Pine	*Pinus taeda* L.	Associate Canopy	Pin_tae
Shining Fetterbush	*Lyonia lucida* K. Koch	Dominant Sub-canopy	Lyo_luc
Wax Myrtle	*Myrica cerifera* L.	Associate Sub-canopy	Myr_cer
Myrtle Holly	*Ilex myrtifolia* Walter	Associate Sub-canopy	Ile_myr
Persimmon	*Diospyros virginiana* L.	Associate Canopy	Dio_vir
Swamp Bay	*Persea palustris* (Raf.) Sarg.	Associate Sub-canopy	Per_pal
Water Oak	*Quercus nigra* Rugel ex A. DC.	Associate Canopy	Que_nig

Figure 2.1: *Map of AOI with sampled ponds marked and numbered in order of sampling.*

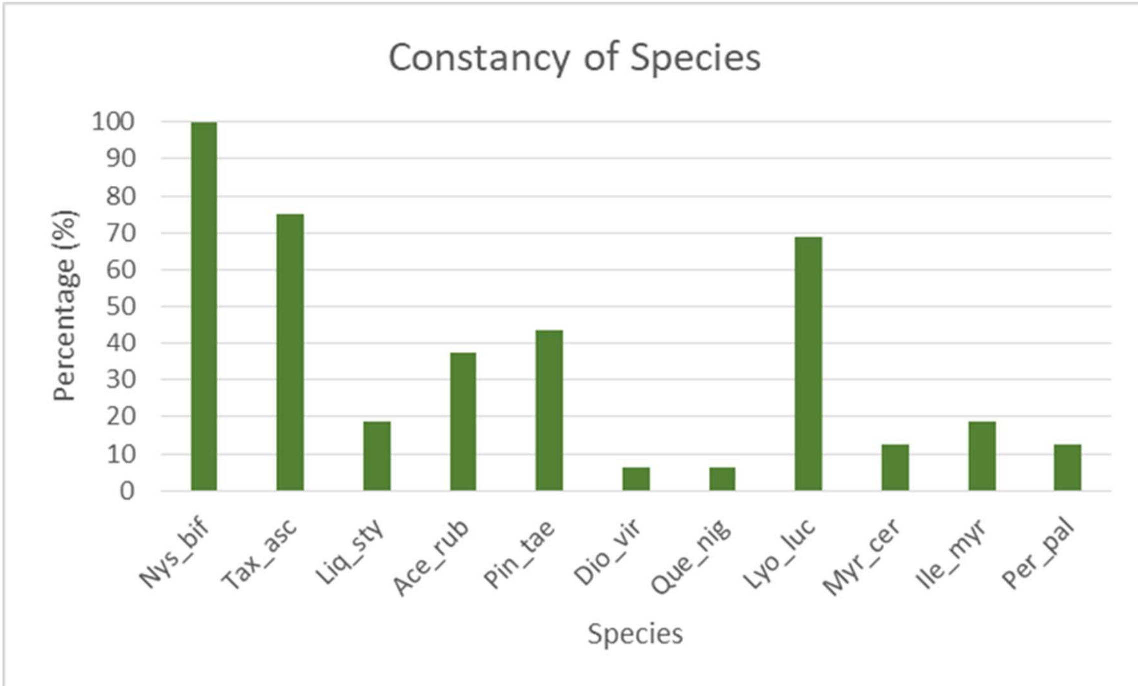

Figure 2.2: Constancy of each species.

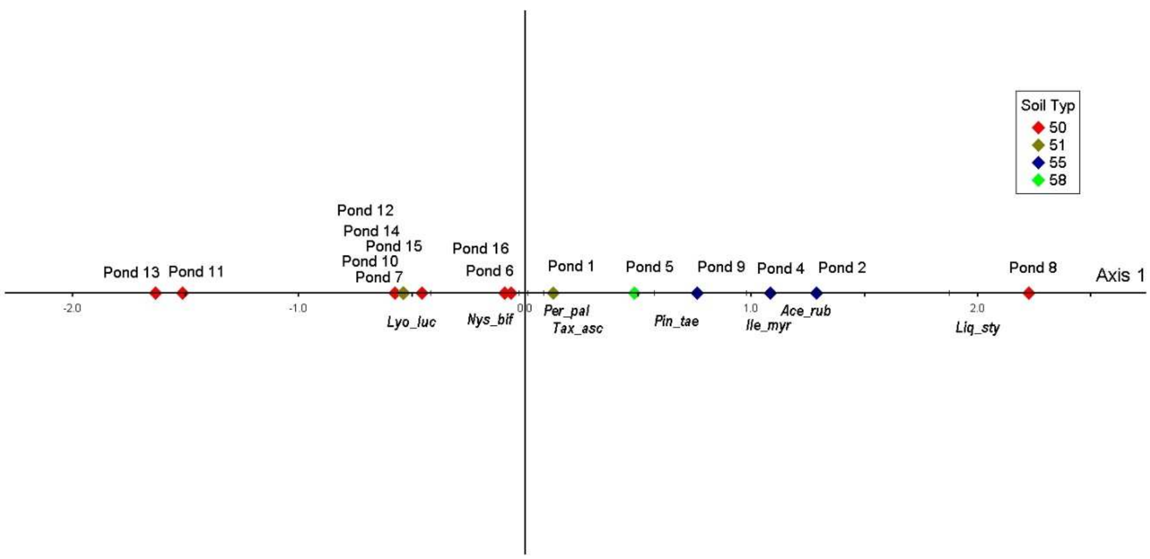

Figure 2.3: *NMS Axis 1 ordination of wade ponds. Legend displays the soil ID numbers with assigned color coordination.*

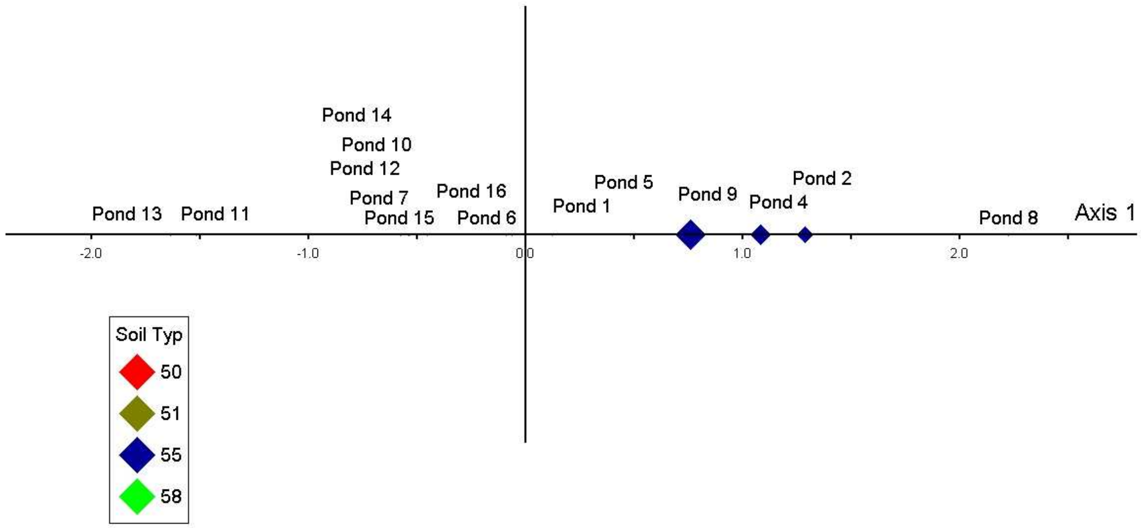

Figure 2.4: NMS ordination with only myrtle holly displayed.

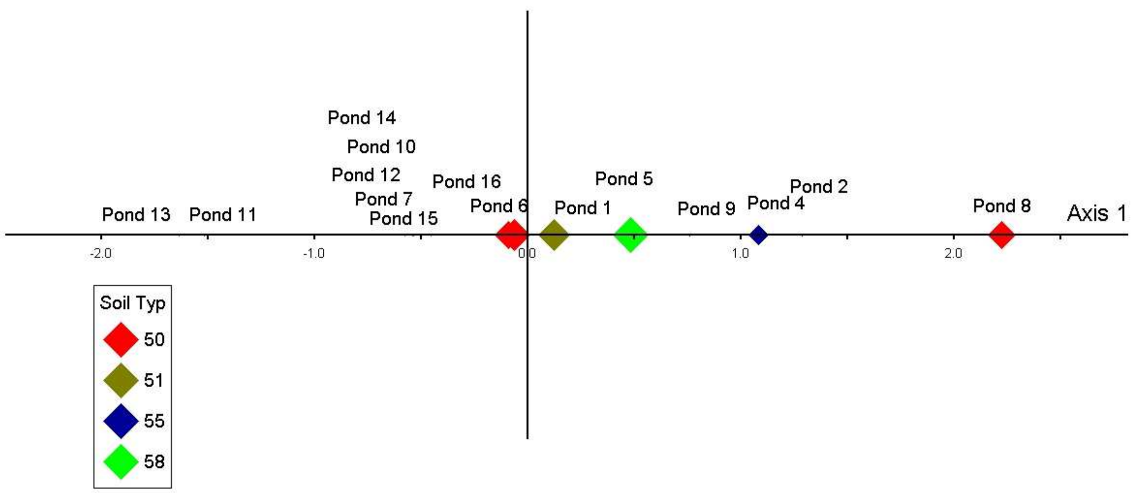

Figure 2.5: NMS ordination with only loblolly pine displayed.

