Balcones Canyonlands Parks
Tim Fennell's Planet Earth Classes
LASA High School
Spring 2016

Bull Creek Area (Two bird and one plant report)

Emma Long Park (One plant report)

Gus Fruh Area (Three plant reports)

St. Edward's Park (One plant report)

The Effects of Proximity to Water on Northern Cardinal Populations in Bull Creek Park

Hannah Whellan 2016

Abstract

This study was conducted to discover how the distance from water affects populations of Northern Cardinals (*Cardinalis cardinalis)* in Bull Creek Park, Austin, TX. The hypothesis for this study was that there is a higher concentration of Northern Cardinal populations in closer proximity to the water source (Bull Creek) than there are in the transects in areas of the park that are farther away from the creek. In this study, two transects were placed throughout the park and ran parallel to the creek in order to maintain a consistent distance from the water and was .5 km long. The far transect was 240 meters away from the creek in the southern part of the park. Data was collected using the Emlen Strip Transect Method. The p-value for the total number of detections was .35 while the p-value for the population estimate was .87. This means that the data collected and results of the testings can be attributed to random chance instead of actual observations. The highest population estimate was found on the far transect with 5.5 birds per hectare and 5.2 birds per hectare for the close transect. This means the hypothesis for this study was not supported.

Introduction

Purpose

This study will be conducted to discover how the distance from water affects populations of Northern Cardinals (*Cardinalis cardinalis)* in Bull Creek Park, Austin, TX. The study will test the correlation between the population of cardinals and the distance from Bull Creek, which runs through the park.

Hypothesis

This study will show that there is a higher concentration of Northern Cardinal populations in closer proximity to the water source (Bull Creek) than there are in the transects in areas of the park that are farther away from the creek.

Site Description

Location:

Bull Creek park is located in the northwest region of Austin, TX. From the intersection of Loop 360 and FM 2222 it is .76 km from the southern most point of Bull Creek park. Bull Creek park borders Lakemoore Drive.

Size and Shape:

The lower part of Bull Creek Park is shaped like a short rectangle with a small triangular section coming off the side of it. The upper part of the park is shaped like a half circle across the highway following the curvature of the creek. Another section is rectangular that borders urbanized neighborhoods. The area of the park is 212.46 Hectares.

Topography:

The maximum elevation of Bull Creek Park is 256 meters and the minimum elevation is 158 meters. The entrance to the park from the road is flat and there is a decrease in elevation along the creek bed.

Geology:

In Bull Creek Park, there is limestone visible because of creek flow over time. Clay is seen on the ground where trees and other flora are growing. There is Alluvium from the Quaternary Period and Tributary Terrace Deposits also from the Quaternary Period that make up the geology of the Park. Alluvium is made up of sand, silt, clay, and gravel that tends to be tan to light gray colored, while Tributary Terrace Deposits are also made up of sand, silt, clay, and gravel and is also tan to light gray. The Tributary Terrace Deposits can be seen in and along the creek and the Alluvium is seen along the trails and transects where the flora is growing. There is also Glen Rose Formation from the Cretaceous period that includes limestone, dolomite, and marl that is gray to tan colored.

Aerial Extent and General Vegetation:

The area of Bull Creek Park that will be studied is 15% grassland and shrubbery and 85% woodlands. Flora of the park includes ash junipers, cactus species, live oaks, and cedar trees.

Availability of Water:

Bull Creek Park has a creek running through the greenbelt. This creek enters the Colorado River and eventually flows into the Gulf of Mexico. Part of the creek is dry while the deepest area is about one meter deep at one end of the creek and around two to three meters deep at the other end of the park before it runs into the highway. Flooding is possible and has occurred due to

evident erosion of the surrounding riverbed rock that reaches about 7-8 meters high and the debris that sits about 7-8 meters above the creek.

Proximity to Urban or Industrial Areas:

Bull Creek Park runs next to Loop 360 highway and Lakewood drive, a road running parallel to the highway. The highway is audible from the park, though the roads cannot be seen from the park. Part of the creek is surrounded by a small limestone cliff and the rest of the park's elevation increases in a hilly manner. The different areas of Bull Creek Park are all relatively close to an urbanized neighborhood or road/highway. At one part of the park, there are restrooms, a volleyball court, and a picnic area as well as used trails that have bikers, joggers, and people walking their dogs.

History:

Bull Creek Park was purchased from early settlers in the area by the Walden family in 1850. The family owned the park for the next hundred years and opened the park in the 1900's to public and began to charge a fee for the swimming hole. In 1959, the Moore Family bought the park and operated it until 1967. In 1979, the City of Austin bought the lower part of the park from the Heater Trust, then acquired the rest of the greenbelt to Spicewood Springs Road in the 1990's. At the entrance to the trailhead, there is historical evidence in the limestone over the creek that this area was once used as a commerce highway for wagons in the 1800's as settlers were moving into the area. In 1994, the Bull Creek Foundation was created and today works to maintain the delicate balance between nature, recreation, and development in the Bull Creek Watershed area (City of Austin – Park Sign).

Research Plan

Design of Study

In order to study the correlation between the population of Northern Cardinals and their distance from water in Bull Creek Park, two transects will be placed throughout the park. This method of placing transects will yield varying data that can be compared in class. Each transect will run parallel to the creek in order to maintain a consistent distance from the water in each set of data. The transects will be .5 km long in order to ensure consistent areas of the data being taken on each transect. The transect that will be running along the creek will be 500 meters in length. The transect is elevated from the creek and the trail is surrounded by ash junipers and small brush in the northern area of the park. The transect that will be the farthest from the creek will be 500 meters in length and will have very similar vegetation as the second transect. This transect will be the farthest from the creek and the highway, so it will also be quieter than the other transect. This transect will be 240 meters away from the creek in the southern part of the park. To take data, I will walk along their transect. As I walk, I will record all Northern Cardinals detected by song, call, or sight. After all data is collected will take data along the two transects six times), this information will be used to determine the effect of distance from water on the population of Northern Cardinals in Bull Creek Park.

Natural History

Northern Cardinals can be found year round in the eastern half of the United States. They range from west Arizona to the eastern border of the United States, from central Minnesota to the southern tip of Mexico. Northern Cardinals most often live in backyards, parks, woodlots, and forest edges. These birds build their nests in areas of dense shrubs and tangled vines, and often in sapling trees between forked branches (Dewey). Nests are commonly seen in dogwood, honeysuckle, hawthorn, grape, red cedar, spruce, pine, hemlock, blackberry brambles, rose

bushes, elms, and box elders. Northern Cardinals have a nesting period of around 7-13 days, eggs being grayish to buffy white, often with speckles. Nests take 3-9 days to build with most of the work being done by the female. Northern Cardinals can most often be seen foraging on or near the ground, hopping through low branches, and usually singing and preening from high branches of shrubs. During the breeding season, cardinals are often observed moving in pairs, while they act in large flocks of a dozen or more throughout the fall and winter. These pairs usually stay together through the winter with 80 percent staying together until the next breeding season. During foraging, adult birds take priority over young birds, females giving way to males. Cardinals are not known for flying much, mostly taking short trips between thickets to forage in different areas, and can often be seen foraging with other bird species such as sparrows like the White-throated Sparrows, Dark-eyed Juncos, Tufted Titmice, goldfinches, and Pyrrhuloxias (Northern Cardinal). Males vigorously defend their territory, and have been known to attack reflections and small red objects when feeling threatened. The characteristic crest of the Northern Cardinal usually stands straight when they are agitated, such as when males attack, but lay flat when the bird is resting (Northern Cardinal (Cardinalis Cardinalis)).

Background Information

The correlation between birds and water can be seen in one study looking at the effects of the Texas drought and bird populations. This study shows that due to the little rainfall that occurred over the Laguna Madre, along the western coast of the Gulf of Mexico, salinity levels shifted from 30% above sea strength to 150% above sea strength. This caused a decline in the water bird population along the lagoon due to the fact that the water was no longer drinkable for some birds. Using Christmas Bird Count (CBC) data, the bird population went from 340,000 during the 111th CBC to less than 100,000. This study also listed the percent declines of specific bird species

along this lagoon. The Ring-necked Pheasant suffered the greatest decline of 80% of its population during the time of the Texas drought. However, the drought also brought some birds' population increase due to the availability of low level water. One species that benefitted the most from the low level lakes was the Smith's Longspur with a 332% population increase from the 107th to the 114th CBC (Audubon). Overall, this study demonstrates how water affect the increase and decrease of bird populations based on each species adaptations.

Materials

- binoculars
- aerial map
- topographic map
- pens for recording data
- ruler for organizing data table
- field guide (Peterson, 1980)

Procedure

1. Before data is taken, one should record some basic informations about the conditions data was taken under, including the date, starting time of data recording, transect length and number, bird species, temperature outside, Beaufort number, wind direction, and sky conditions.
2. Begin taking data by walking to the start of the transect data will be taken along. Data is only to be taken along this transect line, so no songs or called heard as well as birds seen while walking to the transect should be recorded.

3. To take data, one should walk along their transect at about 1 km/hr. It is important that data is taken slowly so all birds can be heard, but at a reasonable pace so results are accurate. This pace should be consistent among all group members as well as for each set of data. If speed is not consistent, the data recorded will not have been taken under the same situations, and therefore cannot be effectively compared.

4. As one walks along their transect, they should take note of all of the Northern Cardinals they are able to detect by either their call, song, or sight. In the project notebook, these detections should be recorded in a chart that specify the detection cue used to first identify the bird as well as the estimated distance the bird is from where is was detected. Distances should be recorded in ranges of 5 km, until 35 km. From then on, distances should be estimated in 30 km ranges. Totals should then be taken in each category.

5. As data is being taken, one should also record human activity such as number of planes, bikers, dogs, and hikers seen and/or heard along the transect during data detection.

6. Using this data, one should then calculate the full detection strip, population estimate, and coefficient of detectability. The full detection strip is found by looking at the data and ending the strip distance at which there is at least a 20% decrease from the previous strip. The population estimate will be found by the following equation: [(Strip Transect width/Full detection strip width)/ the number of detections in Full-Detection Strip] / the area being tested by transect in hectares. Once this number has been found, the coefficient of detectability can be found by dividing the total number of detections by the population estimate for the area being tested by the transect.

7. Take six sets of data along the same transect, each approximately one week apart at the same time of day.

Bibliography

Christoferson, Laurel L., and Michael L. Morrison. "Integrating Methods to Determine Breeding and Nesting Status of 3 Western Songbirds." *JSTOR*. Wildlife Society Bulletin, 2001. Web. 28 Feb. 2013.

Dewey, Tanya, and Jonathan Crane. "Northern Cardinal." *BioKIDS*. University of Michigan, n.d. Web. 28 Feb. 2013.

Flather, Curtis H., and Therese M. Donovan. "Relationships among North American Songbird Trends, Habitat Fragmentation, and Landscape Occupancy." *Ecological Applications* 12 (2002): 364-74. *JSTOR*. Web. 28 Feb. 2013.

"Northern Cardinal." *All About Birds*. Cornell Lab of Ornithology, n.d. Web. 28 Feb. 2013.

"Northern Cardinal (Cardinalis Cardinalis)." *Texas Parks and Wildlife Department*. Texas Parks and Wildlife, 2013. Web. 27 Feb. 2013.

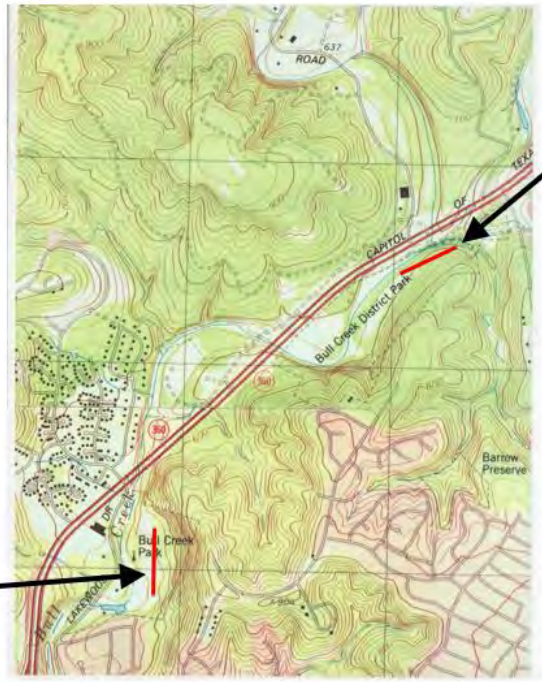
Peterson, Roger Tory. *A Field Guide to the Birds of Easter and Central North America*. 4th ed. New York City: Houghton Mifflin, 1980. Print

"The Effects of Drought on Texas Bird Populations." *Audubon*. N.p., 09 Jan. 2015. Web. 10 Mar. 2016.

Topographic Map

Topographic map of Bull Creek Park

Contour Interval:20



Close Transect
(<10m from creek)

Far Transect
(>240 m from creek)

N

Aerial Photo

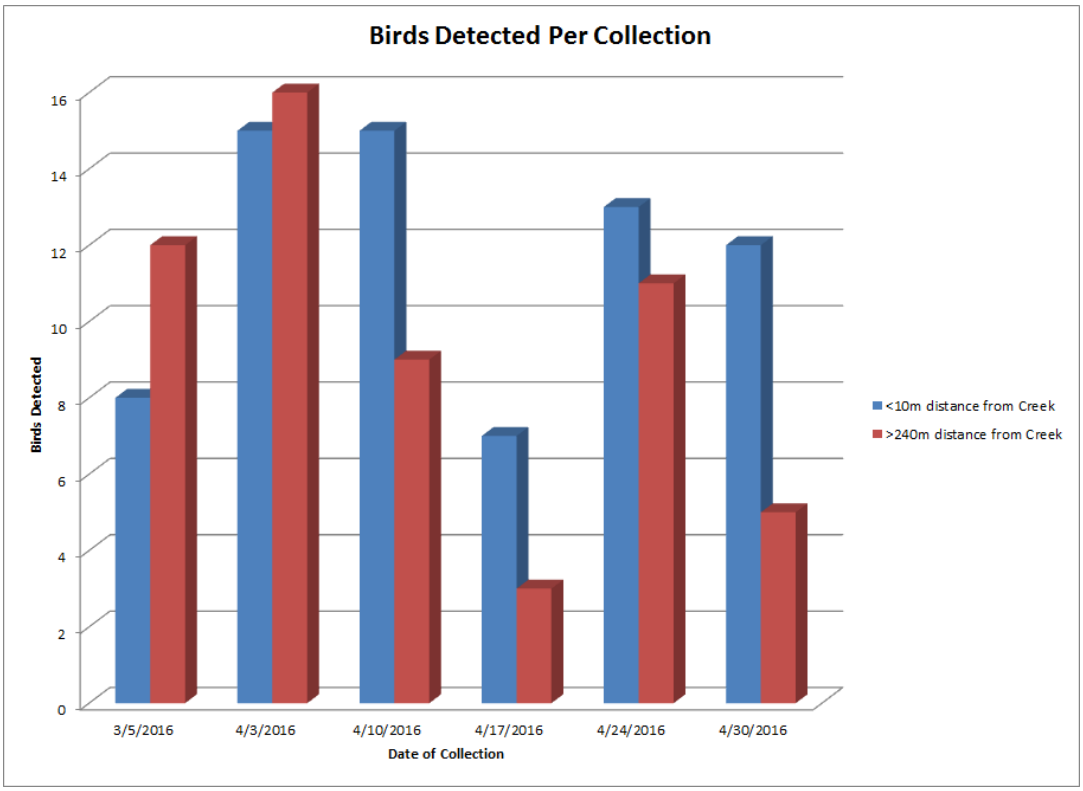


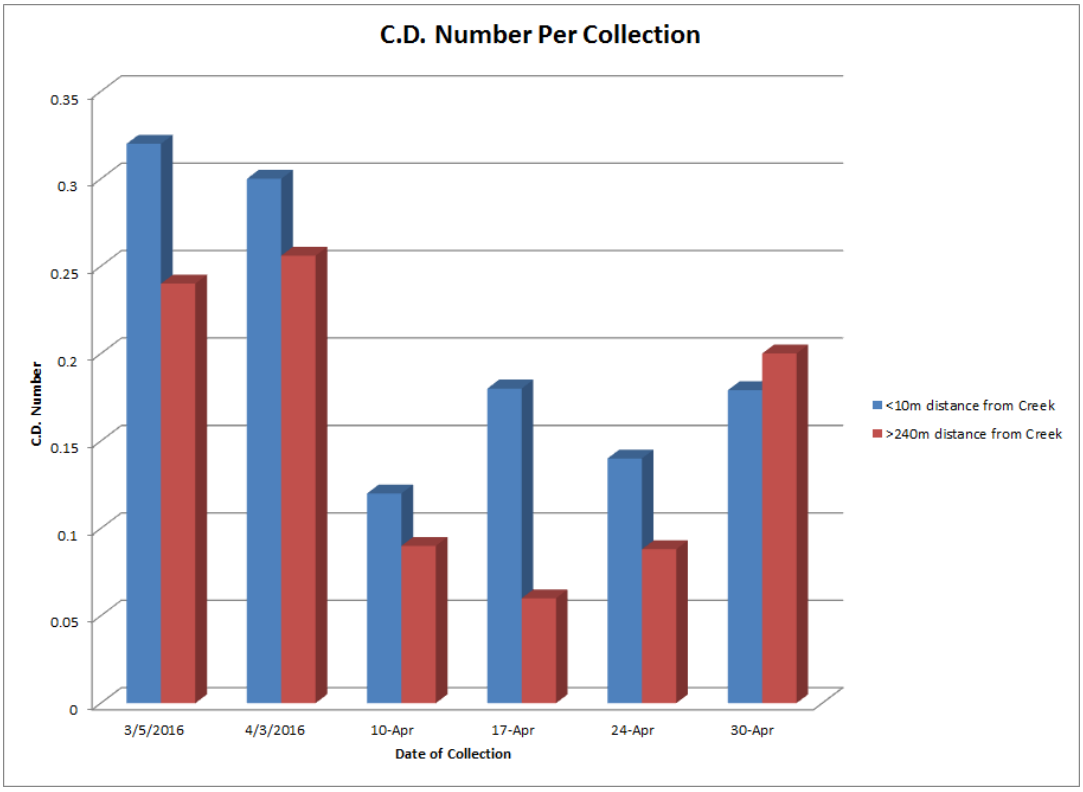
Close Transect
(<10m from creek)

Far Transect
(>240 m from creek)

N

Aerial map of Bull Creek Park


Birds Detected Per Collection
Birds Detected
16
14
12
10
8
6
4
2
0
3/5/2016
4/3/2016
4/10/2016
4/17/2016
4/24/2016
4/30/2016
Date of Collection
<10m distance from Creek
>240m distance from Creek


C.D. Number Per Collection
C.D. Number
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
3/5/2016
4/3/2016
10-Apr
17-Apr
24-Apr
30-Apr
Date of Collection
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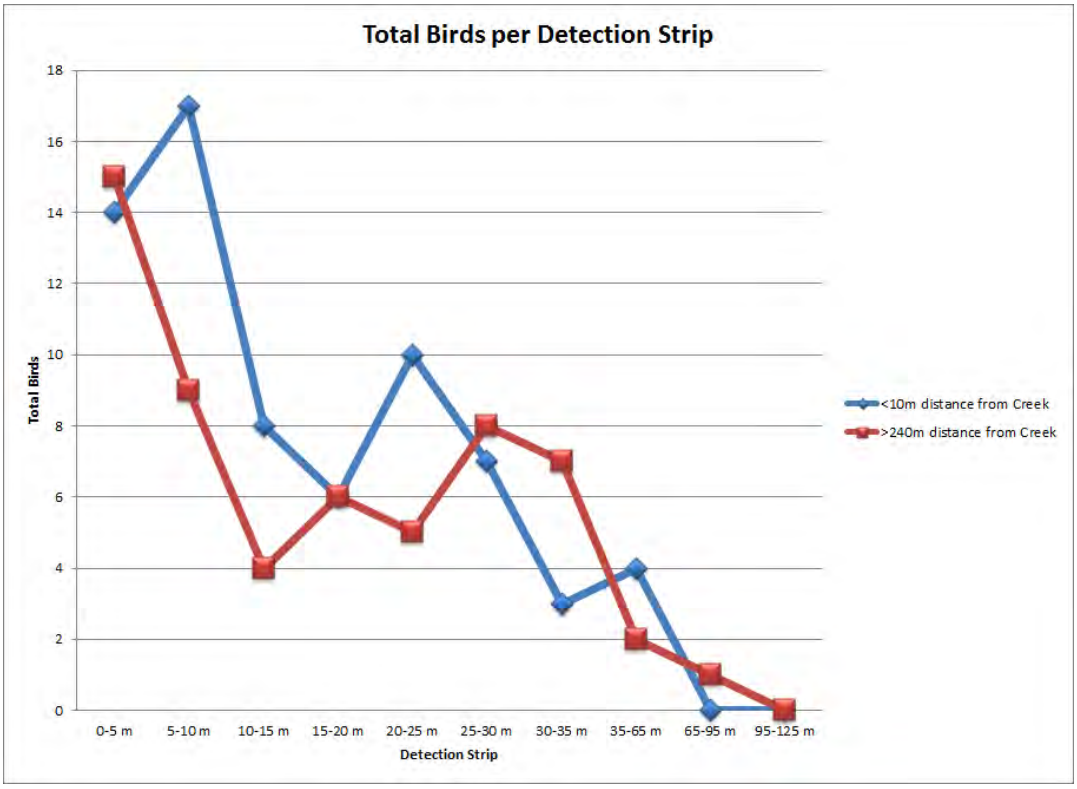
>240m distance from Creek


