Student investigations of biological diversity in the Big Thicket

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Introduction

As part of an undergraduate course in the Department of BioSciences at Rice University, students surveyed the species diversity of various taxonomic groups within the Turkey Creek Unit of the Big Thicket National Preserve (BTNP). The course—EBIO 327: Biological Diversity Lab—focuses on the theory and practice of estimating biodiversity for a variety of taxonomic groups. Students were assigned to one of five different groups, each of which focused on a particular taxonomic group: trees, butterflies and moths, fish, reptiles and amphibians, and birds and mammals. The students researched their group and designed a protocol to sample it within a 24-hour period (i.e. a "bioblitz").

The bioblitz survey took place from October 10-11, 2015. Our group was joined by several expert volunteers: Dr. Nancy Grieg (Director of the Cockrell Butterfly Center at the Houston Museum of Natural Sciences), Dr. Cassidy Johnson (Lecturer in Ecology and Evolutionary Biology at Rice), Chris Valdez (Herpetology Keeper at the Houston Zoo), Dr. Kevin W. Conway (Assistant Professor and Curator of Fishes at Texas A&M University), Dr. Evan Siemann (Professor of Ecology and Evolutionary Biology at Rice), and bird expert Tim Perkins (Rice Class of 2004).

Identification of species was performed in the field whenever possible, and digital photographs were taken when possible to assist in identification and to provide GPS coordinates for the observation. For taxa that could not be identified in the field, voucher specimens were collected and identified in the lab. All specimens will be deposited in the Sam Houston State University Natural History Collection in Huntsville, TX. The students have also posted their photographs, along with the species' name and the precise location where it was observed, on iNaturalist.org, a website that allows anyone with an interest in the natural world to document observations.

This report contains the written summary by each group submitted as part of their course requirements. They have not been modified from their original versions except for formatting for consistency.

Acknowledgments

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Trees

Julian Wilson and Stacey Yi

Abstract

With growing concerns over loss of biological diversity, a survey was conducted in order to examine to species composition of trees in the Big Thicket National Preserve in East Texas. Specifically focusing on the southern quarter of the Turkey Creek Unit, samples were conducted in October of 2015 using size classifications that would allow information collected to be consistent with long-term data available for the area. Diversity was quantified using the Simpson's and Shannon-Weimer Diversity Indices, which both suggested relatively high biodiversity represented in the nine samples that were conducted. Sample size ranged from 26 to 48 individuals, with a total of 408 individuals belonging to 37 distinct species. This survey contributes to ongoing research into the biodiversity of Big Thicket conducted by the "Thicket of Diversity," and will aid in cataloging the changes that occur over time in the area, particularly if invasive species begin to spread and dominate the landscape.

Introduction

We are experiencing a biodiversity crisis globally. Biodiversity is decreasing at a rate that we've never seen before, with current rates of species extinction 1,000-10,000 times greater than the background extinction rate of 10^{-7} species/species year inferred from the fossil record (Singh, 2002). Given this, we need to monitor biodiversity to better inform our efforts to understand why this loss is occurring.

Big Thicket National Preserve originally consisted of 3.5 million acres of land, but it is now approximately one-tenth of that size (Eisner, 1973). Ecologists across the nation petitioned to have it authorized as a national preserve, which was achieved in 1974. The Thicket is a region of unique diversity, in that many different plant communities exist within it and it is very uniquely substructured. For this reason, ecologists are very invested in monitoring and protecting it to preserve its incredible diversity.

Long-term monitoring and analysis of forest dynamics in Big Thicket National Preserve has been done by Harcombe and colleagues (Harcombe et al., 2002). This kind of long-term monitoring is important with trees, because trees develop relatively slowly and thus, changes in composition can occur at a slower rate and requires longitudinal data for more accurate tracking.

Rice University's EBIO 327 Biodiversity Lab regularly contributes biodiversity survey data of Big Thicket National Preserve, TX, for various taxa groups. Our report will focus on biodiversity of trees surveyed in the southern quarter of the Turkey Creek Unit of the Big Thicket on October 10, 2015.

Methods

Our survey consisted of a total of nine samples, with a maximum of 48 individual trees recorded per sample. Tree species was recorded for all known individuals. If an individual could not be identified within a reasonable amount of time, a specimen was collected and pictures were taken to aid in later identification[1]. All of our samples were conducted in the southern quarter of Turkey Creek Unit, along existing trails. Our path followed the Kirby Nature Trail from the parking area around the left side of the Inner Loop, around the Cypress Loop, and continued on to include the Sandhill Loop. Samples were conducted after walking for five minutes along the trail. Time spent stopped did not count toward these five minutes. Samples were conducted on alternating sides of the trail.

The placement of each sample was chosen by standing a few feet off the trail, facing the trail, and throwing a roll of flagging tape over one's shoulder to designate a central point from which to collect data. From there, the area was divided into four quadrants based on cardinal directions. If a tree was located on a border between quadrants, it was only considered to be part of a single quadrant. Dead trees and anything less than .5 meters tall, or approximately knee-height, was not counted. If there were not a full four individual trees in a size group within a reasonable distance of approximately 20 meters, only those present were included in our data.

Within each quadrant, trees were divided into different groups based on size and the closest four individuals to the central point were counted for that size group. The smallest size group was anything from .5 meters tall to 1.5 meters tall, approximately shoulder-height. The intermediate size group was anything taller than 1.5 meters that had

[1] Note: A sample clipping was not collected for unknown one, as its diminutive size would have meant any clipping taken would almost certainly result in its death.

a diameter less than 2.5 inches, the length of the shorter side of the compasses we carried in the field. The final and largest size group consisted of the remaining trees, all with a diameter greater than 2.5 inches and all taller than 1.5 meters. These size groups were chosen due to recommendation from Dr. Evan Siemann of Rice University, in order to keep our data consistent with the long-term data available for the Big Thicket.

Unknown species were identified by examining the labelled clippings and pictures taken in the field. This identification process relied heavily on the expertise of Dr. Evan Siemann and Dr. Nancy Greig, who employed prior knowledge, the Peterson guide on Eastern trees, and other resources available at the Big Thicket National Preserve field research station.

Data was analyzed using Simpson's Diversity Index and the Shannon-Weimer Diversity Index in order to quantify biodiversity. A graph of Rank Abundance and a Species Accumulation Curve were also constructed in order to demonstrate species evenness in the data and consider whether this survey can be considered representative of the number of species present in the area.

Results

As can be seen in Table 1, the total species richness combined from our nine samples was 37. Table 2 shows that samples two and three had the highest species richness, while sample four had the lowest. All samples consisted of 48 individuals with the exception of samples one and two with only 47 individuals, and sample six with a mere 26. Sample six was conducted in a river bottom with a comparatively low density of vegetation.

Simpson's Diversity Index

D = 0.9356257209

D ranges from 0 to 1-(1/37) = 36/37 = .9729

Simpson's Diversity index describes the likelihood of two random individuals in a population being from different species. Therefore, a value of D that is closer to the maximum value means that a population is more diverse. Based on our data, there is a relatively high likelihood of two randomly chosen individuals being from different species because our D value of .936 was close to the maximum value of .9729.

Shannon-Weimer Diversity Index

H = 3.081197791

H ranges from 0 to ln37 = 3.61

Equitability = H/ln37 = .8535

The Shannon-Weimer Diversity index also seeks to quantitatively measure diversity in a population. This diversity index works by determining how easy it would be to predict the species composition of an additional sample if one was taken. The closer an H value is to $H_{max,}$, the more diverse the population. Another way to describe this relationship is with the equitability, E, which is measured by dividing H by H_{max}. Because our equitability value was a relatively high 85.35%, it would be hard to accurately predict the species composition of an additional sample, meaning our samples suggest a high level of tree biodiversity in the southern portion of the Turkey Creek Unit.

Discussion

We had a total species richness of 37 and total species abundance of 408, with *Ilex vomitoria,* or Yaupon holly, prevailing as the most abundant species. The calculated Simpson's Diversity Index tells us that there is a 96.1% (D/D_{max}) chance that two individuals randomly selected from our samples will be of different species. This indicates relatively high species diversity. The Shannon-Wiener Index is fairly close to the H_{max} value, and the calculated equitability (E) of 0.854 indicates comparatively high heterogeneity and species evenness. The rank abundance curve has a relatively shallow slope, which indicates high species evenness, as confirmed by the aforementioned equitability value.

The species accumulation curve shows initial increase and decrease in slope, then increase again before the curve appears to level out with a decreased slope. This indicates that our samples may be a fairly close representation of the species composition of Big Thicket National Preserve. However, we would need more data to state with greater confidence that our sampling was an accurate representation, as we would expect to see the graph continue to level out. In the graph, we also see an interesting trend with an initial increase then decrease in slope, before it increases again.

Big Thicket National Preserve consists of a variety of vegetation types, separated into four main categories: Upland, Slopes, Floodplains, and Flatlands. Each of these is represented in the area of Turkey Creek Trail that we sampled from. As we progressed through the trail, a greater number of vegetation types were represented, and this could have caused the second increase in slope as new species from new vegetation types were recorded. Each sampling site itself was not necessarily extremely diverse, but Big Thicket

National Preserve's diversity comes from the multitude of vegetation types in very close proximity to one another.

Our results would have been enhanced with more sampling throughout Turkey Creek Trail and additional samples over a period of years. Due to time constraints, we were limited to 9 sampling locations and areas right off of the trail. Given more time, we would have had sampling locations further off the trail, as the areas further off the trail versus right off the trail may host different tree species. There were also some areas of forest that had extremely dense underbrush and would have been very difficult to sample. Sampling from these areas may have also yielded new, unrepresented tree species. Additional surveys conducted over later years would also help to track biodiversity changes over time and determine if invasive species such as Chinese tallow are having a detrimental impact on the richness of species present and/or their relative abundance.

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Table 1. Species list and abundance

	Common Name	Scientific Name	Species Abundance
1	yaupon holly	*Ilex vomitoria*	62
2	American holly	*Ilex opaca*	46
3	black cherry	*Prunus serotina*	33
4	loblolly pine	*Pinus taeda*	27
5	water oak	*Quercus nigra*	22
6	water tupelo	*Nyssa aquatica*	18
7	blackjack oak	*Quercus marilandica*	18
8	cyrilla	*Cyrilla racemiflora*	17
9	sweetgum	*Liquidambar styraciflua*	15
10	bald cypress	*Taxodium distichum*	13
11	laurel oak	*Quercus laurifolia*	13
12	shortleaf pine	*Pinus echinata*	12
13	longleaf pine	*Pinus palustris*	12
14	black tupelo	*Nyssa sylvatica*	11
15	viburnum	*Viburnum odoratissimum*	11
16	eastern hophornbeam	*Ostrya virginiana*	8
17	Carolina beech	*Fagus grandiflora*	8
18	red bay	*Persea borbonia*	8
19	white oak	*Quercus alba*	7
20	magnolia	*Magnolia grandiflora*	7
21	post oak	*Quercus stellata*	6
22	chinese tallow	*Triadica sebifera*	5
23	deciduous holly	*Ilex decidua*	4
24	river birch	*Betula nigra*	4
25	green ash	*Fraxinus pennsylvanica*	3
26	black hickory	*Carya texana*	3
27	laurel cherry	*Prunus caroliniana*	2
28	fringetree	*Chioanthus virginicus*	2
29	carolina silver-bell	*Halesia carolina*	2
30	sweetbay magnolia	*Magnolia virginiana*	2
31	sebastian bush	*Ditrysinia fruticosa*	1
32	eastern wahoo	*Euonymus atropurpureus*	1
33	american beautyberry	*Callicarpa americana*	1
34	American hornbeam	*Carpinus caroliniana*	1
35	cedar elm	*Ulmus crassiflora*	1
36	pignut hickory	*Carya glabra*	1
37	chesnut oak	*Quercus prinus*	1
			Total Abundance: 408

Table 2. Sample number and corresponding species richness

Sample	1	2	3	4	5	6	7	8	9
Richness	9	14	14	8	9	10	13	9	9

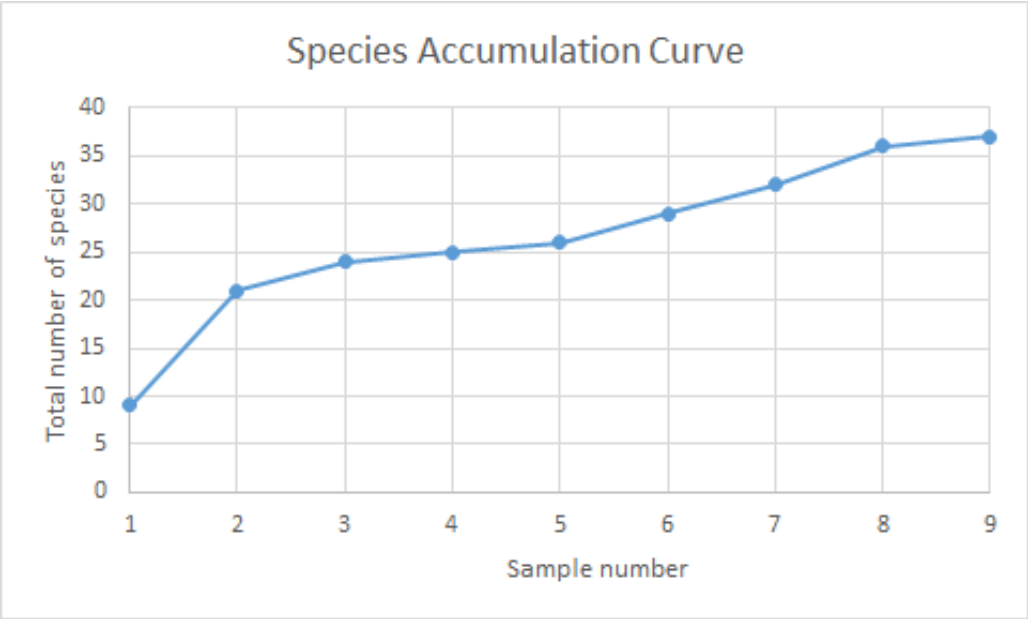


Figure 1. Species Accumulation Curve showing an initial increase, followed by a gradual leveling off up until sample five. After sample five there is another increase which can tentatively be said to appear to reach a final leveling off portion by sample nine.