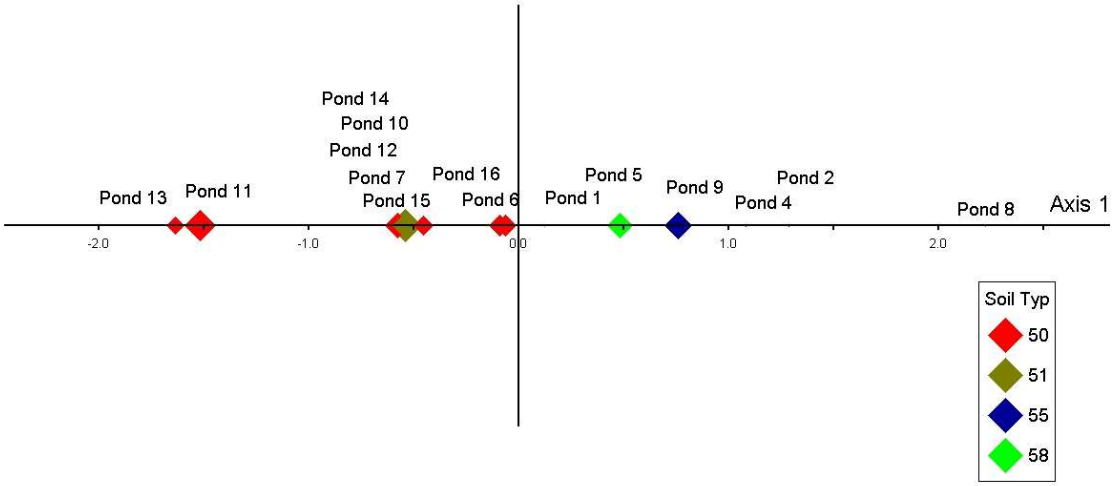

Figure 2.6: NMS ordination with only fetterbush displayed.

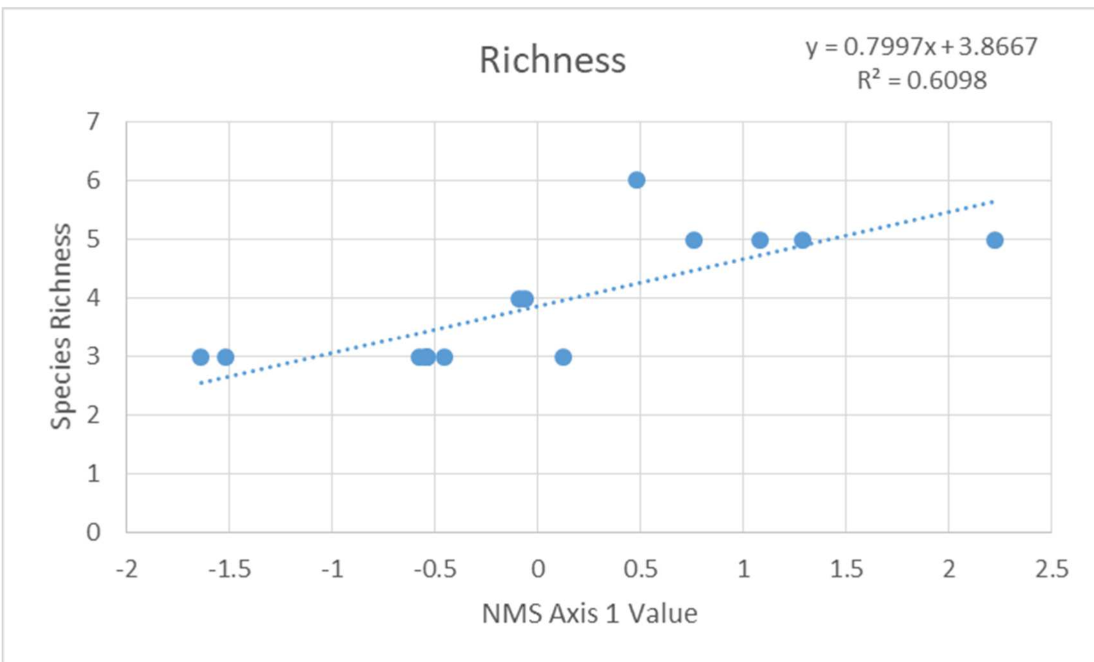

Figure 2.7: Species richness vs NMS Axis 1 Value.

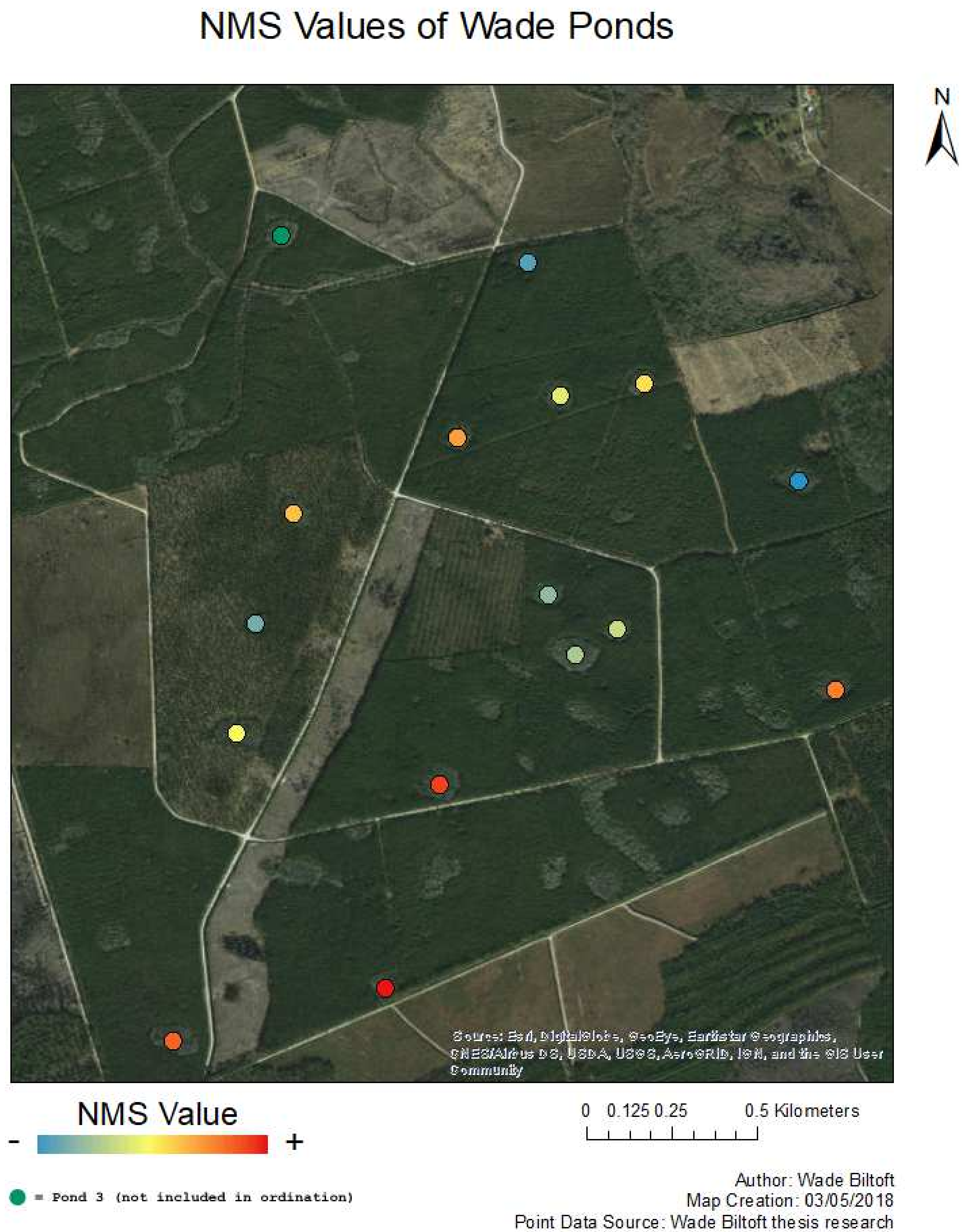

Figure 2.8: This map shows the spatial distribution of the ordination results.

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Appendix A: Raw Field Data

POND 1 Point Along Transect		**Quad 1**		**Quad 2**		**Quad 3**		**Quad 4**	
	5	Nb		Nb		Nb		Nb	
diameter (cm)			10.5		12		10		16.5
distance (m)			0.8		2.08		1.8		3.6
	7	Nb		Nb		Nb		Nb	
diameter (cm)			9		16		12.5		14
distance (m)			1.8		0.01		3.8		1.5
	10	Ta		Nb		Ta		Ta	
diameter (cm)			12		15.5		9		14
distance (m)			0.65		2.01		1.1		2.1
	18	Nb		Nb		Ta		Ta	
diameter (cm)			13		18		16.5		35
distance (m)			2.8		2.5		0.65		3.4
	22	Nb		Nb		Ta		Ta	
diameter (cm)			17		21		35		15
distance (m)			3.8		2.8		3.6		2.7
	25	Nb		Nb		Ta		Ta	
diameter (cm)			18		15		15		20
distance (m)			1.9		2.65		0.85		2.3
	37	Nb		Nb		Nb		Nb	
diameter (cm)			13		16		10.5		18.5
distance (m)			2.6		2.2		0.65		0.85
	38	Nb		Ta		Nb		Ta	
diameter (cm)			9.5		13		18		19.5
distance (m)			0.25		2.4		0.25		2.3
	40	Nb		Nb		Nb		Nb	
diameter (cm)			15		15.5		12.5		17.5
distance (m)			0.45		0.9		0.8		2
	47	Nb		Nb		Nb		Ta	
diameter (cm)			13		14		13		27
distance (m)			1.8		0.85		1.5		1.1

		Quad 1	Quad 2	Quad 3	Quad 4
	51	Nb	Nb	Nb	Nb
diameter (cm)		12.5	11	13.5	11.5
distance (m)		0.45	1.7	1.75	0.7
	55	Nb	Nb	Nb	Nb
diameter (cm)		13	9	9	12.5
distance (m)		1.3	3.1	1.2	0.55
	58	Nb	Nb	Nb	Nb
diameter (cm)		9.5	10	11	14
distance (m)		1.2	0.3	0.35	1.25
	60	Ta	Nb	Nb	Nb
diameter (cm)		6.5	9	8	6
distance (m)		1	1.1	1.4	0.8
	63	Nb	Nb	Nb	Nb
diameter (cm)		12	7.5	10	15
distance (m)		0.75	2	2.5	1.2
	66	Nb	Pt	Ta	Nb
diameter (cm)		15	7	11	12
distance (m)		2.5	1.3	2.27	1.7