Total Birds per Detection Strip
18
16
14
12
10
8
6
4
2
0
Total Birds
0-5 m
5-10 m
10-15 m
15-20 m
20-25 m
25-30 m
30-35 m
35-65 m
65-95 m
95-125 m
Detection Strip
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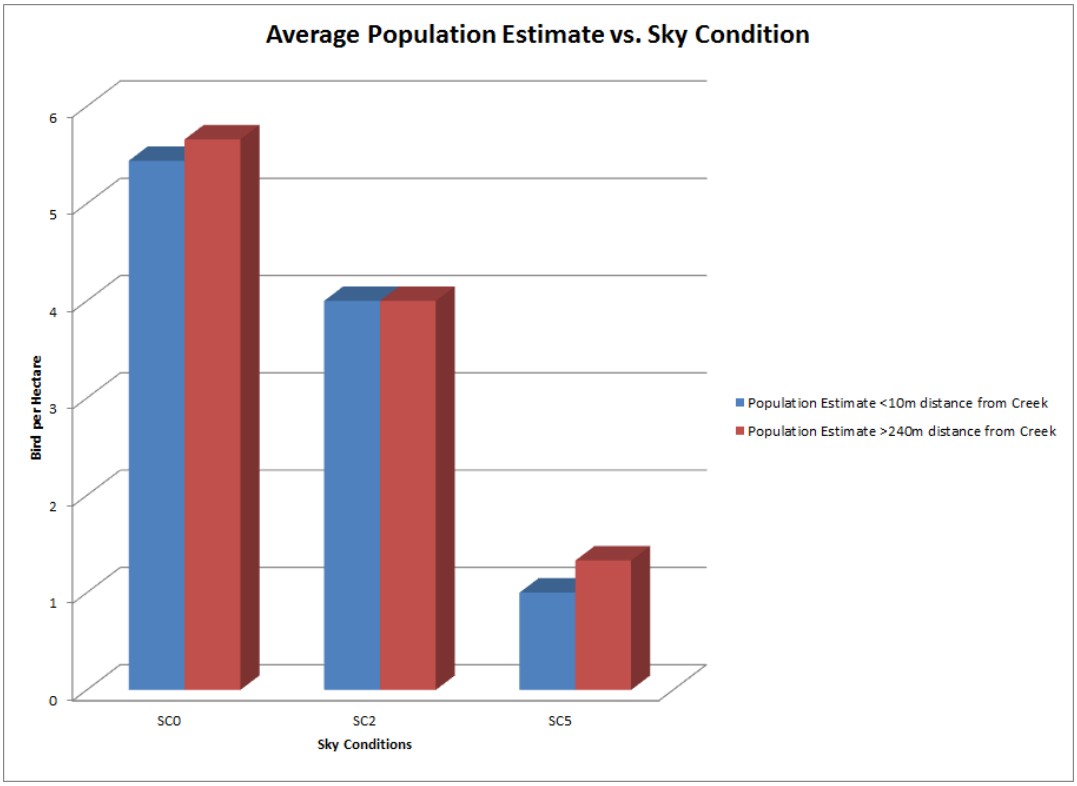
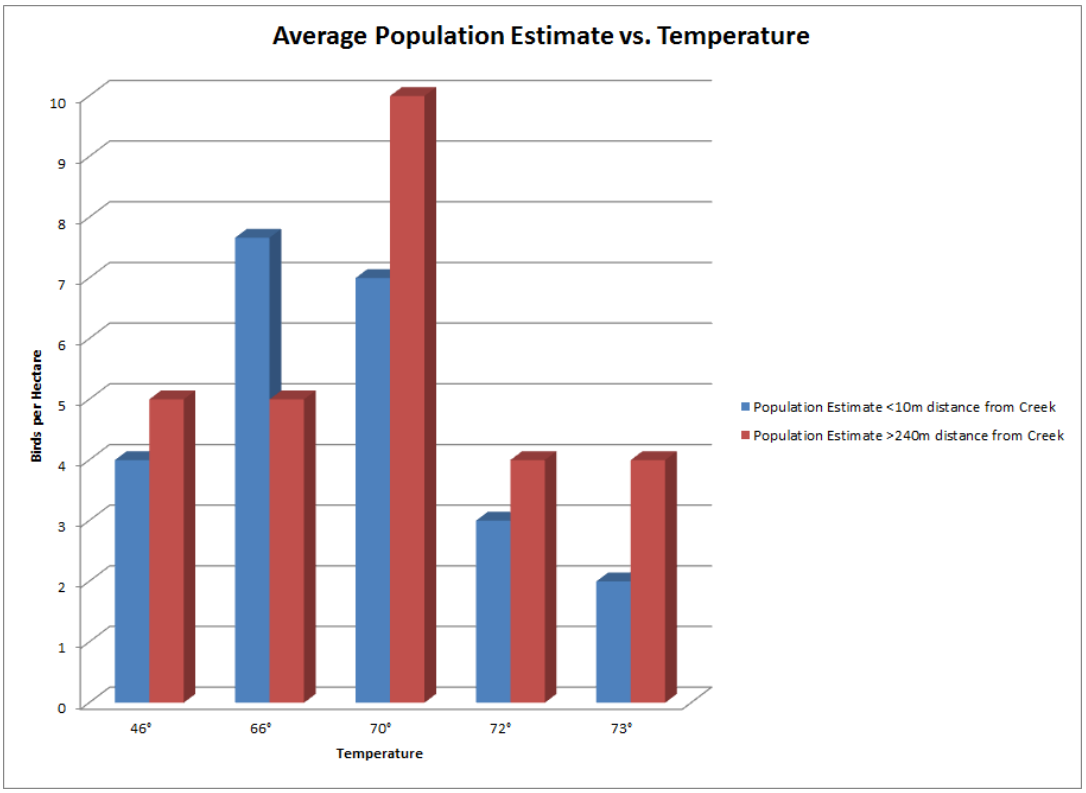
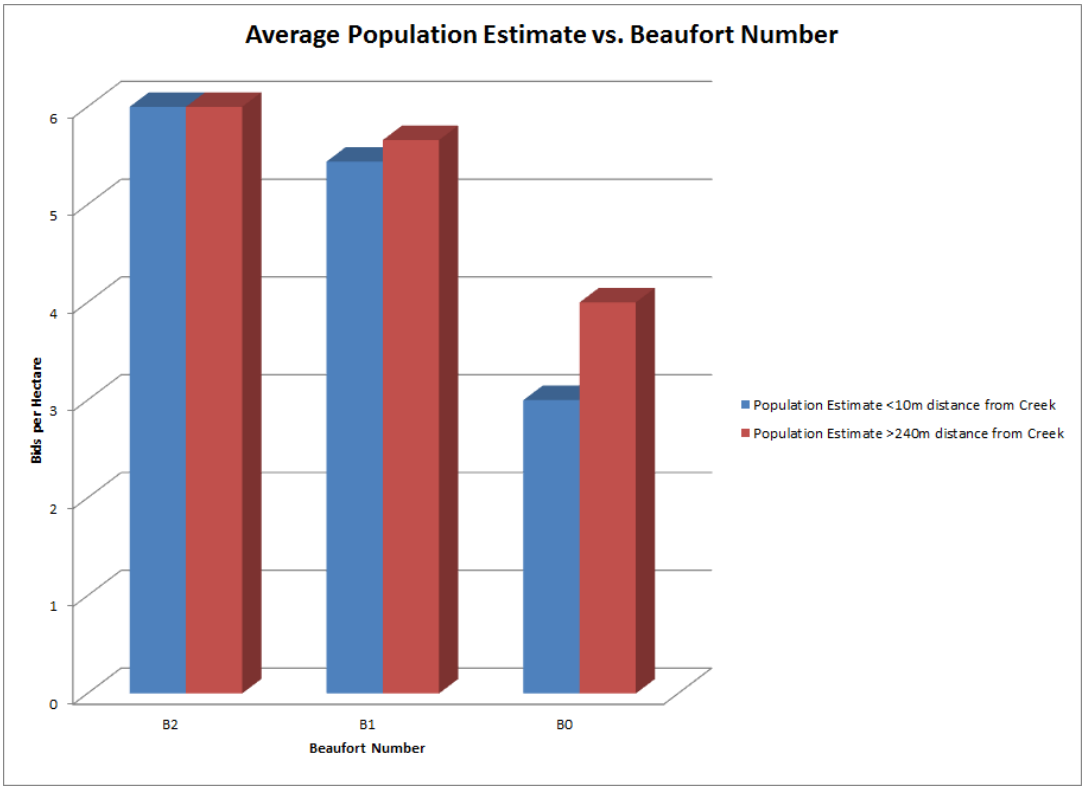
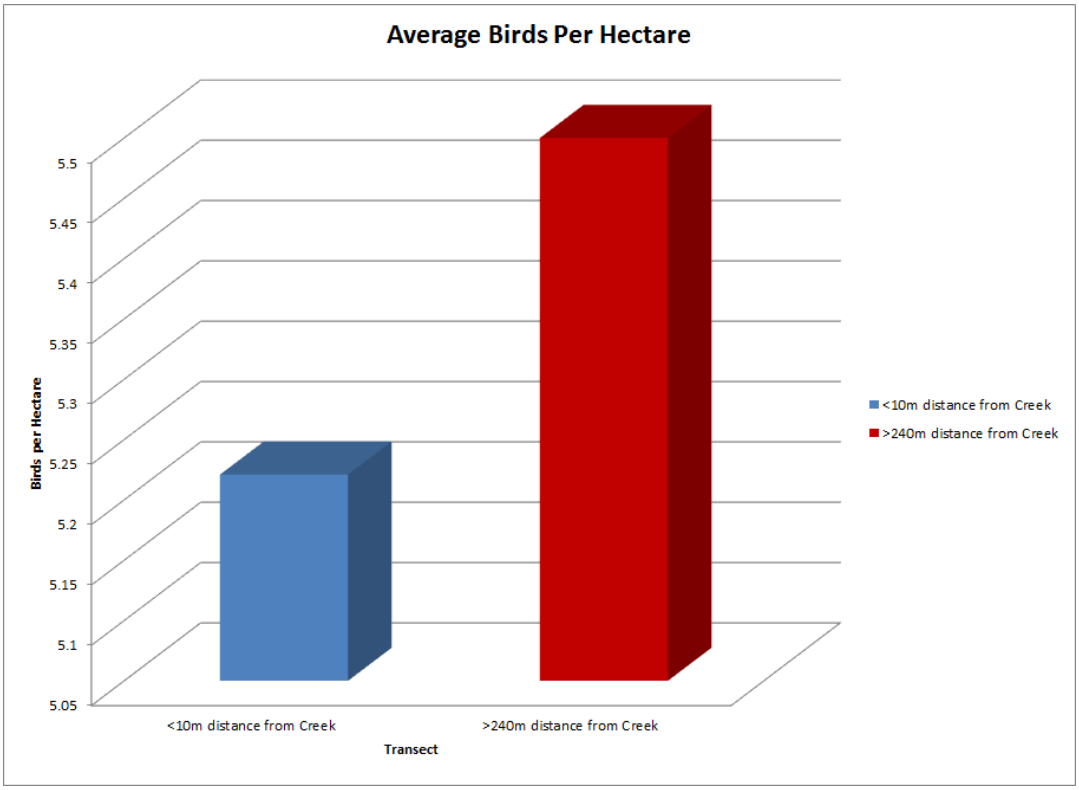
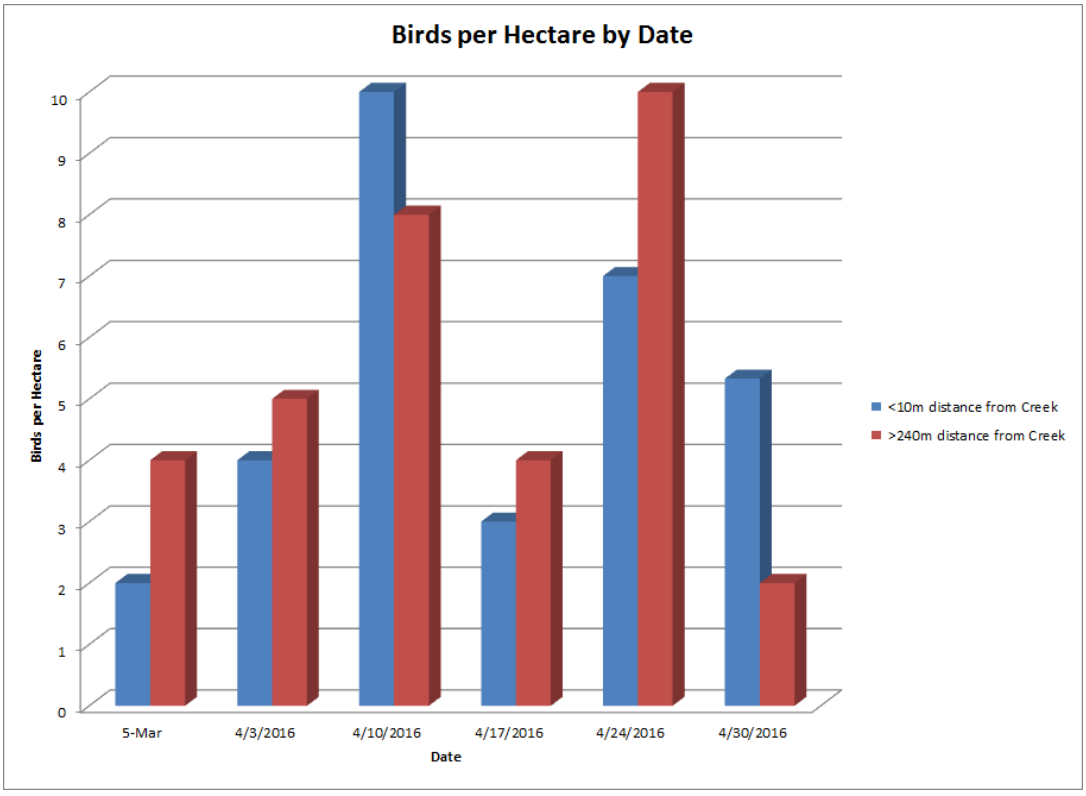
>240m distance from Creek


Average Population Estimate vs. Sky Condition
6
5
4
3
2
1
0
Bird per Hectare
SC0
SC2
SC5
Sky Conditions
Population Estimate <10m distance from Creek
Population Estimate >240m distance from Creek


Average Population Estimate vs. Temperature
Birds per Hectare
10
9
8
7
6
5
4
3
2
1
0
46°
66°
70°
72°
73°
Temperature
Population Estimate <10m distance from Creek
Population Estimate >240m distance from Creek


Average Population Estimate vs. Beaufort Number
Birds per Hectare
6
5
4
3
2
1
0
B2
B1
B0
Beaufort Number
Population Estimate <10m distance from Creek
Population Estimate >240m distance from Creek





T-Test Total Detections	Close Transect	Far Transect

Mean	11.6666666666667	9.33333333333333
Variance	11.8666666666667	22.6666666666667
Observation	6	6
Hypothesized Mean Difference	0	
df	9	
t Stat	0.972597525159274	
P(T<=t) one-tail	0.178083120596542	
t Critical one-tail	1.83311292255007	
P(T<=t) two-tail	0.356166241193083	
t Critical two-tail	2.26215715817358	

T-Test Population Estimate	Close Transect	Far Transect
Mean	5.22166666666667	5.5

Variance	8.56281666666667	8.7
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.164091096392103	
P(T<=t) one-tail	0.436464317798727	
t Critical one-tail	1.81246110219722	
P(T<=t) two-tail	0.872928635597454	
t Critical two-tail	2.22813884242587	

Conclusion

The average population estimate for Northern Cardinals within close proximity to water (transect one) was 5.2 birds per hectare while at a farther proximity to water (transect two) the average population estimate of Northern Cardinals was 5.5 birds per hectare over a six week period of testing. This means that the initial hypothesis of this project that there is a higher concentration of Northern Cardinal populations within a close proximity to water is not supported by the data collected.

In summary, the data collected testing Northern Cardinal diversity in relation to proximity to water shows that there is greater Northern Cardinal diversity farther away from water. However, in total, there were more detections of Northern Cardinals at a closer proximity to water. The population estimate is greater for transect 2 because of how far away from the transect each bird was detected.

When looking at a t-test comparing the population estimates of each transect and the total detections of each transect, the results turn out to not be statistically significant for both tests. The p-value for the total number of detections was .35 while the p-value for the population estimate was .87. This means that the data collected and results of the testings can be attributed to random chance instead of actual observations.

The first trend observed by this data is the total number of detections each day per transect. Overall, there were more detections of Northern Cardinals while walking transect one

except for the second week of data collection (4/3/2016). On this day, the total number of detections differed by one. The greatest difference between the two transect detection totals was on the last day of collection (4/30/2016) at a difference of seven total detections. This shows that there is a trend of more cardinals being detected at a closer proximity to water. One experiment watching song sparrows in dry and wet baths concluded that access to water was an important factor in song sparrow populations (Wingfield 2012). Both Cardinals and song sparrows are songbirds possibly indicating similar environmental needs. This justifies the data collected because there were more Northern Cardinals detected within a close proximity to water.

In the second graph, the data is comparing C.D. (coefficient of detection) number per transect each data collection. The C.D. number represents the proportion of the population of Northern Cardinals that is ordinarily detected in that specific area, transect length, and time of year. To calculate the C.D. number you find the ratio of Northern Cardinals detected to the population estimate per hectare. The average C.D. number for transect one was .21 while the average C.D. number for transect two was .15. This shows that both transects shared relatively close C.D. numbers each time data was collected. This number takes both the total detections and population estimates into account providing a more full understanding of the data collected. The C.D. numbers are more closely related than the total detections and population estimates because the C.D. number takes into account both elements of the data collected instead of just one.

For the third graph, the data compares the total number of Northern Cardinals and where they were on the detection stips for both transects. This graph shows how the Northern Cardinals

were detected and gives more insight to the population estimates. The population estimate comes from the total birds detected within a detection strip. The detection strip is determined by when there is a 20% drop in bird detections along the transect. This graphs tells that for transect one, the most birds detected were five to ten meters away from the transect while for transect two the most birds detected were zero to five meters away from the transect. This data shows that the detection stips were longer for transect one.

In graph number four, the data shows the average population estimate vs. the the sky conditions. The sky conditions are a representation of the weather that day and more specifically what the sky looks like. The three sky condition descriptions that were encountered over the six week period of testing were clear, overcast, and drizzle. The population estimates show that there was a higher estimate of Northern Cardinals on clear days at an average of 5.44 Cardinals per hectare for transect one and 5.66 for transect two. For the average population estimates on a day with a sky condition of five, the average Northern Cardinal population for transect one was one bird and 1.33 for transect two. This difference shows that on a clear day, there will be more Northern Cardinals detected than on a day with precipitation. In one experiment, the songs of Cardinals, Robins, Mourning Doves, House Wrens, and Catbirds were all observed. The results showed that songs became regular for these birds at daybreak, or when the sky was bright and clear. Out of 118 days where no song was observed, only six percent of failure to hear a daybreak song was due to weather (Leopold, Aldo, Eynon).

For the fifth graph, the data compares the average population estimate for Northern Cardinals vs. temperature. In this graph, it can be seen that there was always a greater population estimate for transect 2 no matter what the temperature was except for when the temperature was 60 degrees Fahrenheit. One study looking at the effects of urbanization on Northern Cardinals mentions that there was an increase in Northern Cardinals due to warmer January weather (Leston, Rodewald). This study also spoke of how this increased temperature can be attributed to urbanization and climate change. Overall, for this graph, the change at a 66 degree temperature in population estimate is most likely not significant.

In graph number six, the graph compares the average population estimate to the Beaufort number for each collection day. The Beaufort number is a description of wind speed and its indicators. The indicators observed over the six week period of data collection for this project were smoke rising vertically indication no wind, a smoke drift, and leaves rustling. The graph shows that there was a higher population estimate for both transects on days where the Beaufort number was 0 (smoke rises vertically). One study revealed that mechanoreceptors are able to provide information on wind speed as long as the bird is mounted on the ground (Brown, Fedde). This information can be paired with the assumption made by another experiment saying that birds seem to "know" its own airspeed based on common power consumption and preferred flight direction (Wiltschko and Wiltschko). Together, these two studies tell that birds are able to understand wind conditions. The Northern Cardinals being studies in Bull Creek Park are

permanent residents of Texas (The Texas Breeding Bird Atlas) and do not need high tail winds to help with migrations making little to no wind a preferable condition.

For graph number seven, the data is showing the average population estimate for both transects. This information shows that the population estimate for transect 2 was .3 higher than the population estimate of transect 1. The population estimate is the estimated population of birds per hectare. It is dependent upon the strip transect width which is being covered, the total detection strip and the number of birds within the detection strip. This information illustrates that there is a higher population of Northern Cardinals at a farther proximity to water. However, the t-table of this data tells that the information is not statistically significant. This makes the first graph showing a higher number of Northern Cardinals detected closer to water correct.

For the last graph, the chart shows the birds per hectare each data collection for each transect. Overall, the birds per hectare in transect two were greater than transect one. However, on March 10th and 30th, transect one had a greater birds per hectare. This difference can be attributed to the difference in total detections these days. However, it is notable to look at the temperature for these two days and see that both days were 66 degrees Fahrenheit. No other data was taken to show if this has any significance but it is a common factor between the two collections.

If this study were to be redone by another party, modifications would need to be made in order to create a more significant result. One change that should occur would be a more consistent time at which data was collected. The time slots differed by about 30 minutes each

time. However, this is still enough time to create inconsistent results. A more structured study plan would have decreased the p-value of the results significantly. Another problem that occurred during the six week period of testing was the accessibility to each transect. The walk from one transect to the next differed each day due to the prior week's weather conditions. Choosing more accessible transects would also create a more controlled study with less room for error.

An additional study that could prove helpful in the study of Northern Cardinal populations in Bull Creek Park would be looking at the effects of urbanization on the populations. This study would help account for the close by highway and the excess noise and how it has affected the Northern Cardinals. By producing this study, a more complete understanding of all the aspects of life as a Northern Cardinal in Bull Creek Park would be better understood. This would lead to more accurate population estimates. Also, because the highway is so close the creek, more information could be discerned to see if urbanization or water proximity effect bird populations more.

Bibliography

Brown RE, Fedde MR (1993) Airflow sensors in the avian wing. J Exp Biol 179:13–30

Leopold, Aldo, and Alfred E. Eynon. "Avian Daybreak and Evening Song in Relation to Time and Light Intensity". *The Condor* 63.4 (1961): 269–293. Web.

Leston, Lionel F.v., and Amanda D. Rodewald. "Are Urban Forests Ecological Traps for Understory Birds? An Examination Using Northern Cardinals." *Biological Conservation* 131.4 (2006): 566-74. Print.

Liechti, Felix. "Birds: Blowin' by the Wind?" *J Ornithol Journal of Ornithology* 147.2 (2006): 202-11. Print.

Meddle, Simone L., Jessica Jaxion-Harm, Kimberley Sullivan, and John C. Wingfield. "The Presence of Water Influences Reproductive Function in the Song Sparrow (Melospiza Melodia Morphna)." *General and Comparative Endocrinology* 178.3 (2012): 485-93. *ScienceDirect*.

"The Texas Breeding Bird Atlas." *The Texas Breeding Bird Atlas*. Web. 17 May 2016.

Wiltschko R, Wiltschko W (2003) Mechanism of orientation and navigation in migratory birds. In: Berthold P, Gwinner E, Sonnenschein E (eds) Avian migration. Springer, Berlin Heidelberg New York, pp 433–456

Austin Biodiversity Census: Testing The Effect of Distance from Water on the Population of Carolina Chickadees at Bull Creek District Park

By Raavi Chokhawala and Russell Coleman

Periods 3 and 7

Abstract

This project analyzed the effects of proximity to water on Carolina Chickadee populations in Bull Creek Preserve using the Emlen Strip Transect Method. Two transects were established, one less than 10 meters from water, and another greater than 50 meters from water. Then, the number of birds detected at each transect was recorded at six different data collection dates. Data was collected in approximately one week intervals. Though more birds were detected at far from water than were detected near water, the predicted number of birds per hectare for the transect far from water was 1.83 birds per hectare, and predicted number of birds per hectare for the transect near water was 1.7 birds per hectare. The data collected was not found to be statistically significant, so more data must be collected before coming to a final decision as to whether or not proximity to water has any significant effect on bird populations in Bull Creek Preserve.

Introduction

Purpose: The group will measure the effect of proximity to running water on the population of Chickadees in Bull Creek Preserve.

Hypothesis: This group believes that there will be more chickadees less than 10 meters away from running water then there will be greater than 50 meters away from a water source.

Location: Bull Creek Preserve is located in northwest Austin, 2.01 kilometers northeast of the intersection of Loop 360 and FM 2222.

Size and Shape: Bull Creek Preserve is 19.42 hectares. Bull Creek Preserve is an irregular rectangular shape with two protrusions on the north and south ends of the park bordering Lakewood Dr.

Topography: Bull Creek District Park has both a relatively flat section of land, as well as a very large hilly section. The greatest elevation within the park is 256m, and the lowest elevation is 158m, giving a 98m difference.

Geology: Bull Creek is located on limestone, and there is a lot of it throughout the park. On the east side of the park bordering Valburn Drive, there is a limestone cliff about 60.96m high. Incomplete and use metric. Along the creekbed is alluvium, which is a combination of substances including sand, silt, clay, and gravel deposited by the creek. Alluvium is light-gray to tan and formed recently, in the quaternary period. Additionally, surrounding the alluvium in some areas are tributary terrace deposits. This formation is gravel, sand, silt, and clay, and is usually tan to light-gray in color. It formed earlier than the alluvium, in the mid pleistocene era. Most of the land in Bull Creek District Park is a Glen Rose Formation, made of limestone, dolomite, and marl. It is usually gray to tan in color, and was formed near the beginning of the lower cretaceous period. There is a section of the park, outlined below in red,

which has a interesting, cliff-like geologic feature. This cliff, and area at similar levels, are Walnut Formations. Walnut Formations are composed of limestone, marl, marly limestone, and are typically gray-to-tan, and formed in the first part of the lower cretaceous period. At the top of the cliff is an Edwards Formation, which is composed primarily of limestone and dolomite. It is light-gray to tan, hard to soft, and was formed in the mid-lower cretaceous period. No faults or volcanoes exist in the park.

Areal Extent and General Type of Vegetation: Lots of Ash Juniper, around 90% woodland, 8% tall grass, 2% water. There are algal blooms in the creek

Availability of Water: Bull Creek passes through Bull Creek Preserve. It has a high level of flow, and flooding sometimes occurs in the creek. Evidence of this is that several of the rocks in the water, as well as the cliff on the side of the creek furthest away from the parking lot have markings that are usually made when flooding occurs, that are ½ meter to 1 meter higher than the water level was when the group visited the preserve.

Proximity to Urban or Industrial Areas: The park borders many urban areas, for example along Laurelwood Dr., Ladera Norte, Valburn Dr., Backtrail Dr., and Lemonwood Dr. It also borders the N. Capital of TX Highway.

History: Bull Creek District Park was founded in 1971. It gets the name “Bull” from the 1860s when a male buffalo was killed by the creek. Before then, it was called “Cascade”. The creek itself has a long history of use by humans, and the first archaeological account of such activity was from the Early Archaic to Late Prehistoric periods.

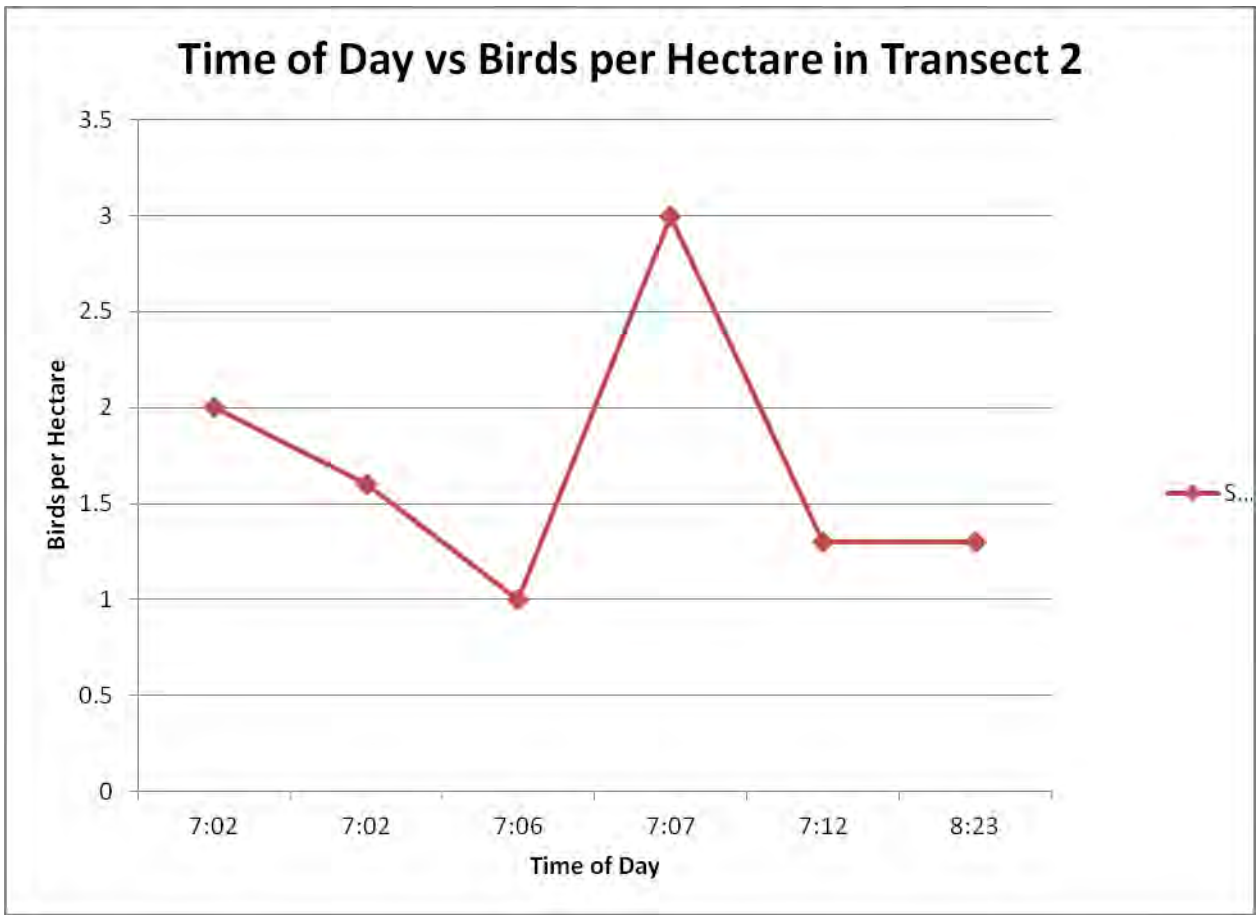
Aerial Photo

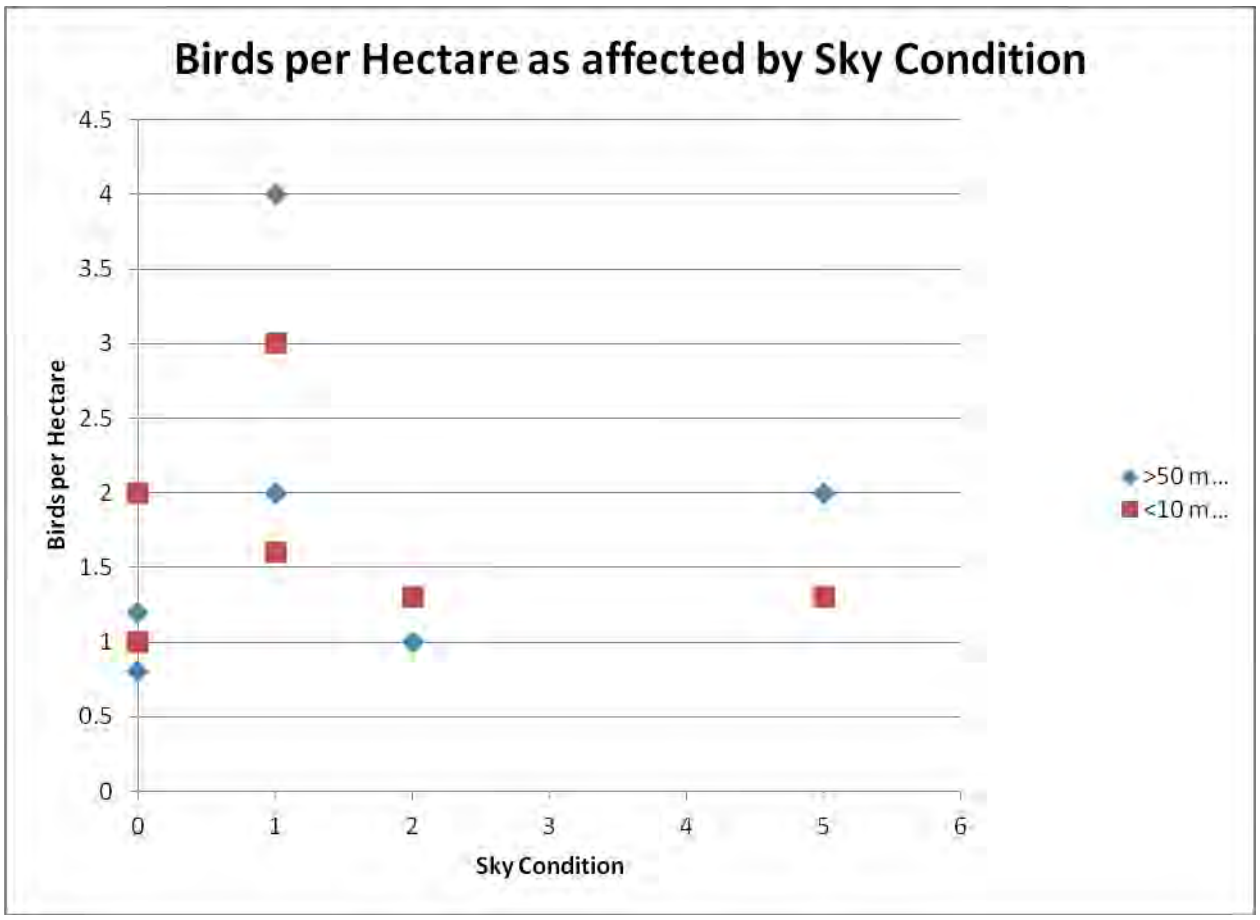
< 10 km from water
> 50 km from water
Park Boundary