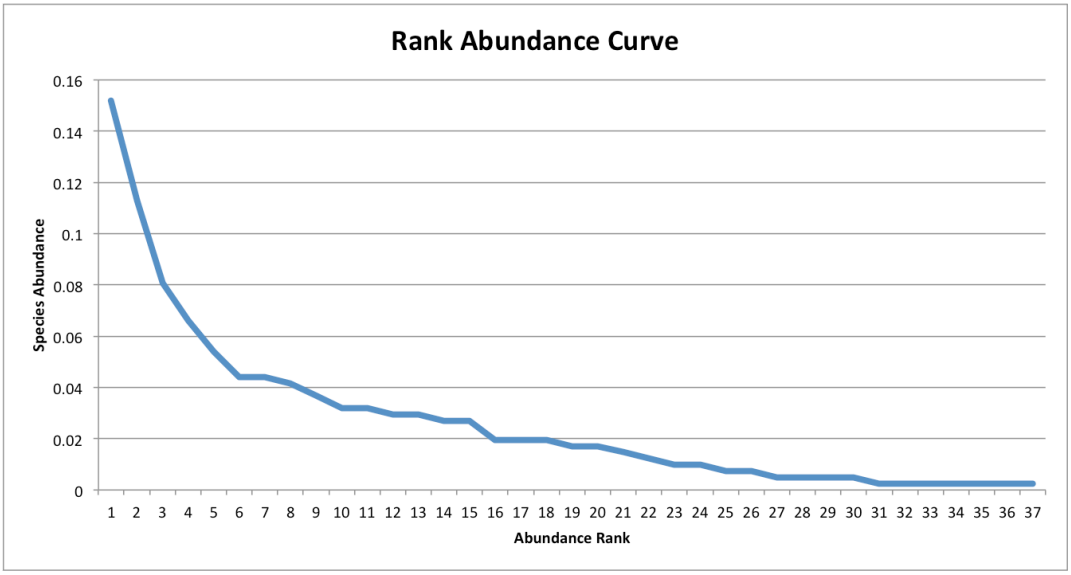


Figure 2. Rank Abundance Curve showing a long tail and relatively low slope. No species had a relative abundance value of greater than .1519, and seven out of 37 species were represented by only one individual.

Lepidoptera

Kevin Czachura and Gabriela Zambrano

Abstract

Surveying the world's biodiversity is on the frontier of modern ecology. In light of widespread loss of biodiversity, there is greater need to train and inform future scientists on its study. In southeast Texas, the Big Thicket National Preserve (BTNP) represents a relatively unexplored ecosystem in which to practice sampling methods. Over a two-day period in October 2015, we conducted an intensive "bioblitz" focused on Lepidoptera in the Turkey Creek unit (TCU) of the BTNP. We utilized survey methods such as aerial nets, visual census, and light traps. Diversity was quantified using multiple common indices. Our results indicate differential success between sampling methods. While aerial net sampling resulted in high species evenness, the light traps captured the highest species richness and the largest sample size. Visual searching, while logistically simple, resulted in a statistically weak sample size. The most striking conclusion from our study is that there is a large body of Lepidoptera species remaining to be found in the BTNP.

Introduction

One of the outstanding problems in modern ecology is cataloging the world's declining biodiversity. Biodiversity contains inherent value and offers multiple ecosystem services that contribute to the greater health of the biosphere. A human understanding of biodiversity provides rich source material for biological inquiry. Accurate and robust ecological surveys both inform and shape political policy and cultural attitudes toward conservation. Ultimately, humans exist within and because of ecosystems. On a national scale, government and scientific institutions collaborate to study and protect biodiverse areas. Locally, the Big Thicket National Preserve (BTNP) is surveying the wealth of diversity contained within its borders.

The Big Thicket region of southeast Texas is a forested area recognized for the unique mixture of eastern and western species that occur amongst a patchwork of diverse habitats such as palmetto hardwood flats, sandylands, and cypress sloughs (Hill n.d.). The BTNP is noted for its plant, fungi, bird, and insect diversity (Big Thicket Association 2015). Since 2006, an All Taxa Biological Inventory (ATBI) has been ongoing (Hill n.d.) in the hope of cataloging the region's biodiversity under the threat of further human impact (Callicott 2006). Student-based initiatives serve to bolster ATBI efforts within the preserve and educate future scientists about the ecological importance of the BTNP. As part of the biodiversity lab at Rice University, students conducted self-guided sampling of taxonomic groups in the Turkey Creek unit (TCU) of the preserve. To this effect, we surveyed Lepidoptera biodiversity over a two-day period in October 2015.

Methods

The Lepidoptera biodiversity survey was conducted in the southern region of the TCU of the BTNP on 10-Oct-2015 and 11-Oct-2015. The mean day temperature was 22.2 degrees Celsius, with an average wind speed of 6.44 kph and little to no cloud cover. To sample diurnal Lepidopterans, we used a combination of aerial nets and visual surveying. We visually scanned areas with open understory and flowers present along the Kirby Nature Trail and the Sandhill Loop Trail in the southern part of the TCU (Figure 1). In suitable habitats (high visibility with flowers present), we searched for fluttering movements for 5 minutes. If no movement was seen within this timeframe, a new site was located and surveyed. If Lepidopteran movement was observed, we actively captured specimens using nets. Two people searched for 30 concurrent minutes at every sampling location.

Samples were collected if they were novel to our study or if expert Nancy Grieg, Ph.D. could not identify them on site. Captured individuals were euthanized in "kill jars" partially filled with ethyl acetate-soaked plaster. Dead specimens were stored in labeled glassine envelopes. Individuals from species that had already been recorded and preserved were released. Visually observed individuals were only recorded when specimens could confidently be identified.

Sampling effort was quantified using person-hours. Three people worked within the 30 minute timeframe at each sampling site, but one researcher handled labeling and storage of specimens. Thus calculation of person-hours was performed only for the two active surveyors.

We used overnight light traps at two locations, Village Creek and Cypress Slough, to sample nocturnal Lepidopterans. The light traps were set up approximately 2 hours before sunset and specimens were collected approximately 2.5 hours after sunrise.

To construct the light traps, ethyl acetate-soaked cotton balls were placed in a perforated container, and the container was placed in a bucket to act as an asphyxiant. A plastic sheet was secured over the opening of the bucket, and a funnel was pierced through the sheet. A battery-powered black light was hung over the funnel from the tree branch (Figure 2).

Butterflies and skippers were identified by Nancy Grieg and the researchers using *Butterflies of North America* by Kenn Kaufman and Jim P. Brock. We identified 9 species using this method. The remaining 30 species were identified using the online database DiscoverLife.Org. Data analysis was performed using Microsoft Excel.

Results

Overall, we identified 327 individuals belonging to 39 different species (Table 1). There were eight butterfly/skipper species and 31 moth species (Table 2). Overall Simpson's diversity (D) was calculated as 0.677. The Shannon-Wiener index (H) was 1.80 with overall equitability of 0.491. Each sampling method resulted in different indices of diversity (Table 3). Aerial net sampling resulted in 12 specimens, visual searching resulted in 193 individuals, and the two light traps captured a total of 122 specimens. The two light traps, at Village Creek and Cypress Slough, captured different sample sizes (five and 22, respectively) with different diversity indices (Table 4).

The species accumulation curve shows a nearly linear relationship between the cumulative number of species and the number of person hours, and exhibits no asymptotic behavior (Figure 3). The rank-abundance curve decays exponentially, with the majority of species having an abundance of 1 (Figure 4).

Discussion

The steadily increasing slope of the species accumulation curve indicates that sampling effort has not resulted in discovery of all Lepidoptera species in the TCU. The relatively steep and constant slope of this sampling curve implies that the Lepidoptera species of BTNP are both numerous and evenly distributed (Gotelli 2011).

The rapid decay of the rank abundance curve implies that the species assemblage of the TCU is dominated by a few common species (Magurran 2004). However, the biases inherent within our sampling methods, such as the high proportion of sedentary *Hyphantria cunea* larvae, undermines this claim.

The Shannon-Wiener biodiversity index and its associated equitability value indicate that the abundance of individual species is fairly well distributed within this biome. The Shannon-Wiener method takes both the species richness and the equitability of these species into account.

In comparison to this method, Simpson's diversity index gives low weight to rare species and high weight to common species. We feel that the Shannon-Wiener index is more appropriate for Lepidoptera in BTNP because the disproportional impact of highly abundant species, such as the sedentary *H. cunea* and the numerous *Scopula limboundata*, is reduced and because rare species tend to represent a significant proportion of Lepidoptera communities. It has also been suggested that numerical dominance of moth species can occur when surveying at small spatial scales (Summerville 2003). In our samples, more moths were present than butterflies and skippers, which is a natural occurrence.

Wind speed, temperature, and cloudiness may possibly influence the efficacy of Lepidoptera sampling methods; butterfly flight increases in duration with temperature

and decreases with cloudiness and high wind speed (Cormont 2010). It is also evident that different sampling methods are biased toward different taxa, size classes, and activity levels of arthropods. The effectiveness of a sampling method is also affected by height and density of vegetation (Doxon 2011).

The samples obtained from the net-capture method exhibited high Shannon-Wiener equitability, equal distribution of species abundance. However, the net capture results are unreliable because of our indiscriminate mixing of visual and net sampling. In addition, there were only 12 specimens captured using this method.

The visual sampling method yielded both low species richness and low Shannon-Wiener equitability. This is most likely due to the disproportionate representation of *H. cunea* using this method. *H. cunea* was the most abundant species in our survey at 168 individuals (compared to 26 individuals from other species sampled visually). This was also the only species we identified by observing live caterpillars. We found three trees infested with *H. cunea* larvae at our sample sites. The larvae live and feed inside communal webs on host trees. Due to this life history trait and the fact that these webs are extremely conspicuous, the abundance of *H. cunea* may appear artificially high.

Moreover, larval abundance is often not equivalent to adult abundance in Lepidoptera species. Generally 54 percent of larval Lepidoptera do not survive to adulthood (Zalucki 2002). If this is the case, then species evenness measures would be lower if we used adult *H. cunea* data. Visual sampling is biased toward microclimates with high visibility, and is likely to succeed only with diurnal, sedentary, clumped, or visually conspicuous Lepidoptera (Yoo 2003).

The light traps provided the highest species richness of the three sampling methods (25) and the largest sample size (122 specimens). The samples from the light

trap displayed fair biodiversity using both the Shannon-Wiener and Simpson's indices (H= 0.566, D =0.621.) Although this method allowed a wide variety of species to be sampled, there was mechanical bias towards smaller species of Lepidoptera due to the limited diameter of the funnel spout. Moreover, the microclimate of the sampling site may have had a strong effect on the species present in the sample (Summerville 2003). This effect may have resulted in the strong differences in specimen composition between the two light traps (Cypress Slough = 22 species, Village Creek = 5). This difference may also be due to the fact that the Village Creek light trap ceased functioning at an unknown time previous to its retrieval. In addition, moon phase and brightness can affect nocturnal Lepidoptera flight patterns (Yela 1997). On our sampling date, the moon was new and provided little to no light, which may have affected the results.

Overall, the light trap method is simply more effective and enduring than human-based methods, which may have unintentionally skewed species representation in this study toward nocturnal moths over diurnal butterflies and skippers.

The application of multiple sampling techniques allowed us to gauge the relative successes and failures of each method. Although no method was perfect on its own, each method provided slightly different biases toward the species represented. These biases allowed us to compensate for the wide variety of activity levels, morphologies, and preferred habitats of Lepidoptera. However, future studies utilizing these methods could benefit from extensive improvement of sampling protocols.

For visual and net sampling, the application of transects for longer amounts of time would most likely reduce human bias. The introduction of additional light traps would allow for sampling in more microclimates of the TCU. Moreover, diversity within BTNP could be evaluated in an alternative manner besides species richness and the

Shannon-Wiener and Simpson's indices. It has been found that ecological diversity can be linked to biodiversity indices (Izsak 2000). There is a possibility that Lepidoptera biodiversity is correlated with ecological diversity present in BTNP. This concept has been implied by studying tetrapod diversity and ecological diversity (Sahney 2010). Application of such an index would provide a more holistic index of ecological conditions in the preserve, while simultaneously covering larger spatial areas.

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Figures and Tables:

Table 1: Species identifications and abundances from our 24-hour Lepidoptera biodiversity survey.

Common Name	Scientific Name	Abundance
Fall Webworm	*Hyphantria cunea*	168
Large Lace-Border Moth	*Scopula limboundata*	75
Carolina Satyr	*Hermeuptychia sosybius*	23
One-Spotted Variant	*Hypagyrtis unipunctata*	9
Lead-Colored Lichen Moth	*Cisthene plumbea*	5
Celery Leaftier Moth	*Udea rubigalis*	3
Omnivorous Platynota Moth	*Platynota rostrana*	3
Smoky Tetanolita Moth	*Tetanolita mynesalis*	3
Sweetgum Leafroller Moth	*Sciota uvinella*	3
Texas Gray	*Glenoides texanaria*	3
Brown-Shaded Gray	*Iridopsis defectaria*	2
Cypress Emerald Moth	*Nemoria elfa*	2
Dead-Wood Borer Moth	*Scolecocampa liburna*	2
Anacampsis conclusella	*Anacampsis conclusella*	1
Banded Tussock Moth	*Halysidota tessellaris*	1
Black-Spotted Schrankia	*Schrankia macula*	1
Blister Coneworm Moth	*Dioryctria clarioralis*	1
Ceraunus Blue	*Hemiargus ceraunus*	1
Common Fungus Moth	*Metalectra discalis*	1
Diabolical Fungus Moth	*Metalectra diabolica*	1
Dotted Leaftier Moth	*Psilocorsis reflexella*	1
Garden Tortrix Moth	*Clepsis peritana*	1
Gemmed Satyr	*Cyllopsis gemma*	1
Green Cloverworm Moth	*Hypena scabra*	1
Gulf Fritillary	*Agraulis vanillae*	1
Isogona scindens	*Isogona scindens*	1
Kearfottia albifasciella	*Kearfottia albifasciella*	1
Lambdina laeta	*Lambdina laeta*	1
Little Sulphur	*Pyrisitia lisa*	1
Lychnosea intermicata	*Lychnosea intermicata*	1
Ozarba sp.	*Ozarba sp.*	1
Palamedes Swallowtail	*Papilio palamedes*	1
Porcelain Gray	*Protoboarmia porcelaria*	1
Red Admiral	*Vanessa atalanta*	1
Small Tolype Moth	*Tolype notialis*	1
Tropical Checkered Skipper	*Pyrgus oileus*	1
Waterlily Borer Moth	*Elophila gyralis*	1
Watermilfoil Leafcutter Moth	*Paraponyx allionealis*	1
White-Marked Tussock Moth	*Orgyia leucostigma*	1

Table 2: Breakdown of butterfly and moth composition of the surveyed individuals.