POND 2 **Point Along Transect**		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	1	Nb	Nb	Nb	Ta
diameter (cm)		17	12	18.5	11.5
distance (m)		2.8	2.67	1.58	2.92
	6	Nb	Nb	Nb	Nb
diameter (cm)		15.5	17	17.5	16
distance (m)		3.58	2	3.28	1.52
	8	Nb	Nb	Nb	Nb
diameter (cm)		15.5	17	16	10.5
distance (m)		1.68	2.85	0.9	1.5
	12	Nb	Nb	Nb	Nb
diameter (cm)		18.5	14.5	13	27
distance (m)		1.12	1.25	1.27	2.92
	16	Nb	Nb	Ta	Nb
diameter (cm)		18	18	32	16
distance (m)		1.2	2.79	2.75	3.84
	17	Ta	Nb	Ta	Nb
diameter (cm)		16	18	32	15
distance (m)		2.52	1.78	2.92	3.45
	18	Nb	Ta	Nb	Ta

diameter (cm)		19.5	16	15	15
distance (m)		2.13	2.24	3.43	3.81
	24	Nb	Nb	Ta	Ta
diameter (cm)		20	21	25	17
distance (m)		2.97	3.66	2.59	1.83
	27	Nb	Nb	Ta	Im
diameter (cm)		28	19	17	3.5
distance (m)		1.22	1.17	2.92	1.4
	29	Nb	Nb	Nb	Ta
diameter (cm)		22	24	9	34
distance (m)		2.26	1.45	1.14	4.47
	33	Nb	Nb	Nb	Nb
diameter (cm)		9	18.5	12	17
distance (m)		0.33	0.61	2.9	1.6
	34	Nb	Nb	Nb	Nb
diameter (cm)		14	9	17	18
distance (m)		2.06	0.81	3.15	0.61
	35	Nb	Nb	Nb	Nb
diameter (cm)		9	17.5	18	13
distance (m)		3.51	2.11	0.38	6.17
	47	Nb	Nb	Nb	Nb
diameter (cm)		17	15	20	15
distance (m)		1.75	1.27	1.65	5.06
	50	Ta	Nb	Nb	Nb
diameter (cm)		11	17	19	9
distance (m)		4.06	2.16	3.73	2.13
	56	Nb	Nb	Ls	Ar
diameter (cm)		14.5	9.5	12.5	52
distance (m)		1.88	3.84	3	5.28

POND 3 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	1	Nb	Mc	Mc	Ls
diameter (cm)		3	7	4	11
distance (m)		0.71	2.39	1.98	1.75
	6	Ls	Ls	Pt	Ls
diameter (cm)		14	19	18	6
distance (m)		2.54	0.97	2.16	0.97
	8	Ls	Ls	Ls	Ar
diameter (cm)		14	19	6	4

distance (m)			0.71		2.29		1.27		0.48
	12	Ar		Nb		Ls		Nb	
diameter (cm)			6		20		15		20
distance (m)			0.66		1.4		2.31		1.04
	16	Ls		Ls		Ls		Ls	
diameter (cm)			23.5		15		20		16.5
distance (m)			1.32		3.05		3.91		2.06
	17	Ls		Ls		Ar		Ls	
diameter (cm)			23.5		15		16.5		16.5
distance (m)			0.48		3.58		3.66		1.12
	18	Ar		Ls		Ls		Ar	
diameter (cm)			9		18		16.5		8.5
distance (m)			1.12		0.51		0.56		1.63
	24	Ls		Nb		Ls		Ls	
diameter (cm)			13		35.5		21.5		24
distance (m)			4.14		3.76		4.72		1.45
	27	Ls		Nb		Ls		Nb	
diameter (cm)			12		35.5		24		25.5
distance (m)			1.3		4.83		2.79		2.92
	29	Nb		Nb		Nb		Nb	
diameter (cm)			14		13		25.5		13
distance (m)			2.24		1		3.05		1.02
	33	Nb		Nb		Nb		Nb	
diameter (cm)			20		19		14		25.5
distance (m)			2.9		0.31		0.86		2.08
	34	Nb		Nb		Nb		Nb	
diameter (cm)			19		19		14		23
distance (m)			4.6		0.89		1.65		6.33
	35	Nb		Nb		Nb		Nb	
diameter (cm)			19		19		27		23
distance (m)			3.84		1.98		2.44		8.53
	47	Nb		Ls		Nb		Nb	
diameter (cm)			33		38		23		9
distance (m)			2.35		1.88		4.65		1.7
	50	Ar		Nb		Nb		Ls	
diameter (cm)			22		33		9		38
distance (m)			5.03		1.7		1.88		2.9
	56	Ar		Ar		Ls		Qn	
diameter (cm)			16		13		38		13
distance (m)			2.69		1.25		4.42		0.56
	57	Ar		Ar		Qn		Nb	
diameter (cm)			26		13		13		22

distance (m)		4.72	1.88	0.41	1.04
	63	Nb	Ar	Nb	Nb
diameter (cm)		24	26	28	14
distance (m)		3	5.39	2.13	1.78
	71	Ar	Nb	Ar	Nb
diameter (cm)		17	9	31	19
distance (m)		2.01	3.2	1.7	2.03

POND 4 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	1	Nb	Nb	Ta	Nb
diameter (cm)		20	15	14	8.5
distance (m)		2.69	1.83	1.09	0.66
	6	Nb	Nb	Nb	Nb
diameter (cm)		22	13	22	8
distance (m)		2.44	4.72	1.47	1.96
	8	Nb	Nb	Nb	Ta
diameter (cm)		11	25	7	19
distance (m)		5.99	2.27	1.78	2.27
	12	Ta	Nb	Nb	Ta
diameter (cm)		22	11	19	20
distance (m)		2.29	5.49	3.89	2.26
	16	Nb	Ta	Nb	Nb
diameter (cm)		11	24	6	24
distance (m)		1.65	1.32	2.01	2.52
	17	Nb	Ta	Nb	Nb
diameter (cm)		11	24	6	24
distance (m)		0.91	2.29	2.24	2.26
	18	Nb	Nb	Nb	Nb
diameter (cm)		20	10	25	19
distance (m)		1.98	0.97	2.39	4.7
	24	Ta	Nb	Nb	Ta
diameter (cm)		31	16.5	19	14
distance (m)		3.18	1.35	2.57	3.28
	27	Ta	Nb	Nb	Nb
diameter (cm)		23	7	10	9

distance (m)		2.79	3.45	3.81	1
	29	Nb	Nb	Nb	Nb
diameter (cm)		14	16.5	13	7.5
distance (m)		1.12	2.49	0.51	3.45
	33	Nb	Ta	Nb	Nb
diameter (cm)		26	25.5	21.5	53
distance (m)		3.25	0.84	3.96	3.81
	34	Nb	Ta	Nb	Nb
diameter (cm)		26	25.5	21.5	53
distance (m)		2.57	1.78	4.34	3.56
	35	Nb	Ta	Nb	Nb
diameter (cm)		26	25.5	21.5	53
distance (m)		2.03	2.67	4.83	3.33
	47	Ta	Nb	Nb	Ta
diameter (cm)		29.5	26	21.5	19
distance (m)		0.91	2.92	7.57	5.03
	50	Nb	Ta	Ta	Nb
diameter (cm)		11.5	29	19	21.5
distance (m)		2.67	1.73	4.27	2.72
	56	Ta	Ta	Ta	Ta
diameter (cm)		21.5	14	15	17.5
distance (m)		4.06	1.52	2.24	1.49
	57	Ta	Ta	Ta	Ta
diameter (cm)		26.5	12.5	14.5	17.5
distance (m)		5.26	2.16	3.18	1.04
	62	Ta	Ta	Nb	Ta
diameter (cm)		17.5	26.5	11	28
distance (m)		1.68	4.85	1.5	2.95
	64	Nb	Nb	Nb	Ta
diameter (cm)		25.5	17.5	10	28
distance (m)		3.43	0.36	2.44	1.22
	68	Nb	Nb	Nb	Nb
diameter (cm)		15	25.5	6.5	16.5
distance (m)		0.58	3.66	1.73	1.8
	72	Nb	Nb	Im	Ta
diameter (cm)		7.5	13	10	14
distance (m)		2.34	1.02	1.5	1.25

		Quad 1	Quad 2	Quad 3	Quad 4
	73	Nb	Nb	Im	Ta
diameter (cm)		7.5	13	10	14
distance (m)		1.91	1.85	1.68	0.41
	74	Ta	Nb	Nb	Ta
diameter (cm)		15	7.5	17.5	21.5
distance (m)		2.72	1.98	0.81	2.57
	80	Nb	Nb	Ta	Nb
diameter (cm)		21.5	16.5	21.5	14
distance (m)		2.77	0.64	1.27	3.12
	83	Nb	Nb	Nb	Nb
diameter (cm)		7.5	23	14	12
distance (m)		3.1	2.74	2.21	1.27
	85	Nb	Nb	Nb	Ta
diameter (cm)		7.5	24	9	34.5
distance (m)		1.83	4.32	1.19	1.3
	89	Nb	Pt	Ta	Ta
diameter (cm)		5	34.5	35	32
distance (m)		1.09	4.5	2.64	4.04
	95	Nb	Nb	Nb	Nb
diameter (cm)		18	16.5	14	9
distance (m)		3.35	1.88	0.71	1.58
	106	Ar	Im	Nb	Ar
diameter (cm)		12.5	4	7	21.5
distance (m)		4.6	0.58	1.07	5.23

POND 5 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	5	Nb	Nb	Nb	Ta
diameter (cm)		5	5.5	5.5	23.5
distance (m)		4.14	3.18	1.47	3.38
	7	Nb	Nb	Ta	Mc
diameter (cm)		5	5.5	24	3
distance (m)		2.36	3.51	1.83	0.74
	10	Ar	Nb	Pt	Mc
diameter (cm)		11.5	5	43	4
distance (m)		3.3	1.3	1.17	0.66

	18	Nb	Nb	Nb	Nb
diameter (cm)		9.5	3	13	15
distance (m)		2.79	0.36	0.41	1.6
	22	Nb	Ta	Ll	Mc
diameter (cm)		7.5	20	4	4.5
distance (m)		2.31	1.42	2.24	2.44
	25	Ta	Ta	Mc	Mc
diameter (cm)		27	23	4.5	7.5
distance (m)		2.06	0.36	1.5	1.88
	37	Nb	Ll	Ll	Nb
diameter (cm)		9	4	3.5	19
distance (m)		2.08	0.31	1.73	0.38
	38	Nb	Ll	Nb	Nb
diameter (cm)		8	3	21	13
distance (m)		1.12	1.17	0.97	0.24
	40	Nb	Nb	Nb	Nb
diameter (cm)		5	20	10	10
distance (m)		1.85	2.13	1.5	1.47