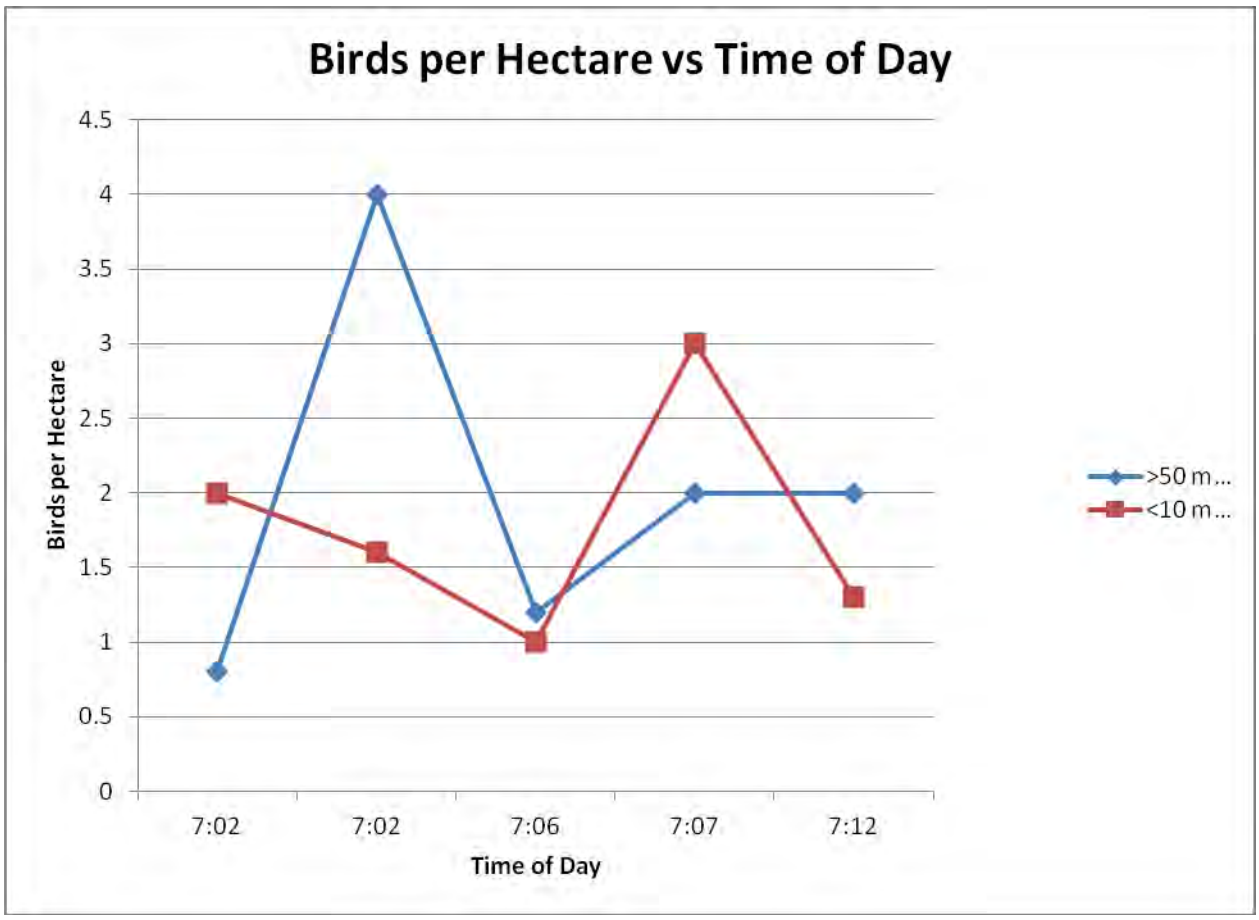


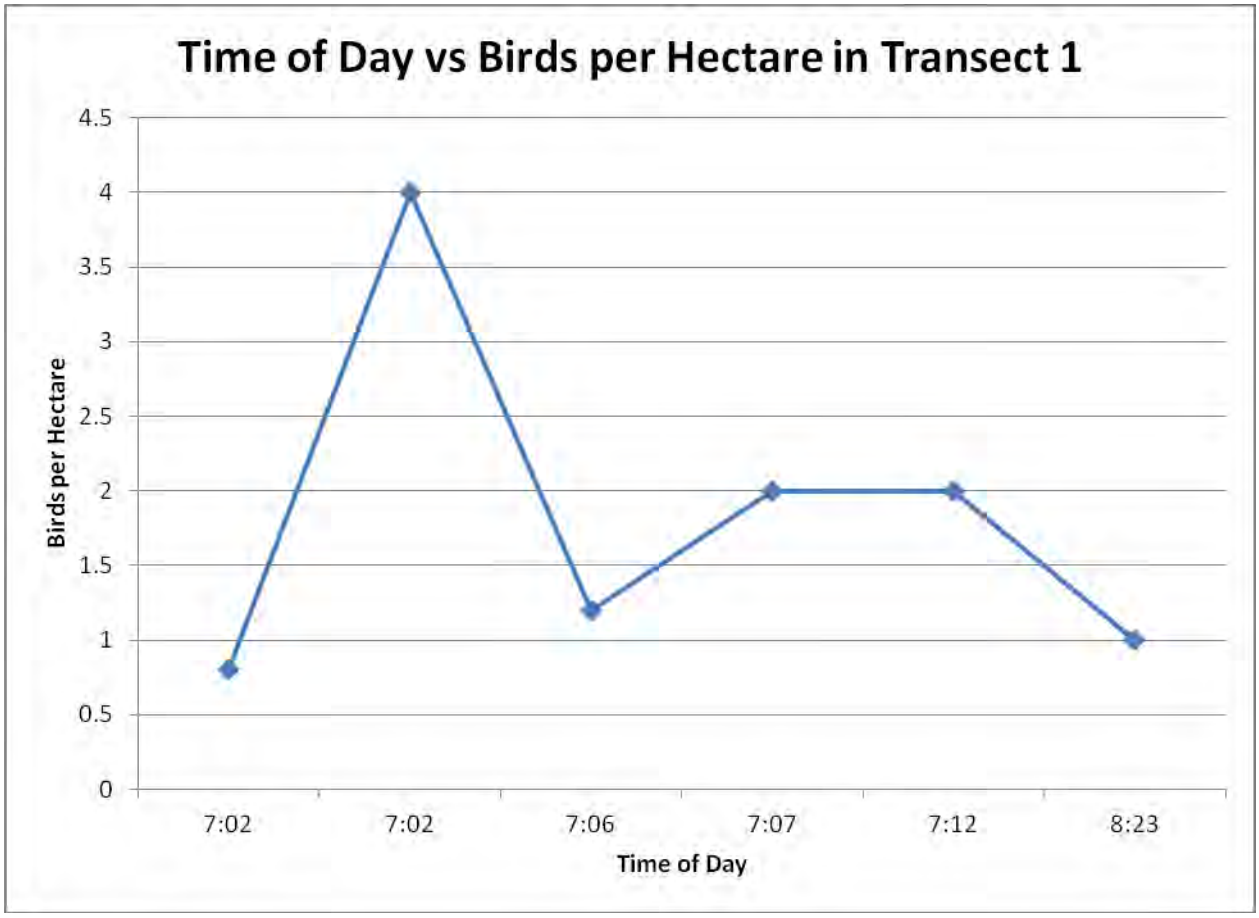
This is an aerial photo of Bull Creek district park, from Google Maps

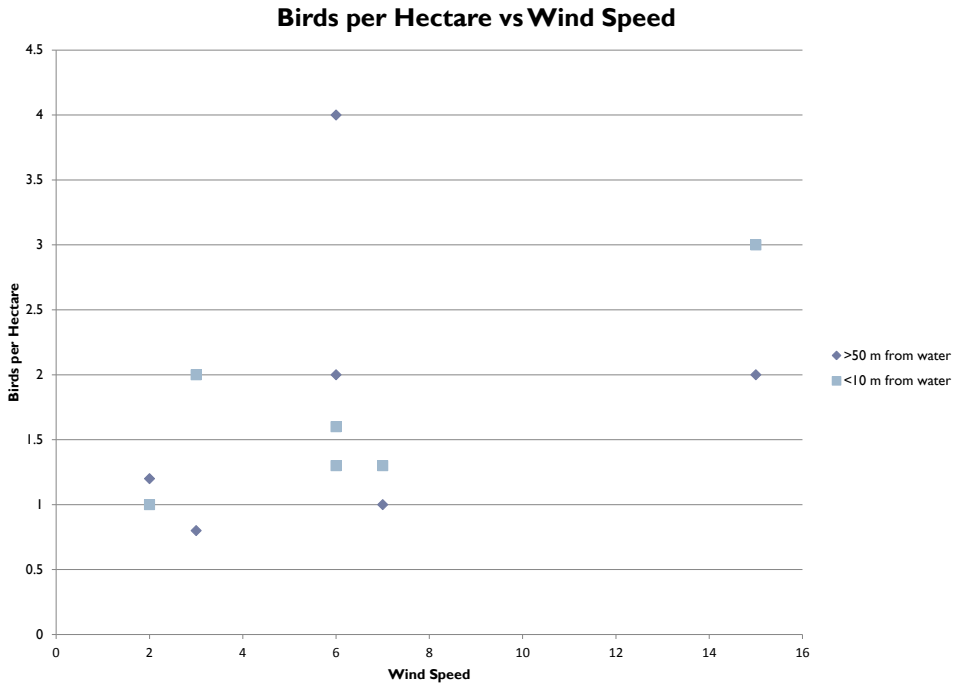
Graphs

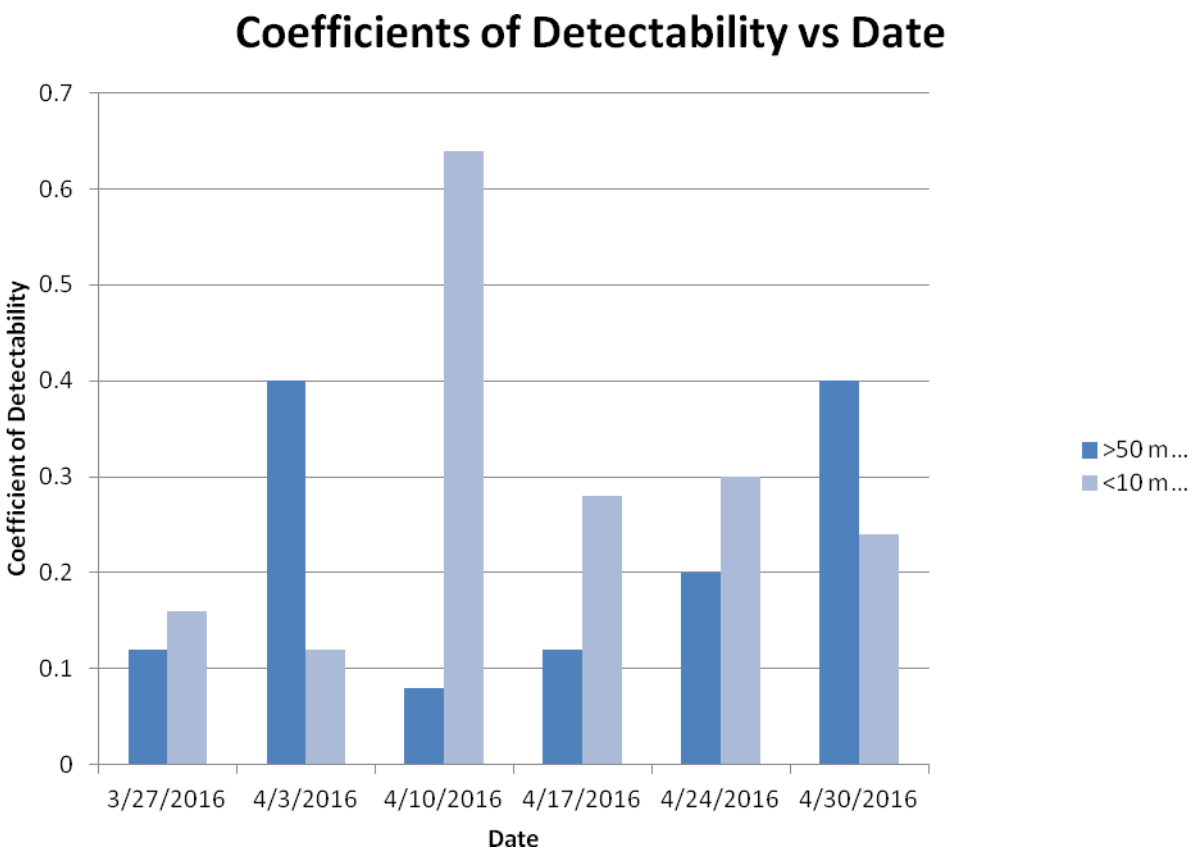

Time of Day vs Birds per Hectare in Transect 2
Birds per Hectare
3.5
3
2.5
2
1.5
1
0.5
0
7:02
7:02
7:06
7:07
7:12
8:23
Time of Day
S...

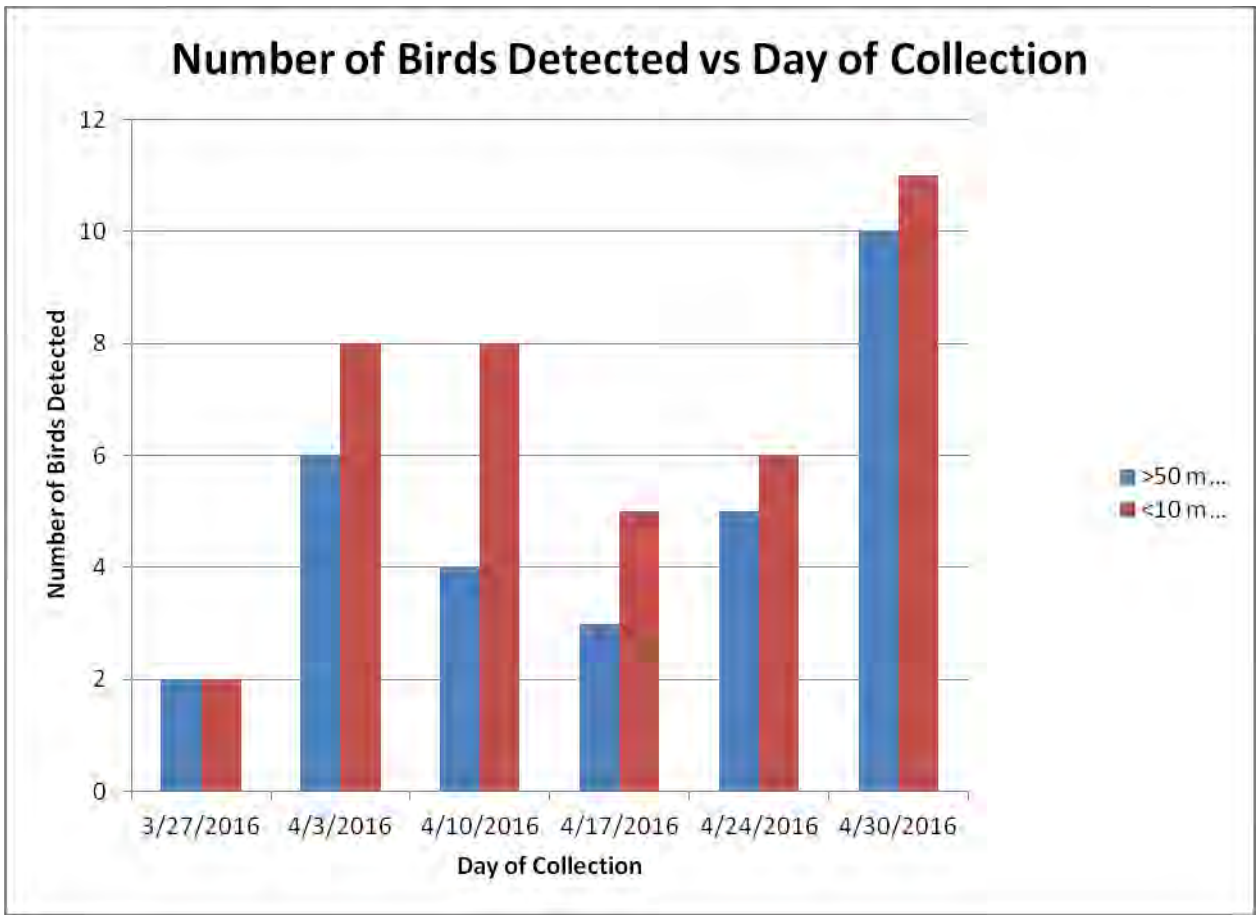

Birds per Hectare as affected by Sky Condition
Birds per Hectare
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Sky Condition
>50 m...
<10 m...

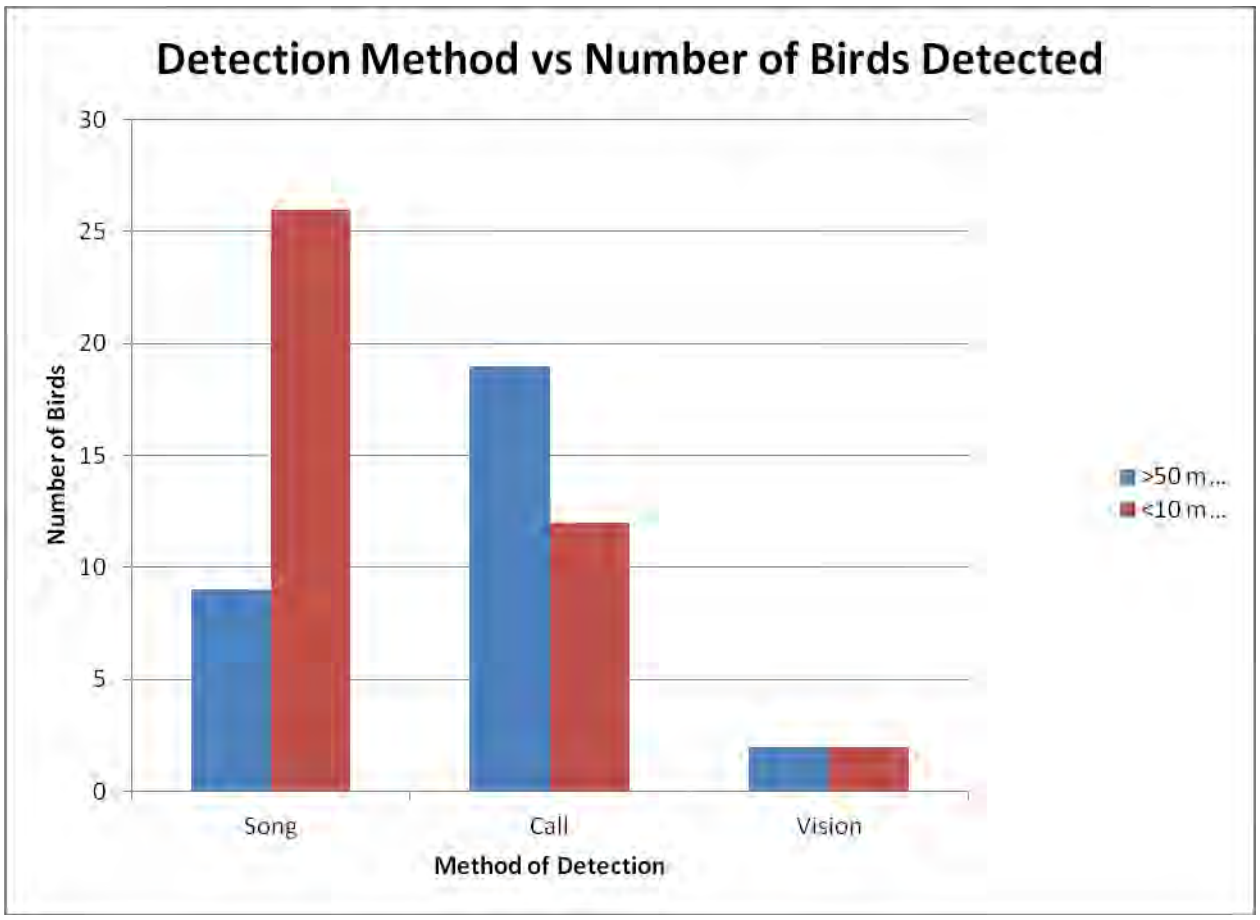

Birds per Hectare vs Time of Day
Birds per Hectare
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
7:02
7:02
7:06
7:07
7:12
Time of Day
>50 m...
<10 m...