Type	Species Richness	Abundance
Butterflies/Skippers	8	30
Moths	31	297

Table 3: Comparison of biodiversity quantifications between each sampling method as well as for the overall study.

Sampling Method	Species Richness	Simpson's Diversity	Equitability (Shannon-Wiener)
Net	11	0.903	0.988
Light Trap	25	0.621	0.566
Visual Searching	6	0.230	0.263
Overall	39	0.677	0.491

Table 4: Comparison of biodiversity quantifications between our two light traps.

Sampling Method	Species Richness	Simpson's Diversity	Equitability (Shannon-Wiener)
Village Creek	5	0.750	0.928
Cypress Slough	22	0.570	0.533

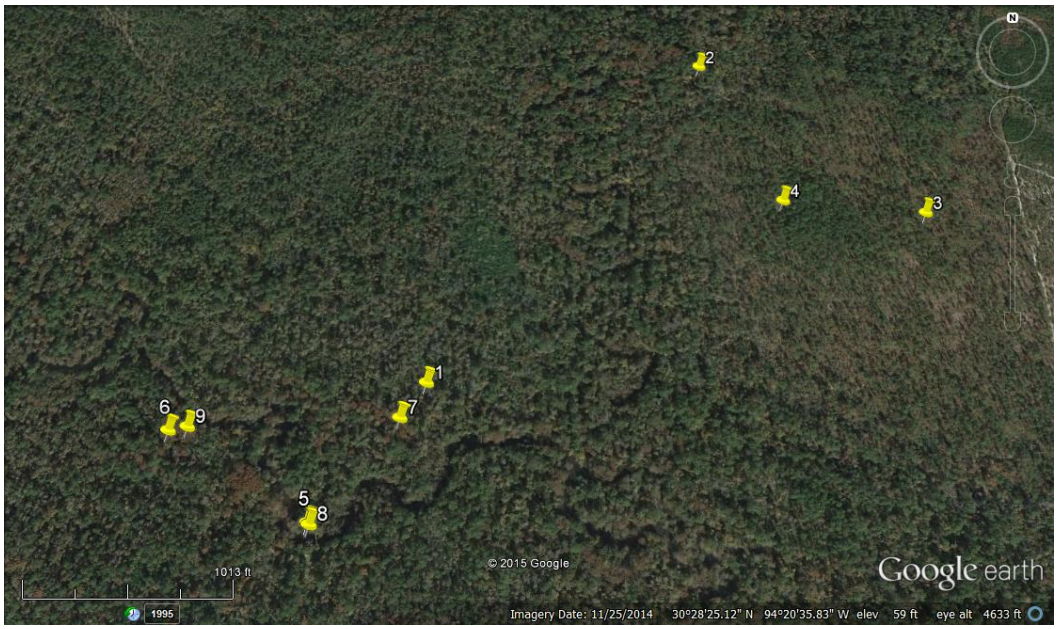


Figure 1: Turkey Creek unit sampling sites mapped using Google Earth numbered in the order of sampling. The east-west water feature is Village Creek and the north-south water feature is Turkey Creek.

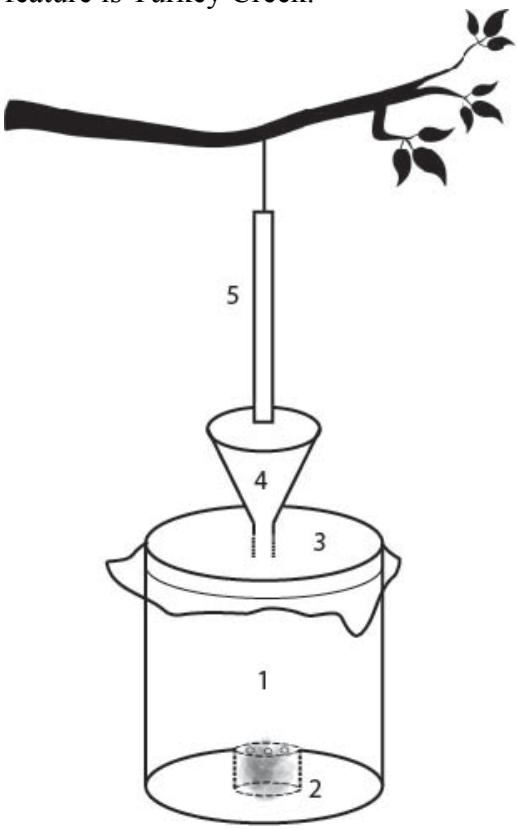


Figure 2: Diagram of our light trap. 1) A large bucket. 2) Perforated container holding cotton balls soaked in ethyl acetate. 3) Plastic sheet secured over lid using twine. 4)

Funnel with wide aperture pierced through plastic lid. 5) 120V Black light suspended with twine from tree branch over funnel.

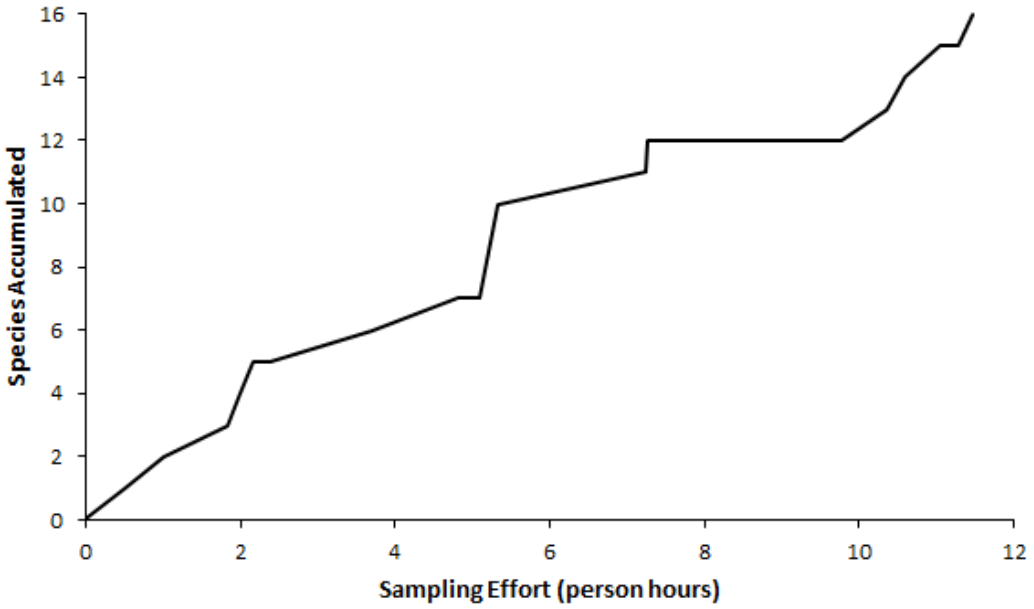


Figure 3: Species accumulation curve for net captures and visual observations. Sixteen species were identified in total using these two methods.

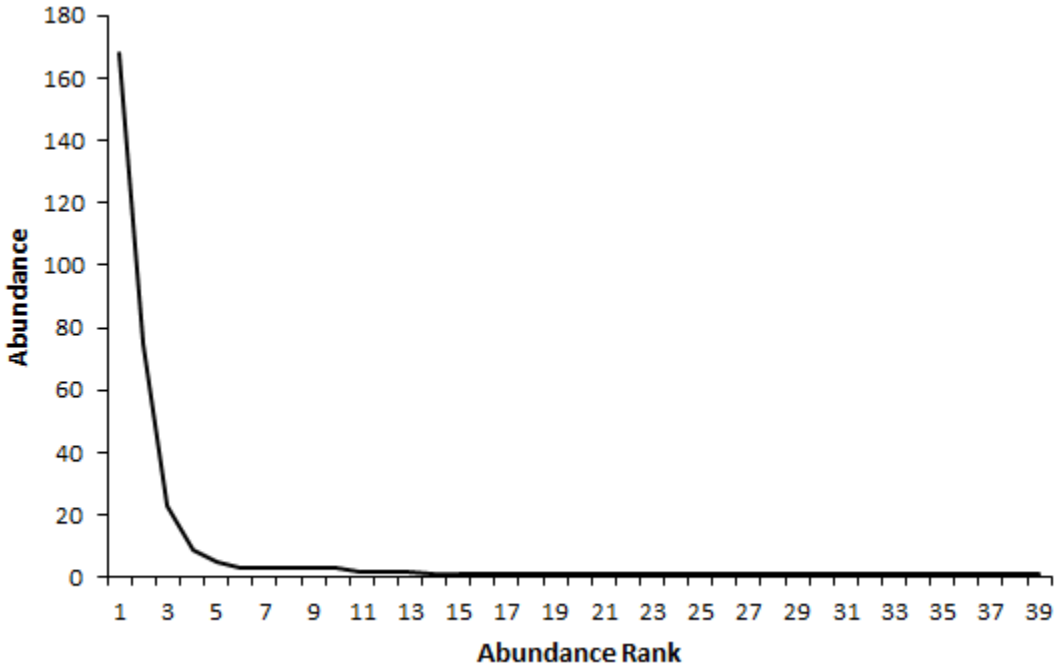


Figure 4: Rank abundance curve for the overall survey exhibiting exponential decay.

Fish

Ivana Ezuede, Justin Park, Mini Bhattacharya

Abstract

The study of biodiversity is a neglected field given that biodiversity is declining rapidly with time. Many species have the potential to better the lives of human beings, but their existence is threatened due to the rise in anthropogenic and natural activities. In order to shed light on biodiversity levels as well as draw a comparison between the biodiversity of different habitats in Big Thicket National Preserve located in Kountze, TX, a survey of its two creeks—Village Creek and Turkey Creek—was conducted using seining and electrofishing. Through this survey, it was determined that the two sites exhibited a noticeable degree of difference in their biodiversity. For example, Turkey Creek was more species rich and abundant. That being said, it was also concluded that our survey was incomplete, and that more extensive surveying needed to be employed in order to draw conclusions that are more representative and accurate regarding the biodiversity levels in those two particular areas of Big Thicket.

Introduction

Biodiversity today is at an alarming decline, despite the degree of biological, ecological, and economical importance it has proven to carry (Singh, 2002). This decline has mainly been due to the rise in anthropogenic activities in addition to natural forces such as fire and predation (Collins, 1998). Therefore, in order to elucidate the presence of any threats or trends and consequently devise appropriate methods for conservation, it is critical to expend effort and resources to survey the areas of ecological importance and document their species.

Among many forms of biodiversity, freshwater biodiversity has recently become the center of attention (Dudgeon et al., 2006). Because only a miniscule fraction of global water consists of fresh water, freshwater species across the globe are experiencing a rapid decline in biodiversity that is far greater than that observed among terrestrial species. A combination of major threats, including pollution, overexploitation, and species invasion, is known to greatly reduce the freshwater biodiversity, which is a major concern given that freshwater biodiversity is essential in the natural and economic resources it provides (Constanza et al., 1997).

In Texas, Big Thicket National Preserve located north of Houston is considered an ecologically unique region marked by its wet climate, “botanical exuberance,” and broad range of species in a mix of various ecosystems (Eisner, 1973). Big Thicket continues to serve as a popular location for biology research in Texas; however, there has not been a comprehensive survey of its fish diversity since 1979 (Evans & Noble, 1979). It is expected that these lists do not accurately represent the current fish fauna at Big Thicket.

The goal of this study is to quantify and compare the fish biodiversity of Village Creek (VC) and Turkey Creek (TC), two of the nine classified bodies of freshwater in Big Thicket. We will also utilize this data to quantify the general fish biodiversity of Big Thicket observed today.

Methods

Our study was conducted at Big Thicket National Preserve in Kountze, TX in mid-October. Two sites were observed—TC and VC (Fig. 1). The data collection at each site took place in areas nearby the established hiking trail. Only areas containing chest-deep water (around 150 cm) at the time of observation were surveyed. The TC survey took place from approximately 11 a.m. to 1 p.m. It was a sunny, clear day, and the temperature ranged from 24-27°C. No precipitation was observed. The VC survey took place between 1:20 p.m. and 3:15 p.m. It was also sunny and clear; the temperature mainly stayed around 28°C with no precipitation. It is important to note that both sites were scattered with debris. Most of the debris was composed of a variety of fully or partially submerged tree branches.

Our strategy was to capture as many different species as we could at each site. Nine samples were collected at each site. Eight of those samples came from seining, and the ninth sample came from electrofishing. For the first eight samples, two individuals swept a small area with a seine net of 360 cm in width, 180 cm in height, and a mesh size of 6.35 mm. The caught fish were stored in a bucket. Kevin Conway, an ichthyologist from Texas A&M University, College Station, TX, identified the captured fish on site with the exception of few unidentifiable species. Each new observed species was photographed with a GPS-enabled camera. One observer recorded the species and sample

method of all captured fish for that particular sample. After the fish data was recorded and the pictures had been taken, the fish from that sample were discarded into another bucket containing a bubbler. The ninth sample involved the same process mentioned above, but the fish capturing method differed: the seine net was held in place by two group members and Conway shocked the area surrounding the net using a electric fish shocker, so the stunned fish could drift into the net. After approximately 30 seconds of shocking, we pulled the net up and put the captured fish in a bucket. This process was repeated for five minutes. At the end of data collection at each site, the captured and stored fish were released altogether. Any fish that were not identified by Conway were identified by their photographs at a later time using resources from the Fishes of Texas and Texas Parks & Wildlife databases based on the fish's physical traits such as its lateral length, shape of its jaws and fins, and colorations.

To quantify the biodiversity of each site, we calculated its species richness, the Simpson's diversity index, and the Shannon-Wiener diversity index. Species richness indicates how many different species were present at each site. The Simpson diversity index measures the probability that two specimens picked from the site are be the same species; this index gives more weight to dominant species, and rarer species do not affect the measurement of diversity. The Shannon-Wiener diversity index measures the difficulty of correctly predicting the next species chosen in a sample. This index combines both the number of species and how evenly spread they are, and it also allows for the calculation of equitability, which ranges from 0 to 1, with 1 being maximum evenness (Solomon, 2015).

Results

TC showed higher species abundance when compared to VC. TC had an abundance of 116, while VC had an abundance of 28; both sites had a total of 144. *L. fumeus* was the most abundant species observed during the course of the entire survey (Table 1).