POND 6 **Point Along Transect**		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Nb	Nb	Nb	Nb
diameter (cm)		15.5	19	16	12
distance (m)		2.69	2.67	4.01	3.63
	4	Nb	Nb	Nb	Nb
diameter (cm)		15	17	11	13
distance (m)		1.04	4.12	4	2.31
	7	Ta	Ta	Nb	Ta
diameter (cm)		15	24	18	29
distance (m)		1.8	0.89	2.1	2.36
	11	Nb	Nb	Ta	Ta
diameter (cm)		21	20	29	28
distance (m)		2.29	1.22	1.42	1.72
	14	Nb	Nb	Ta	Ta
diameter (cm)		30	22	28	33
distance (m)		3.2	2.93	2.67	2.82
	19	Ta	Nb	Ta	Nb

diameter (cm)		21	27	33	14
distance (m)		1.4	3.51	2.39	2.82
	20	Ta	Nb	Nb	Nb
diameter (cm)		19.5	32	13	40
distance (m)		0.31	4.22	2.69	2.7
	23	Nb	Ta	Nb	Ta
diameter (cm)		12	21	40	15
distance (m)		1.22	2.5	1.42	2.97
	24	Nb	Ta	Nb	Nb
diameter (cm)		13	22	40	37
distance (m)		0.29	3.61	2.08	7.6
	34	Nb	Pt	Nb	Ta
diameter (cm)		17	19	23	40
distance (m)		3.54	2.36	4.22	4.5
	36	Nb	Pt	Nb	Ta
diameter (cm)		17	19	13	36
distance (m)		1.98	3.71	4.5	3.48
	39	Ta	Nb	Ll	Nb
diameter (cm)		25	19	4	20
distance (m)		0.43	1.04	3.76	3.68
	41	Nb	Nb	Nb	Nb
diameter (cm)		18	17	21	15
distance (m)		1.19	0.27	3.81	2.31
	47	Ta	Ll	Ta	Nb
diameter (cm)		31	3	14	33
distance (m)		2.34	4.62	1.22	2.82
	51	Nb	Ta	Nb	Ta
diameter (cm)		15	32	38	17
distance (m)		1.25	2.13	3.02	0.58
	55	Ta	Nb	Ta	Ll
diameter (cm)		29	14	19	3
distance (m)		1.46	2.82	1.4	1.07
	60	Nb	Nb	Nb	Nb
diameter (cm)		35	30	15	16
distance (m)		5.18	1.63	2.44	0.18
	64	Nb	Nb	Nb	Ll

diameter (cm)		17	15	15	4
distance (m)		2.82	3.63	3.33	1.47
	67	Nb	Nb	Ta	Ta
diameter (cm)		12	25	21	18
distance (m)		2.16	0.36	0.81	2.67
	68	Nb	Nb	Ta	Ta
diameter (cm)		12	25	17	18
distance (m)		1.27	1.04	1.75	2.16
	70	Ll	Nb	Ta	Nb
diameter (cm)		3	22	20	11
distance (m)		2.06	0.15	2.31	2.67
	74	Ll	Ll	Nb	Nb
diameter (cm)		3.5	4	10	37
distance (m)		0.48	1.52	2.36	2.39
	77	Nb	Ll	Nb	Ta
diameter (cm)		22	3	37	24
distance (m)		2.64	2.13	0.13	4.55
	80	Ta	Nb	Nb	Nb
diameter (cm)		14	20	37	13
distance (m)		1.14	0.79	3.35	2.24
	82	Ta	Ta	Ta	Nb
diameter (cm)		24	14	21	13
distance (m)		0.91	0.84	4.48	0.61
	86	Nb	Nb	Nb	Nb
diameter (cm)		13	17	14	21
distance (m)		2.08	1.91	1.47	2.26

POND 7 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Nb	Nb	Nb	Nb
diameter (cm)		18	13	15	11.5
distance (m)		0.76	1.37	1.93	0.28
	4	Nb	Nb	Nb	Ll
diameter (cm)		14	4	16.5	4
distance (m)		1.75	2.64	0.94	0.86

		Quad 1	Quad 2	Quad 3	Quad 4
	7	Nb	Nb	Nb	Nb
diameter (cm)		13	14	7.5	18
distance (m)		3.05	1.32	1.7	0.94
	11	Ll	Nb	Ta	Nb
diameter (cm)		3	16.5	23	14
distance (m)		1.14	1.52	1.78	1.42
	14	Ll	Nb	Ll	Nb
diameter (cm)		6.5	20	5	11.5
distance (m)		2.57	0.13	1.5	0.66
	19	Nb	Nb	Nb	Nb
diameter (cm)		13	13	7.5	37
distance (m)		1.47	1.4	2.62	1.83
	23	Ta	Nb	Nb	Nb
diameter (cm)		10	9	19	11.5
distance (m)		1.7	1.47	1.45	0.64
	24	Ta	Nb	Nb	Nb
diameter (cm)		10	9	11.5	5
distance (m)		0.71	2.49	1.17	2.85
	34	Nb	Nb	Nb	Nb
diameter (cm)		11.5	12.5	15	18
distance (m)		1.25	2.18	0.24	0.91
	36	Ta	Nb	Nb	Nb
diameter (cm)		18	10	16.5	10
distance (m)		1.3	0.86	1.04	0.48

POND 8 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	1	Nb	Nb	Nb	Nb
diameter (cm)		21.5	9	18	11.5
distance (m)		2.21	1.65	1.04	0.75
	8	Nb	Nb	Nb	Nb
diameter (cm)		5	16.5	14	4
distance (m)		1.31	4.6	6.15	0.58
	9	Nb	Nb	Nb	Nb
diameter (cm)		6.5	4	3.5	31
distance (m)		2.69	1.65	0.97	5.39
	14	Nb	Nb	Nb	Nb
diameter (cm)		5	7.5	4	30
distance (m)		1.91	1.25	5.77	1.98
	16	Nb	Nb	Nb	Nb
diameter (cm)		4.5	5	31	4
distance (m)		1.17	0.22	2.64	1.89

		Quad 1	Quad 2	Quad 3	Quad 4
	18	Ls	Nb	Nb	Ls
diameter (cm)		10	4	3.5	4
distance (m)		2	1.37	0.79	5.91
	24	Nb	Ls	Nb	Ls
diameter (cm)		47	11.5	4	3.5
distance (m)		4.22	0.2	6.2	0.71
	28	Nb	Nb	Nb	Nb
diameter (cm)		28	16.5	27	27
distance (m)		1.75	1.45	2.57	2.34
	29	Nb	Nb	Nb	Nb
diameter (cm)		28	16.5	27	27
distance (m)		1.52	1.73	3.66	1.93
	31	Nb	Nb	Nb	Nb
diameter (cm)		20	28	27	18
distance (m)		0.33	2.52	2.39	3.91
	35	Nb	Nb	Nb	Nb
diameter (cm)		20	15	20.5	14
distance (m)		1.17	1.4	3.48	1.78
	36	Nb	Nb	Nb	Nb
diameter (cm)		20	15	14	16.5
distance (m)		0.18	1.98	1.96	1.7
	39	Pp	Nb	Nb	Nb
diameter (cm)		4	19	16.5	11.5
distance (m)		0.28	1.63	3.38	0.66
	44	Ar	Pp	Pt	Nb
diameter (cm)		11.5	4	23	32
distance (m)		1.73	1.79	0.53	4.32

POND 9 **Point Along Transect**		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Ta	Ta	Nb	Im
diameter (cm)		3	12	32	13
distance (m)		3.89	2.11	0.71	0.1
	4	Nb	Ta	Im	Ll
diameter (cm)		6	15	13	7
distance (m)		1.74	2.95	1.96	1.12
	7	Nb	Ll	Nb	Nb
diameter (cm)		12	3	11	10
distance (m)		0.79	0.81	2.65	0.58
	11	Nb	Nb	Nb	Im
diameter (cm)		13	6	33	7
distance (m)		1.83	2.39	0.53	2.69

	14	Nb	Nb	Nb	Nb
diameter (cm)		19	11	12	17
distance (m)		1.42	0.81	0.41	1.97
	19	Ta	Nb	Ta	Nb
diameter (cm)		29	12	33	17
distance (m)		3.05	0.89	0.47	0.84
	20	Ll	Nb	Ta	Nb
diameter (cm)		3	12	33	17
distance (m)		0.55	1.63	1.32	0.23
	23	Nb	Nb	Nb	Ll
diameter (cm)		8	21	12	3
distance (m)		1.42	1.78	0.71	1.96
	24	Nb	Nb	Nb	Nb
diameter (cm)		4	7	12	19
distance (m)		2	1.75	1.61	0.86
	34	Nb	Nb	Ta	Nb
diameter (cm)		15	11	37	10
distance (m)		1.3	1.14	2.29	1.04
	36	Ar	Nb	Nb	Nb
diameter (cm)		7	11	14	13.5
distance (m)		1.69	0.53	1.98	0.75

POND 10		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
Point Along Transect					
	2	Nb	Ll	Nb	Nb
diameter (cm)		19.5	4	27	16
distance (m)		1.05	1.75	2.5	0.93
	4	Ll	Ll	Nb	Nb
diameter (cm)		5	3	13.5	15
distance (m)		1.22	1.17	0.93	0.28
	9	Nb	Nb	Nb	Ta
diameter (cm)		10	8.5	26	19
distance (m)		0.83	1.3	1.04	0.4
	10	Ll	Nb	Ta	Nb
diameter (cm)		3	9.5	19	19
distance (m)		2.2	1.22	0.4	0.73
	13	Ll	Ll	Ta	Nb
diameter (cm)		3	3	21	13.5
distance (m)		0.34	1.12	0.95	1.21
	14	Nb	Ll	Ta	Nb

diameter (cm)		16	3.5	21	13
distance (m)		1.68	0.74	1.78	0.58
	18	Nb	Nb	Ll	Ll
diameter (cm)		16.5	11	4	3.5
distance (m)		2.27	0.5	0.52	1.25
	20	Nb	Nb	Ll	Ta
diameter (cm)		30.5	19	3.5	26
distance (m)		1.27	1.44	1.74	1.92
	23	Ta	Nb	Ll	Ta
diameter (cm)		15	30.5	4	20
distance (m)		1.68	3.12	1.58	0.57
	27	Nb	Nb	Ta	Nb
diameter (cm)		19.5	23	16.5	8
distance (m)		0.87	2	3.09	1.48
	29	Ll	Nb	Nb	Nb
diameter (cm)		3	13	13	16.5
distance (m)		1.21	0.48	1.38	1.35
	30	Nb	Ll	Nb	Nb
diameter (cm)		8.5	3	16.5	13
distance (m)		2	0.86	0.91	2.94
	35	Nb	Nb	Nb	Nb
diameter (cm)		14.5	17	17	10.5
distance (m)		0.9	1.88	1	0.78