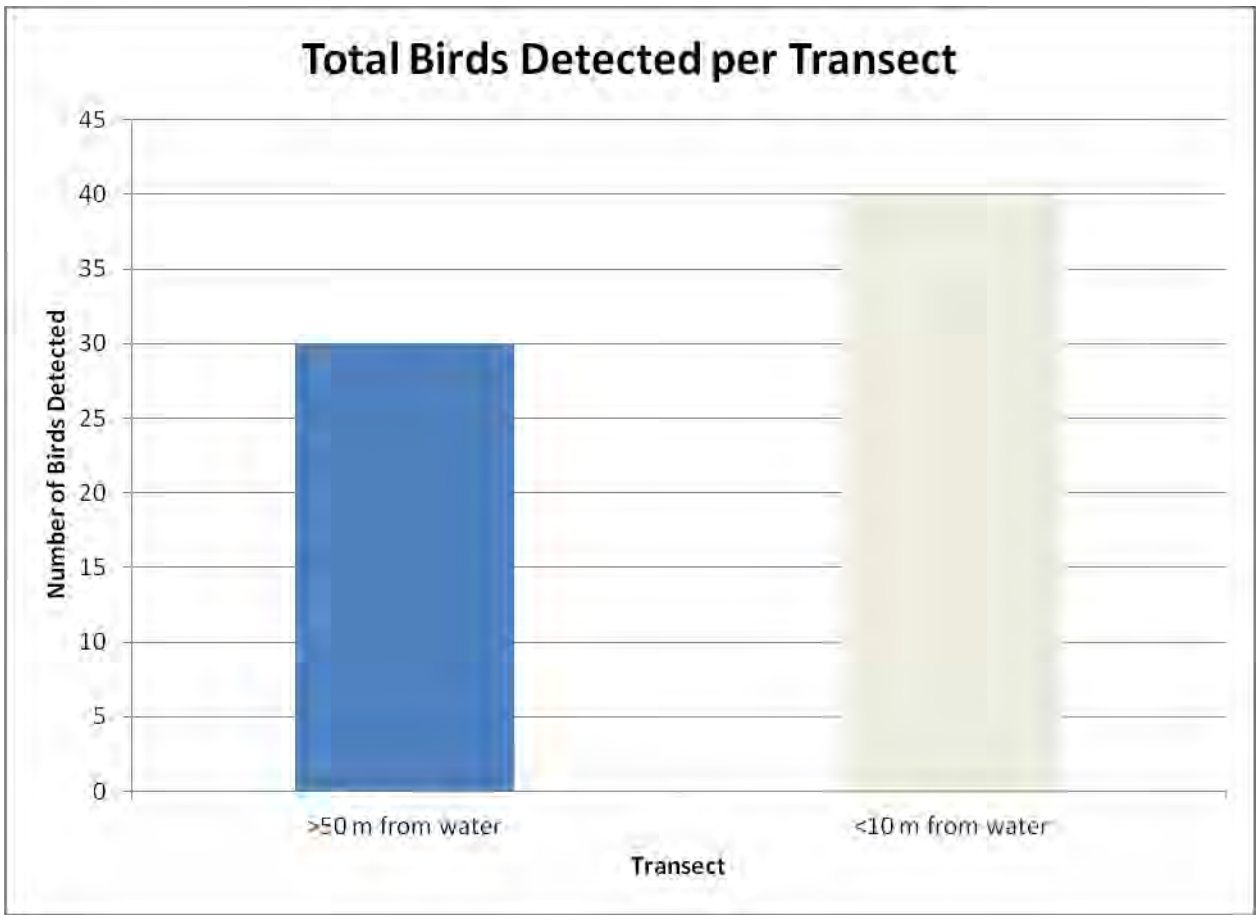

Time of Day vs Birds per Hectare in Transect 1
Birds per Hectare
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
7:02
7:02
7:06
7:07
7:12
8:23
Time of Day

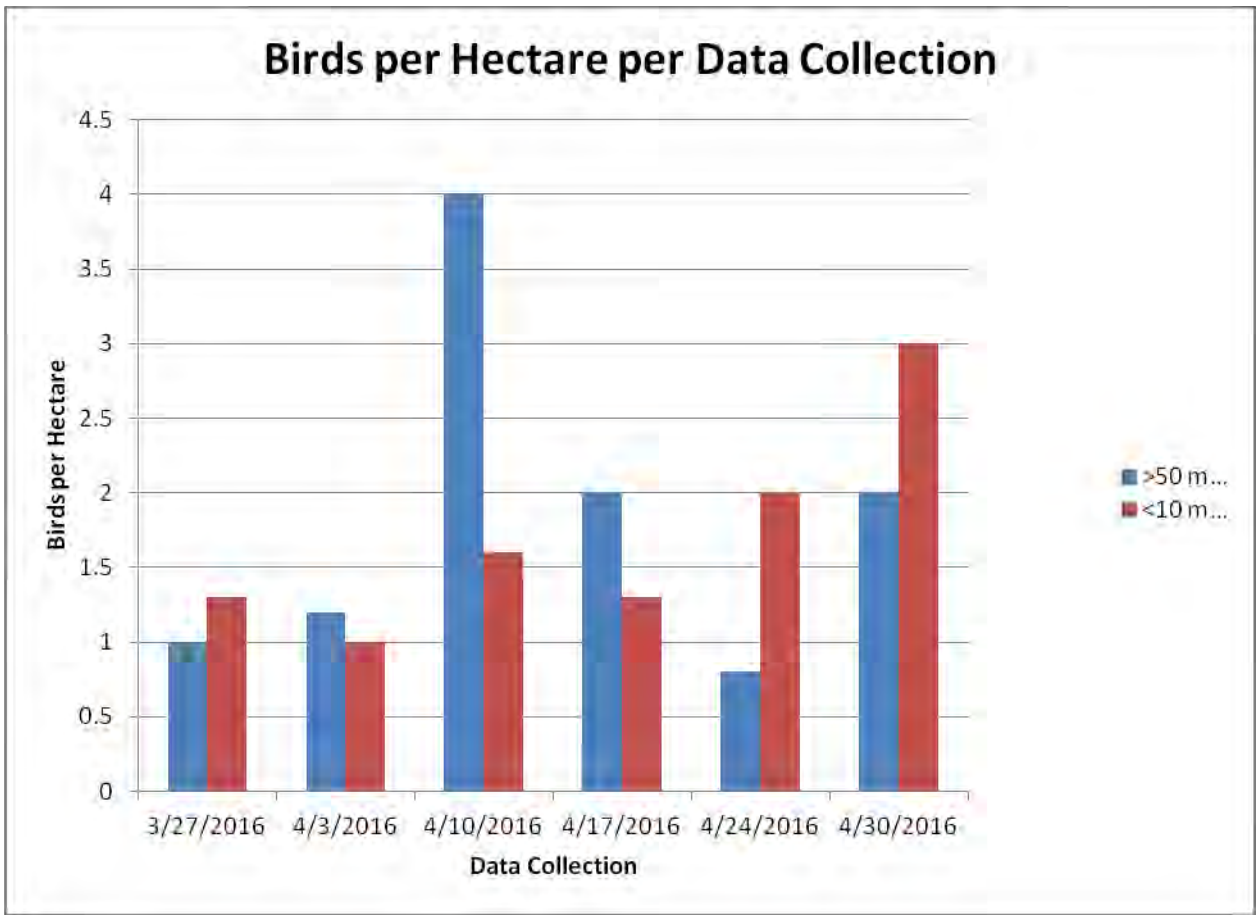

Birds per Hectare vs Wind Speed
Birds per Hectare
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12
14
16
Wind Speed
>50 m from water
<10 m from water

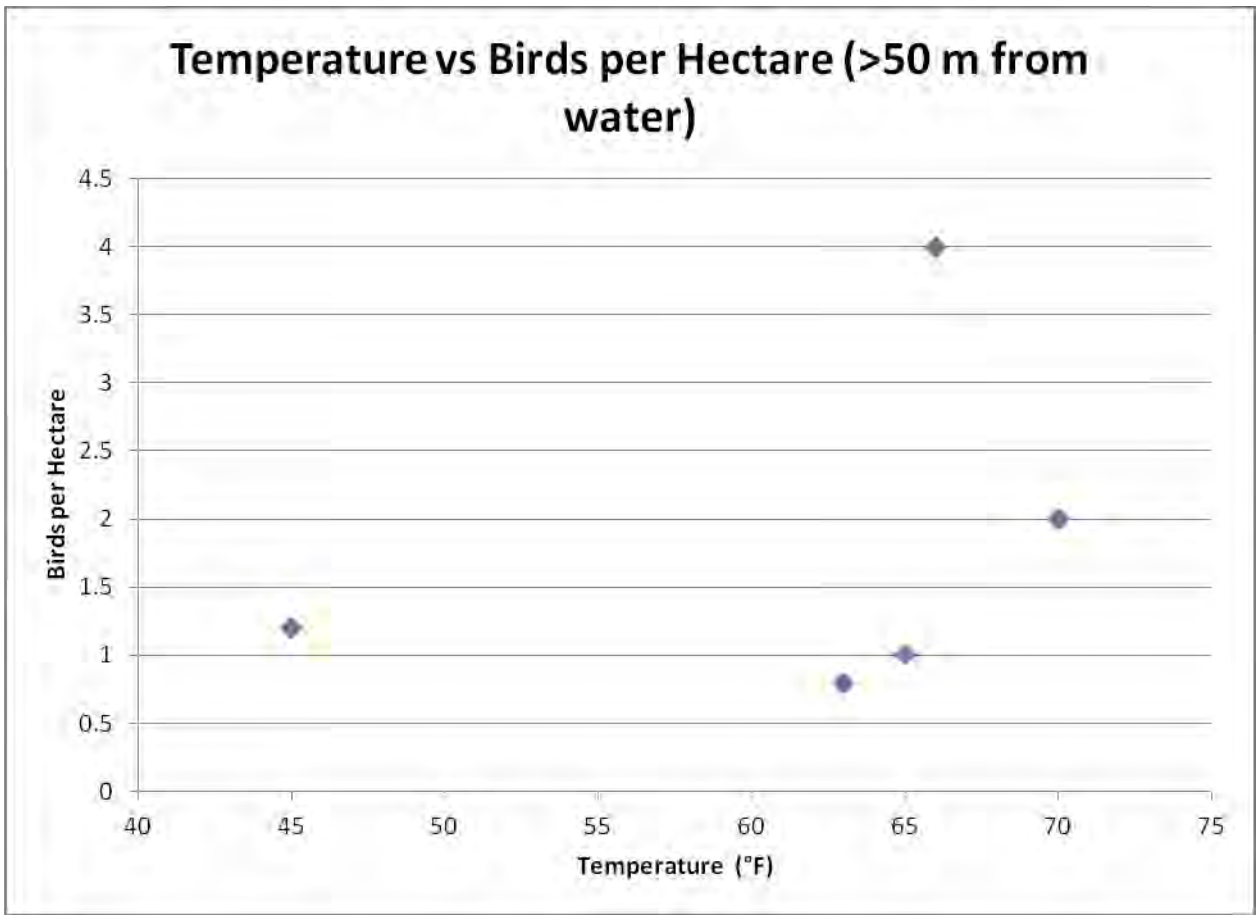

Coefficients of Detectability vs Date
Coefficient of Detectability
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3/27/2016
4/3/2016
4/10/2016
4/17/2016
4/24/2016
4/30/2016
Date
>50 m...
<10 m...

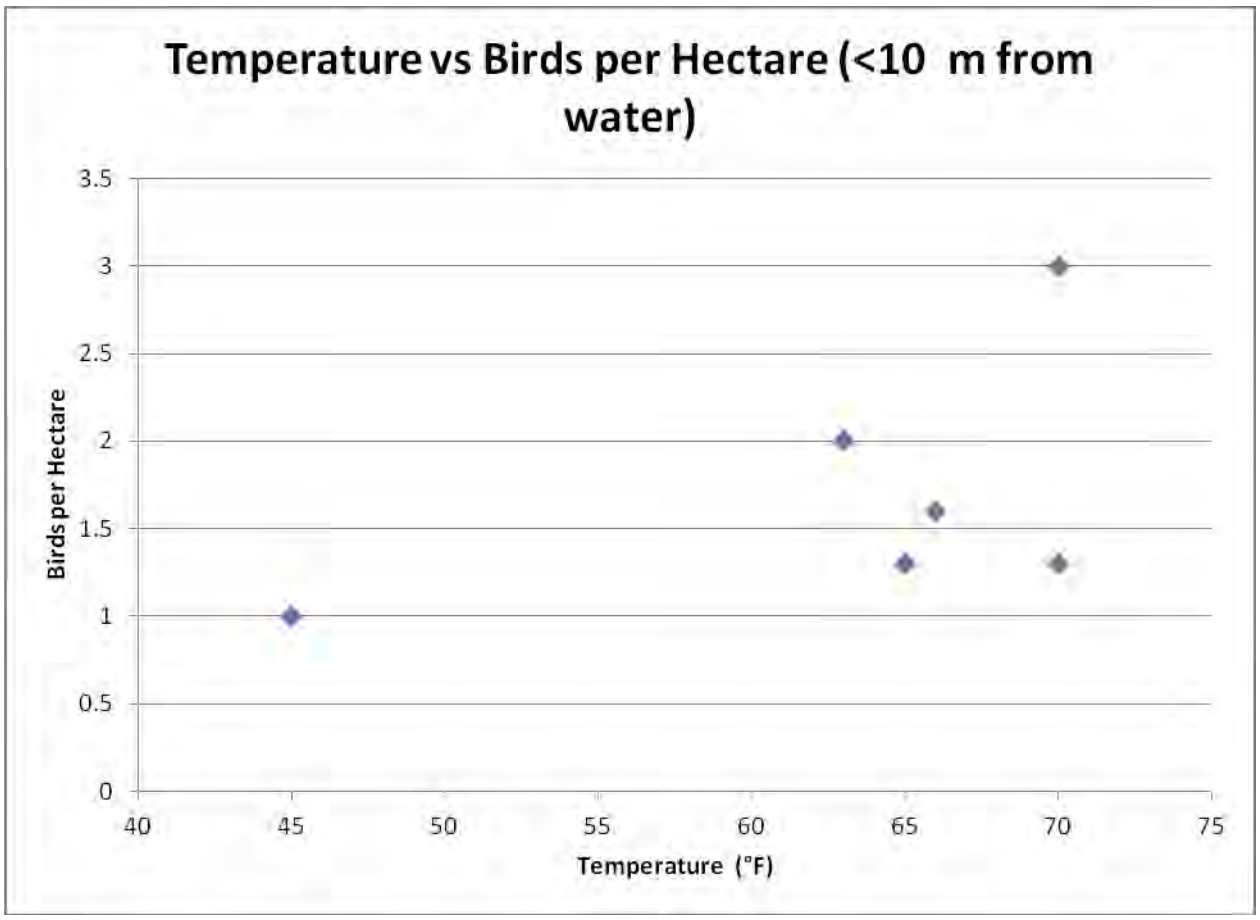

Number of Birds Detected vs Day of Collection
Number of Birds Detected
12
10
8
6
4
2
0
3/27/2016
4/3/2016
4/10/2016
4/17/2016
4/24/2016
4/30/2016
Day of Collection
>50 m...
<10 m...

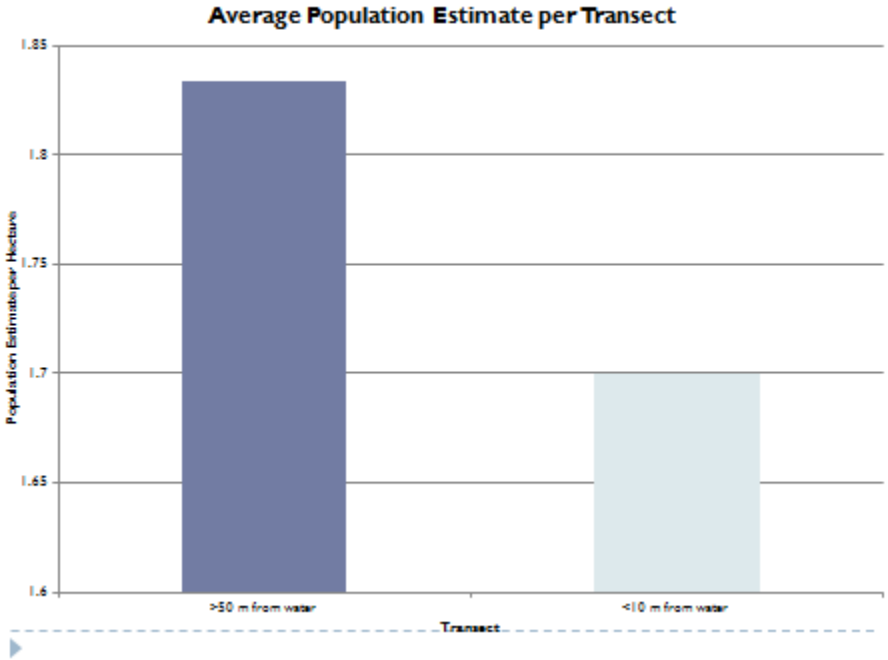

Detection Method vs Number of Birds Detected
30
25
20
15
10
5
0
Number of Birds
Song
Call
Vision
Method of Detection
>50 m...
<10 m...


Total Birds Detected per Transect
Number of Birds Detected
45
40
35
30
25
20
15
10
5
0
>50 m from water
<10 m from water
Transect


Birds per Hectare per Data Collection
Birds per Hectare
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
3/27/2016
4/3/2016
4/10/2016
4/17/2016
4/24/2016
4/30/2016
Data Collection
>50 m...
<10 m...


Temperature vs Birds per Hectare (>50 m from water)
Birds per Hectare
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
40
45
50
55
60
65
70
75
Temperature (°F)


Temperature vs Birds per Hectare (<10 m from water)
Birds per Hectare
3.5
3
2.5
2
1.5
1
0.5
0
40
45
50
55
60
65
70
75
Temperature (°F)


Average Population Estimate per Transect
Population Estimate per Hectare
1.85
1.8
1.75
1.7
1.65
1.6
>50 m from water
<10 m from water
Transect

Conclusion

More total birds were detected less than 10 meters from water than were found greater than 50 meters from water, and in general, more birds were detected near water than were found away from water in the individual data collections. This is shown in the graph Number of birds Detected vs. Day of Collection. In the first data collection, taken on 3/27/2016, two birds each were detected at both transects. In all of the five other data collections, more birds were detected at the transect near to water than were in the transect far from water. Because of this, the total number birds detected in the transect near to water was 40, while only 30 birds were detected in the transect far from water.

However, population estimates showed that whether there was a greater estimated number of birds per hectare varied depending on the data collection and was not dependent on whether the transect was near or far from water. On three of the six transects, the population estimate was greater for the transect greater than 50 meters from water, and on the other three, the population estimate was greater for the transect less than 10 meters from water. The average population estimate for the transect near to water was 1.7 carolina chickadees per hectare. The average population estimate for the transect far from water was 1.83 birds per hectare.

For both transects, there seemed to be no clear relationship between other graphed factors. For example, there was no clear relationship between temperature and estimated number of birds per hectare. There was also no clear relationship between time of day and estimated number of birds per hectare for either transect.

The data collected was not statistically significant. When a T-test was conducted on the data, it was found the p value for the population estimate was 0.82, and the p value for the birds detected was 0.35.

These findings do not support the hypothesis, which was that there would be more Carolina Chickadees less than 10 meters from water than there would be greater than 50 meters from water.

The results show no relationship between distance of birds to water and population density. However, because they are not statistically significant (p value > 0.05), this does not actually indicate whether or not there is a relationship, so there could be.

This is supported by a 2011 study by Jessica Gorchow, in which she analyzed population trends of insectivorous songbirds, like the Carolina Chickadee. That study found no significant correlation, and had a p-value of 0.356 (Gorchow 4), making their results statistically insignificant as well. This went against the study's expectations as well (5). Both this study and Gorchow's predicted that, because of an increased amount of insects near water, there would be a significant increase in bird population close to water. Gorchow concluded that more study was required, as did this study.

There are many possible explanations for the results. First, as is likely, this study simply did not take enough data to show a good correlation over time. There was, with some consistency, a greater number of birds on the transect closest to water, however the amount was not enough. Additionally, there was a tremendous amount of variation in weather conditions, and a significant variation in time of day between some collections as well. This all adds up to sources of error that could have made the results

appear less consistent. Another possible reason that neither study found results is that there is not enough of a difference between the populations that it is hard to get statistically significant data. The flight speed of Chickadees is around 3.3 meters per second (Greenewalt 3). This means it would take a Chickadee 12 seconds to go from 10 meters of water, the range of one of the transects, to 50 meters from water, in range of the other transect. It is very possible that the distance from water for the transect far from water was simply not large enough to have any real difference between the two populations.

Additionally, the hypothesis was based upon the idea that chickadees would be found closer to water because there were more insects closer to water, and so they would congregate around the insects. However, chickadees also eat things such as sunflower seeds (Myton 1). It is very possible that other food sources could have had just as much of an impact on their locations as insects. This could have once more made the results appear as close as they did. However, again, there is no statistical significance to these results, and this is all just speculation.

If this study were to be repeated, it could be improved by reducing the sources of error, with more consistent start times, more consistent speed, and attempting to factor weather conditions into the final calculations. It might also be beneficial to measure chickadee food sources, such as insect populations, in order to get an idea as to whether or not there is an actual correlation between food abundance and Chickadee population.

Woody Plants Diversity and Abundance at Various Elevations in Emma Long Park.

By: Keenan Riordan and Conor Heffernan

Abstract

This project was a study on the abundance and diversity of woody plants at various elevations in Emma Long Metropolitan park. The data was taken using the line-intercept method on six 50 meter transects, with three above 210 m in elevation and three below 185 m. The data found had small changes in the amount of abundance and diversity, transects above 210 m had fewer individuals and a smaller amount of diversity than the transects below 185 m, however the data did not have any statistical significance.

Purpose: The purpose of the study is to study the effects of elevation on woody plants.

Hypothesis: When the elevation of the park increases, the plant diversity and abundance will increase to a specific elevation then decrease from that elevation, following a mid-elevational peak of species diversity.

Site Description

Location

Emma Long Park is located in northwest Austin near the intersection of Loop 360 and Lake Austin. About 762m north of the crossing is the intersection of Loop 360 and RM 2222. Follow 2222 west for about 640.1m until the intersection between 2222 and City Park Rd. Follow City Park Rd. to the southwest for 4.8km which will, and it will lead into the park. City Park Rd. runs through the entirety of the park until it ends at the river.

Size and Shape

Emma Long Park is approximately 464.2 Hectares in the shape of an irregularly shaped half-arrowhead

Topography

The topography of Emma Long park is flat near the Colorado River then climbs from a minimum elevation of 151.79m to a high of 242.011m at the peak of the hill.

Geology

The geology of Emma Long Park is mainly composed of the Glen Rose Formation of limestone and dolomite formed in the Lower Cretaceous period, River Terrace Deposits of gravel, sand, silt, and clay formed in the Eocene period, and Alluvium Deposits of sediment that were formed recently along the banks of the Colorado River.

Areal Extent and General Type of Vegetation

In Emma Long Park a good percentage of the vegetation is cedar, and oak trees with multiple species of grasses scattered throughout the trail, and the vast majority of the park.

Proximity to Water

Emma Long Park includes the Colorado River (Lake Austin), Turkey Creek, and Connor's Creek. Flooding is very evident along Turkey Creek and Connor's Creek with large amounts of debris lying as high as 5 meters from the banks of the stream, but is not evident along the Colorado River probably due to human interaction with the recreational area. Turkey Creek and Connor's Creek are both approximately 20 cm deep. The Colorado River, Turkey Creek, and

Connor's Creek are located approximately 900m, 510m, and 390m in that order, from the Tee of Oak Shores Drive, and City Park Road.

Proximity to Urbanized Area

Emma Long Park has several roads running through it including City Park Road, Pearce Road, and Oak Shores Drive. The bank across the river to the southwest have multiple houses. Houses border the park on every other side.

History

City Park now known as Emma Long Park was established in 1939. City Park was reestablished on December 10, 1993 as Emma Long Park named after long term activist Emma Long, the first female city council member,who advocated for the Parks Board and a controversial Open Housing bill which lost her the reelection. The park was previously known as City Park, and in that time recreational space was cleared bordering the Colorado River, and multiple trails were created in the park.

Research Plan:

Design of Study:

Data Collection will occur at, and around 210 meters, and 185 meters along the Turkey Creek Trail. The transects will be placed all along the trail and will be chosen at densely populated areas in order to see the effects of elevation on biodiversity and abundance of Woody Plants within the park.

Background info

In a study conducted by Hans Henkrik Brun, John Moen, and an assortment of other researchers of the species richness of vascular plants, lichens, and a multitude of other species in Northernmost Fennoscandia from an altitude of 250-1525m across 6 mountainous areas showed an unimodal set of results whereas the elevation increased the abundance and diversity increase to a peak and sharply turns downward. Points were sampled in 0.8mx0.8m (Brun 1). quadrants then plugged into a model (Poisson regression)to show their final results. Their final graph supports the hypothesis in terms of general direction of a graphed final result.

In a study conducted by David A. Coomes and Robert B. Allen in New Zealand, The effects that elevation had on trees show that as the altitude in m went up the competition between the trees meaning that the total abundance of the trees was going down This drop in abundance may also be attributed to the drop in the air and soil temperatures, the increased exposure to wind, reduced supply of nutrients and the shorter growing seasons. Each individual plot in the study sampled 9000 ha of forest and the researchers established 246 plots. The graphs shown in this study went against the hypothesis because it showed abundance going down (David A. Coomes and Robert B. Allen 1086 and 1095).

In an article written by Christy McCain, and John-Arvid Grytnes showed that general trends of elevational gradients of biotic life including vascular plants match the hypothesis of a mid-elevational peak wherein the species abundance increases to a point then falling from that point onward. It references multiple studies, but the general results of said studies on vascular plants indicate that approximately 80% of studies show this mid-elevational peak (Grytnes, McCain 4). The study also puts abiotic factors such as precipitation, productivity, among others into account wherein the species richness increases, and increase to a point then turns down, among other trends, however these specific abiotic factors are not being studied, elevation is being studied and ⅝ of these specific factors show a mid elevational peak. The mid-elevational peaks showed more than 25% more species richness at the mid-point than the top and bottom. (Grytnes, McCain 4).

Materials

The materials that will be needed in the field to conduct this experiment are the following:

- A 50 meter transect line
- A pencil/ pen
- The researcher's journal

Procedure:

- The group will plot transect lines in various points in the park at different elevations.
- Next, the group will use a measuring device to measure out 50m in those specific transect.

- The group will then walk along said transect recording all of the different types of vegetation within that line
- While completing this process, the group will also plot the intersect lines of those species as well as the overhang of those trees, the sum of those intercepts, and the number of intervals within our 50 meter transects. We will also spot and identify plants using the dichotomous key.
- Then the group will calculate the relative dominance, relative density, and the relative frequency of species, species intervals, and the importance value of each species within the park to attempt to support the hypothesis.

Bibliography

Bruun, Hans Henrik, Jon Moen, Risto Virtanen, John-Arvid Grytnes, Lauri Oksanen, and Anders Angerbjörn. "Effects of Altitude and Topography on Species Richness of Vascular Plants, Bryophytes and Lichens in Alpine Communities." *Journal of Vegetation Science* 17.1 (2006): 37-46. Web. 24 Feb. 2016.

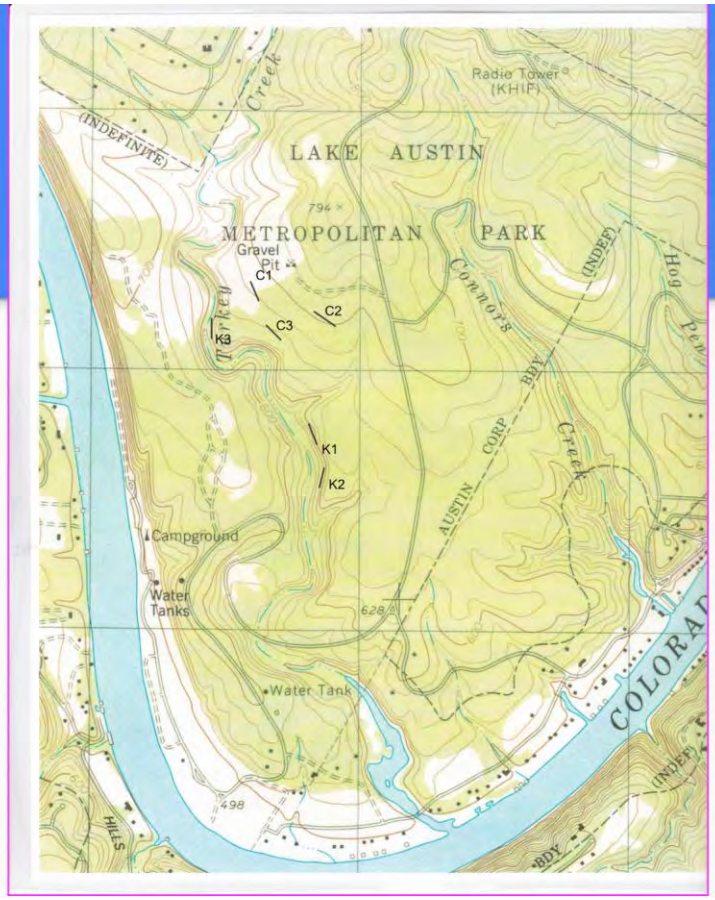
Coomes, David A., and Robert B. Allen. "Effects of Size, Competition and Altitude on Tree Growth." *Journal of Ecology J Ecology* 95.5 (2007): 1084-097. Web. 24 Feb. 2016.