TC had greater species richness than VC, with 14 and 10 species respectively. For both sites, we found that the species richness was 17 (Table 2). Our Simpson's diversity index (D) for TC was slightly lower than VC. For TC, the calculated D was 0.71998, whereas D_{max} was 0.99138; for VC, D was 0.85714, whereas D_{max} was 0.96429. When the two sites were pooled, D was 0.76881 and D_{max} was 0.99306 (Table 3).

The Shannon-Weiner diversity index (H) was 1.69202 and 2.11273 for TC and VC respectively; for both sites, H was 1.9027. Our Equitability (E) for TC was 0.35595 and 0.63403 for TC and VC respectively, and 0.38285 for both sites (Table 3). In addition, the species accumulation curve for both sites had a noticeably steep slope (Fig. 4).

Discussion

When looking at Big Thicket as a whole, various indices tell us that while its biodiversity does not seem to be alarmingly low, it also is not as nearly as high as what is suggested in our previous findings regarding the fish fauna at Big Thicket (Evans & Noble, 1979). Our Simpson's diversity index (D) of 0.76881 for all of Big Thicket, when compared to our D_{max} of 0.99306, is relatively high. Our equitability value is relatively low, which can be explained by the presence of few heavily dominant species, such as *C. venusta* and *L. fumeus* (Table 1).

The two sites exhibited a noticeable degree of difference in their biodiversity. For instance, the species richness of TC was much higher than that of VC (Table 2). However, our Simpson's diversity index was shown to be slightly smaller in TC than in VC. This is expected since homogenization of the population is largely evident in TC. In TC, more than 80% of samples were either *C. venusta* or *L. fumeus* (Table 1). Although in VC 25% of samples were *F. notatus*, such high degree of homogeneity is not observed (Table 1). All in all, our Simpson's diversity indices show that while there may be more species found in TC, and therefore a higher maximum possible Simpson's diversity index, VC exhibits a higher level of heterogeneity.

We found that the Shannon-Wiener index was higher in the VC sample than the TC sample, indicating a higher level of uncertainty as to which species would be sampled next (Table 3). This finding coincided with the results of the Simpson's index, because when there is a lower probability of choosing the same species, it becomes more difficult to predict which species will be chosen next. The Shannon-Wiener index accounts for both the number of species and the evenness with which they are distributed—because the TC samples had high levels of dominance by *L. fumeus* and *C. venusta,* as well as more species present overall, it presented a lower amount of uncertainty as to which species would be sampled next. The values of this index indicate a higher amount of biodiversity in VC.

Equitability ranges from 0 to 1 (no evenness to complete evenness) and it measures how well individuals are distributed among different species. We found that equitability was higher at VC than TC. This is expected; when looking at Table 1, the abundance for each species is generally around the same numerical value. However when looking at Table (total abundance for observed species at TC), the total abundances of *C.*

venusta and *L. fumeus* are much greater than the total abundances observed for the other species found at that site. This discrepancy between the observed species accounts for the low level of equitability at that site.

Figure 4 shows that the surveys conducted at each site were not complete. The steepness of both lines at Sample 8 points to the fact that, if more samples were collected, new species would be observed at each site. Several factors contributed to the possible incompleteness of our survey and may explain the relatively small findings compared to previously established lists of fish observed in Big Thicket. Our survey was done in a span of a single day with less than five hours allotted for each site. Significant temperature and sunlight changes also occurred between our sampling in TC and our later sampling in VC. The heavy amount of tree debris present in the water made sampling very difficult, as certain locations were physically inaccessible. In addition, the deepest level of water we explored is around 140 cm, which is at chest height of our tallest observer. Only three individuals actively participated in sampling, due to our constraints in manpower. In addition, fish were not killed as a part of conservation efforts, and the level of voltage for electrofishing was lowered and limited as a result. We could address these issues by sampling with more people (so that both creeks could be sampled at the same time and more area could be covered) and obtaining a permit for higher voltage.

Another way to quantify the biodiversity of our samples is the Berger-Parker Index (Meredith, 2013). This index measures the proportion of the most abundant species in a community as a measure of the dominance of this species. For both of our samples, the most abundant species was *L. fumeus,* with an abundance of 52. Our total abundance was 144, so the Berger-Parker Index overall is 0.354.

Previous literature findings suggest a combination of various factors could contribute to a change in freshwater biodiversity, which may partially explain why our results were significantly lower than previous findings. First, homogenization of the freshwater fish population has been observed across the U.S. as a result of a rise in food and sports fisheries and an introduction of nonnative, cosmopolitan species intended to enhance these activities (Rahel, 2000). Although the faunal homogenization is more frequently observed in the southwestern region of the U.S., the state of Texas is not an exception of this phenomenon. In fact, fish species such as *G. affinis*, which we observed in TC (Table 1), were originally native to eastern North America but were introduced to new regions as part of mosquito control (Rahel, 2000). An introduction of new species is important, since a negative correlation between non-native and native fish species is generally observed, most likely due to competition (McKinney, 2001). In addition, it is known that fish biodiversity is at a great decline due to increasing water pollution. Threats such as excessive nutrient enrichment and increase of chemical input into the waters contribute to the decrease of freshwater biodiversity (Dudgeon et al., 2006).

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Table 1. Total abundance and method of capture of each fish species found at Turkey Creek (TC) and Village Creek (VC) at Big Thicket National Preserve in Kountze, TX.

Species	**Site(s) Observed (TC or VC)**	**Method of Capture (Seining or Electrofishing)**	**Abundance [# for TC/# for VC (Total)]**
Ammocrypta vivax	TC	Seining	1/0 (1)
Crystallaria asprella	Both	Seining	4/2 (6)
Cyprinella venusta	Both	Both	38/4 (42)
Etheostoma histrio	TC	Seining	1/0 (1)
Etheostoma nigrum	VC	Seining	0/1 (1)
Fundulus notatus	Both	Seining	6/7 (13)
Gambusia affinis	TC	Seining	2/0 (2)
Labidesthes sicculus	VC	Seining	0/1 (1)
Lepomis cyanellus	TC	Electrofishing	1/0 (1)
Lepomis macrochirus	Both	Both	5/2 (7)
Lepomis microlophus	TC	Electrofishing	2/0 (2)
Lepomis miniatus	TC	Electrofishing	1/0 (1)
Lythrurus fumeus	Both	Both	47/5 (52)
Menidia beryllina	VC	Seining	0/2 (2)
Micropterus punctulatus	Both	Electrofishing	1/2 (3)
Notropis volucellus	TC	Both	3/0 (3)
Percina sciera	Both	Both	4/2 (6)
Total			**116/26 (144)**

Table 2. Fish species richness at Turkey Creek (TC) and Village Creek (VC) of Big Thicket National Preserve, Kountze, TX. Samples 1-8 were collected through seining and Sample 9 was collected through electrofishing. Species richness for both sites was determined by pooling the two groups of samples together.

Sample Number	**TC**	**VC**	**Both Sites**
Sample 1	4	1	
Sample 2	2	4	
Sample 3	3	2	
Sample 4	2	2	
Sample 5	2	4	
Sample 6	7	2	
Sample 7	1	3	
Sample 8	3	2	
Sample 9 (Electrofishing)	9	2	
Total Richness	**14**	**10**	**17**

Table 3. Quantifications of fish biodiversity observed at Big Thicket National Preserve in Kountze, TX. Shannon-Wiener and Simpson diversity indices and Equitability were used as our measure of biodiversity.

Diversity Indices	**Turkey Creek**	**Village Creek**	**Both Sites**
Simpson's (D)	0.71998	0.85714	0.76881
Maximum Simpson's diversity (D_{max})	0.99138	0.96429	0.99306
Shannon-Weiner (H)	1.69202	2.11273	1.90270
Equitability (E)	0.35595	0.63403	0.38285

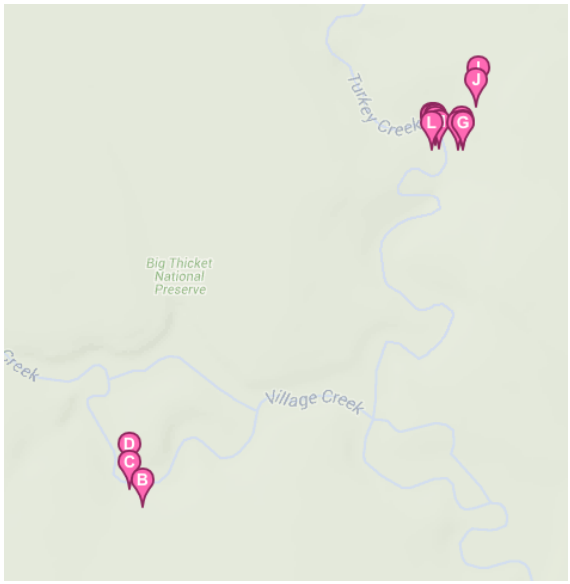


Figure 1. Geographic locations of areas surveyed for fish diversity of Big Thicket National Preserve in Kountze, TX with a location marker for each new species found.

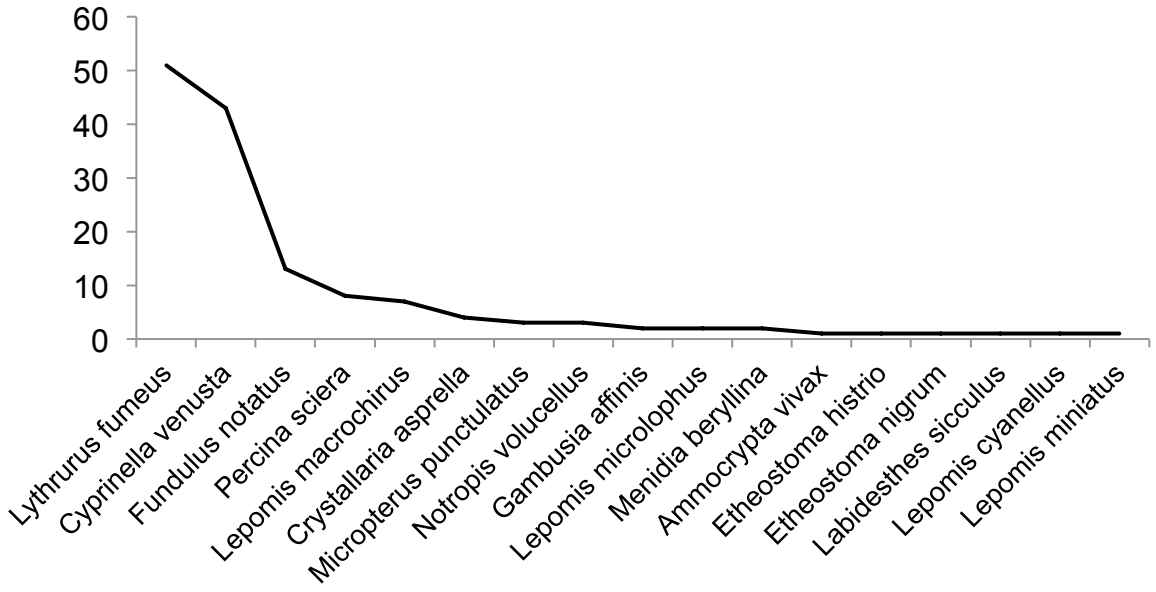


Figure 2. Rank-abundance of fish species found in Turkey Creek and Village Creek of the Big Thicket National Preserve in Kountze, TX.

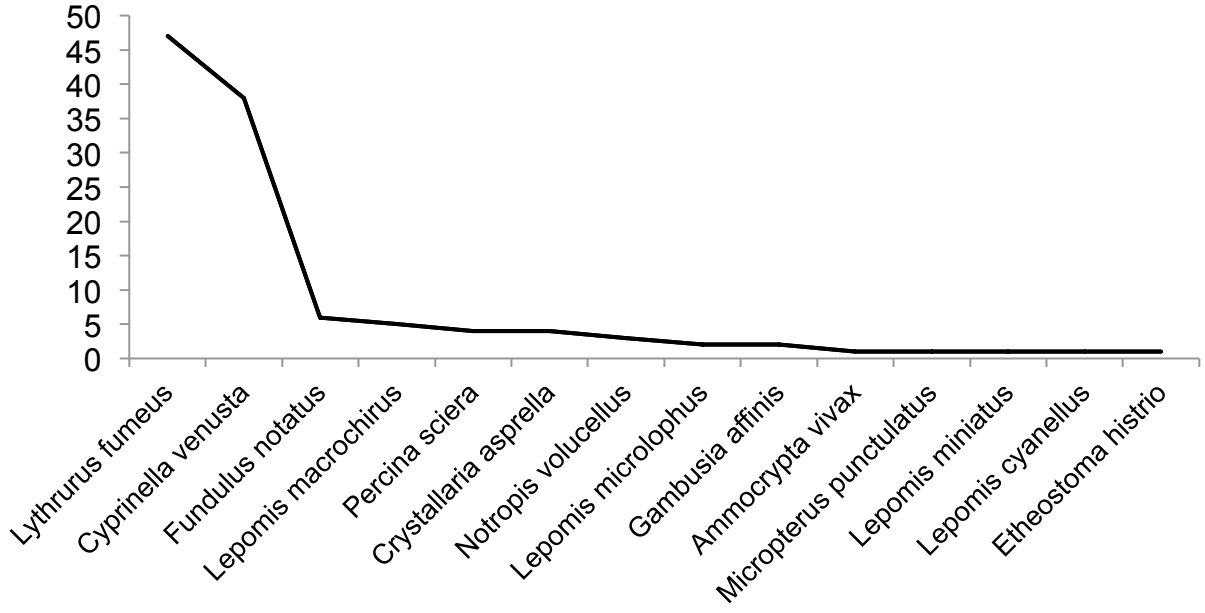


Figure 2. Rank-abundance of fish species found in Turkey Creek of the Big Thicket National Preserve in Kountze, TX.