POND 11 Point Along Transect		Quad 1	Quad 2	Quad 3	Quad 4
	2	Nb	Nb	Ll	Ll
diameter (cm)		6.5	13	3.5	3
distance (m)		0.93	2.03	0.56	0.29
	4	Nb	Nb	Ll	Nb
diameter (cm)		7	9.5	3	17
distance (m)		1.23	0.91	0.64	0.58
	9	Nb	Nb	Nb	Nb
diameter (cm)		13.5	13	7.5	10
distance (m)		0.35	2.47	0.84	1.15
	10	Nb	Nb	Nb	Nb
diameter (cm)		12	13	9.5	16
distance (m)		0.87	0.82	1.52	1.59
	13	Pp	Nb	Nb	Nb
diameter (cm)		3	8	12	11.5

distance (m)	1.9	2.1	0.52	1.92

<u>POND 12</u> Point Along Transect	**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
2	Nb	Nb	Ll	Nb
diameter (cm)	12	18	4	10
distance (m)	0.77	0.16	1.88	2.76
4	Nb	Nb	Nb	Nb
diameter (cm)	10	15	9	10
distance (m)	0.41	1.29	0.8	0.85
9	Nb	Ta	Nb	Nb
diameter (cm)	13	13	7	10
distance (m)	1.02	2.07	1.1	2.45
10	Ta	Nb	Nb	Nb
diameter (cm)	24	13	7	10
distance (m)	1.44	0.8	1.82	1.7
13	Ta	Ll	Nb	Nb
diameter (cm)	16	3.5	16	7
distance (m)	1.38	0.98	1.15	0.56
16	Nb	Nb	Ll	Nb
diameter (cm)	22	13	4	10
distance (m)	5.05	2.15	1.8	1.39
18	Nb	Nb	Nb	Nb
diameter (cm)	5	13	22	10
distance (m)	3.22	3.1	2.43	3.98
20	Nb	Nb	Nb	Nb
diameter (cm)	7	17	22	16
distance (m)	1.3	3.2	4.13	2.25
23	Nb	Nb	Ll	Nb
diameter (cm)	5.5	17	5	24
distance (m)	1.25	0.19	1.71	2.8
27	Nb	Nb	Nb	Nb
diameter (cm)	8.5	5	22	8
distance (m)	0.88	1.97	1.72	1.04
29	Nb	Nb	Nb	Nb
diameter (cm)	9	9	8	10
distance (m)	1.55	1.45	0.96	0.52
30	Nb	Nb	Nb	Nb
diameter (cm)	9	8	12	10
distance (m)	0.62	2.39	0.82	0.96

	35	Nb	Nb	Ll	Nb
diameter (cm)		11	6	3	12.5
distance (m)		0.22	2.2	0.42	1.5

POND 13 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Nb	Nb	Nb	Nb
diameter (cm)		12	4	14	13
distance (m)		1.36	1.95	1.45	0.88
	4	Nb	Nb	Nb	Nb
diameter (cm)		22	12	13	7
distance (m)		1.24	1.15	1	0.55
	9	Nb	Nb	Nb	Nb
diameter (cm)		8	9	16	21
distance (m)		0.67	1.37	3.13	0.65
	10	Nb	Nb	Nb	Nb
diameter (cm)		34	9	22	22
distance (m)		3.9	1.44	0.68	1.85
	13	Nb	Nb	Nb	Dv
diameter (cm)		19	9	22	4
distance (m)		5.08	3.6	3.12	0.6
	16	Nb	Nb	Dv	Dv
diameter (cm)		41	19	6	7
distance (m)		4.87	4.95	1.17	3.21
	18	Nb	Nb	Dv	Dv
diameter (cm)		41	18	7	7
distance (m)		3.25	5.6	2.89	2.95
	20	Nb	Nb	Dv	Dv
diameter (cm)		41	17	7	7
distance (m)		2.37	6.87	3.77	1.54
	23	Nb	Nb	Dv	Dv
diameter (cm)		22	24	7	5
distance (m)		3.67	3	2.87	2.4
	29	Nb	Nb	Dv	Nb
diameter (cm)		18	21	5	26
distance (m)		1.17	2.66	4.68	0.68
	30	Nb	Nb	Nb	Nb
diameter (cm)		7	18	26	27
distance (m)		0.61	0.36	0.4	3.34
	35	Nb	Nb	Nb	Nb

diameter (cm)		13	22	2	22
distance (m)		1.84	1.37	2.17	2.8
	43	Nb	Nb	Nb	Nb
diameter (cm)		23	23	21	19
distance (m)		1.7	2.44	3.63	3.48
	46	Ll	Nb	Nb	Nb
diameter (cm)		4	34	19	11
distance (m)		4.64	2	3.61	2.79
	49	Ll	Nb	Nb	Nb
diameter (cm)		4	31	21	22
distance (m)		1.74	4.32	1.67	2.88
	54	Nb	Nb	Nb	Nb
diameter (cm)		27	30	19	18
distance (m)		1.59	0.25	0.93	1.97
	60	Nb	Nb	Nb	Nb
diameter (cm)		23	7	21	8
distance (m)		1.95	1.53	1.58	2.77

POND 14 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Nb	Ta	Nb	Ll
diameter (cm)		23	29.5	7.5	4.5
distance (m)		2.57	2	1.52	2.64
	4	Nb	Nb	Nb	Ll
diameter (cm)		23	8.5	7	4.5
distance (m)		1.14	2.08	3.14	1.9
	5	Nb	Nb	Ll	Nb
diameter (cm)		13	24	4.5	30
distance (m)		1.72	1.19	2.16	1.83
	8	Nb	Nb	Ll	Ta
diameter (cm)		30.5	12	3	17.5
distance (m)		1.24	1.42	0.69	0.88
	10	Nb	Nb	Ta	Nb
diameter (cm)		30.5	10	14.5	10
distance (m)		2.5	1	1.82	1.87
	14	Ta	Nb	Nb	Nb
diameter (cm)		24	16	10	10
distance (m)		3.24	2.02	2.2	1
	15	Ta	Nb	Nb	Nb

diameter (cm)		24	16	10	13
distance (m)		2.91	2.68	1.08	1.72
	18	Nb	Ta	Nb	Ta
diameter (cm)		18.5	22	13	22
distance (m)		4.67	3.65	2.25	2.21
	20	Nb	Nb	Ta	Nb
diameter (cm)		27.5	17.5	22	14
distance (m)		1.68	4.54	5.04	1.11
	27	Nb	Nb	Ll	Ll
diameter (cm)		24	26	5.5	4.5
distance (m)		5.07	3.83	3.22	4.85
	28	Nb	Nb	Ll	Ll
diameter (cm)		24	26	5.5	4.5
distance (m)		4.68	4.85	4	4.12
	30	Ll	Nb	Ll	Ll
diameter (cm)		4	24	5.5	4
distance (m)		4	4.27	5.62	3.36
	33	Ll	Nb	Ll	Nb
diameter (cm)		4.5	25.5	4	30.5
distance (m)		1.4	4.94	4.12	2.02
	36	Nb	Ll	Nb	Nb
diameter (cm)		22	6	18.5	20.5
distance (m)		3.32	1.5	0.93	4.46
	42	Ll	Nb	Nb	Nb
diameter (cm)		3	14	9	16.5
distance (m)		1.74	1.46	1.38	1.92
	44	Ta	Ta	Nb	Nb
diameter (cm)		25.5	24.5	20	65
distance (m)		0.68	1	1.4	1.55
	47	Nb	Nb	Nb	Nb
diameter (cm)		10.5	10	6.5	11.5
distance (m)		1.29	1.4	1.73	0.84
	48	Nb	Nb	Ll	Nb
diameter (cm)		11	10	3	11
distance (m)		1.66	1.07	0.76	0.23
	51	Nb	Nb	Nb	Nb
diameter (cm)		13.5	16	5.5	21
distance (m)		2.34	1.08	0.67	0.52
	54	Ta	Nb	Ta	Nb
diameter (cm)		30	8.5	33.5	26
distance (m)		1.44	1.1	0.6	2.43

	56	Nb	Ll	Nb	Nb
diameter (cm)		14.5	3	28	8.5
distance (m)		0.57	1.96	2.52	2.8
	58	Nb	Nb	Nb	Nb
diameter (cm)		23.5	16.5	15	8.5
distance (m)		1.24	1.53	3.35	1.77
	60	Ll	Nb	Nb	Nb
diameter (cm)		3.5	24.5	8.5	9.5
distance (m)		1.61	0.5	2.57	2.57
	64	Nb	Nb	Nb	Nb
diameter (cm)		9	7.5	9.5	6
distance (m)		2.67	0.83	2.05	0.4

POND 15 Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Nb	Nb	Ll	Ta
diameter (cm)		20	21.5	6.5	15
distance (m)		3.17	1.18	2.1	2.3
	4	Nb	Nb	Nb	Ta
diameter (cm)		20	21.5	11.5	15
distance (m)		1.46	2.66	4.05	0.58
	9	Nb	Nb	Nb	Nb
diameter (cm)		7.5	15	15	17
distance (m)		1.26	1.77	3.75	2.35
	10	Nb	Nb	Nb	Nb
diameter (cm)		8.5	17	17.5	21
distance (m)		0.95	2.22	2.62	2.76
	15	Ta	Ta	Nb	Nb
diameter (cm)		11	12	24	17
distance (m)		1.55	1.82	2.25	1.3
	18	Ta	Ll	Nb	Nb
diameter (cm)		15.5	5.5	23	19.5
distance (m)		2.12	1.55	0.04	4.27
	20	Ta	Ta	Nb	Nb
diameter (cm)		11	16	23	19.5
distance (m)		3	1.32	1.95	2.92
	23	Ta	Ta	Nb	Ta
diameter (cm)		15	16	19.5	16
distance (m)		0.18	3.26	2.74	2.55
	27	Nb	Nb	Nb	Nb

diameter (cm)		29	20.5	20	10.5
distance (m)		4.93	2.37	2.15	1.64
	29	Nb	Nb	Nb	Nb
diameter (cm)		13.5	20.5	20	20.5
distance (m)		4.52	4.13	1.55	2.52