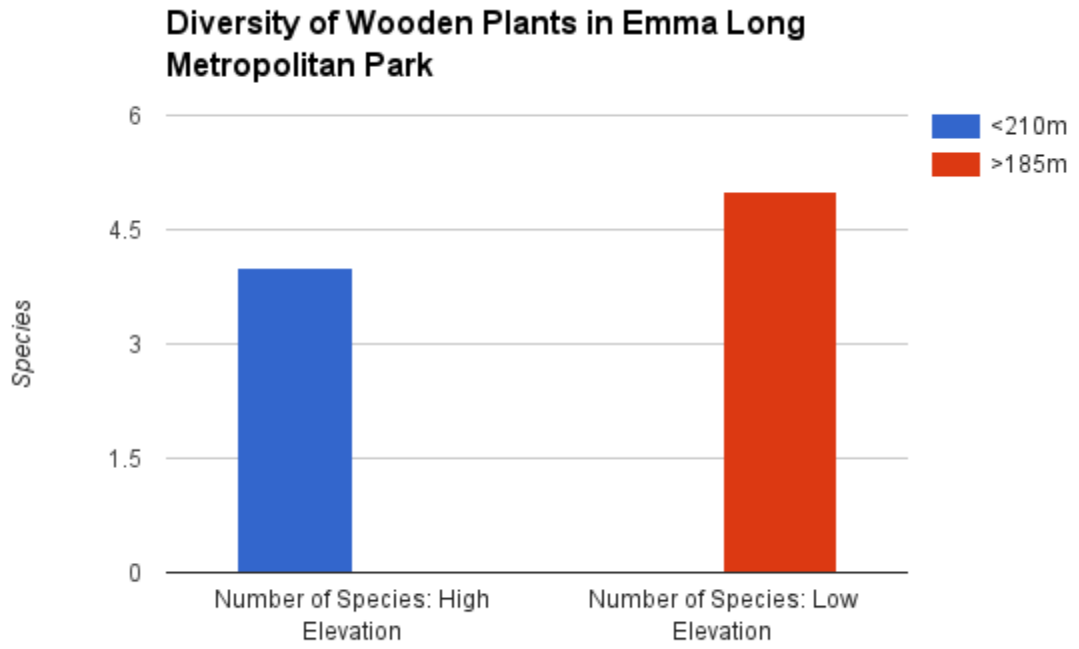
Mccain, Christy M., and John-Arvid Grytnes. "Elevational Gradients in Species Richness." *Encyclopedia of Life Sciences* (2010): n. pag. Web. 23 Feb. 2016.

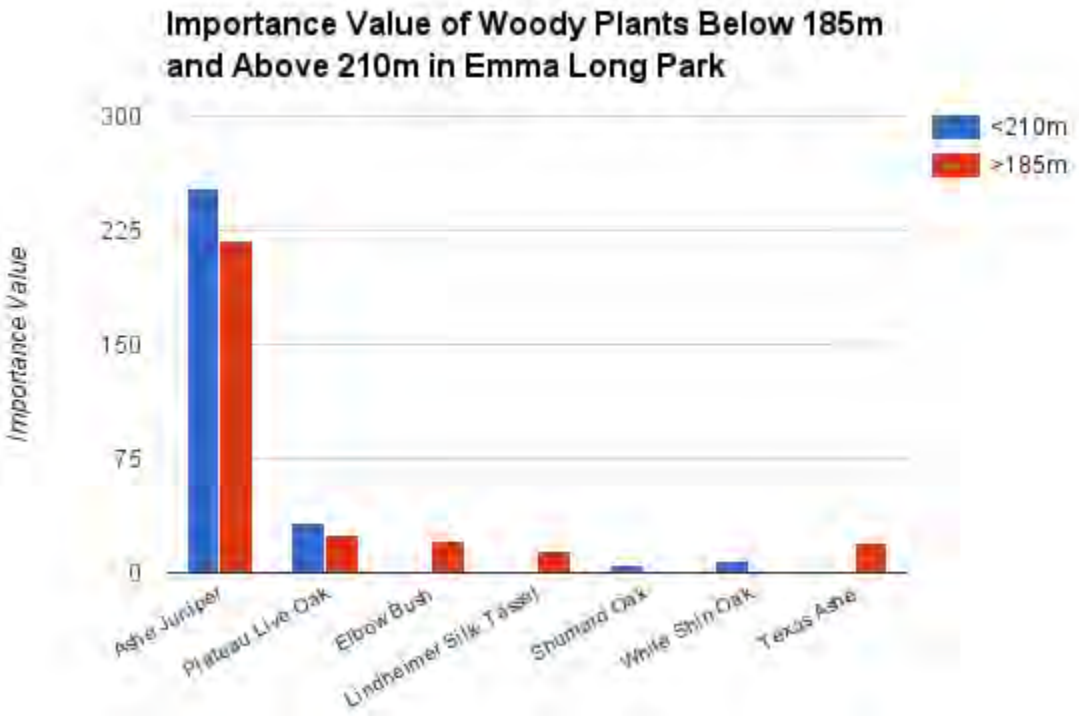
"Emma Long Metropolitan Park." *Austin Texas*. The City of Austin, n.d. Web. 23 Feb. 2016.

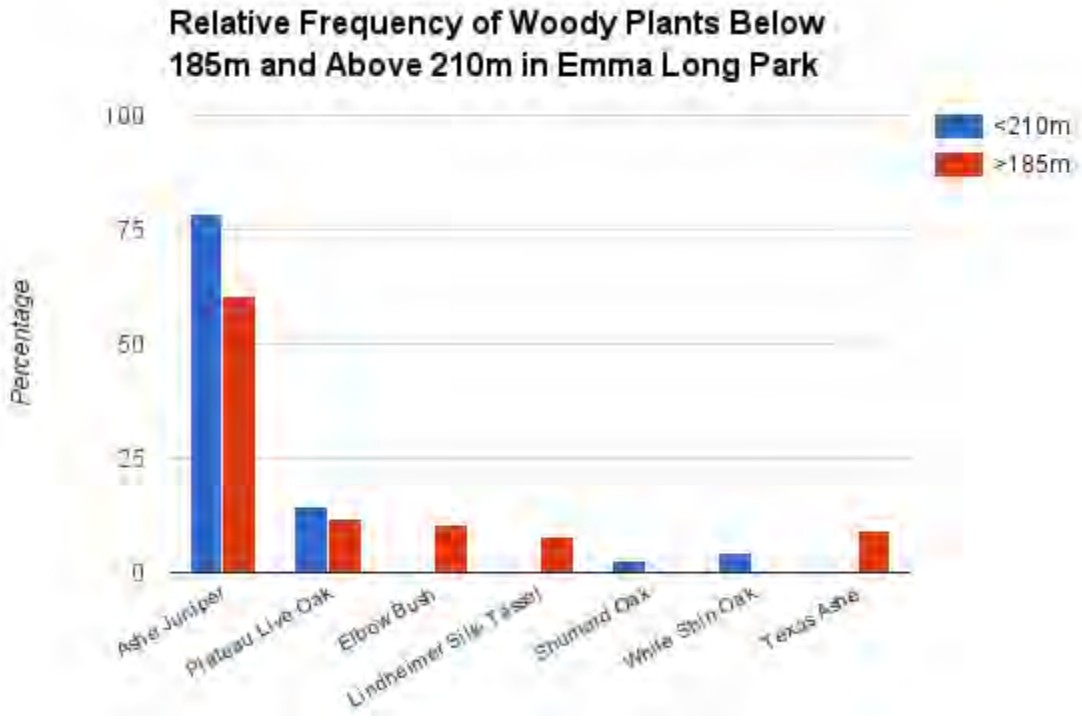
"Emma Long Park - Lake AustinAustin, Texas (Travis County)." *Wild Texas Parks Recreation Travel*. Wild Texas Parks Recreation Travel, n.d. Web. 23 Feb. 2016.

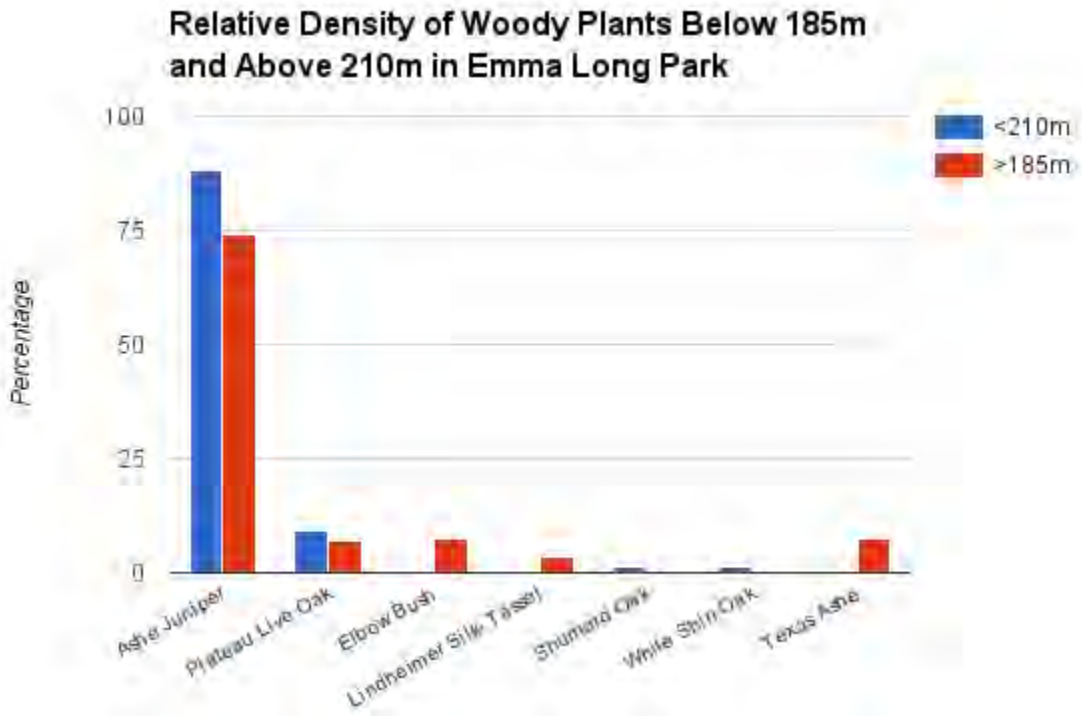
50m
transects

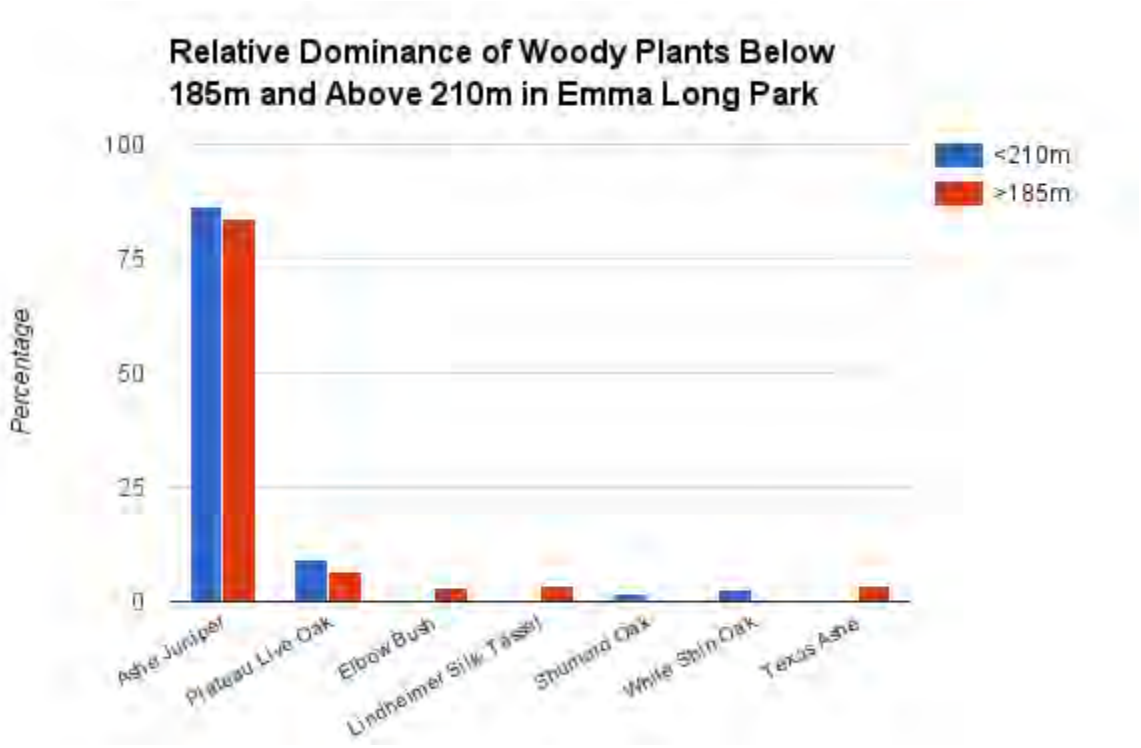



Diversity of Wooden Plants in Emma Long Metropolitan Park
Species
6
4.5
3
1.5
0
Number of Species: High Elevation
Number of Species: Low Elevation
<210m
>185m


Importance Value of Woody Plants Below 185m and Above 210m in Emma Long Park
Importance Value
300
225
150
75
0
Ashe Juniper
Plateau Live Oak
Elbow Bush
Lindheimer Silk Tassel
Shumard Oak
White Shin Oak
Texas Ashe
<210m
>185m


Relative Frequency of Woody Plants Below 185m and Above 210m in Emma Long Park
100
75
50
25
0
Percentage
<210m
>185m
Ashe Juniper
Plateau Live Oak
Elbow Bush
Lindheimer Silk Tassel
Shumard Oak
White Shin Oak
Texas Ashe


Relative Density of Woody Plants Below 185m and Above 210m in Emma Long Park
100
75
50
25
0
Percentage
<210m
>185m
Ashe Juniper
Plateau Live Oak
Elbow Bush
Lindheimer Silk Tassel
Shumard Oak
White Shin Oak
Texas Ashe



Conclusion

Results:

The original hypothesis was that if the elevation of the park increases, then the plant diversity and abundance will decrease to a specific point the decrease from that point, following a mid-elevational peak of species abundance and diversity. Though after gathering data it was found that when the elevation of the park increases the diversity of woody plants decreases and the abundance decreases as well, the data gathered did not show a mid elevational peak with both plant diversity and abundance going up to a particular peak then decreasing from that point. The the data collected did not display statistical significance the abundance t test having a p value of 0.403 and the diversity t test having a p value of 0.139. Four species were found above 210m, and five species being found below 185m. 13, 27 and 26 individuals for a total of 66 being found on transect one, two, and three above 210m and 24, 29, and 28 individuals for a total of 81 being found on transects one, two, and three below 210m individuals being found above 210 meters and 81 individuals below 185m.

The data collected on April 3rd, April 17th, and May 1st were very similar apart from several species involved in each transect like Shumard Oak, Elbow Bush, and Texas Ashe. All six transects showed a greater relative density, frequency, and dominance of Ashe Juniper compared to the other species found. In all data gathered Ashe Juniper had a high importance value (relative density, frequency, and density added together), five out of six those transects having Ashe Juniper going above 200 in importance value. However Ashe Juniper did have a higher importance value of 253.1667 at higher elevations (<210m) compared to the lower elevations (>185m) 218.1. The group also found that Plateau Live Oak was higher in importance value at higher elevations than lower (32.8667 compared to 25.4667). Texas Ashe, Lindheimer Silktassel, and Elbow Bush were greater in importance value (21.1667, 14.7667, and 21.4667) in lower elevations because those species were not found in higher elevations, similarly Shumard Oak and White Shin Oak were greater in importance value (5.6667, and 8.2333) because they were not found in lower elevations.

Discussion:

The reason that these variations, specifically in the amount of species above 210 meters compared to below 185 meters, probably has something to do with the proximity to Turkey Creek as the plants below 185 meters are closer to Turkey Creek than the plants above 210 meters. Ashe Juniper is found in such abundance in Austin because it mainly appears in rocky soil derived from limestone and in Texas is mainly found on the eastern, and southern parts of the Edwards Plateau (Fuhlendorf and Smeins), Austin is located in these regions so the city allows for the growth of Ashe Juniper. The variance of importance value in the lower elevations near the creek is due to the amount of water, while the overwhelming importance value in the higher elevations is due to Ashe Juniper's ability to survive in harsh climates and their ability to reproduce quickly large trees producing somewhere between 100,000 and 250,000 seeds per tree (Fuhlendorf and Smeins) but conditions can vary due to climate conditions. Ashe Juniper also does not grow very tall reducing the amount of water (Fuhlendorf and Smeins) they need and when the species grows together an extensive canopy can form allowing them to dominate an area very easily, essentially pushing out other species in a "war of attrition" (Tom and Amy

Thurow). All of the conditions that allow Ashe Juniper thrive are present at Emma Long Park such as the rocky soil and the vast availability of water. Another reason for the smaller importance value nearer to Turkey Creek could be the presence of large floods that occur almost annually. Most of the plants that the group observed were young in the lower elevations and mangled trees could be seen after large floods in the area. However the difference in importance value between Ashe Juniper in high and low elevation is not great, and species such as Plateau Live Oak, Elbow Bush, and Lindheimer Silktassel are shown taking a back seat in importance value similarly to the Shumard Oak, and White Shin Oak in the higher elevations, and even though Shumard, White Shin, and Plateau Live Oak are very adapted to the conditions of central Texas (Texas Native Plants Database) Ashe Juniper seems to have pushed those species out, at least in Emma Long Park.

The major problem with this study was the lack of variance in data, and the lack of data on different and more drastic elevation changes. The original study was supposed to be done with 3 people but due to unforeseen circumstances only two sets of data could actually be gathered The original study was supposed to be done with three people but due to unforeseen circumstances only two sets of data could be collected. The elevational variance was supposed to be over 50 meters in elevation in the original planned study however the transects <210m and >185 meters were chosen, this left the group only 25 meters to differentiate our data. This could be the reason why both t-tests did not achieve statistical significance This complicated the process of actually gathering the data and different , and it is also the reason the group could not provide evidence for a mid-elevational peak of diversity and abundance. If this project could be redone some changes that could have been put in place to help provide a more valid study should be: Transect choice, this is very important for the data as the transects provide the window for all of the other conclusions to be drawn. Specifically the first transect taken above 210 meters could have been changed as it had the smallest number of individuals, amount of coverage and the lowest amount of diversity. This transect represents a missed opportunity in the data and demonstrates the importance of transect choice. Another change that should be made if this project were to be redone should be the contrast in elevation. 185 and 210 meters may have some difference but the two are close enough that they won't allow for an extreme difference.

Smeins, F. E., and S. D. Fuhlendorf. "Texas Natural Resources Server." *Biology and Ecology of Ashe Juniper «*. Texas A&M University, n.d. Web. 17 May 2016. http://texnat.tamu.edu/library/symposia/juniper-ecology-and-management/biology-and-ecology-of-ashe-juniper/

"Texas Native Plants Database." *Texas Native Plants Database*. Texas A&M Forest Service, n.d. Web. 16 May 2016. http://aggie-horticulture.tamu.edu/ornamentals/natives/QUERCUSFUSIFORMIS.HTM

"Texas Native Plants Database." *Texas Native Plants Database*. Texas A&M University, n.d. Web. 16 May 2016. http://aggie-horticulture.tamu.edu/ornamentals/natives/QUERCUSSINUATAVARBREVILOBA.HTM

Thurow, Amy, and Tom Thurow. "Texas Natural Resources Server." *Juniper Management in the Edwards Plateau: Policy Issues and Options «*. Texas A&M University, n.d. Web. 16 May 2016. http://texnat.tamu.edu/library/symposia/juniper-ecology-and-management/juniper-management-in-the-edwards-plateau-policy-issues-and-options/

WOODY PLANT POPULATION AND DIVERSITY IN GUS FRUH

Samantha Wallace and Marissa Graf

SPRING 2016

FENNELL 2/6

Abstract

This study was conducted in order to survey the effects of water proximity on the population and diversity of woody plants in Gus Fruh park. It was hypothesized that these two aspects would increase as proximity to water increased. This study consisted of an experiment using the line intercept method conducted on woody plants with a total of six transects, three near water and three far from water, placed in the park. Data was collected on the identity and population of species and showed that Ashe Juniper was most frequent and common far from water while Cedar Elm was the most frequent and common woody plant close to water. Far from water, Ashe Juniper was dominant while Pecan was dominant close to water. It was concluded that Ashe Juniper was most important far from water because of its tendency to cause the mortality of other plants around it. Cedar Elm was most important close to water because it needs an abundant amount of water to survive. Although the calculated t-Tests were not statistically significant, trends could still be seen in the data.

Introduction

Purpose

The purpose of this study is to survey the effects of water proximity on the population and diversity of woody plants in Gus Fruh park.

Hypothesis

The population and diversity of woody plants will increase as proximity to water increases in Gus Fruh park.

Site Description

Location: Gus Fruh park is southwest of downtown Austin. The park is located 0.609 km meters east of the intersection of South MoPac Expressway (Loop 1) and South Capital of Texas Highway (Highway 360). It is 1.2 km southeast of Barton Creek Square Mall.

Size and Shape: The park is 196.9 hectares. The northern section of the park is an irregular rectangle, while the southern section of the park is an irregular square. The irregular shape of the park is due the area of the park being determined by the flow of Barton Creek.

Topography: The minimum elevation of Gus Fruh is 146.3 meters, while the maximum elevation is 210.3 meters. The difference in elevation is 64 meters. A cliff about 7 meters tall stands approximately 9 meters from the water. The park is heavily forested. On the western side of the creek, the land is very hilly. The land along the southern portion of the creek is flat with few elevation changes.

Geology: The Edwards Formation, consisting of limestone and dolomite, borders the majority of Barton Creek. The Georgetown Formation, consisting of limestone and marly limestone, borders the large curve in the creek is also found in small areas further away from the creek. A small amount of Del Rio Formation, made of clay, borders the creek. The Buda Formation, made of limestone, lies on top of Del Rio in a very small section of land. The Edwards, Georgetown, Del Rio, and Buda formations were all formed during the lower Cretaceous period. Tributary terrace deposits, including gravel, sand, silt, and clay, formed during the Pleistocene Epoch, border the large curve in the creek and fills the area between the fork in the creek. The river bed is composed of Alluvium, a mixture of sand, silt, clay, and gravel, which was formed during the

recent Quaternary. The rocks in the area appear to be made from slabs leading to the conclusion that the main geologic feature in the area is the Mount Bonnell dip-slip fault.

Areal Extent and General Type of Vegetation: Gus Fruh park is composed of 60% woodland, 25% grassland and 15% water. Some vegetation that grows in the park is Mustang grape vine and Cedar Trees.

Availability of Water: The main source of water in the area is Barton Creek. Near the riverbank, the depth of the creek is approximately 60 cm, which increases to more than 2 meters in the center of the creek. There is evidence of a flooding to a great degree, with debris being found caught in the underbrush near the top a cliff about 7 m tall. There was also a group of about 15 trees toppled over with their branches intertwined on the creekbed. This is also evidence of severe flooding because the trees were likely carried there from another location. The creek also appears to be experiencing a period of drought as large parts of Barton Creek are dried up and bare, exposing chalky white rocks. Several of these dry sections are approximately 100 meters in length.

Proximity to Urban or Industrial Areas: To the northeast of Gus Fruh is Barton Hills neighborhood, which borders the park. Gus Fruh is also located near Barton Creek Square Mall, which is found 1.2 km northwest of the park.

History: Gus Fruh was established in 1980 as a part of the Barton Creek Greenbelt. Prior to being added to the Barton Creek Greenbelt, much of the area was under the protection of The Trust for Public Land, who bought up roughly 400 hectares of the Barton Creek watershed between 1992

and 1999. The land was donated to the park in 2007. The park is currently used for recreation, mainly in the forms of hiking and swimming.

Research Plan

Design of Study

The largest source of water in Gus Fruh is Barton Creek. To address the hypothesis, three of the 50 meter transects will be gathered less than 10 meters from the creek and three 50 meter transects will be gathered more than 100 meters from the creek. The transects will be parallel to the creek.

Background Information

With a deprivation of water, woody plants experience wilting, leaf scorch, leaf loss, root loss, dieback, increased susceptibility to diseases and insects, susceptibility to water injury, and short and long-term drought. These reactions are all negative responses of woody plants due to water loss, showing that plants survive better in the presence of water (Gauthier). In 2000, a study done in Italy observed changes in the water status of plants. The study was done several times during each season and discovered that there was a decrease in the population of woody plants during the dry seasons and an increase in woody plant population during the seasons that received more rainfall (Nardini). Another study shows that when trees are irrigated, and therefore have a constant supply of water, they will grow larger more consistently than trees without access to water. During the month of February, when water was scarce for the non-irrigated tree, the non-irrigated tree experienced .75 millimeters less growth per day than the irrigated tree (Luxmoore). In the Karst region of Southwest China, the amount of rainfall was recorded throughout several months. Woody plants near a freshwater source were compared with those far from a water

source. It was concluded that more than 80% of the plants near the water increased in variety while the plants far from the water increased in variety by about 50%. It was also concluded that had there not been as much rainfall, the percentage of variation in the plants far from the water would have decreased much more than that of the plants near the water source (Nie).

Materials

- Woody Plant field guide
- 50 meter transect
- Garden clippers
- Plastic baggies
- Tape
- Gardening gloves

Procedure

Data will be collected from 6 transects, each measuring 50 meters in length. The transects will be parallel to the flow Barton Creek. Three transects will be less than 10 meters from the creek, and three transects will be more than 100 meters from the creek.

The steps used for collecting data are as follows.

1. Stretch the 50 meter transect line as straight as possible in a wooded area.
2. Move along the transect line and record the woody plant species found that overhang the transect line in the field data table with a pen. Record the common name of the woody plant, the intercept range and length (the distance that the woody plant overhangs the transect line) to the nearest decimeter, and the intervals that the woody plant is found.

a. The intervals will be categorized in the following manner: 0m-5m is Interval 1, 5m-10m is Interval 2, 10m-15m is Interval 3, and so on until reaching Interval 10 at 45m-50m.

3. Collect a representative leaf sample from each species encountered. Press and tape the sample in the back of the notebook on the unnumbered pages. Leaf samples should include multiple leaves still attached to the branch so that leaf arrangement may be observed. The specimen must be labeled with the common name, the Latin name (which is underlined with a ruler), whether the simple is simple or compound, the leaf arrangement, the bark of the woody plant, and a description of the fruit and/or flower. This step will be complete in the field.

. If one is unable to to identify a plant while in the field, then simply label the leaf sample with a letter. If the same leaf is encountered on that transect, then label it with the same letter in the data collection charts. Later, likely during the following class period, identify the plant.

a. Collect more than one sample is there is a variation of the leaves.

b. If a tree is too tall to reach a leaf sample, use as stick to carefully pull a pliable limb down or look for smaller trees of the same species from which to collect a sample. One may also look for fallen leaves on the ground if they are certain the leaves are from the same species as the tree being studied.

c. Samples of all species found the transects except Poison Ivy and fleshy cacti must be collected in the project notebook. Poison Ivy and fleshy cacti data will be recorded, but no specimen page is needed.