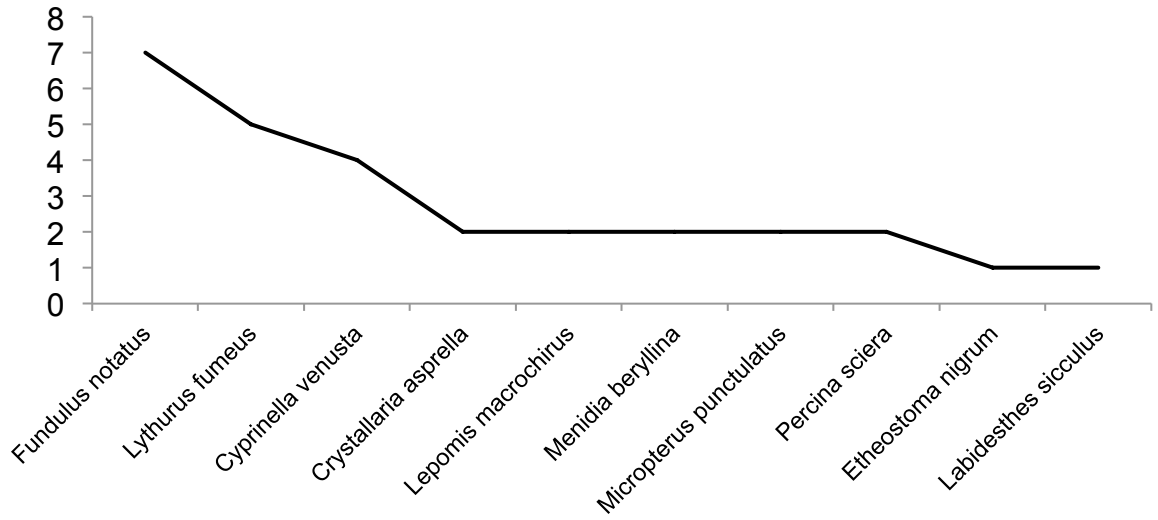


Figure 3. Rank-abundance of fish species found in Village Creek of the Big Thicket National Preserve in Kountze, TX.

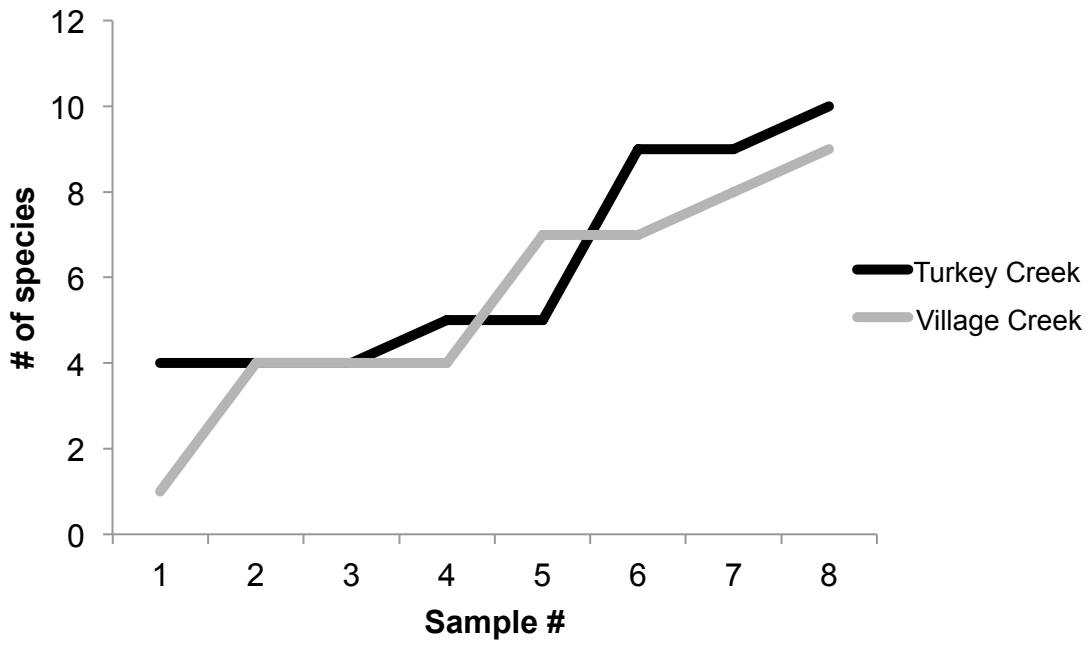


Figure 4. Species accumulation curve for seine sampling of fish for Turkey Creek and Village Creek of Big Thicket National Preserve in Kountze, TX.

Reptiles and Amphibians

Kathryn Hokamp, Adam Kassir, Sunyoung Moon

Abstract

As part of a BioBlitz project, we conducted a one-day survey of reptiles and amphibians in a section of the Turkey Creek Unit in the Big Thicket National Preserve. Our group focused our efforts on reptiles and amphibians in a small area of the unit, searching visually and aurally during the morning/afternoon and again during evening/night. We found and identified 73 individuals of sixteen distinct species of reptiles and amphibians, with significance dominance by the Texas Toad *Anaxyrus speciosus*. While our survey was limited by time and area, we report a wide range of orders and provide evidence for the need of continued study to truly estimate the abundance of species in the area.

Introduction

The Big Thicket National Preserve is a national park north of Houston and Beaumont (Eisner 1973). The division of the preserve into manageable units makes it an ideal place for monitoring biodiversity. Our group looked at reptiles and amphibians in the Turkey Creek Unit of Big Thicket National Preserve to provide useful data on the species present and the diversity of species for use by the preserve. This data can help with conservation efforts and inform park policies by giving the management of the area reliable data on the species present and the species that exist in abundance (Sutherland 2009). While our limited sampling time likely means we only observed a fraction of reptiles and amphibians in the Turkey Creek Unit, even this fraction can be useful in assessing ecosystem help and contributing to the ongoing list of species present in the area.

The Big Thicket Preserve is an important focus for conservation because it contains diverse ecosystems including sandhill pine uplands, floodplains, and mixed forests that provide habitats for many plants and animals. Quantifying biodiversity in the preserve gives numerical value to the natural park, helping lawmakers, citizens, and recreationalists to understand the importance of the area. Our project is a small part in a greater network of scientific data that help to enumerate the species that would be affected by any change in policy for the preserve.

Methods

Our group was tasked with obtaining as diverse of a sample as possible from among the reptile and amphibian populations found in the Turkey Creek subunit of the Big Thicket National Preserve in East Texas. We were not explicitly given an exact

measure of diversity to adhere to during our sampling endeavors. Instead, we were pointed in the direction of various commonly employed biodiversity metrics by which to quantify the diversity of our sample. Among these were the Simpson's Diversity Index, the Shannon-Weiner Diversity Index, and other representations of sampling diversity such as species accumulation curves, and graphs/tables of species richness and abundance.

As to the actual collection of our data, a significant amount of preparation occurred before the official weekend of the Bioblitz. Earlier in the semester our class visited a supermarket and conducted a mock Bioblitz with the goal of obtaining a diverse sample of food items, in order to formulate an initial idea of how to approach actually going out into the field and sampling live specimens. A few weeks prior to the big weekend, the class, now split into the teams that would be focusing on their respective taxonomic groups, created and presented detailed sampling proposals complete with methods, resources available, a species pool, and even contingency plans. Shortly after, we visited the Big Thicket in order to walk through the area where we would all be sampling and troubleshoot/edit anything out of our initial plan that might seem problematic. Our group also left out a three fiberglass boards out on various places along the trail in hopes that when we returned, herps would be found taking shelter underneath.

In terms of our actual sampling methodology once the Bioblitz weekend arrived, our group, along with the two specialists who joined us for the weekend, walked all the way to the end of our sampling area, at the very start of the Sandhill loop where one of our fiberglass boards had been placed. We wanted to be the first group to reach the end of the trail before turning back so that other groups wouldn't disturb and scare off any of the herps we were trying to sample, so we completed only fast-paced sampling initially. Our method consisted of walking down the trail for about 20 meters, stopping, and then

splitting up and fanning out into the woods on either side of the trail and scanning the leaf litter and fallen logs and branches for herps. We actively turned over logs and brushed away fallen leaves in hopes of revealing specimens of interest, and we actively searched along the trails as we traveled to each sampling site. Whenever a specimen was found, our timer was paused in order to obtain clear photographs for a reliable identification later. The GPS location of each sample was also recorded. We checked our fiberglass boards as we encountered them along the trail, although someone else had already flipped them upright, nullifying their impact on our sample.

All of the time spent actively searching was recorded along with the number of researchers (typically five or four) engaging in the search efforts. We quantified our samples by man-hours, where one man hour was calculated by dividing 60 minutes by the number of researchers actively searching. Therefore, we typically completed one man-hour of searching in 12 minutes during the daytime (with five researchers) and 15 minutes at night (with only four researchers). This allowed us to include samples we found while walking along the trail into our data since we were actively searching for herps during our travel time. Efforts were made during the daytime sample to sample aquatic herps by wading out into shallow pools and streams with dip nets, but due to faulty equipment and murky water, we had minimal success. The group that was targeting fish did catch one salamander in their nets which we photographed and included in our sample.

Once the group made it back to the trailhead, the daytime sample was concluded. One of our specialists departed at this time. We took a break until dusk, at which point the group headed back out onto the trail searching for nocturnal herps. We didn't stray off the trail during the night sample for safety reasons, and therefore visual identification of

any herps was a challenge. However, our remaining specialist in the field was able to identify a handful of frog and toad species by listening to their calls. The night sample consisted of our group walking down the trail all the way to the base of the sandhill loop and back, as before, only without stopping to search off of the trail. A slightly different, more direct route, was followed during the nighttime sample.

After the weekend of the Bioblitz, the photographs taken of our specimens were identified using field guides on Texas herps (Bartlett 1999 and Tennant 1999). The GPS locations, photos taken, common and scientific names, and other details regarding the sampling were all formatted together and then submitted to iNaturalist.com as a contribution to the ongoing ATBI for the Big Thicket National Preserve. Our sampling data was also analyzed using the previously mentioned diversity indices.

Results

After running a number of different tests to determine how diverse the samples, we determined that our samples did not show the true diversity of Big Thicket National Preserve. We are basing this conclusion based on the Simpson's and the Shannon-Weiner Diversity Indices (Table 3). The Simpson's Diversity Index is a number between 0 and 1, and is the probability that two randomly selected individuals from a community are of two different species. Our calculations yielded a value of D = 0.728 out of a maximum possibility of D_{max}=0.938. Equitability for Simpson's Diversity Index was a value of 0.777 The Shannon-Weiner Diversity Index is a measure of how difficult it would be to predict which species a random individual pulled out of our sample would belong to. Our calculations yielded a Shannon-Weiner value of H=1.979 out of a possible H_{max} = 2.773. Equitability is the quotient of these two values and the equitability for Shannon-Weiner

values equaled 0.714 for our data. Thus, there is a roughly 71.4% chance we couldn't predict the species identity of a random individual pulled out of our sample.

Furthermore, as shown through our Rank Abundance Curve (Figure 4), the Texas Toad dominate the samples in terms of abundance, so our samples did not show strong evenness in species. Our Species Accumulation Curve (Figure 3) also indicates that our sample was not complete. The curve does not reach a plateau, so there is still a significant possibility of discovering new species if we collected more samples. Because our Species Accumulation Curve does not taper off and remains significant after our last sample, we were still discovering new species at a high rate.

Discussion

As indicated by our species accumulation curve, our group didn't come close to an exhaustive sample of herps in the Turkey Creek subunit. The way the the curve doesn't really taper off towards the end but instead continues to climb indicates that when we stopped sampling, we were still discovering new species at a formidable rate. In order to be satisfied with the completeness of the sampling efforts, we would need to keep sampling until we were confident that no new species would
be found.

The major factor that affected the completeness of our sample was the time constraint. Only so many samples can be taken in a single weekend. Given an indefinite amount of time, it is realistic to assume a complete sample could be taken, even if it does end up taking months or even years to achieve that goal. Additionally, the manpower available to our group also played an important role in the completeness of our sample.

The amount of ground the group can sample during a given amount of time is directly related to the number of people in that group. With enough people, the group could even split up and survey different parts of the subunit simultaneously. The group also wasn't fully equipped or rested enough for a full night excursion, and was thus limited to staying on the path. It is quite likely that more herp species could have been encountered with a more extensive night survey. It was also extremely difficult to sample any aquatic herps with the resources we had at our disposal.

According to outside sources, including the in-progress ATBI for the Big Thicket, there is a large amount of diversity in reptiles and amphibians at the survey site, and while the ATBI does include samples taken from other subunits it feels safe to apply its findings specifically to the Turkey Creek subunit. In the sampling proposal, 43 different species of various reptile and amphibian orders were listed as potential species we could encounter while out in the field (Crump 2015). After a long day and evening of sampling, our group only turned up 16 different species. Considering the various factors affecting completeness that we just described, it is safe to assume that the species count estimated by the ATBI is much closer to being accurate. And since it is only a work in progress, there could potentially be many more herp species in the Big Thicket that have yet to be found. A factor that could help explain the large biodiversity of herps at this location is the many different microbiomes in the Turkey Creek subunit. The subunit features different vegetation types including upland, slopes, floodplains, and flatlands and these categories are further divided (Solomon 2015). This vast variety of vegetation not only directly supports a large variety of herp species, but many other birds, small mammals, and other organisms that serve as prey for herps to thrive on. The combination of wet and dry areas also satisfies the needs of many different species, further promoting diversity.

The fact that the Big Thicket is federally protected land also contributes to the diversity that teems there.

An additional measure of the biodiversity of our sample, beyond the metrics we've already discussed, could be the number of different reptile and amphibian families we found. For example, although we found a relatively large quantity of Anura, we only found one member of Caudata, and absolutely no Testudines. In theory, a diverse sample would include a larger number of species from different orders. This ties back into species evenness, or heterogeneity, the property of a sample to be composed of evenly represented species. An ideal, diverse sample would have fairly even representation of species. However this approaches the area of the Simpson's and Shannon-Weiner Diversity Indices, so we won't go into it too much.

Our study did not account for difficulties in finding certain organisms, a problem faced in herpetological studies due to the camouflage of many species. This could be mediated by using a sampling method that does not rely on searching, such as pitfall trapping. The study could also be improved by spending additional time in the unit. We ran into a few problems with equipment during the Bioblitz, including waterproof boots that leaked and a GPS camera that didn't save pictures. Spending more time prior to actual sampling troubleshooting our equipment would also improve this study if replicated.

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Tables

Table 1. Table of each species and its total abundance.

Rank	Species	Abundance
1	*Anaxyrus speciosus* (Texas Toad)	36
2	*Anolis carolinensis* (Green Anole)	7
3	*Rana sphenocephala* (Southern Leopard Frog)	6
4	*Plestiodon fasciatus* (5-lined skink)	5
5	*Scincella lateralis* (Brown Skink)	4
6	*Acris gryllus* (Cricket Frog)	3
7	*Hyla squirella* (Squirrel Treefrog)	2
8	*Rana clamitans clamitans* (Bronze Frog)	2
9	*Agkistrodon contortrix* (Copperhead)	1
10	*Agkistrodon piscivorus* (Cottonmouth)	1
11	*Gastrophryne carolinensis* (Eastern Narrowmouth Toad)	1
12	*Hyla versicolor* (Gray Tree Frog)	1
13	*Necturus maculosus* (Mud Puppy Salamander)	1
14	*Pseudacris*(Chorus Frog)	1
15	*Storeria dekayi texana* (Texas Brown Snake)	1
16	*Thamnophis proximus* (Ribbon snake)	1

Table 2. Total Species Richness

Total	**Value**
Abundance	73
Species Richness	16

Table 3. Shannon-Weiner and Simpson diversity indices and Equitability across all samples from data.