POND 16

Point Along Transect		**Quad 1**	**Quad 2**	**Quad 3**	**Quad 4**
	2	Nb	Nb	Nb	Nb
diameter (cm)		11.5	15	20	12
distance (m)		1.1	1.83	1.96	3.41
	5	Nb	Nb	Nb	Nb
diameter (cm)		13	10.5	12	16.5
distance (m)		1.43	2.19	2.37	0.47
	7	Nb	Nb	Nb	Nb
diameter (cm)		6.5	13	16.5	19
distance (m)		1.12	1.6	1.75	1.65
	10	Nb	Nb	Nb	Nb
diameter (cm)		21	22.5	19	14
distance (m)		2.37	1.85	1.31	1.7
	13	Nb	Nb	Nb	Nb
diameter (cm)		27.5	21	14	9
distance (m)		0.8	2.13	3.27	2.48
	16	Nb	Nb	Ta	Ta
diameter (cm)		7	25	19	12
distance (m)		0.85	2.47	2.48	2.22
	18	Nb	Nb	Ta	Nb
diameter (cm)		15	8	20	11.5
distance (m)		0.7	1.28	3.65	0.04
	20	Nb	Nb	Ta	Nb

diameter (cm)		16	14.5	12	6
distance (m)		1.38	1.12	2.82	0.97
	24	Nb	Ll	Nb	Nb
diameter (cm)		11	3	17	11
distance (m)		1.18	0.91	1.05	0.59
	25	Nb	Nb	Nb	Nb
diameter (cm)		16.5	11	11	18
distance (m)		2.88	0.87	1	0.3
	30	Nb	Nb	Nb	Ta
diameter (cm)		22	13	13	37
distance (m)		0.46	2.5	2.35	3.07
	32	Nb	Nb	Ta	Ta
diameter (cm)		8	22.5	37	47
distance (m)		0.37	1.8	2.15	1.83
	35	Ll	Nb	Nb	Nb
diameter (cm)		4	12	10.5	24
distance (m)		0.54	2.03	1.29	1.04
	41	Nb	Nb	Nb	Ta
diameter (cm)		23.5	10.5	14	16
distance (m)		2.17	1.28	1.73	0.1
	45	Nb	Nb	Ta	Nb
diameter (cm)		13	24	9.5	12.5
distance (m)		1.74	2.5	2.25	2.06
	49	Pt	Nb	Nb	Nb
diameter (cm)		58	10.5	13	19
distance (m)		0.62	0.8	0.82	2.97

Appendix B: Abundance Measures

Relative Density

Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	76.56	21.88	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	78.13	17.19	1.56	1.56	0.00	0.00	0.00	1.56	0.00	0.00	0.00
Pond 3	43.42	0.00	32.89	17.11	1.32	0.00	2.63	0.00	0.00	0.00	2.63
Pond 4	63.79	31.03	0.00	1.72	0.86	0.00	0.00	2.59	0.00	0.00	0.00
Pond 5	55.55	13.89	0.00	2.78	2.78	11.11	13.89	0.00	0.00	0.00	0.00
Pond 6	59.62	30.77	0.00	0.00	1.92	7.69	0.00	0.00	0.00	0.00	0.00
Pond 7	80.00	10.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
Pond 8	85.71	0.00	7.14	1.79	1.79	0.00	0.00	0.00	0.00	3.57	0.00
Pond 9	65.91	15.91	0.00	2.27	0.00	9.09	0.00	6.82	0.00	0.00	0.00
Pond 10	59.62	15.38	0.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00
Pond 11	80.00	0.00	0.00	0.00	0.00	15.00	0.00	0.00	0.00	5.00	0.00
Pond 12	84.62	5.77	0.00	0.00	0.00	9.61	0.00	0.00	0.00	0.00	0.00
Pond 13	82.35	0.00	0.00	0.00	0.00	2.94	0.00	0.00	14.71	0.00	0.00
Pond 14	68.75	12.50	0.00	0.00	0.00	18.75	0.00	0.00	0.00	0.00	0.00
Pond 15	70.00	25.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00
Pond 16	81.25	14.06	0.00	0.00	1.56	3.13	0.00	0.00	0.00	0.00	0.00

Absolute Density

Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	1162.78	332.31	0.00	0.00	23.69	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	547.28	120.41	10.93	10.93	0.00	0.00	0.00	10.93	0.00	0.00	0.00
Pond 3	325.57	0.00	246.62	128.30	9.90	0.00	19.72	0.00	0.00	0.00	19.72
Pond 4	423.64	206.07	0.00	11.42	5.71	0.00	0.00	17.20	0.00	0.00	0.00
Pond 5	773.81	193.49	0.00	38.73	38.73	154.76	193.49	0.00	0.00	0.00	0.00
Pond 6	454.95	234.80	0.00	0.00	14.65	58.68	0.00	0.00	0.00	0.00	0.00
Pond 7	1633.06	204.13	0.00	0.00	0.00	204.13	0.00	0.00	0.00	0.00	0.00
Pond 8	739.39	0.00	61.59	15.44	15.44	0.00	0.00	0.00	0.00	30.80	0.00
Pond 9	1290.78	311.58	0.00	44.46	0.00	178.02	0.00	133.56	0.00	0.00	0.00
Pond 10	1438.70	371.14	0.00	0.00	0.00	603.28	0.00	0.00	0.00	0.00	0.00
Pond 11	2401.84	0.00	0.00	0.00	0.00	450.34	0.00	0.00	0.00	150.11	0.00
Pond 12	1294.99	88.30	0.00	0.00	0.00	147.07	0.00	0.00	0.00	0.00	0.00
Pond 13	597.46	0.00	0.00	0.00	0.00	21.33	0.00	0.00	106.72	0.00	0.00
Pond 14	575.38	104.61	0.00	0.00	0.00	156.92	0.00	0.00	0.00	0.00	0.00
Pond 15	537.72	192.04	0.00	0.00	0.00	38.41	0.00	0.00	0.00	0.00	0.00
Pond 16	1244.71	215.39	0.00	0.00	23.90	47.95	0.00	0.00	0.00	0.00	0.00

Absolute Frequency

Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	1.00	0.50	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	1.00	0.50	0.06	0.06	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Pond 3	0.68	0.00	0.63	0.47	0.05	0.00	0.05	0.00	0.00	0.00	0.11
Pond 4	0.93	0.76	0.00	0.03	0.03	0.00	0.00	0.10	0.00	0.00	0.00
Pond 5	0.89	0.44	0.00	0.11	0.11	0.33	0.44	0.00	0.00	0.00	0.00
Pond 6	1.00	0.73	0.00	0.00	0.08	0.27	0.00	0.00	0.00	0.00	0.00
Pond 7	1.00	0.40	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Pond 8	1.00	0.00	0.14	0.07	0.07	0.00	0.00	0.00	0.00	0.14	0.00
Pond 9	1.00	0.46	0.00	0.09	0.00	0.36	0.00	0.27	0.00	0.00	0.00
Pond 10	1.00	0.54	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00
Pond 11	1.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.20	0.00
Pond 12	1.00	0.23	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Pond 13	1.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.35	0.00	0.00
Pond 14	1.00	0.38	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00
Pond 15	1.00	0.60	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
Pond 16	1.00	0.44	0.00	0.00	0.06	0.13	0.00	0.00	0.00	0.00	0.00

Relative Frequency

Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	64.00	32.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	59.26	29.63	3.70	3.70	0.00	0.00	0.00	3.70	0.00	0.00	0.00
Pond 3	34.20	0.00	31.60	23.70	2.63	0.00	2.63	0.00	0.00	0.00	5.25
Pond 4	50.00	40.76	0.00	1.85	1.85	0.00	0.00	5.53	0.00	0.00	0.00
Pond 5	38.12	19.04	0.00	4.76	4.76	14.28	19.04	0.00	0.00	0.00	0.00
Pond 6	48.15	35.20	0.00	0.00	3.70	12.95	0.00	0.00	0.00	0.00	0.00
Pond 7	58.82	23.53	0.00	0.00	0.00	17.65	0.00	0.00	0.00	0.00	0.00
Pond 8	69.99	0.00	10.01	5.00	5.00	0.00	0.00	0.00	0.00	10.01	0.00
Pond 9	45.81	20.84	0.00	4.16	0.00	16.68	0.00	12.51	0.00	0.00	0.00
Pond 10	43.35	23.32	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Pond 11	62.50	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	12.50	0.00
Pond 12	61.88	14.29	0.00	0.00	0.00	23.82	0.00	0.00	0.00	0.00	0.00
Pond 13	67.98	0.00	0.00	0.00	0.00	8.02	0.00	0.00	24.00	0.00	0.00
Pond 14	52.16	19.56	0.00	0.00	0.00	28.27	0.00	0.00	0.00	0.00	0.00
Pond 15	55.56	33.33	0.00	0.00	0.00	11.11	0.00	0.00	0.00	0.00	0.00
Pond 16	61.52	26.95	0.00	0.00	3.84	7.69	0.00	0.00	0.00	0.00	0.00

Average Basal Area

Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	0.014	0.030	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
Pond 2	0.022	0.039	0.012	0.212	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Pond 3	0.037	0.000	0.034	0.025	0.025	0.000	0.003	0.000	0.000	0.000	0.013
Pond 4	0.030	0.041	0.000	0.024	0.093	0.000	0.000	0.006	0.000	0.000	0.000
Pond 5	0.010	0.044	0.000	0.010	0.145	0.001	0.002	0.000	0.000	0.000	0.000
Pond 6	0.040	0.047	0.000	0.000	0.028	0.001	0.000	0.000	0.000	0.000	0.000
Pond 7	0.017	0.021	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000
Pond 8	0.030	0.000	0.005	0.010	0.042	0.000	0.000	0.000	0.000	0.001	0.000
Pond 9	0.018	0.053	0.000	0.004	0.000	0.001	0.000	0.010	0.000	0.000	0.000
Pond 10	0.023	0.031	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Pond 11	0.011	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Pond 12	0.013	0.026	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Pond 13	0.036	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.003	0.000	0.000
Pond 14	0.029	0.048	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000
Pond 15	0.028	0.016	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Pond 16	0.020	0.055	0.000	0.000	0.264	0.001	0.000	0.000	0.000	0.000	0.000