4. If possible, create a checklist of as many other plants as can be identified in the area (both woody and nonwoody plants).

For each species, the relative density, relative dominance, relative frequency, and importance value will be calculated.

Bibliography

"Barton Creek Greenbelt." *The Trust for Public Land*. The Trust for Public Land, n.d. Web. 24 Feb. 2016.

Gauthier, Nicole Ward, Susan Fox, and Kathy Wimberly. *How Dry Seasons Affect Woody Plants. UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT.* University of Kentucky, n.d. Web. 23 Feb. 2016.

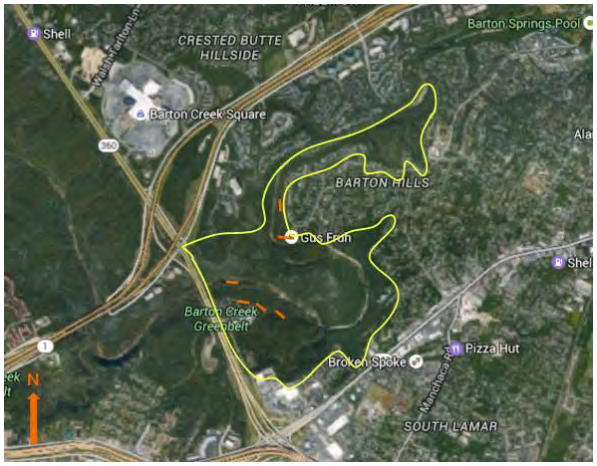
Hiernaux, P., Diarra, L., Trichon, V., Mougin, E., Soumaguel, N., Baup, F., Woody plant population dynamics in response to climate changes from 1984 to 2006 in Sahel (Gourma, Mali), Journal of Hydrology (2009)

Luxmoore, R. J., J. J. Landsberg, Merrill R. Kaufmann, and Paul J. Kramer. "Experimental Approaches to the Study of the Effects of Nutrients and Water on Carbon Assimilation by Trees." *Coupling of Carbon, Water and Nutrient Interactions in Woody Plant Soil Systems: Proceedings of a Symposium of the International Union of Forestry Research Organizations*. Victoria, Canada: Heron Pub., 1986. 427-42. Print.

Nardini, Andrea, Sebastiano Salleo, Patrizia Trifilo, and Maria Assunta Lo Gullo. *Water Relations and Hydraulic Characteristics of the Three Woody Species Co-occurring in the Same Habitat. Ann. For. Sci.* INRA, EDP Sciences, 22 July 2002. Web. 24 Feb. 2016.

Nie, Yun-peng, and Ke-Lin Wang. "Water Source Utilization by Woody Plants Growing on Dolomite Outcrops and Nearby Soils during Dry Seasons in Karst Region of Southwest China." *Research Gate*. Research Gate, 5 Dec. 2011. Web. 29 Feb. 2016.

Aerial Photo of park with transects:



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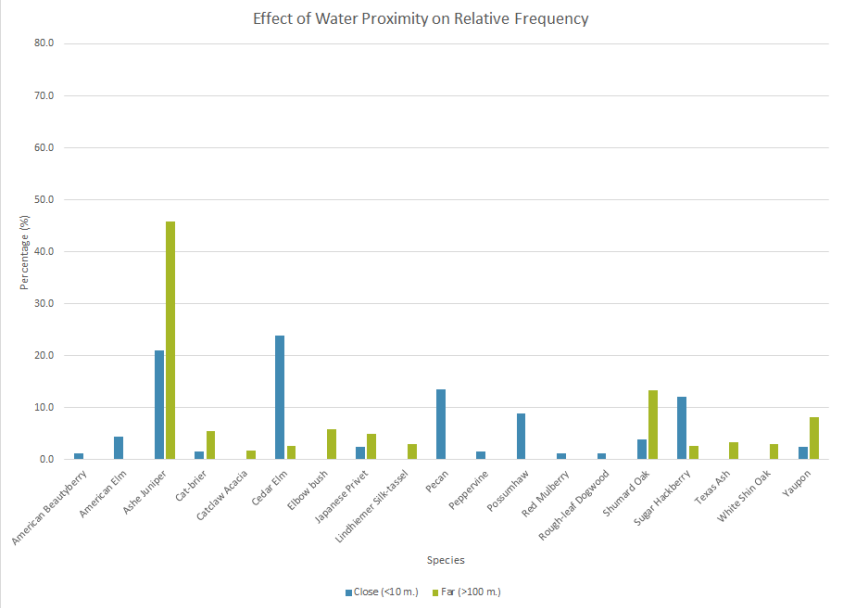
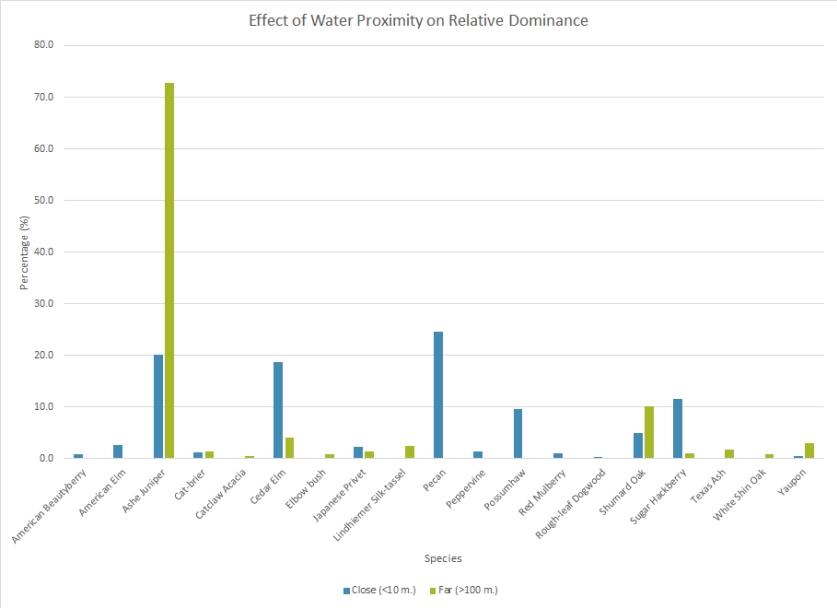
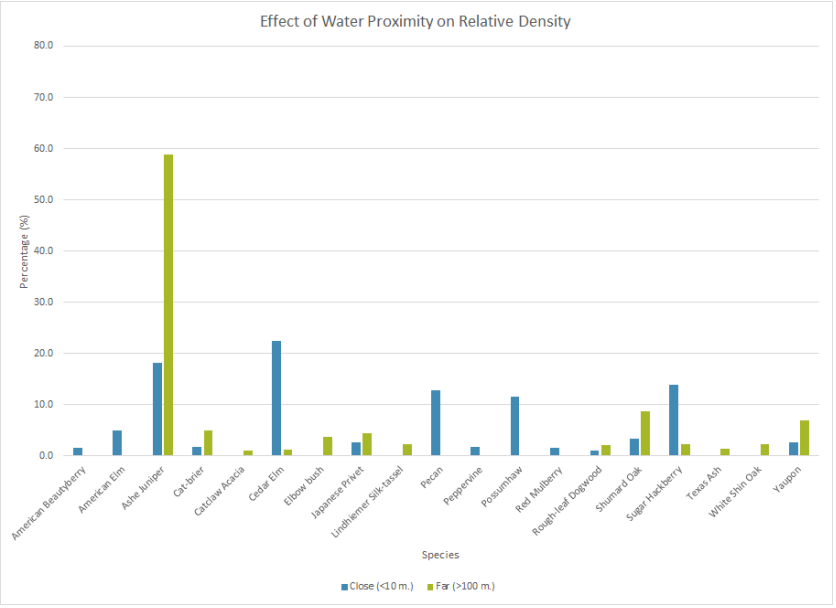



Effect of Water Proximity on Relative Dominance
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percentage (%)
American Beautyberry
American Elm
Ashe Juniper
Cat-brier
Catclaw Acacia
Cedar Elm
Elbow bush
Japanese Privet
Lindheimer Silk-tassel
Pecan
Peppervine
Possumhaw
Red Mulberry
Rough-leaf Dogwood
Shumard Oak
Sugar Hackberry
Texas Ash
White Shin Oak
Yaupon
Species
Close (<10 m.)
Far (>100 m.)


Effect of Water Proximity on Relative Density
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percentage (%)
American Beautyberry
American Elm
Ashe Juniper
Cat-brier
Catclaw Acacia
Cedar Elm
Elbow bush
Japanese Privet
Lindheimer Silk-tassel
Pecan
Peppervine
Possumhaw
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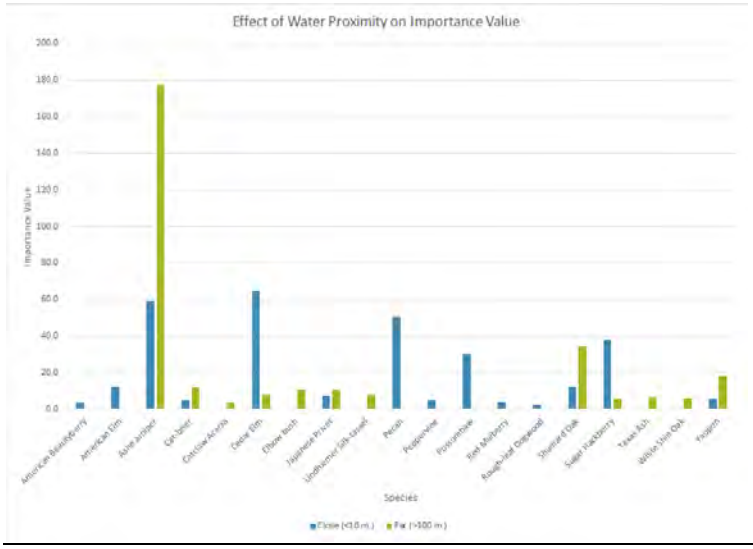
Sugar Hackberry
Texas Ash
White Shin Oak
Yaupon
Species
Close (<10 m.)
Far (>100 m.)



Conclusion

Results:

The data shows that nine species (American Beautyberry, American Elm, Cedar Elm, Pecan, Peppervine, Possumhaw, Red Mulberry, Rough-leaf Dogwood, and Sugar Hackberry) increased in importance in the study area close to water (CTW), which is within five meters of Barton Creek, compared to their importance value in the study area far from water (FFW), which is more than 100 meters from the Creek. The most notable species that were present in both study areas and increased in average importance as proximity to water increased were Cedar Elm and Sugar Hackberry. Cedar Elm's average importance value was 57.3 greater in CTW compared to FFW, with average values of 65.1 and 7.8. Sugar Hackberry was less prevalent than Cedar Elm, with an average importance of 37.7 in CTW and an average importance of 5.9 in FFW, and a difference between the two values of 31.8.

Conversely, ten species (Ashe Juniper, Cat-brier, Elbow bush, Japanese Privet, Lindhiemer Silk-tassel, Shumard Oak, Texas Ash, White Shin Oak, and Yaupon) increased in importance as the distance between them and the creek increased. For example, Ashe Juniper was present in both study areas. Its importance value nearly tripled from CTW to FFW, increasing from 59.3 to 177.4. Ashe Juniper was by far the most important species that increased from CCW to FFW, with the next most significant species being Shumard Oak. However, Shumard Oak only increased by 22.1, with an average importance value of 12.2 in CTW and 34.3 in FFW.

In CTW, a total of 14 species were present. The species unique to this area were American Beautyberry, American Elm, Pecan, Peppervine, Possumhaw, Red Mulberry, and Rough-leaf Dogwood. A total of 12 species were present in FFW, with Catclaw Acacia, Elbow bush, Lindhiemer Silk-tassel, Texas Ash, and White Shin Oak being species unique to the area. Seven species were present in both CCW and FFW. These species were Ashe Juniper, Cat-brier, Cedar Elm, Japanese Privet, Shumard Oak, Sugar Hackberry, and Yaupon.

There were two t-Tests conducted after the data was taken. One t-Test was taken on the number of individuals between the two areas FFW and CTW. The critical P value to come from this test was 0.381. This number is not statistically significant and shows that there is no relationship between the number of individuals in the areas FFW and CTW. The second t-Test showed similar results. The second t-Test was taken on the number of species between the areas FFW and CTW. The critical P value was 0.778. This value was also not statistically significant and shows that there is no relationship between the number of species in the areas FFW and CTW. From these t-Tests, it is shown that this study did not come up with any significant results.

Discussion:

The study found that Ashe Juniper was very abundant in FFW. It has been researched that Ashe Juniper significantly reduces the production and diversity of plant species (Smeins). It was also shown in this same study that the growth of Ashe juniper in the immediate vicinity of other woody species may in time cause mortality of the other species (Smeins). For example, in a study conducted near San Angelo, Texas it was found that the presence of 117 Ashe Juniper decreased the potential production of a area by about 40% (McGinty). Should the junipers have created a closed-canopy, the area would have experienced an 85% decrease from its potential production (McGinty). This shows several reasons why Ashe Juniper dominates the areas FFW.

The Pecan tree was the most common tree in the area CTW. A study showed that a Pecan tree need an estimated amount of about 55 inches of water a year which is about 190 gallons per tree per day (Rohla). These statistics show that Pecan trees need an abundance of water per day. This goes further to show why Pecan trees show up more frequently in the areas CTW than the areas FFW. Pecan trees would not be able to survive FFW, especially in this drought, because they would not be receiving the water they need.

The data from the study showed negative results because the t-Test values were not statistically significant. This occurred in the study because the average number of species and individuals close to water did not vary much from the number of species and individuals far from water. For example, negative results can be helpful to show what went wrong in the study. It helps to pinpoint what exactly went wrong.

To improve the study if redone, one could make several revisions to the procedures. One change would be to attempt to keep the transects as parallel to the creek or other water source as possible. Another helpful revision would be to have a method of obtaining leaf samples from woody plants even if it they are out of reach.

Bibliography

McGinty, Allan. "Juniper Ecology." *Texas Natural Resources*. Texas A&M, 18 Mar. 1997. Web. 18 May 2016.

Rohla, Charles. "Consider Pecan Trees' Water Needs During Drought."*Noble*. Samuel Roberts Noble Foundation, Sept. 2006. Web. 18 May 2016.

Smeins, F. E., and S. D. Fuhlendorf. "Texas Natural Resources Server." *Biology and Ecology of Ashe Juniper «*. N.p., n.d. Web. 18 May 2016.

Diversity of Woody Plants in Relation to Proximity to Water and Elevation

Michael Johnson, Spring 2016

Abstract: This study was conducted to assess the diversity of woody plants in relation to proximity to water and elevation by hypothesising that at a higher elevation and larger distance from water, plant diversity would decrease. This study was conducted by taking data for the various woody plants encountered along 3 different 50m transects placed at 10 m from water and 146 meters in elevation, 120 m from water and 155 meters in elevation, and lastly 240 m from water and 167 meters in elevation. This study resulted in a surprising data set consisting of 4 species at the first transect, 6 species at the 2nd transect and 7 species at the last transect. This data showed a negative correlation between species diversity and increasing elevation and distance from water which is the exact opposite of this study's hypothesis. With the various data collected throughout the study a question as to why the number of species went up as the transects got farther and farther from water and increased in elevation arose as well as why the most dominant plants were Ashe Juniper and Cedar Elm.

Introduction: Purpose

The purpose is to assess the diversity of woody plants in relation to proximity to water and change in elevation. The research will be conducted at Gus Fruh Park in South Central Austin, Texas.

Hypothesis

At higher elevation and farther distance from water, there will be a decrease in abundance of and a change in diversity woody plants. This is due to the fact that shrubs and other woody understorey are unable to thrive in conditions at higher elevations, while evergreens and certain species of trees are.

Site Description

Location

Gus Fruh Park, a part of the larger Barton Creek Greenbelt, is in South Central Austin. It is 2.75 km southwest of Barton Springs Pool, as the crow flies.

Size and Shape

Gus Fruh Park is in the shape of a distorted arch that opens towards the south. The park occupies 141.1 hectares of land.

Topography

The elevation descends towards Barton Creek. The east side descends slowly, while the west side is a cliff. The maximum elevation is 213 m. and the minimum is 146 m.

Geology

Alluvium deposits from Barton Creek are regular throughout. Erosion from the creek is evidenced by the large drop off in elevation and the wide bend in the creek itself. The main geologic formation exposed is the Edwards. The south and east borders of the park appear to contain Del Rio Shale. Alluvium is smoothed limestone fragments and silts and and they are constantly deposited by the creek. The terrace deposits were formed during the early Quaternary period and are composed of gravel, sand and large cobble stones. The Georgetown Formation is formed of limestone and was created in the Lower Cretaceous. The Edwards Formation consists of limestone and dolomite, with fine to medium particles, and was formed also in the Lower Cretaceous (Bureau of Economic Geology - Austin)

Areal Extent and General Type of Vegetation

The park is 90% covered in woody plants and 10% area covered with rocks. The general vegetation consists of Oak, Japanese Privets, and Poison Ivy.

Availability of water

Barton Creek runs through Gus Fruh and is mostly flowing. The flooding depth is around 7 meters and there is evidence in the liter in high parts of some trees and of

flooding from the smooshed vegetation and broken trees in the dry areas of the creek.The water is 1/4 meter deep at the shallowest areas and 2 meters deep at the deepest

Proximity to Urban or Industrial areas

The park is adjacent to a neighborhood to its east. It is also adjacent to two highways Loop 1 and Loop 360.

History

William Barton named the creek that later became the park in 1837. In 1976 the Bicentennial Commission and the Austin City Council set aside Barton Creek as a preserve. In March 2009, The Trust for Public Land donated 5.7 acres of land to the Greenbelt, in addition to the 18 hectares they donated in early 2007. (Barton Creek Greenbelt)

Research Plan

Design of Study

Transects will be 50 meters in length. One will be placed 10 m from water at 480 feet (146 meters) of elevation, one 120 m from water at 510 feet (155 meters) of elevation, and one 240 m from water at 550 feet (167 meters) of elevation. The total percentage of Gus Fruh being studied is about .4%.

Background Information

A study on structure and advancement of woody vegetation was conducted in a semi-arid rangeland of southern Ethiopia under three land-use systems and along a variation in distances from water sources by Solomon Tefera H.A. Synman. They measured the density of each type of the 54 woody plants they were studying at

different distances from water. The prevalence of these species followed the pattern of intensity of use within the livestock grazing area. Most of the woody species had the highest abundance in the heights greater than 0–2 m regardless of land use and distance from water. All encroaching woody species had the highest density in the communal land. This study explains that grazing and urbanization as more significant than distance from water. Distance from water is not as significant a factor. This means that woody plant diversity and abundance may not be affected by distance from water. (Tefera 2006)

This study was conducted in a forest in Jalisco, México. Data of composition, structure, and diversity of plants were taken along a 1 kilometer altitudinal transect. 470 species were studies, 173 of which were woody plants. Shrubs along with other understorey declined in abundance with increasing elevation. The proportion of evergreen woody plants increased with elevation increase due to less seasonal aridity and greater soil leaching. The average number of species per 0.1 ha declined linearly. While this study investigated a larger range of topography, it still has relevance to the study being conducted. It supports that there will be a possible decline in shrub population, an increase in evergreens, as well as a general decrease in species abundance at higher elevations. (Givnish, Vasquez 1998)

Maria Fernandez-Gimenez and Barbara Allen-Diaz conducted a study of plant species sampled over two years along different distances of water sources in three grazed Mongolian steppe ecosystems of varying productivity. Distance from water was a significant driving factor in steppe and mountain-steppe ordinations of grazing, and was negatively seen in the density of plants.They concluded that higher nutrient

concentrations near water sources resulted from livestock redistributing nutrients in the landscape in the form of urine and feces in the areas where they live. This supports our hypothesis by explaining how water sources will attract animals that will provide nutrients to the plants growing there resulting in a higher density near water. (Fernandez-Gimenez, 2001)

Materials

- Journal
- Black/Blue Pen
- 50 m. transect tape
- Scissors
- Clear Tape
- Field Guide (Lynch, 1981)

Procedure

Data Collection:

1. Stretch the 50 m transect tape as straight as possible along the predetermined transect, which should have 60% coverage.
2. Move along the transect and record woody plant species that overhang the transect up to 5m away from the transect in the field data table. Also record the common name, if known, and its intercept length and range. Record the interval on which the plant is found (intervals are 5m).
3. Collect a leaf sample for each species encountered. Press and tape each sample into the back of the project notebook. Make sure to identify each sample with the common and latin name or a letter if the sample is unknown. Write the leaf

arrangement, whether the leaves are simple or compound, the bark type, and a description of its fruit or flower.

   a. observe the whole tree; young leaves will appear different than mature ones. Take multiple samples if there is leaf variation.
   b. If a tree is too tall, pull a branch down with a stick, or collect fallen leaves.
   c. Samples from each woody plant must be taken.

4. A list of as many other plants in the area may be helpful
5. Data will be analyzed with these formulas

Relative Density

Density is defined as number per unit area. It answers the question: How many? It is useful to express the contribution of individuals of one species in relation to the total. This is referred to as relative density expressed as a percent.

$$\text{Relative Density} = \frac{\text{Total \# of individuals of that species}}{\text{Total \# of individuals of all species}} \times 100$$

Relative Dominance

Dominance is a measure of the size or bulk of the vegetation. It answers the question: How much? The size is expressed by the canopy cover which is the intercept length of the plant with the transect line. It is usual to express relative dominance as a percentage. It compares 'how much' of one species to 'how much' of all species.

$$\text{Relative Dominance} = \frac{\text{Total intercept length of that species}}{\text{Total intercept length of all species}} \times 100$$

Relative Frequency

Frequency is a measure of the commonness and distribution of a species within a study area. It answers the questions: Where is a species located and how common is it? Relative frequency is expressed as a percentage of the number of intervals within the transect in which a species occurs over the total number of intervals for all species.

$$\text{Relative Frequency} = \frac{\text{Total \# of intervals of that species}}{\text{Total \# of intervals of all species}} \times 100$$

Importance Value

The importance value gives an overall estimate of the influence or importance of a plant species in a community. It is expressed as a whole number out of 300 and is a function of the three relative measurements.

Importance Value = Relative Density + Relative Dominance + Relative Frequency

Bibliography

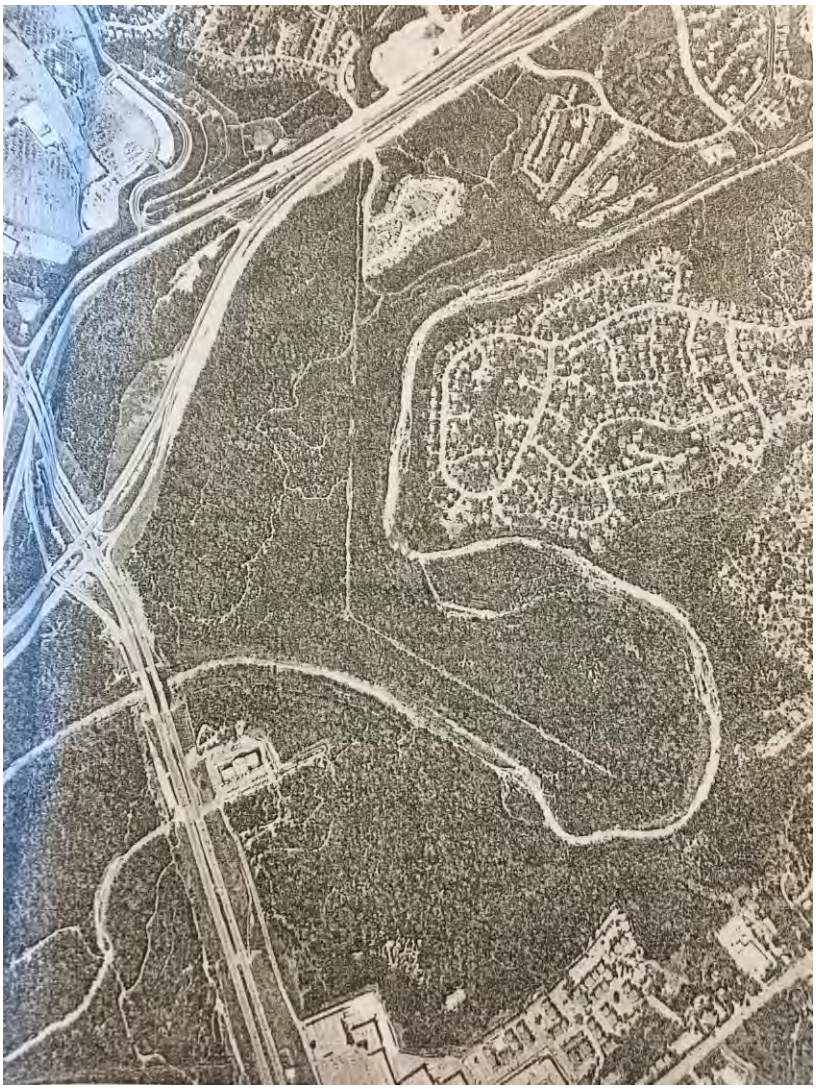
"Barton Creek Greenbelt." *Barton Creek Greenbelt*. Texas Outside, n.d. Web. 25 Feb. 2016.