Index	Value
Simpson's Diversity	$D=0.728$
Maximum Simpson's Diversity	$D_{max}=0.938$
Simpson's Diversity Equitability	$E_D=0.777$
Shannon-Weiner	$H=1.979$
Maximum Species Diversity (Maximum possible value of Shannon-Weiner)	$H_{max}=2.773$
Shannon-Weiner Equitability	$E_H=0.714$

Figures

Figure 1: The path in red follows our route during the daytime sample.

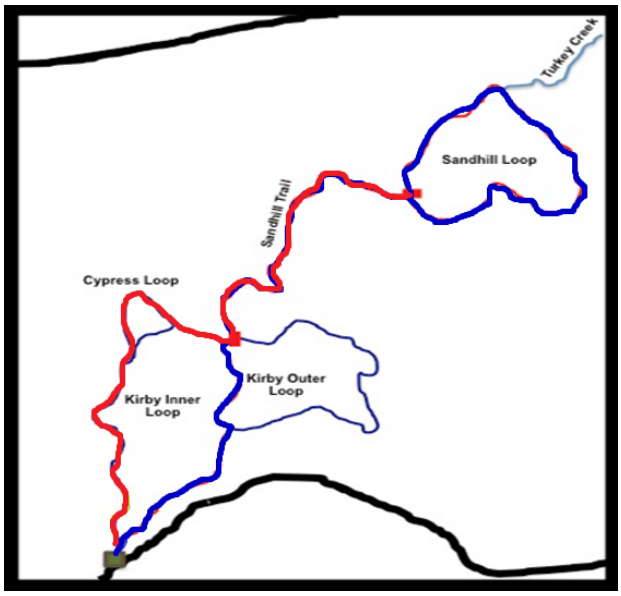


Figure 2: The path in red follows our route during the nighttime sample.

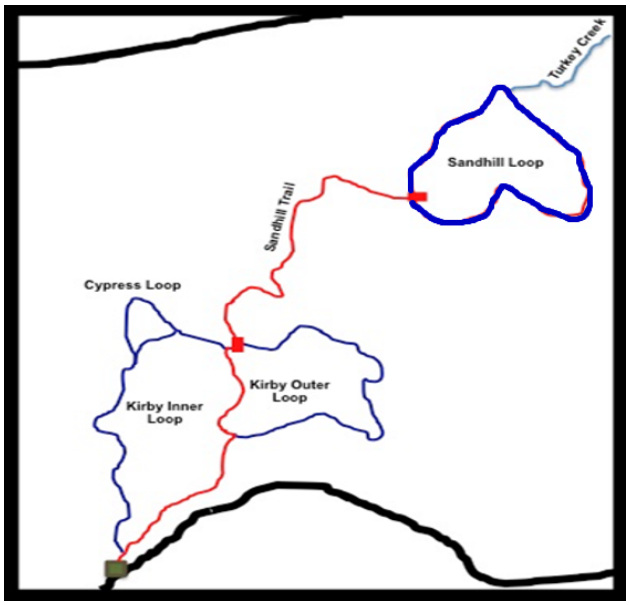


Figure 3. Species Accumulation Curve

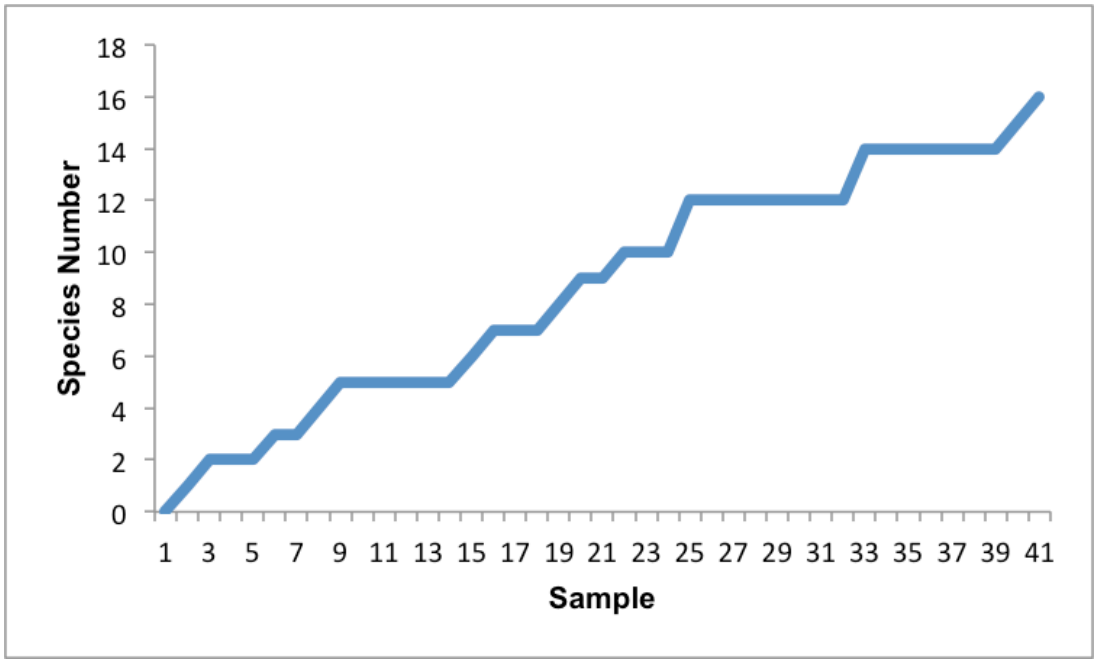
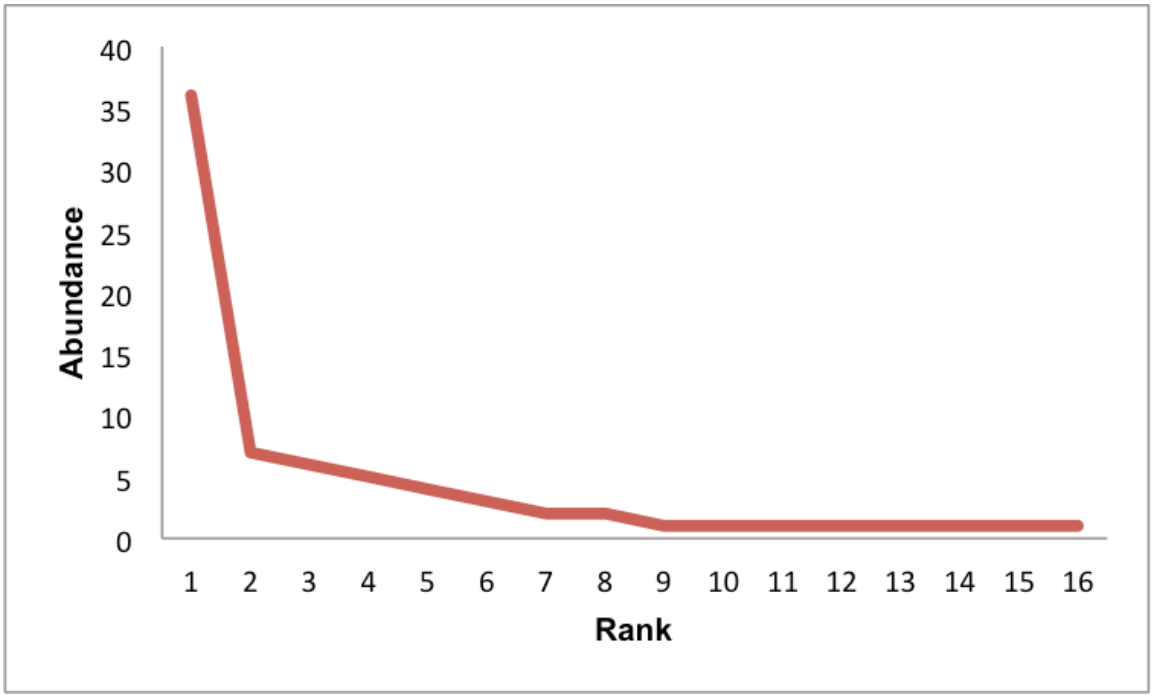


Figure 4. Rank Abundance Curve



Birds and Mammals

Miranda Zapata & Steven Pappas

Abstract:

The Big Thicket National Preserve presents an area of Texas which houses a rich, diverse ecosystem and serves as an important wildlife corridor. In order to maintain this area, biological surveys are used as important tools used to study species richness and evenness of abundance. Our research team sought to sample the diversity of birds and mammals in the Turkey Creek Unit of Big thicket National Preserve. In this report we offer analysis of data gathered using camera traps, over a two week period, to identify mammal species. In addition song recordings and visualizations were used to identify and collect data on bird species. We then analyzed this data using the Simpsons Indices, Shannon-Weiner Indices, and Equitability values. In addition, accumulation curves and rank abundance curves were also created for each animal group. Both survey groups were shown to be representative samples of the area in regards to richness and abundance. Our data and analysis suggest that birds were relatively diverse with regards to evenness of abundance between species while mammals were only moderately diverse.

Introduction:

The Big Thicket National Preserve is a national park made up of smaller units spread throughout a region of eastern Texas, north of Houston (Calicott 2007). This park represents a portion of the larger area, also called the Big Thicket, which once made up a large diverse portion of East Texas. Since the area also serves as a wildlife corridor, particularly during migration seasons of many bird species it is an important area for conservation (Calicott 2007). Much of this forested area has been reduced over time due to human activities, such as harvesting for timber resources, clearing for agricultural land, and urban development (Calicott 2007). In 1974, the Big Thicket National Preserve was created under the U.S. National Parks Service in an attempt to preserve some of the diversity of the area (Calicott 2007). Strategies continue to be developed and implemented to preserve and restore diversity to the area. For this reason, the Big Thicket National Preserve provides ample opportunity for ecologists to study the techniques of biological surveys.

Important for the management of a biological community, such as the Big Thicket National Preserve, is knowledge of the biological diversity found throughout the area. This is largely due to the positive correlation between species diversity and ecosystem stability (Calicott 2007). Equally important to the stability of an ecosystem is the evenness of abundance of organisms in an ecosystem. Biological surveys seek to gather a sample of the diversity from an ecosystem in order to properly create management and conservation strategies. Effectiveness of these surveys is largely determined by a research group's ability to collect a representative sample of the area (Srbek-Araujo 2013). In this study, we conduct a biological survey on the biodiversity of two distinct groups using two different methodologies. We examine the biodiversity of the Birds and Mammals.

Methods:

The biological survey was conducted at the Turkey Creek Unit of the Big Thicket National Preserve in Texas. A total of twelve stationary motion-activated camera traps were placed at locations within the unit, off the main trail, on 23 September 2015. These locations were chosen based on ease of access and variety of habitat type, as well as the likelihood, in our judgement, of mammals of all sizes to freely traverse in front of them. Each camera site defined a sample area where data was gathered for later analysis and species identification. The camera traps were left in the preserve for two weeks and then retrieved on 10 October 2015. The GPS coordinates for these camera traps were determined by taking a picture of the camera trap locations using a Nikon Cool Pix digital camera which had GPS location tags and can be found in Table 1.

All traps were placed on tree trunks approximately a foot off the ground. Pictures were taken by the traps when the cameras detected motion. These pictures were then used to identify mammal species in the park. Definitions for individual specimens and sampling effort were based on similar procedures used by Srbek-Araujo, et al. (2013). Each photograph captured by a camera trap was considered a specimen for abundance analysis unless there was more than one photograph of a species taken within an hour period. Sampling effort was then calculated by multiplying the number of days of sampling by the number of sample sites. Identification of mammal species was then accomplished off site after retrieval by consulting resources from the Texas Parks and Wildlife Department, such as the Texas Wildlife Identification Guide (2005).

The sampling sites for birds exactly matched the locations of the camera traps as they offered a convenient distribution throughout the park in a variety of habitats that were easily accessible. 2 circuits of the park were conducted during sampling. On the morning of October 10, 2015 sampling at sampling began at the first site at 7:00, and continued to the other 12 sites until 11:30, the time of the last morning sample. Another sampling circuit was conducted at 18:30. Due to time constraints and a scheduling error in which samplers were unable to enter the park at the original scheduled time of 17:30, only the first 7 sampling sites were recorded during the dusk circuit.

During the morning circuit, 10 minutes were spent at each sampling site using a Samsung Galaxy S6 cell phone voice recorder to record all of the bird calls and songs. Noises such as the drumming of woodpeckers' beaks or the flapping of wings were not considered viable samples, but any call, song, or visual spot of a bird counted as a sample, and if multiple calls of the same bird were heard, that bird species would be counted multiple times only if it could with certainty be determined. Such situations arose when two calls from two different birds would quickly proceed one another from different locations, or one call was coming from close by, while the other was coming from far off. During the evening circuit, 5 minutes were spent at each sampling site rather than the 10 minutes spent in the morning recordings. This was due to multiple factors; time constraints from other sampling groups required that sampling be completed more quickly than would have been preferred, as well as the fact that in the evening, far fewer species of bird were both active and vocal, especially after sunset.

A third sampling method was used in which during the day circuit, a bird was counted as a sample if a visual spot of the bird was obtained on the trail in between our sampling locations. Vocal calls did not count as samples during this "trail" sampling

location. Bird call recordings and pictures present on Cornell University's online ornithological database, allaboutbirds.org, were used as a means to identify the bird species.

After all species had been identified from the data collected at the preserve, species richness was determined overall and per sample for both mammals and birds. Abundance was also determined overall, per species, and per sample. A rank abundance graph and species accumulation curve were then created for each animal group based on this data. Additionally, the Simpson and Shannon-Weiner indices, as well as Equitability values were used to measure diversity across all data for each animal group.