Absolute Dominance

Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	16.29	10.13	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	12.20	4.64	0.13	2.32	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Pond 3	12.05	0.00	8.43	3.22	0.25	0.00	0.05	0.00	0.00	0.00	0.26
Pond 4	12.57	8.45	0.00	0.28	0.53	0.00	0.00	0.10	0.00	0.00	0.00
Pond 5	7.46	8.47	0.00	0.40	5.62	0.16	0.37	0.00	0.00	0.00	0.00
Pond 6	18.00	11.04	0.00	0.00	0.42	0.06	0.00	0.00	0.00	0.00	0.00
Pond 7	27.92	4.22	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
Pond 8	22.02	0.00	0.32	0.16	0.64	0.00	0.00	0.00	0.00	0.04	0.00
Pond 9	23.30	16.66	0.00	0.17	0.00	0.27	0.00	1.35	0.00	0.00	0.00
Pond 10	33.56	11.58	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00
Pond 11	25.31	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.11	0.00
Pond 12	16.63	2.31	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
Pond 13	21.42	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.33	0.00	0.00
Pond 14	16.79	4.97	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00
Pond 15	15.11	3.12	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00
Pond 16	24.46	11.92	0.00	0.00	6.31	0.05	0.00	0.00	0.00	0.00	0.00

Relative Dominance

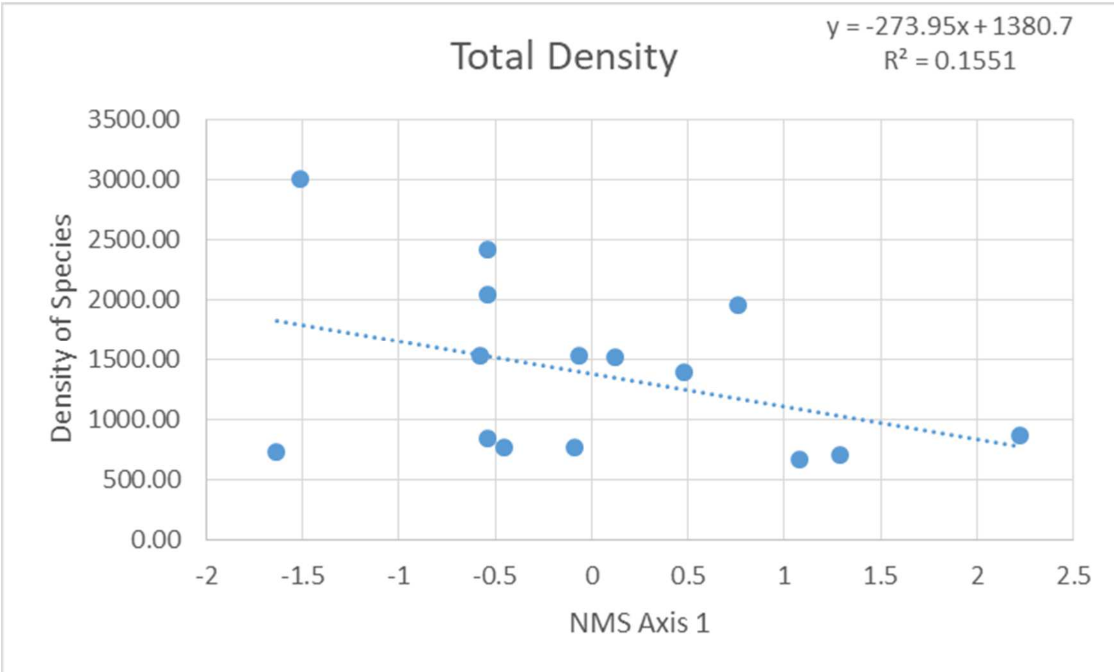
Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	61.45	38.21	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	63.20	24.03	0.69	12.02	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Pond 3	49.64	0.00	34.75	13.28	1.04	0.00	0.21	0.00	0.00	0.00	1.08
Pond 4	57.33	38.52	0.00	1.27	2.44	0.00	0.00	0.44	0.00	0.00	0.00
Pond 5	33.19	37.65	0.00	1.79	25.01	0.72	1.65	0.00	0.00	0.00	0.00
Pond 6	61.00	37.41	0.00	0.00	1.41	0.19	0.00	0.00	0.00	0.00	0.00
Pond 7	85.88	12.98	0.00	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00
Pond 8	95.01	0.00	1.36	0.69	2.77	0.00	0.00	0.00	0.00	0.17	0.00
Pond 9	55.80	39.91	0.00	0.41	0.00	0.64	0.00	3.24	0.00	0.00	0.00
Pond 10	73.38	25.32	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00
Pond 11	98.20	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.41	0.00
Pond 12	86.95	12.10	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00
Pond 13	98.35	0.00	0.00	0.00	0.00	0.12	0.00	0.00	1.52	0.00	0.00
Pond 14	76.32	22.61	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00
Pond 15	82.39	17.02	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00
Pond 16	57.22	27.89	0.00	0.00	14.77	0.11	0.00	0.00	0.00	0.00	0.00

Importance Values

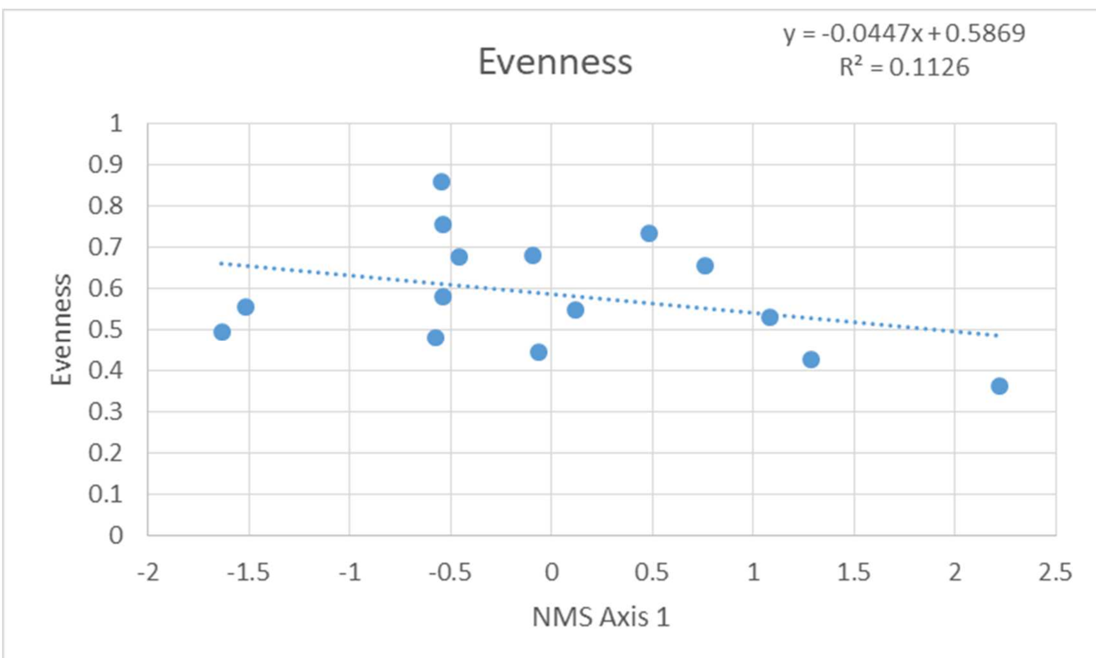
Pond #	Nys_bif	Tax_asc	Liq_sty	Ace_rub	Pin_tae	Lyo_luc	Myr_cer	Ile_myr	Dio_vir	Per_pal	Que_nig
Pond 1	202.01	92.09	0.00	0.00	5.90	0.00	0.00	0.00	0.00	0.00	0.00
Pond 2	200.59	70.85	5.96	17.28	0.00	0.00	0.00	5.32	0.00	0.00	0.00
Pond 3	127.26	0.00	99.24	54.09	4.99	0.00	5.47	0.00	0.00	0.00	8.96
Pond 4	171.12	110.31	0.00	4.84	5.15	0.00	0.00	8.57	0.00	0.00	0.00
Pond 5	126.86	70.58	0.00	9.33	32.55	26.11	34.57	0.00	0.00	0.00	0.00
Pond 6	168.77	103.37	0.00	0.00	7.03	20.83	0.00	0.00	0.00	0.00	0.00
Pond 7	224.70	46.51	0.00	0.00	0.00	28.78	0.00	0.00	0.00	0.00	0.00
Pond 8	250.71	0.00	18.51	7.48	9.56	0.00	0.00	0.00	0.00	13.75	0.00
Pond 9	167.52	76.66	0.00	6.84	0.00	26.40	0.00	22.57	0.00	0.00	0.00
Pond 10	176.35	64.02	0.00	0.00	0.00	59.64	0.00	0.00	0.00	0.00	0.00
Pond 11	240.70	0.00	0.00	0.00	0.00	41.38	0.00	0.00	0.00	17.91	0.00
Pond 12	233.45	32.17	0.00	0.00	0.00	34.38	0.00	0.00	0.00	0.00	0.00
Pond 13	248.68	0.00	0.00	0.00	0.00	11.08	0.00	0.00	40.23	0.00	0.00
Pond 14	197.23	54.67	0.00	0.00	0.00	48.10	0.00	0.00	0.00	0.00	0.00
Pond 15	207.94	75.35	0.00	0.00	0.00	16.71	0.00	0.00	0.00	0.00	0.00
Pond 16	199.99	68.90	0.00	0.00	20.18	10.93	0.00	0.00	0.00	0.00	0.00