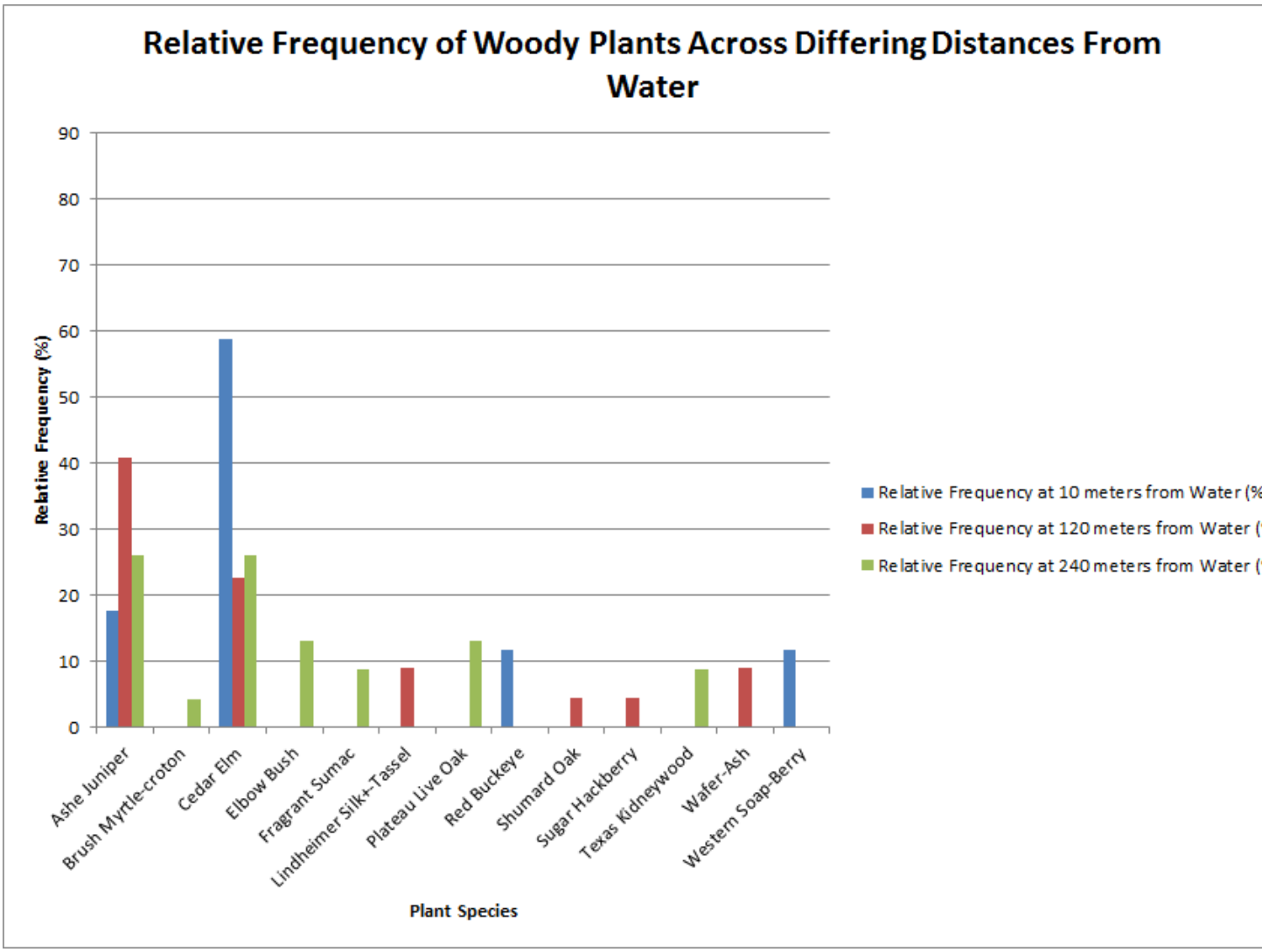
"Bureau of Economic Geology." *Bureau of Economic Geology*. Bureau of Economic Geology, The University of Texas at Austin, 2010. Web. 25 Feb. 2016.

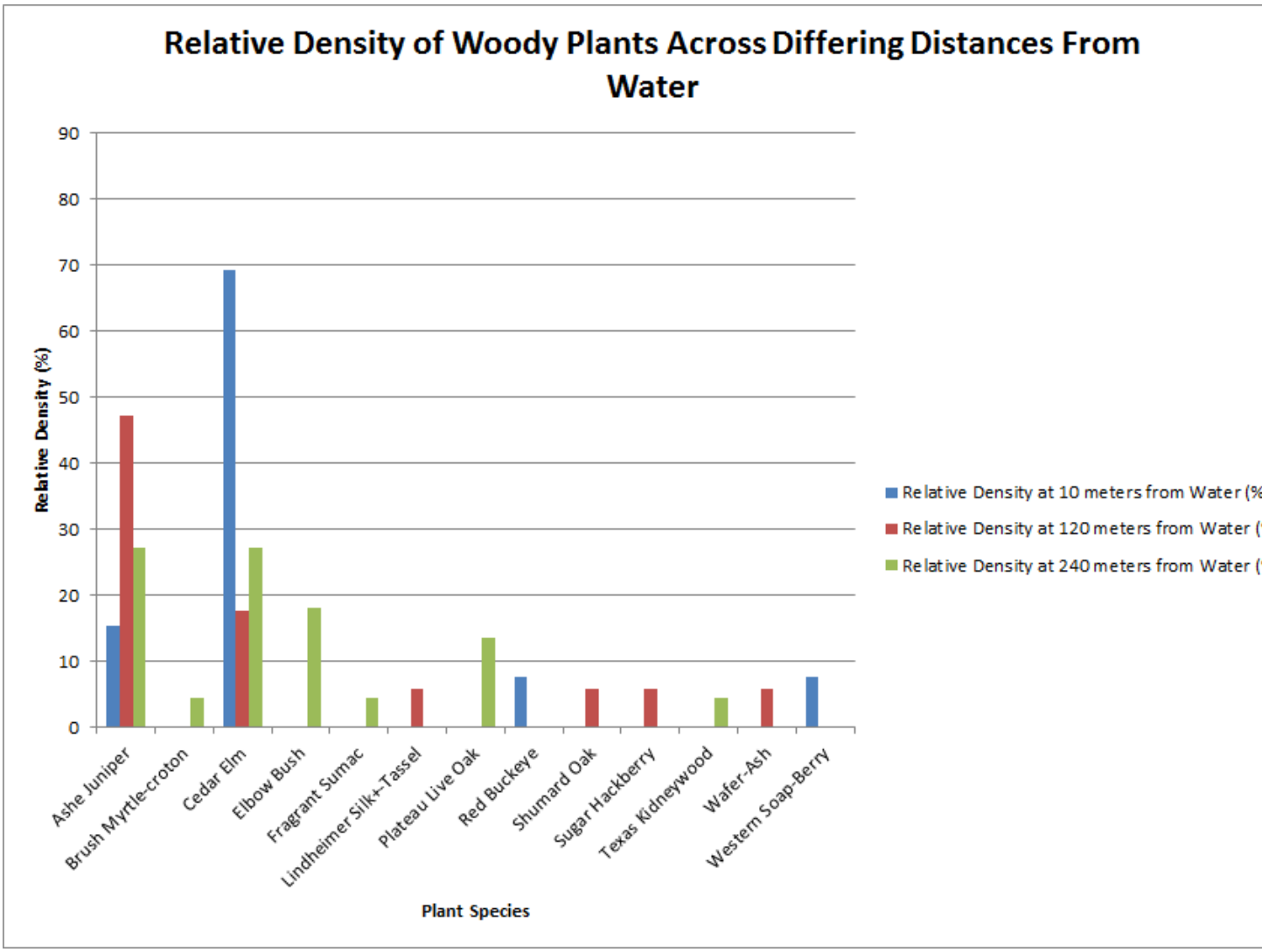
Fernandez-Gimenez, Maria, and Barbara Allen-Diaz. "Vegetation Change along Gradients from Water Sources in Three Grazed M." *Ongolian Ecosystems*. Plant Ecology, Nov. 2001. Web. 25 Feb. 2016.

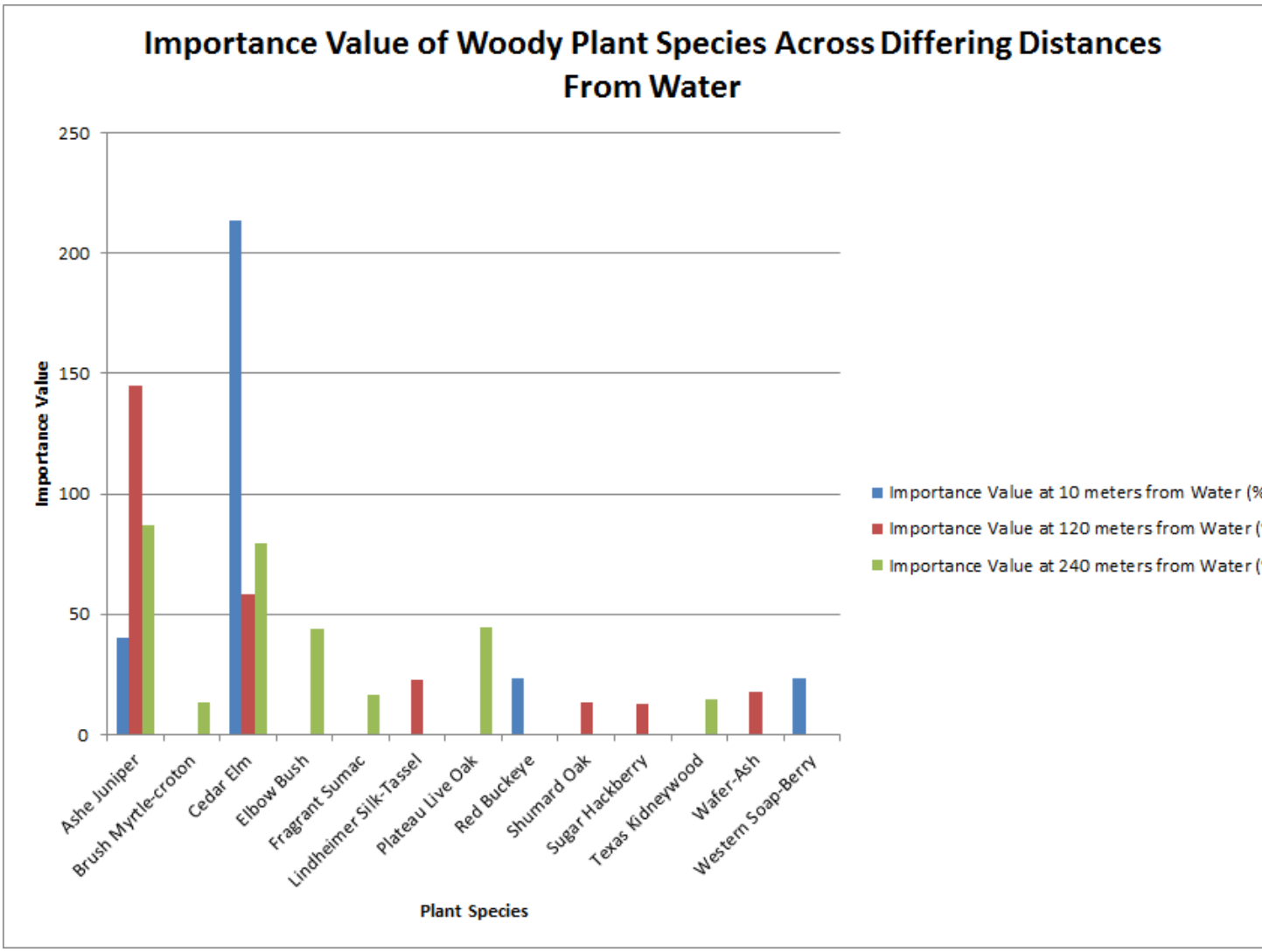
Tefera, Solomon. "Rangeland Dynamics of Southern Ethiopia." *Science Direct*. Elsevier B.V, 17 Oct. 2006. Web. 24 Feb. 2016.

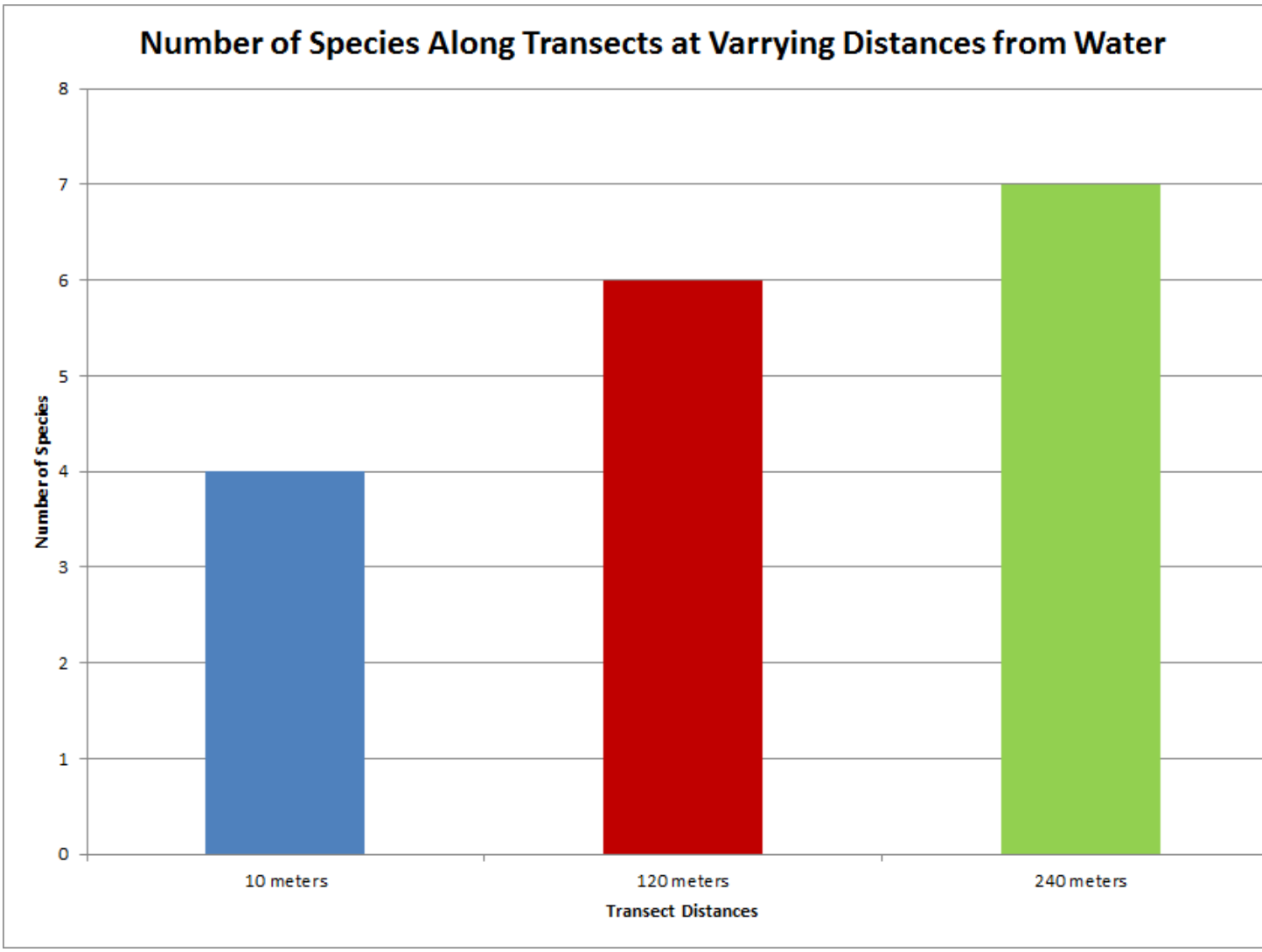
Vázquez, Antonio. "Altitudinal Gradients in Tropical Forest Composition, Structure, and Diversity in the Sierra De Manantlán." *Online LIbrary*. N.p., Dec. 1998. Web. 25 Feb. 2016.

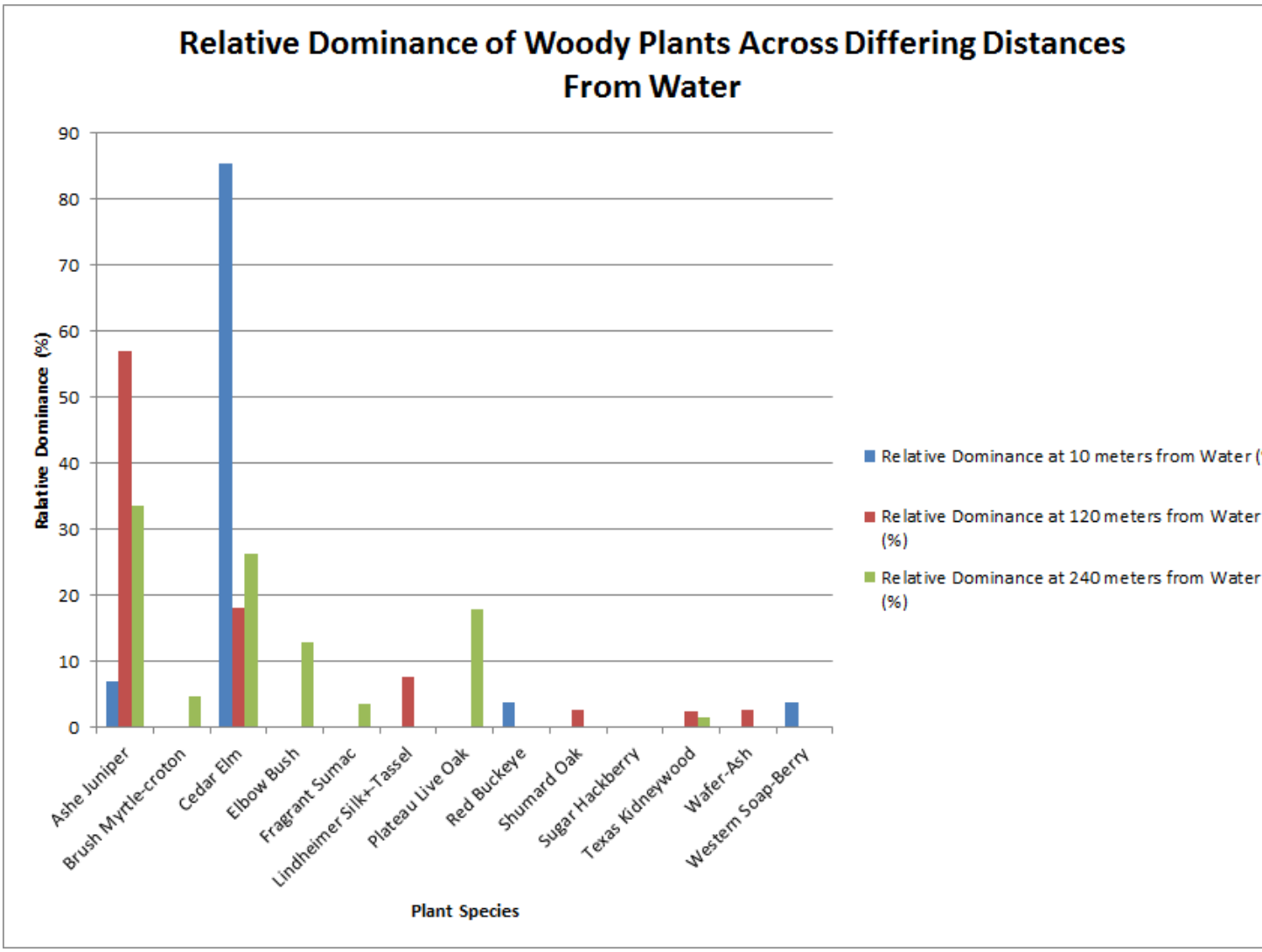



Relative Frequency of Woody Plants Across Differing Distances From Water
90
80
70
60
50
40
30
20
10
0
Relative Frequency (%)
Ashe Juniper
Brush Myrtle-croton
Cedar Elm
Elbow Bush
Fragrant Sumac
Lindheimer Silk+Tassel
Plateau Live Oak
Red Buckeye
Shumard Oak
Sugar Hackberry
Texas Kidneywood
Wafer-Ash
Western Soap-Berry
Plant Species
Relative Frequency at 10 meters from Water (%
Relative Frequency at 120 meters from Water (
Relative Frequency at 240 meters from Water (


Relative Density of Woody Plants Across Differing Distances From Water
Relative Density (%)
90
80
70
60
50
40
30
20
10
0
Ashe Juniper
Brush Myrtle-croton
Cedar Elm
Elbow Bush
Fragrant Sumac
Lindheimer Silk-Tassel
Plateau Live Oak
Red Buckeye
Shumard Oak
Sugar Hackberry
Texas Kidneywood
Wafer-Ash
Western Soap-Berry
Plant Species
Relative Density at 10 meters from Water (%
Relative Density at 120 meters from Water (
Relative Density at 240 meters from Water (


Importance Value of Woody Plant Species Across Differing Distances From Water
250
200
150
100
50
0
Importance Value
Ashe Juniper
Brush Myrtle-croton
Cedar Elm
Elbow Bush
Fragrant Sumac
Lindheimer Silk-Tassel
Plateau Live Oak
Red Buckeye
Shumard Oak
Sugar Hackberry
Texas Kidneywood
Wafer-Ash
Western Soap-Berry
Plant Species
Importance Value at 10 meters from Water (%
Importance Value at 120 meters from Water (
Importance Value at 240 meters from Water (


Number of Species Along Transects at Varrying Distances from Water
Number of Species
0
1
2
3
4
5
6
7
8
10 meters
120 meters
240 meters
Transect Distances



Conclusion: Results:

As seen in the three charts on relative density, dominance, and frequency, the graphs all follow the same basic trends, the most important of which being that as you go from lower elevation and smaller distance from water to a higher elevation and farther distance from water, the number of species gets higher. The three graphs also correlate with the trend of all of the various values being in the same relative neighborhood for each different transect except for Cedar Elm and Ashe Juniper, which are consistently much higher than the other species. For example in the graph of

relative dominance in transect 1 the relative dominance of all the organisms except for Cedar Elm is around 5% while Cedar Elm has a relative dominance of 85%.

Going back to the first trend mentioned, the chart of the number of species in each transect shows that in transect 1 (10 meters from water and 146 meters in elevation) there are 4 different species while in transect 2 (120 meters from water and 155 meters in elevation) there are 6 species and finally in transect 3 (240 meters from water and 167 meters in elevation) there are 7 species.

Lastly, for transects 1 and 2 the relative density, dominance, frequency and importance values are roughly the same except for Ashe Juniper and Cedar Elm which are across the board around 2-4 times the other species. However this trend is much less pronounced in transect 3. In this transect all of the values for all of the species present are roughly the same with Cedar Elm and Ashe Juniper being slightly higher than the others.

Discussion:

A study conducted by Diane Hope, Corinna Gries, Paige Warren, Madhu Katti, Glenn Stuart, Jake Oleson, and Jason Kaye in Phoenix, Arizona looked at the relation of plant richness and size of the species pool in relation to urbanization. The study was set up as a 4x4 km grid and in the urban area 1 random sample was taken every square and in non urban areas a random sample was taken every 3 squares. This study found that overall in urban areas there were 156 different genera and in non urban areas there were only 63 different genera showing that there is an increase in plant diversity with proximity to urbanization. This helps to support the trend in the data that shows hot as the transects got closer to urban areas the species richness increased.

A study conducted by John Arvid Grytnes and Ole R. Vetaas in the Himalayan Mountain range in Nepal looked at various species richness patterns across the various altitudes contained in the study area. They took data which showed the species richness along altitudinal bands 100 meters apart and found that the number of species in each of these bands increases steeply until around 1500m above sea level and then it stays around the same all the way to 2500 meters and then after that a slight decrease begins. The trend of species richness increasing with increasing altitude that is shown through this study supports a similar trend of increasing species richness with increase in distance from water and elevation that was shown through my study.

A study conducted by R. J. Elkington, K. T. Rebel, J. L. Heilman, M. E. Litvak, S. C. Dekker, and G. W. Moore around the Edwards Plateau in Central Texas looked at Ashe Juniper, Honey Mesquite, and Live Oak and how the depth of their roots directly affects not only the prevalence of the species but has an affect on the whole ecosystem. This study was done by looking at the three species at various sites and collecting data on the root depth, soil depth, and sap flux. This data showed that Both Ashe Juniper and Honey Mesquite were dominant and were healthier and that Juniper was able to be healthy and dominant even in area with low soil depth and little water in the soil. This result of Ashe Juniper being able to be dominant in non ideal conditions and across various area gives insight into why in the study I conducted one of the most prevalent and dominant plant species was Ashe Juniper.

The negative trend of species richness in relation to decreasing elevation is important because this could show one of two things. Either that the transects were not in the prime spot for data collection and that I skewed the data in so way during data

collection or that either as an effect of proximity to urbanization or floods and violent rains closer to water at a lower elevation has led to a decrease in the number of species in that area.

In order for a study similar to this one to be conducted in a more efficient manner than this study one would need to begin by taking more transects which would be able to provide more precise statistics that are more representative of the area. Secondly a researcher would need to be more precise with their measurements meaning measuring the intercept distance more precisely and doing a better job of finding good spots to take data. In addition to those things, if one was researching species richness in relation to elevation and proximity to water then the researcher would most likely want to take data that was somewhere farther away from urbanization because that does have a large effect on the various woody plants around that.

In the area that I conducted my study there is a large urban area only 50 meters away which causes lots of various effects on the plants at Gus Fruh. Because there is so much urbanization around this area, a study that could be conducted in Gus Fruh could have to do with looking at the effects of urbanization on woody plants at Gus Fruh. Another study that could tie into the one that I conducted could be one about the various types of woody plants at different elevations and distances from water. This could give a researcher insight into why certain plants in the park were much more dominant than others.

Bibliography:

Grytnes, John Arvid, and Ole R. Vetaas. "Species Richness and Altitude: A Comparison between Null Models and Interpolated Plant Species Richness along the Himalayan Altitudinal Gradient, Nepal." *The American Naturalist* 159.3 (2002): 294-304. Web.

Hope, Diane, Corinna Gries, Paige Warren, Madhu Katti, Glen Stuart, Jake Oleson, and Jason Kaye. "How Do Humans Restructure the Biodiversity of the Sonoran Desert?" *USDA Forest Service Proceedings* (2005): 189-94. Web.

R. J. Elkington, K. T. Rebe, J. L. Heilman, M. E. Litvak, S. C. Dekker, and G. W. Moore. "Species-specific Water Use by Woody Plants on the Edwards Plateau, Texas." *Ecohydrol* (2012): 1-13. Web. 22 May 2016.

Elevation's Effect on Woody Plants in Gus Fruh Park

Mia and Andrew
Spring Semester 2016
Mr. Fennell
Period 3-7

Abstract:

The purpose of this study was to examine the effect of elevation on the diversity and abundance of woody plants within Gus Fruh. This study was conducted by taking six transects using the line intercept method: three were taken below 165 meters in elevation, and three were taken above 190 meters in elevation. It was found that there was a 29.17% greater diversity in lower elevation transects when compared to the high elevation transects. However, there was only a 4.35% greater abundance of woody plants in high elevation transects in comparison to low elevation transects. Ash Juniper had the highest importance in both elevations, while Plateau Live Oak and Evergreen Sumac both had an importance value greater than 50 and were largely present only in higher elevation transects.

Introduction:

Purpose:

The purpose of this project is to study the effects of elevation on the diversity and population of woody plant species in Gus Fruh park.

Hypothesis:

As the elevation increases, the diversity and population of woody plants in Gus Fruh park will also increase.

Site Description:

Location: Gus Fruh is located in south central Austin. Its east side borders Barton Hills Dr. The center of the park is 1174.821 meters southeast away from the intersection of Mopac Expwy and Loop 360.