Results:

During the experiment, 25 species of birds across 129 individuals were sampled (Table 2). The most abundant species sampled was Cardinalis cardinalis (Northern Cardinal), and Cyanocitta cristata (Blue Jay), both numbering 14 individuals sampled. For a complete list of sampled species and their abundances see Table 2

For birds, the Total Species Richness was 25 species. The Simpson's Diversity Index was 0.929 out of a maximum value of 1.000. The Shannon-Weiner Diversity index was 2.841, and Equitability was 0.883 out of a maximum of 1.000 (Table 3) These values indicate a moderate level of bird biodiversity in Big Thicket. The Simpson's Diversity Index indicates a higher level of biodiversity than does the equitability, although the measure of equitability is still moderately high.

A species accumulation curve in which the total number of observed species is graphed as sampling number increases can be found in Figure 1. The species accumulation curve indicates that our sampling efforts came very close to estimating the

total species richness in the park due to the presence of the asymptotic trend in the graph (Figure 1**)**.

A Rank Abundance Curve in which trends in the relative abundance of each species sampled can be easily visualized can be found in Figure 2. The Rank Abundance Curve displays a trend of a moderately even species distribution (Figure 2). The results indicate that no one species dominates in abundance of individual birds in the park, but that a trend of steadily, almost linear decrease is observed among the bird species, although a sizable "tail" can be observed in the graph in which 9 species had only one individual observed (Figure 3).

For mammals, the accumulation curve shows a sequence of steps as total species richness increased with the addition of only some samples (Fig. 3) The curve an asymptotic tendency once species richness reached 10 (Fig. 3). Most species had an abundance less than 10 across all samples, with a large variation between most and least abundant (Fig. 4). *Sciurus carolinensis*, or the eastern grey squirrel, was found to be the most abundant species across all samples at 81 specimens found. Over the roughly two week period the sampling effort was calculated at 204.

Total mammal abundance across all samples was 179 specimens with sample abundance at each site ranging from 0 to 38 individuals, with site 4 being the most abundant (Table 4). While individual samples contained species richness from 0 to 8 species, overall mammal species richness was 10 (Table 5). Overall data reveals a Simpson's diversity value (D) of 0.715 and Shannon-Weiner diversity value (H) of 1.582 with an H_{max} value of 2.303 (Table 5). This gave an Equitability (E) value of 0.687 (Table 5).

Discussion:

The results of the study show that biodiversity of Birds and Mammals in Big Thicket National Preserve, Fox Creek Camp are moderately high. 25 species of birds and 10 species of mammal were observed in the park. The Simpson Diversity Index, or the probability that two individuals, when randomly selected, will be from different species was 0.929 for birds and 0.715 for mammals or about 93% and 72% respectively. Results for the Simpson Diversity Index imply that for birds the biodiversity was much higher, likely due to the lack of a single species that dominated the abundance of the other species, which was not the case for mammals. In the case of mammals, squirrels had a very large majority of Eastern Gray Squirrel (81 individuals) compared to the second highest species White Tailed Dear (43 individuals).

The Equitability, a number ranging from a minimum of 0 to a maximum of 1 is a measure of species evenness offers a similar interpretation to that of the Simpson index. The equitability for the birds (0.883) and the mammals (0.687) are moderately high and reflects the previous trend of the bird abundances being more evenly distributed than the mammal abundances. Equitability divides the observed Shannon Weiner Index, a measure of the uncertainty in predicting the species of any individual, by the maximum possible Shannon-Weiner Index if the distribution were completely even. The reason for this differences is reflected in the Rank a=Abundance curves for these groups. While both groups have long tails which imply the presence of multiple species with relatively little abundance, the mammals have 2 species that are present in much higher quantities than the other mammal species, which alters the shape of the abundance curve into one that sharply decreases rather than one than decreases at a generally constant rate and then levels out into a long tail as in the case of the birds.

Analysis of species accumulation curves for both birds and mammals indicate that our survey closely estimated the total species richness for both groups. The presence of asymptotes in both the bird and the mammal species accumulation curves indicate that further sampling has very diminished returns as far as identifying more species is concerned.

However, a significant problem with the bird accumulation curve is present. Namely, the timing of the sampling was not conducted at identical times. Samples 1-13 were conducted during the day from 7:00-11:30, while samples 14-20 were conducted at night from 18:30-22:00. The problem exists in both morning and evening the bird vocalizations reach their peaks at dawn and dusk. Therefore, a confounding variable exists. Some of the decrease in species accumulation rates from sample to sample is likely explainable by this timing problem. If we only conducted sampling during the morning from 7:00-9:00 for multiple days, it is likely that our species richness would be higher and somewhat possible that our species accumulation curve would not approach a total estimate. We were of course limited by the constraints of the study. We were allowed only one day to sample, and the act of sampling itself requires time to pass. One way we could have overcome this limitation is to have had a technology that allowed recording to occur automatically at all sites on the morning of October 10. This would have allowed us to eliminate the effect that the time of day has on bird vocalization activity.

Another way to improve this study would have been to have had a random distribution of cameras rather than have us place them using our criteria for placement. While our group intentionally looked for areas that would allow for mammals of all sizes to be photographed, clear of branches that would block our accidentally trigger our

motion sensitive cameras, having predetermined GPS coordinates for the placement of our cameras would have increased the academic rigor of the study and the validity of our results. However, we also believe that such a system would have its downfalls as well. Because we used the camera trap locations as our vocalization recording sites, placing the cameras randomly creates a risk of placing a camera that is hard to access, which could drastically impact the time flow during our sampling circuits. Additionally the possibility of a random location being too thickly vegetated may cause our cameras to have been too reactive to motion resulting in many pictures that do not record the presence of mammals, but the presence of leaves and branches.

While we did not explicitly list it in our results, there exist several other values that can be used to indicate the biodiversity of the ecosystems. Our measure of equitability was determined by using the Shannon-Weiner Diversity Indices and dividing them by the maximum possible Shannon-Weiner Diversity for each group. A similar measure of equitability can be calculated using the Simpson Indices; dividing the observed value by the maximum Simpson index (1/species richness) (Morris et al, 2014). Another value that could be valuable in comparing these two groups is the Berger-Parker index. The Berger Parker Index is equal to the maximum pi value in the data (Morris et al, 2014). Previously mentioned differences in the relative amounts of first rank abundance between birds and mammals would be reflective of the differences expected if we did take the Berger-Parker index. Due to the high relative abundance of squirrels in the mammals, the Berger parker index would be much higher in the mammals than the birds (squirrels are 81 out of 179 observed mammals compared to both Northern Cardinals and Blue Jays making up 14 out of 129 observed birds).

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Tables and Figures

Table 1 – GPS coordinates of the sampling sites.

GPS Coordinates of Camera traps. Determined using GPS tracker present in Nikon Cool Pix Digital Camera.

Site #	Latitude	Longitude
1	N 30°27'52.1"	94°21'2.7"
2	30°28'12.3"	94°21'2.0"
3	30°28'20.3"	(94°20'58.9")
4	30°28'8.2"	94°20'52.8"
5	30°28'14.2"	94°20'48.9"
6	30°28'19.4"	94°20'50.2”
7	30°28'25.5"	94°20'44.3"
8	30°28'34.0”	94°20'37.0”
9	30°28'41.5”	94°20'38.7”
10	30°28'9.6"	94°20'47.9"
11	30°28'2.2"	94°20'47.8"
12	30°27'59.0"	94°20'49.9"
Trail	N/A	N/A

Table 2 – Bird Species Richness and Abundance

The Species names and total abundance of all birds sampled at Big Thicket National Park.

Scientific Name	**Common Name**	**Total Abundance**
Cardinalis cardinalis	Northern Cardinal	14
Corvus Brachyrhyncos	American Crow	12
Dumetella carolinensis	Gray Catbird	1
Thryothorus ludovicianus	Carolina Wren	10
Catharus guttatus	Hermit Thrush	1

Baeolophus bicolor	Tufted Titmouse	5
Hylatomus pileatus	Pileated Woodpecker	10
Colaptes auratus	Northern Flicker	8
Vireo griseus	White-eyed Vireo	1
Melanerpes carolinus	Red-bellied Woodpecker	13
Buteo lineatus	Red-shouldered Hawk	7
Picoides pubescens	Downy Woodpecker	3
Cyanocitta cristata	Blue Jay	14
Spizella passerina	Chipping Sparrow	1
Strix varia	Barred Owl	4
Sitta pusilla	Brown-headed Nuthatch	4
Ardea herodias	Great blue Heron	8
Toxostoma rufum	Brown thrasher	2
Setophaga coronata	Yellow-rumped Warbler	1
Passerina cyanea	Indigo bunting	1
Poecile carolinensis	Carolina Chickadee	3
Dendrocygna autumnalis	Black-bellied Whistling Duck	1
Zonotrichia leucophrys	White-crowned Sparrow	1
Cathartes aura	Turkey Vulture	3
Regulus calendula	Ruby-crowned Kinglet	1
Species Richness: 25		Total Abundance: 129

Table 3 – Biodiversity Indeces for Birds

A table summarizing the biodiversity indicator results of the data taken from bird sampling data in Big Thicket National Park

Biodiversity Indicator	Value
Total Species Richness	25
Simpson's Diversity Index	0.929151
Shannon-Weiner Diversity Index	2.841112
Equitability	0.882641

Table 4. Mammal Species Richness and Abundance

The Species names and total abundance of all birds sampled at Big Thicket National Park.

Species		Abundance
Scientific Name	**Common Name**	
Canis latrans	coyote	**3**
Dasypus novemcinctus	nine-banded armadillo	**22**
Didelphis virginiana	virginia opossum	**9**
Glaucomys Volans	flying squirrel	**1**
Lynx rufus	bobcat	**3**
Odocoileus virginianus	white-tailed deer	**43**
Procyon lotor	raccoon	**7**
Sciurus carolinensis	eastern grey squirrel	**81**
Sylvilagus floridanus	eastern cottontail	**9**
Urocyon cinereoargenteus	grey fox	**1**

Table 5. Biodiversity Indeces Summary for Mammals

The Species names and total abundance of all mammals sampled at Big Thicket National Park.

Simpson's (D)	0.715
Shannon-Weiner (H)	1.582
Equitability	0.687
Hmax	2.303

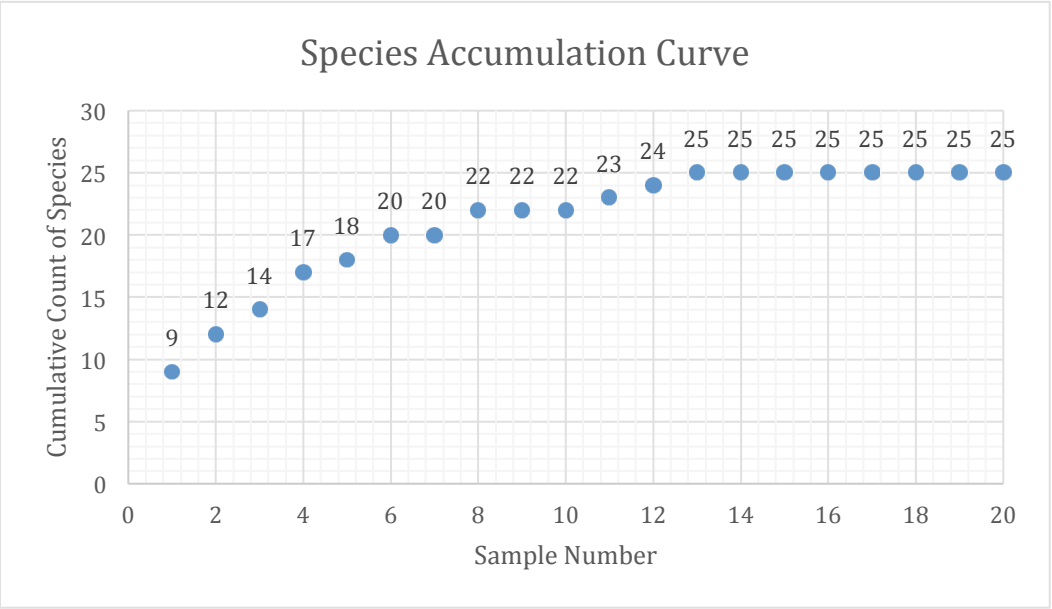


Figure 1 – Bird Species Accumulation Curve

Species Accumulation Curve for Birds in Turkey Creek. Note: Samples 1-13 were collected during the day, and samples 14-20 were collected at night. Sample 13 followed the "Trail" Methodology.

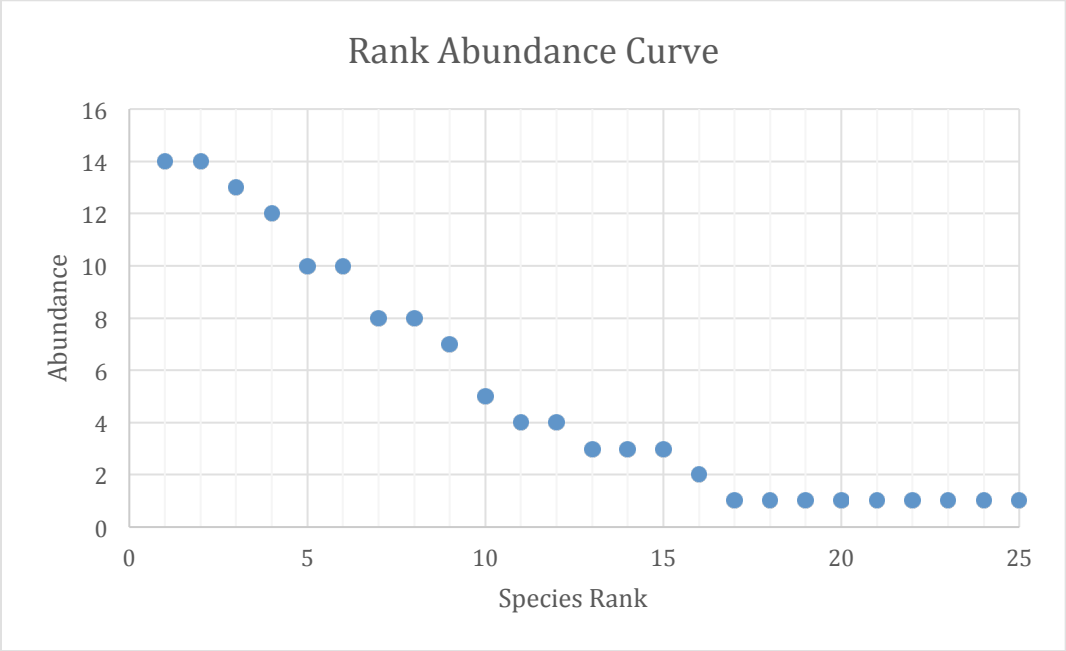


Figure 2 – Bird Rank-Abundance Curve

Total abundance for each bird species was plotted with the highest ranking species being the species with the highest abundance, the species are listed in descending order of abundance

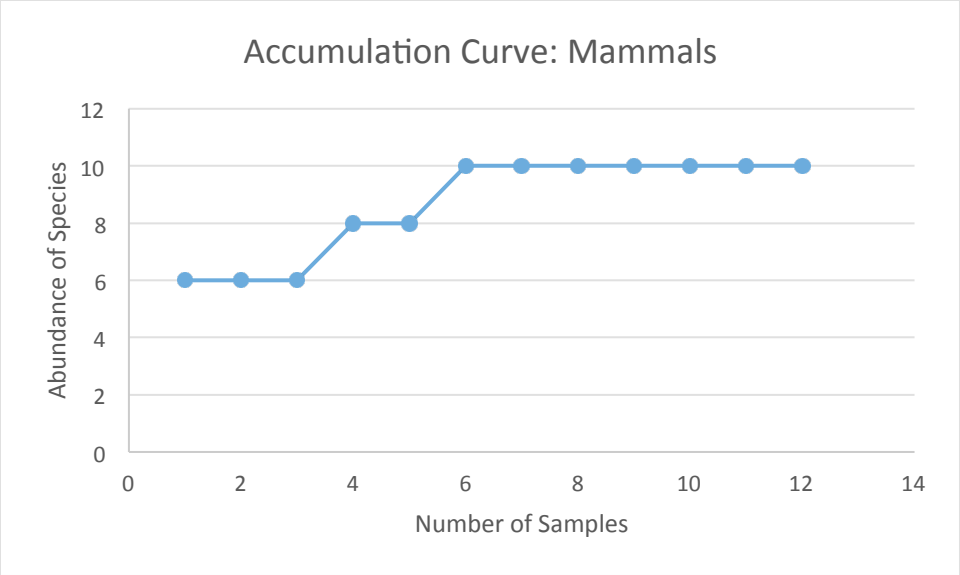


Figure 3. Mammal species accumulation curve.