Appendix C: Diversity Measures and Graphs

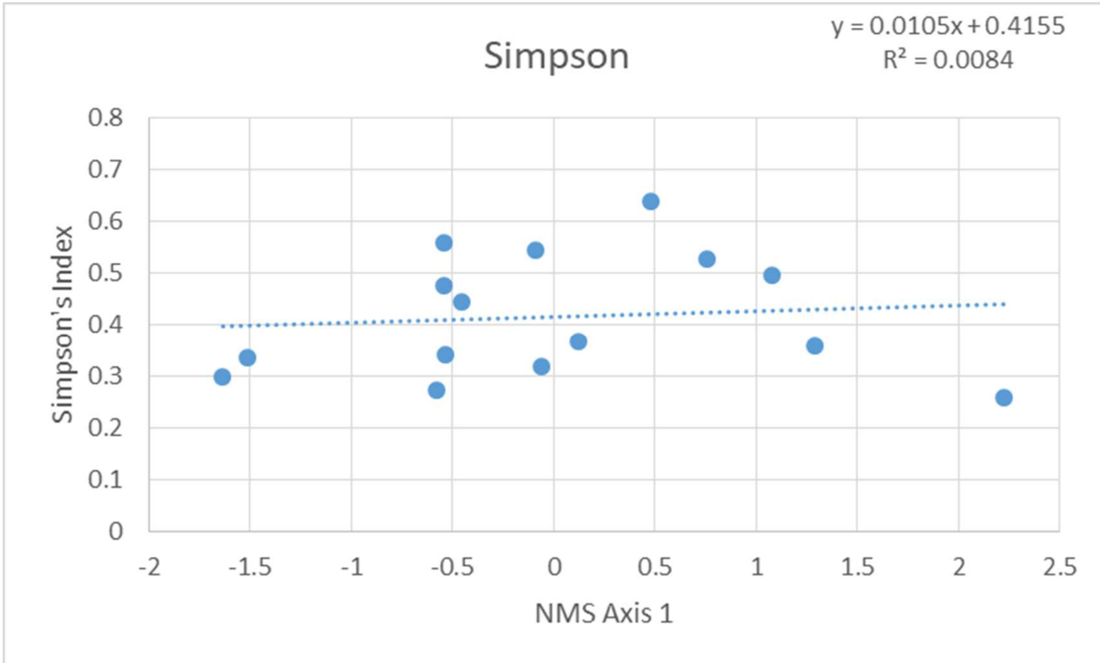
Diversity Measures						
Num.	Richness	Evenness	Shannon-Wiener	Simpson	NMS Axis 1	Total Density
Pond 1	3	0.548	0.602	0.3657	0.12257	1518.78
Pond 2	5	0.429	0.69	0.3593	1.28732	700.48
Pond 3	6	0.714	1.279	0.6725		749.83
Pond 4	5	0.531	0.855	0.4956	1.0814	664.11
Pond 5	6	0.736	1.318	0.6389	0.48137	1393.00
Pond 6	4	0.681	0.944	0.5436	-0.09018	763.09
Pond 7	3	0.582	0.639	0.34	-0.53631	2041.33
Pond 8	5	0.363	0.584	0.2584	2.22474	862.67
Pond 9	5	0.655	1.054	0.5268	0.75869	1958.40
Pond 10	3	0.858	0.943	0.5584	-0.54188	2413.12
Pond 11	3	0.558	0.613	0.335	-1.51617	3002.29
Pond 12	3	0.483	0.531	0.2714	-0.57703	1530.36
Pond 13	3	0.497	0.546	0.2993	-1.63596	725.51
Pond 14	3	0.757	0.831	0.4766	-0.54096	836.92
Pond 15	3	0.679	0.746	0.445	-0.45562	768.17
Pond 16	4	0.446	0.618	0.3189	-0.06199	1531.95



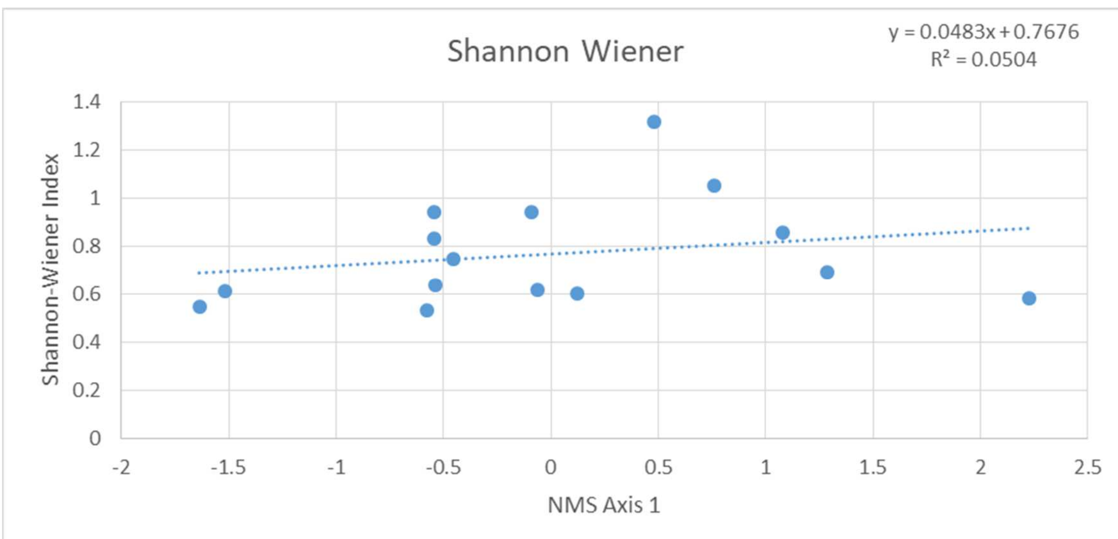
y = -273.95x + 1380.7
R² = 0.1551
Total Density
Density of Species
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
NMS Axis 1



y = -0.0447x + 0.5869
R² = 0.1126
Evenness
Evenness
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
NMS Axis 1



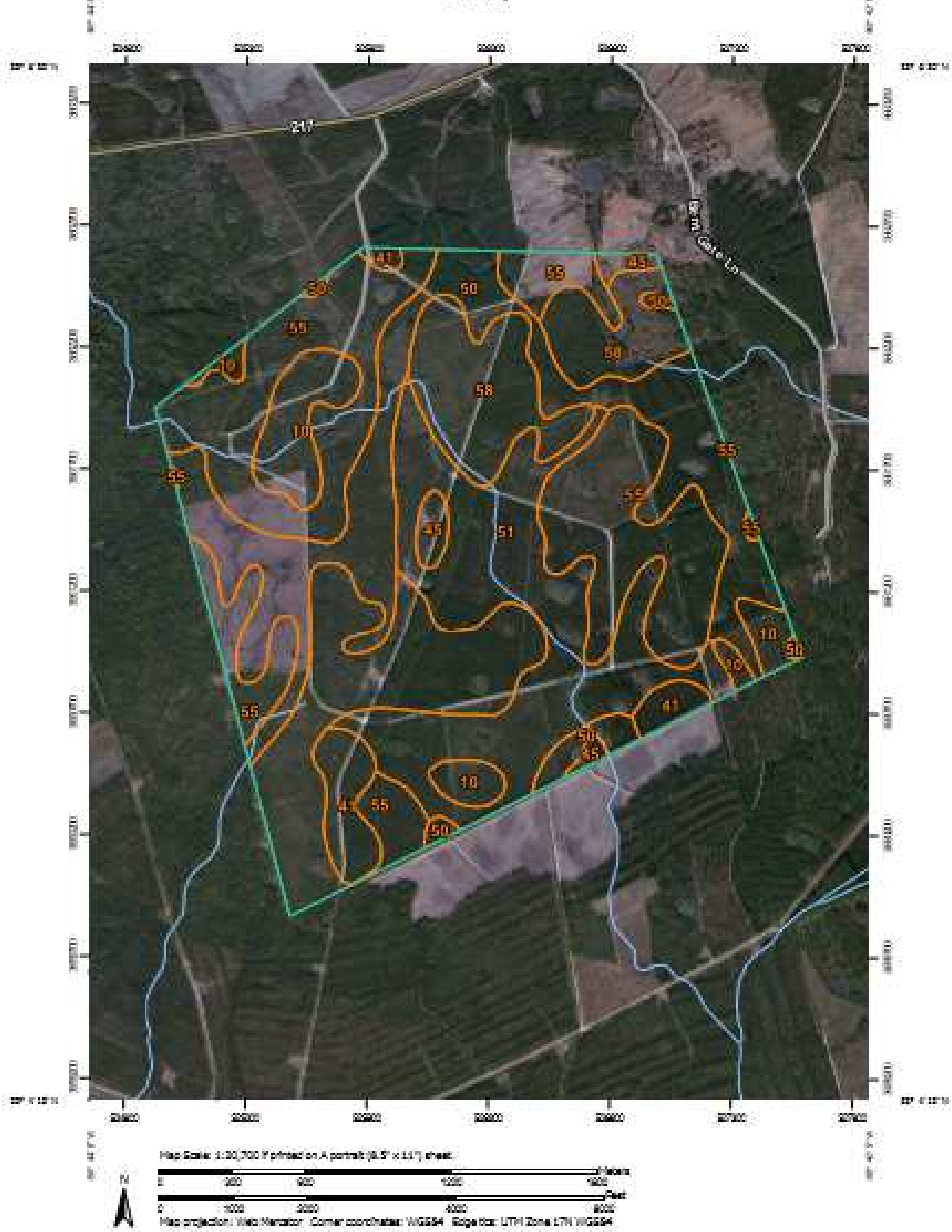
Simpson
y = 0.0105x + 0.4155
R² = 0.0084
Simpson's Index
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
NMS Axis 1



Shannon Wiener
y = 0.0483x + 0.7676
R² = 0.0504
Shannon-Wiener Index
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
NMS Axis 1

Appendix D: NRCS Soils Map and Report

Custom Soil Resource Report
Soil Map



Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
10	Albany loamy sand, 0 to 2 percent slopes	54.0	5.3%
41	Lynchburg loamy fine sand, 0 to 2 percent slopes	40.3	3.9%
45	Ocilla loamy sand	11.3	1.1%
50	Paxville fine sandy loam	165.0	16.1%
51	Pelham loamy sand, 0 to 2 percent slopes	225.8	22.0%
55	Rains sandy loam	429.7	41.8%
58	Scranton loamy sand	100.8	9.8%
Totals for Area of Interest		**1,026.9**	**100.0%**