Accumulated species richness is represented by abundance of species growth with the addition of more samples.

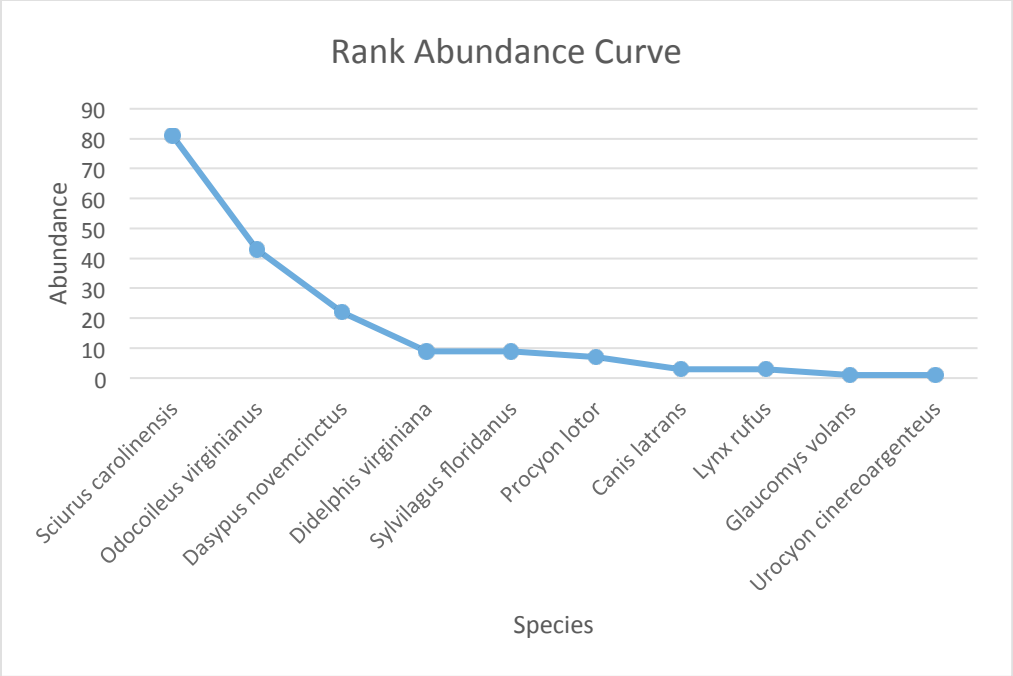


Figure 4. Mammal rank-abundance graph.

Total abundance for each mammal species was plotted with the highest ranking species being the species with the highest abundance, the species are listed in descending order of abundance

Appendix 1 – Combined list of all species observed in the Turkey Creek Unit of the Big Thicket National Preserve from October 10-11, 2015. The total number of species observed was 133.

Taxon	Common Name	Scientific Name
Actinopterygii	Scaly sand darter	*Ammocrypta vivax*
Actinopterygii	Crystal darter	*Crystallaria asprella*
Actinopterygii	Blacktail shiner	*Cyprinella venusta*
Actinopterygii	Bluntnose Darter	*Etheostoma chlorosoma*
Actinopterygii	Harlequin darter	*Etheostoma histrio*
Actinopterygii	Blackstripe Topminnow	*Fundulus notatus*
Actinopterygii	Western Mosquitofish	*Gambusia affinis*
Actinopterygii	Brook Silverside	*Labidesthes sicculus*
Actinopterygii	Green Sunfish	*Lepomis cyanellus*
Actinopterygii	Bluegill	*Lepomis macrochirus*
Actinopterygii	Redear Sunfish	*Lepomis microlophus*
Actinopterygii	Redspotted sunfish	*Lepomis miniatus*
Actinopterygii	Ribbon shiner	*Lythrurus fumeus*
Actinopterygii	Inland silverside	*Menidia beryllina*
Actinopterygii	Spotted Bass	*Micropterus punctulatus*
Actinopterygii	Mimic shiner	*Notropis volucellus*
Actinopterygii	Dusky darter	*Percina sciera*
Amphibia	Southern Cricket Frog	*Acris gryllus*
Amphibia	Texas Toad	*Anaxyrus speciosus*
Amphibia	Hybrid Toad (*B. woodhousii* x *B. fowleri*)	*Bufo woodhousii* x *B. fowleri*
Amphibia	Eastern Narrow-mouthed Toad	*Gastrophryne carolinensis*
Amphibia	Squirrel Tree Frog	*Hyla squirella*
Amphibia	Gray Tree Frog	*Hyla versicolor*
Amphibia	Green Frog	*Lithobates clamitans*
Amphibia	Southern Leopard Frog	*Lithobates sphenocephalus*
Amphibia	Red River Mudpuppy	*Necturus maculosus*
Amphibia	Chorus Frog	*Pseudacris* sp.
Aves	Great blue Heron	*Ardea herodias*
Aves	Tufted Titmouse	*Baeolophus bicolor*
Aves	Red-shouldered Hawk	*Buteo lineatus*
Aves	Northern Cardinal	*Cardinalis cardinalis*
Aves	Turkey Vulture	*Cathartes aura*
Aves	Hermit Thrush	*Catharus guttatus*
Aves	Northern Flicker	*Colaptes auratus*
Aves	American Crow	*Corvus Brachyrhyncos*
Aves	Blue Jay	*Cyanocitta cristata*
Aves	Black-bellied Whistling Duck	*Dendrocygna autumnalis*

Aves	Pileated Woodpecker	*Dryocopus pileatus*
Aves	Gray Catbird	*Dumetella carolinensis*
Aves	Pileated Woodpecker	*Hylatomus pileatus*
Aves	Red-bellied Woodpecker	*Melanerpes carolinus*
Aves	Indigo bunting	*Passerina cyanea*
Aves	Downy Woodpecker	*Picoides pubescens*
Aves	Carolina Chickadee	*Poecile carolinensis*
Aves	Ruby-crowned Kinglet	*Regulus calendula*
Aves	Yellow-rumped Warbler	*Setophaga coronata*
Aves	Brown-headed Nuthatch	*Sitta pusilla*
Aves	Chipping Sparrow	*Spizella passerina*
Aves	Barred Owl	*Strix varia*
Aves	Carolina Wren	*Thryothorus ludovicianus*
Aves	Brown thrasher	*Toxostoma rufum*
Aves	White-eyed Vireo	*Vireo griseus*
Aves	White-crowned Sparrow	*Zonotrichia leucophrys*
Lepidoptera	Gulf Fritillary	*Agraulis vanillae*
Lepidoptera	Anacampsis conclusella	*Anacampsis conclusella*
Lepidoptera	Lead-colored Lichen Moth	*Cisthene plumbea*
Lepidoptera	Garden Tortrix	*Clepsis peritana*
Lepidoptera	Gemmed Satyr	*Cyllopsis gemma*
Lepidoptera	Dioryctria clarioralis	*Dioryctria clarioralis*
Lepidoptera	Waterlily Borer Moth	*Elophila gyralis*
Lepidoptera	Texas Gray Moth	*Glenoides texanaria*
Lepidoptera	Banded Tussock Moth	*Halysidota tessellaris*
Lepidoptera	Ceraunus Blue	*Hemiargus ceraunus*
Lepidoptera	Carolina Satyr	*Hermeuptychia sosybius*
Lepidoptera	One-spotted Variant	*Hypagyrtis unipunctata*
Lepidoptera	Green Cloverworm Moth	*Hypena scabra*
Lepidoptera	Fall Webworm	*Hyphantria cunea*
Lepidoptera	Brown-shaded Gray Moth	*Iridopsis defectaria*
Lepidoptera	Isogona scindens	*Isogona scindens*
Lepidoptera	Kearfottia albifasciella	*Kearfottia albifasciella*
Lepidoptera	Lambdina laeta	*Lambdina laeta*
Lepidoptera	Lychnosea intermicata	*Lychnosea intermicata*
Lepidoptera	Diabolical Fungus Moth	*Metalectra diabolica*
Lepidoptera	Common Fungus Moth	*Metalectra discalis*
Lepidoptera	Nemoria elfa	*Nemoria elfa*
Lepidoptera	White-marked Tussock Moth	*Orgyia leucostigma*
Lepidoptera	Ozarba moth	*Ozarba* sp.
Lepidoptera	Palamedes Swallowtail	*Papilio palamedes*
Lepidoptera	Watermilfoil Leafcutter Moth	*Parapoynx allionealis*

Lepidoptera	Platynota rostrana	*Platynota rostrana*
Lepidoptera	Porcelain Gray	*Protoboarmia porcelaria*
Lepidoptera	Dotted Leaftier Moth	*Psilocorsis reflexella*
Lepidoptera	Tropical Checkered Skipper	*Pyrgus oileus*
Lepidoptera	Little Yellow	*Pyrisitia lisa*
Lepidoptera	Schrankia macula	*Schrankia macula*
Lepidoptera	Sweetgum Leafroller Moth	*Sciota uvinella*
Lepidoptera	Deadwood Borer Moth	*Scolecocampa liburna*
Lepidoptera	Large Lace Border	*Scopula limboundata*
Lepidoptera	Smoky Tetanolita Moth	*Tetanolita mynesalis*
Lepidoptera	Small Tolype Moth	*Tolype notialis*
Lepidoptera	Celery Leaftier	*Udea rubigalis*
Lepidoptera	Red Admiral	*Vanessa atalanta*
Mammalia	Coyote	*Canis latrans*
Mammalia	Nine-banded Armadillo	*Dasypus novemcinctus*
Mammalia	Virginia Opossum	*Didelphis virginiana*
Mammalia	Southern Flying Squirrel	*Glaucomys volans*
Mammalia	Bobcat	*Lynx rufus*
Mammalia	White-tailed Deer	*Odocoileus virginianus*
Mammalia	Raccoon	*Procyon lotor*
Mammalia	Eastern Gray Squirrel	*Sciurus carolinensis*
Mammalia	Eastern Cottontail	*Sylvilagus floridanus*
Mammalia	Gray Fox	*Urocyon cinereoargenteus*
Plantae	River birch	*Betula nigra*
Plantae	American Beautyberry	*Callicarpa americana*
Plantae	American hornbeam	*Carpinus caroliniana*
Plantae	Pignut hickory	*Carya glabra*
Plantae	Black hickory	*Carya texana*
Plantae	White fringetree	*Chionanthus virginicus*
Plantae	Cyrilla racemiflora	*Cyrilla racemiflora*
Plantae	Gulf Sebastian-bush	*Ditrysinia fruticosa*
Plantae	Wahoo	*Euonymus atropurpureus*
Plantae	American beech	*Fagus grandiflora*
Plantae	Green ash	*Fraxinus pennsylvanica*
Plantae	Carolina silverbell	*Halesia tetraptera*
Plantae	Meadow holly	*Ilex decidua*
Plantae	American holly	*Ilex opaca*
Plantae	Yaupon Holly	*Ilex vomitoria*
Plantae	American Sweetgum	*Liquidambar styraciflua*
Plantae	Southern Magnolia	*Magnolia grandiflora*
Plantae	Sweetbay magnolia	*Magnolia virginiana*
Plantae	Water Tupelo	*Nyssa aquatica*

Plantae	Black Tupelo	*Nyssa sylvatica*
Plantae	American hophornbeam	*Ostrya virginiana*
Plantae	Red bay	*Persea borbonia*
Plantae	Shortleaf pine	*Pinus echinata*
Plantae	Longleaf Pine	*Pinus palustris*
Plantae	Loblolly Pine	*Pinus taeda*
Plantae	Laurel cherry	*Prunus caroliniana*
Plantae	Black Cherry	*Prunus serotina serotina*
Plantae	White Oak	*Quercus alba*
Plantae	Laurel Oak	*Quercus laurifolia*
Plantae	Blackjack oak	*Quercus marilandica*
Plantae	Chestnut Oak	*Quercus montana*
Plantae	Water Oak	*Quercus nigra*
Plantae	Post oak	*Quercus stellata*
Plantae	Bald Cypress	*Taxodium distichum*
Plantae	Chinese tallowtree	*Triadica sebifera*
Plantae	Cedar elm	*Ulmus crassiflora*
Plantae	Sweet viburnum	*Viburnum odoratissimum*
Reptilia	Cottonmouth	*Agkistrodon piscivorus*
Reptilia	Green Anole	*Anolis carolinensis*
Reptilia	Common Five-lined Skink	*Plestiodon fasciatus*
Reptilia	Little Brown Skink	*Scincella lateralis*
Reptilia	Texas Brown Snake	*Storeria dekayi texana*
Reptilia	Western Ribbon Snake	*Thamnophis proximus*