Size and Shape: The total area of Gus Fruh is about 109.375 hectares. The northeast part of the park is a small, irregular circle shape and it is connected to the southwest part of the park through a general ‘S’ shape. The southwest part of the park is an irregular triangle shape.

Topography: The highest elevation is about 210.312 meters, and the lowest is roughly 149.352 meters. The east side of the park has a moderate hill that slope into the creekbed, while the west part of the map has a steep cliff that begin to even out as it approaches the creekbed.

Geology: Within Gus Fruh there are Alluvium sediments make up the creek, which made up of sand and silt. This formation was established recently. There are also Tributary terrace deposits making up the creek, consisting of sand, silt, and clay. This formation was established during the Pleistocene Epoch. The Edwards Formation makes up the rest of the park, it being established during the Lower Cretaceous period. The Edwards Formation is made up of limestone and dolomite. Fossils can be found at Gus Fruh around the creekbed.

Area Extent and General Type of Vegetation: Gus Fruh is covered in forested areas, close to 90% of the land. There are mostly Ash Juniper trees, Texas Live Oak, and some smaller shrubs and grasses around the creekbed. 7% of the park is bare due to water flow and occasional flooding. The last 3% is made up of small grasses.

Availability of Water: Barton Creek runs through the middle of the park. The creek is generally 7 meters wide. The creek itself ranges from a depth of 2 meters to almost 4 meters, but during floods this can rise to more than 4 meters. Evidence of flooding can be seen in plant debris stuck within the branches of other woody plants, as well as fallen trees.

Proximity to Urban or Industrial Areas: Barton Hills neighborhood borders Gus Fruh park to the east, along Barton Hills Drive. Some houses directly touch the park, but a trail from the road reaches back into the creekbed. Loop 360 borders the park to the southwest. and Mopac Expwy is to the north of the park at an average distance of 587.411 meters away. A neighborhood area does extend from Mopac Expwy and directly touches the park and its northmost entrance.

History: Gus Fruh is named after E. Gus Fruh, who passed away in 1978 and dedicated his life to improving the environmental quality of Austin. The park was named Horseshoe Bend before this change. The creek that runs through the park, Barton Creek, is named after William Barton who settled on its banks in 1837. Before this, the creek is thought to be inhibited by Tonkawa and Comanche tribes. The park was then protected in 1980 by ordinances that restricted human development within sensitive recharge zones.

Design of Study: To study how elevation affects the diversity and population of woody plants within Gus Fruh park, three 50 meter transects will be taken below 165 meters, and three 50 meter transects will be taken above 190 meters.

Background Information: A study by R. H. Whittaker, Cornell University, and W. A. Niering, Connecticut College, did study that looked at the diversity of woody plants along an elevation gradient in the Santa Catalina Mountains, starting at 760 meters and going all the way up to 2740 meters above sea level. They found that higher land elevations have an increase in diversity in number of tree species. They found that in forests at 2720 meters there were 6 different tree varieties and in areas of 1310 meters elevation, there were 3 different tree species. The areas at 2740 also had an increase in diversity over the 1310 meter areas with a total of 4 different tree species. The data shows that there is some correlation between elevation and plant diversity, where if elevation increase, so does diversity.

Yu Hua of the International Institute for Earth System Science in Nanjing University conducted a study of the plant distribution along the elevation gradient in the Hubei Province, China using published elevation range data from Zheng of the Technology Press. Contemporary flora of spermatophyte plant species were studied. Species richness occurred in the elevation range from 800 meters to 1400 meters with

1000 meters having the greatest species richness, it accounting for 52% of the species richness within the Hubei Province. However, after 1400 meters, the amount of species decreased. This data shows that there is elevational diversity gradient where diversity increases with elevation until an extreme height, such as 1400 meters, is reached.

Finally, a research paper by Khem Raj Bhattarai and Ole R. Vetaas at the University of Bergen, Norway, found that over an elevation gradient in the Himalaya's of East Nepal, as elevation increased, the overall species richness increased. The group counted number of species in 6 different plots, of 50 meters by 20 meters, along their gradient They found that at an elevation of 100 meters, there were 212 different species of vascular plants. Then at an elevation of 1200 meters, there were 241 different species of vascular plants present. As elevation increased, so did the species diversity. They found that there was a 70% variation increase in woody plants along the elevation gradient.

Materials:

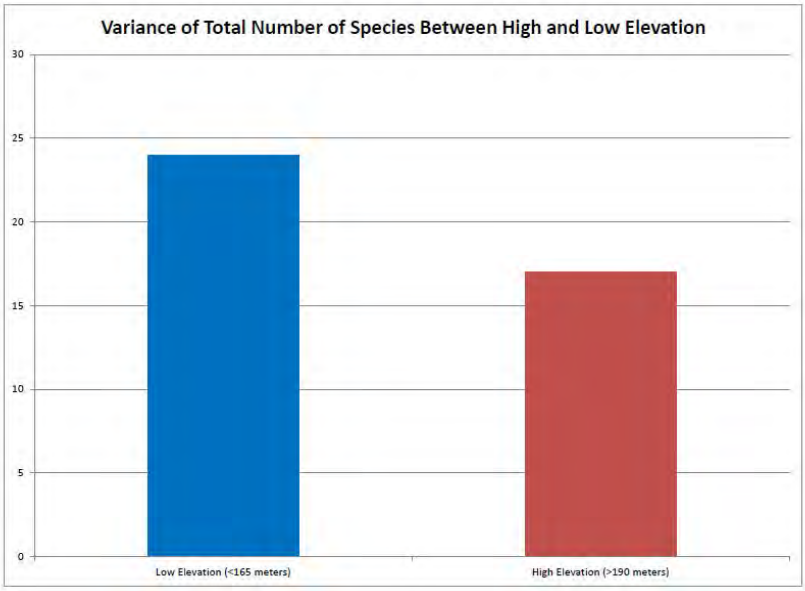
For this project, a Woody Plant field guide will be used along with a 50 meter Transect line, clippers, baggies, tape, and gloves. The clippers, baggies, tape, and gloves will be used for the collection of woody plant samples and possible poison ivy.

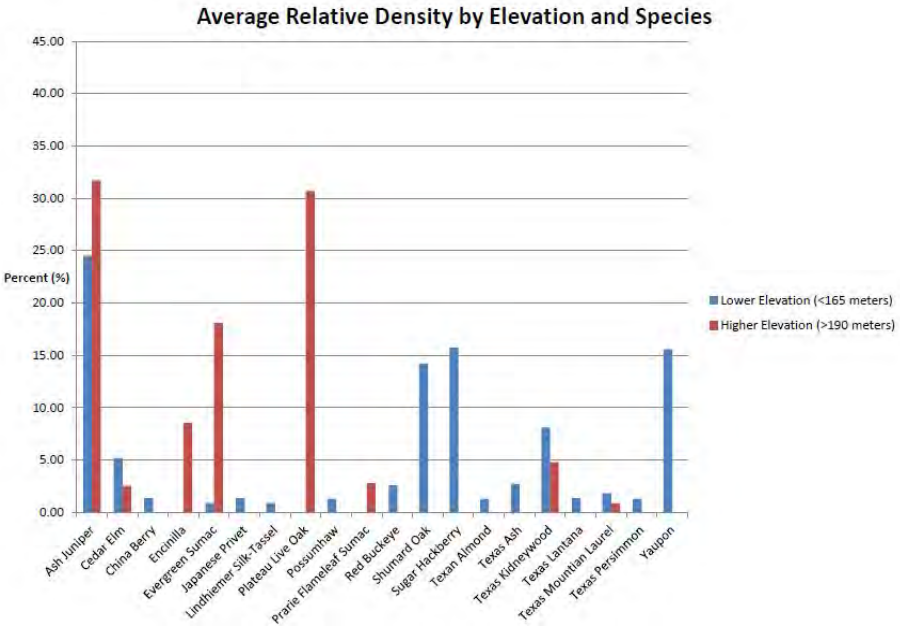
Procedure:

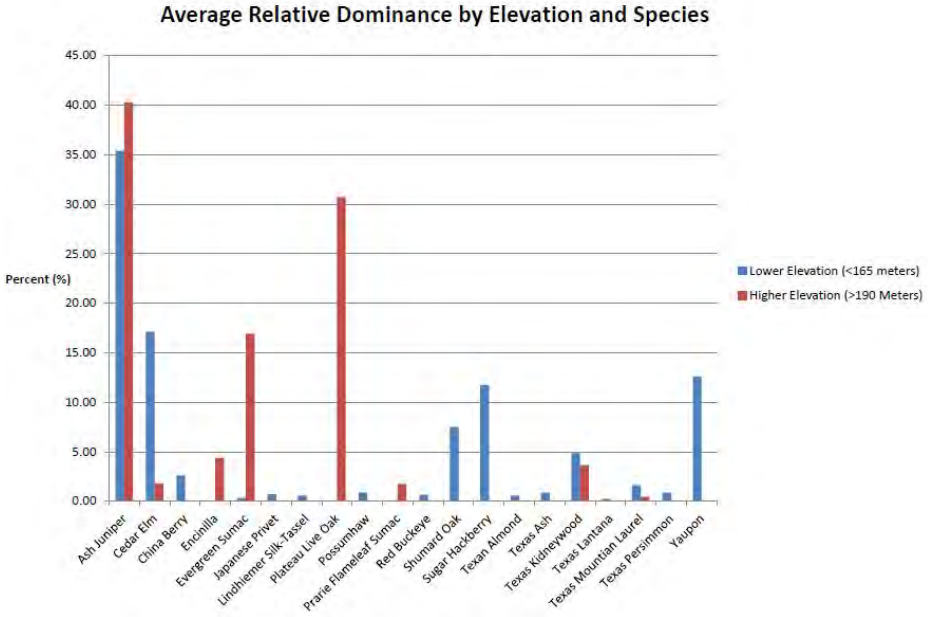
To collect data, first, a 50 meter transect line will be stretched in an area that has a large overhang percentage. Next, the group will walk along the transect line and record what woody plants are present at what intervals. This data will be recorded to the nearest decimeter within the group members' journals. After this is completed, representative leaf samples will be taken from each species encountered. Each sample should be tapped within a group member's journal and the group member should record the common name for the specimen, Latin name, basic description of leaf, along with a bark description and a description of the flower and/or fruit of the woody plant. Woody plant species may be identified by using a Woody Plant field guide. With the collected data, relative density, relative dominance, relative frequency, and importance value will be calculated.

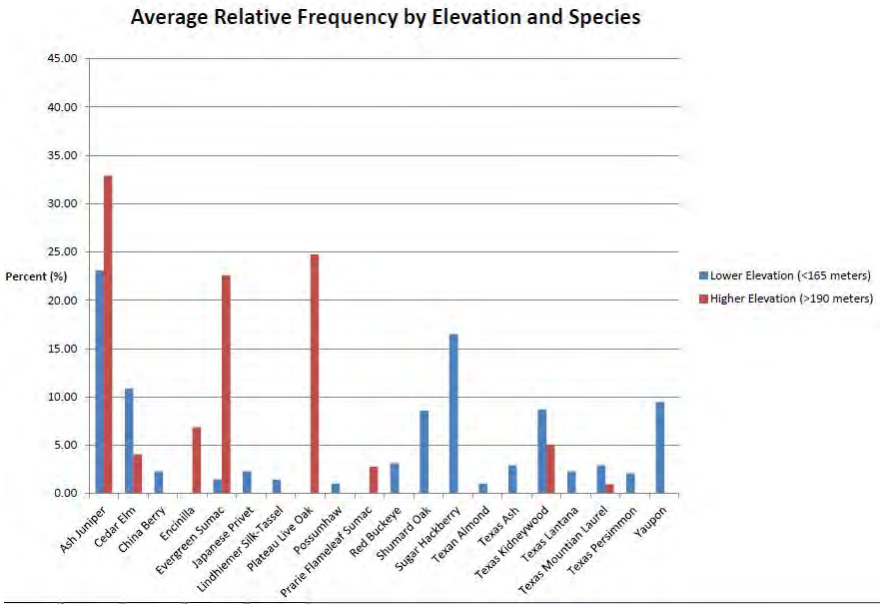

T5
T6
T4
T2
T1
T3
N

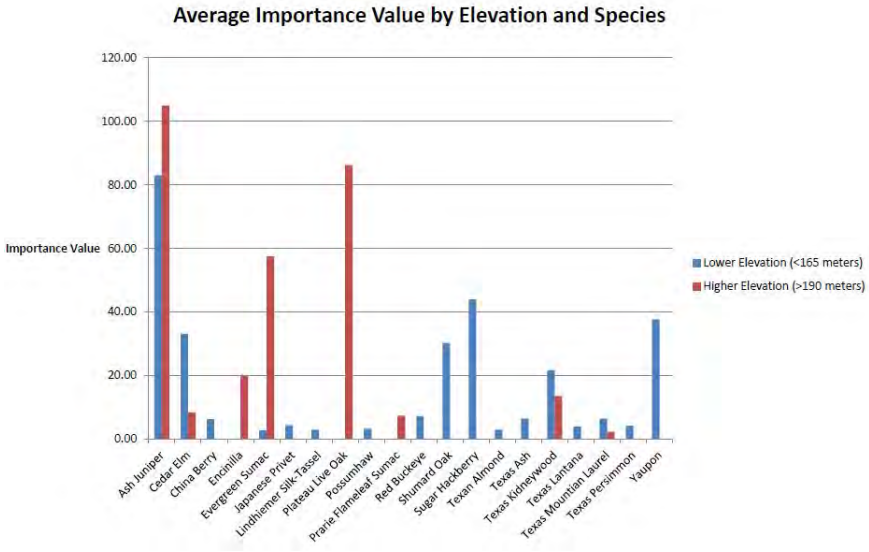
Graphs:


Variance of Total Number of Species Between High and Low Elevation
30
25
20
15
10
5
0
Low Elevation (<165 meters)
High Elevation (>190 meters)


Average Relative Density by Elevation and Species
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Percent (%)
Ash Juniper
Cedar Elm
China Berry
Encinilla
Evergreen Sumac
Japanese Privet
Lindheimer Silk-Tassel
Plateau Live Oak
Possumhaw
Prarie Flameleaf Sumac
Red Buckeye
Shumard Oak
Sugar Hackberry
Texan Almond
Texas Ash
Texas Kidneywood
Texas Lantana
Texas Mountian Laurel
Texas Persimmon
Yaupon
Lower Elevation (<165 meters)
Higher Elevation (>190 meters)


Average Relative Dominance by Elevation and Species
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Percent (%)
Ash Juniper
Cedar Elm
China Berry
Encinilla
Evergreen Sumac
Japanese Privet
Lindheimer Silk Tassel
Plateau Live Oak
Possumhaw
Prarie Flameleaf Sumac
Red Buckeye
Shumard Oak
Sugar Hackberry
Texan Almond
Texas Ash
Texas Kidneywood
Texas Lantana
Texas Mountian Laurel
Texas Persimmon
Yaupon
Lower Elevation (<165 meters)
Higher Elevation (>190 Meters)





Conclusion:

Results:

After collecting and analyzing data of woody plants within the Gus Fruh park, it has been found that there is an almost equal abundance of woody plants between high and low elevation and a statistically significant greater amount of diversity within lower elevations versus high elevations.

Within the low elevations, the total number of individuals totals at 88 while the total amount of individuals for high elevations totals at 92. The average amount of individuals per transect is 29.33 for low elevation and the average amount of individuals per transect is 30.67 for high elevation. After a t-Test resulting in a P-Value of 0.83, it was shown that there was not a statistically significant difference in the abundance of woody plants between high and low elevations.This supports the conclusion that there is

an almost equal abundance of woody plants between high and low elevations.

Plateau Live Oak was only present within the high elevation transects, while Sugar Hackberry was only present within low elevations, and Evergreen Sumac 17x more abundant in high elevation than in lower elevation. However both high and low elevation had an abundance of Ash Juniper: High elevation having a total of 29 individuals and low elevation having a total of 25 individual species.

High elevation has a greater number of large, fully grown trees and lower elevation transects had more young trees. Transects with higher elevation had less species but more individuals per species. There were only a total of 17 species within higher elevation transects while the lower elevation transects had a total of 24 species. Low Elevations had an average of eight species per transect and high elevations had an average of 5.67 species per transect. After a t-Test resulting in a P-Value of 0.04, it was seen that there was a statistically significant greater amount of diversity within lower elevations versus high elevations. This data supports the conclusion that there is a greater amount of diversity within lower elevations in the Gus Fruh park.

Discussion:

The most likely reason it was found that lower elevations had a higher species diversity was because the lower elevations where some transects were located were closer to a creek, which is an active flood-zone. This is because less trees were grown to maturity, leaving more room for an increased number of smaller saplings. However, this study was not testing for species diversity over proximity to water, and the transects weren't set up to test this. This means that even though the data may show a trend in the increase of plant diversity when the plant are closer to a water source, this does not necessarily correlate with elevation. Another plausible explanation is that there wasn't enough difference in elevation to accurately get results.

Evergreen Sumac was more abundant in high elevation because Evergreen Sumac prefers dry soil (Native Plant Database). Since low elevations were prone to flooding and were adjacent to a water source, Evergreen Sumac was not as prevalent. Plateau Live Oak also prefers dry soil, explaining how it is only present within the high elevation transects (Native Plant Database). Sugar Hackberry requires a large amount of water which is present within the lower transects, and not the higher transects (Native Plant Database). This explains how Sugar Hackberry is only present within the lower elevation transects.

As mentioned in the introduction, a study by R. H. Whittaker, Cornell University, and W. A. Niering, Connecticut College, looked at the diversity of woody plants along an elevation gradient in the Santa Catalina Mountains, starting at 760 meters and going all the way up to 2740 meters above sea level. Even though they found that higher land elevations have an increase in diversity in number of tree species (at 2720 meters there were 6 different tree varieties and at of 1310 meters elevation there were 3 different tree species), their elevation difference was much greater than in this study, making it

ludicrous to assume the results from their study would be mirrored in this project. The lack in an extreme elevation difference explains the lack of difference in numbers of individuals between the high and low elevation transects.

This can also be seen in Yu Hua of the International Institute for Earth System Science in Nanjing University's study of the plant distribution along the elevation gradient in the Hubei Province, China using published elevation range data from Zheng of the Technology Press where contemporary flora of spermatophyte plant species were studied. Species richness occurred in the elevation range from 800 meters to 1400 meters with 1000 meters having the greatest species richness, it accounting for 52% of the species richness within the Hubei Province. Originally it was assumed that the data could once again be applied to this project, but this study was taken over 600 meters instead of about 50. The elevation gradient can be applied to large elevation changes, not small ones, which explains the almost equal numbers of individuals between the low and high elevation transects.

In a study conducted by J. V. Ward, K. Tockner, D. B. Arscott, and C. Claret showed that there was an increased plant diversity in areas of a river that flood more. Areas with constrained headwaters, ie the source of the river, were found to have the least diversity, scoring a .4 on the Shannon diversity index. Comparatively, meandering floodplains, the type of area the study looked at, had significantly higher score with a 1.25 on the Shannon diversity index. Meaning that areas that more commonly flood, have a higher number of plant diversity.

In the original study, it was found that there was an increase in elevation created a higher species diversity, but the study that the study had been based on had tested their experiment over thousands of meters. Meaning that for us to actually test this, the study would need a greater scale of elevation.

If the study was redone, it would be necessary try and take into account the proximity to water when setting transects and researching other articles. The scale of the experiment is too small to accurately research whether elevation has any significant effect on woody plant diversity, so if the study could have been changed it would be better to test for other variables like proximity to water. If another student was looking to study in the Gus Fruh park, it is recommend that they understand the importance water has on plant diversity in the park.

Bibliography:

Bhattarai, Khem Raj, and Ole R. Vetaas. "Variation in Plant Species Richness of Different Life

Forms along a Subtropical Elevation Gradient in the Himalayas, East Nepal." *Global Ecology and Biogeography Global Ecol Biogeography* 12.4 (2003): 327-40. *Wiley Online Library*. Web. 23 Feb. 2016.

Hua, Yu. *Distribution of Plant Species Richness along Elevation Gradient in Hubei Province,*

China. Diss. Nanjing U, 2003. Nanjing: International Institute for Earth System Science, Nanjing U, 2003. Print.

"NPIN: Native Plant Database." *Lady Bird Johnson Wildflower Center*. The University of Texas,

12 Aug. 2015. Web. 17 May 2016.

Ward, J. V., K. Tockner, D. B. Arscott, and C. Clarette. "Riverine Landscape Diversity." Diss.

2002. *Freshwater Biology* 47.4 (2002): 517-39. Print.

Whittaker, R. H., and W. A. Niering. "Vegetation of the Santa Catalina Mountains, Arizona. V.

Biomass, Production, and Diversity along the Elevation Gradient." *Ecology* 56.4 (1975): 771. *JSTOR [JSTOR]*. Web. 23 Feb. 2016.

Effect of Elevation on Woody Plant Diversity and Abundance at St. Edward's Park

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Abstract:

In this study done at St. Edward's Park in Austin, TX, plant biodiversity data was collected at low (<213 m), medium (213-234 m), and high (>234 m) elevations attempting to illustrate the effect of elevation on plant biodiversity. It was hypothesized that the higher and lower elevations would hold less biodiversity than the middle elevation. Three transects were laid out at the different elevations and data was collected by walking along the transect and taking note of the intercept length and location of plant species that were positioned directly above the transect. It was found that the low and high elevations held the most biodiversity, with the high elevation data set containing 9 different species, and the lower elevation contained 7 different species, while the middle elevations contained the least amount of biodiversity, with only 3 species.

Carly Smith
St. Edward's Park
Woody Plants

Introduction

Purpose: The purpose of this project is to determine the effect of elevation on woody plant species at St. Edward's Park.

Hypothesis: The diversity of woody plants will peak at intermediate elevations.

Site Description:

Location: St. Edward's park is located in northwest Austin, and it is bordered to the east by Spicewood Springs Rd. It is 3.5 km northwest of the intersection of Capital of Texas Highway and Spicewood Springs Rd.

Size and Shape: St. Edward's park covers 32.375 hectares, and it is shaped roughly like a longhorn with the horns along Spicewood Springs Rd. and the head protruding of to the southwest.

Topography: To the east of Bull creek, the park is relatively flat, with a minimum elevation of 200 meters, and to the west, it is hilly, with a maximum elevation of 275 meters. There is a cliff approximately 17 meters in elevation directly above and to the southwest of the creek.

Geology: St. Edward's Park lies on the Glen Rose Formation with limestone and dolomite, and also the Edward's Formation with limestone and dolomite and the Walnut Formation is limestone and marl, all from the lower Cretaceous period. The strata are relatively flat.
Areal Extent and General Type of Vegetation: The park consists of approximately 20% grassland, with lots of blue stem grass and *Gaillardia pulchella*, and 80% woodlands, mostly comprised of Ashe Juniper trees.

Availability of water: Bull creek runs through the park at a medium speed, to the west of Spicewood Springs Road, northeast to southwest, and it bends approximately halfway through the park and turns to the southeast. The creek crosses paths with Spicewood Springs Road multiple times north and south of the park at various low water crossings. There is evidence of

flooding seen by erosion and debris about 3 meters above the current level of the creek. The creek is about 2 meters deep in the deepest parts, and less than 10 cm in other parts. The creek contains a few small waterfalls, no more than 1.5 meters tall.

Proximity to Urban or Industrial Areas: St. Edward's park is not in close proximity to any major industrial areas. The Great Hills neighborhood is approximately 1 km to the east of the center of the park.

History: The City of Austin bought this preserve in 1987 from a group of biology students at St. Edward's University who were doing research here. The area has never been developed. The volunteer group, Bull Creek Foundation, was formed in 1994, and one of their primary focuses is to preserve the area near Bull Creek, especially in areas around St. Edward's Park.

Design of Study:
Three 50 m transects will be set out in St. Edward's park in the following manner:



Transect 1 will be along the Blue Trail just west of the southernmost part of the trail. The elevation here is approximately 200 m.
Transect 2 will be south of the creek on St. Edward's Trail. The elevation here is approximately 230 m
Transect 3 will be on the eastern edge of the park, also on St. Edward's Trail. The elevation here is approximately 260 m.

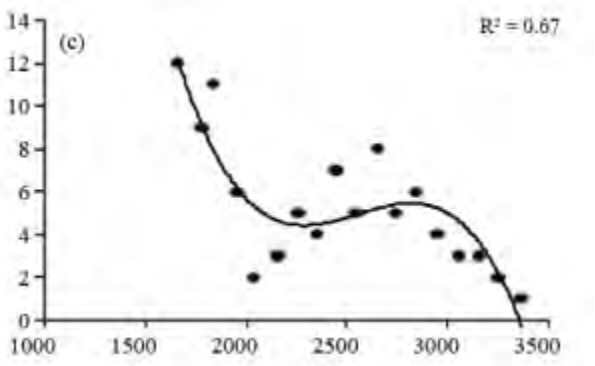
Background Research:
Parenthetical references?

According to one study done in Finland by ecology students at the University of Turku in which the species richness of vascular plants were compared to the altitude and local topography, The species richness of vascular plants was distributed in a unimodal fashion (Bruun 4) In an area that they surveyed with a minimum elevation of 0 m and a maximum elevation of 1200 m, the maximum species richness was found at approximately 500 m. Additionally, in another area they surveyed with an elevation range from 0 - 600 m, the maximum species richness was found at approximately 300 m. (Bruun 9)

In a study done in Hubei province, China by Yu Hua concerning the distribution of plant species richness in regards to elevation, it was also found that the maximum species richness occurred at intermediate altitudes. (Hua 5) The area surveyed had an elevation range from 800 to 1400 m, and the maximum species richness was found at 1000 m. A possible explanation for this pattern is because most species flourish only in higher or lower elevations, but in the intermediate elevations, there is overlap, so both higher and lower elevation species inhabit the area. (Hua 7)

In addition, according to a study of the diversity and richness of plants in Pakistan, The patterns can be grouped into 4 categories: decreasing, low plateau, mid-range peak, and low plateau with a mid-range peak (Akhtar 2109). In this study, it was revealed that though the total plant diversity peaked at a mid-altitude range, the diversity of trees peaked at lower elevations, with an additional local maximum at mid-range altitudes (Akhtar 2110) (see figure 1)

Figure 1:



Materials

- Aerial map
- Topographic map
- Field guide/dichotomous key
- Notebook to record data

Procedure

1. Take notes on environmental conditions (weather, etc).
2. Go to St. Edward's park and set out the transect.
3. Walk along the transect and take note of each species of woody plant that hangs over the transect.
4. Record the intercept range and length of the part of the transect that is covered by the woody plant.

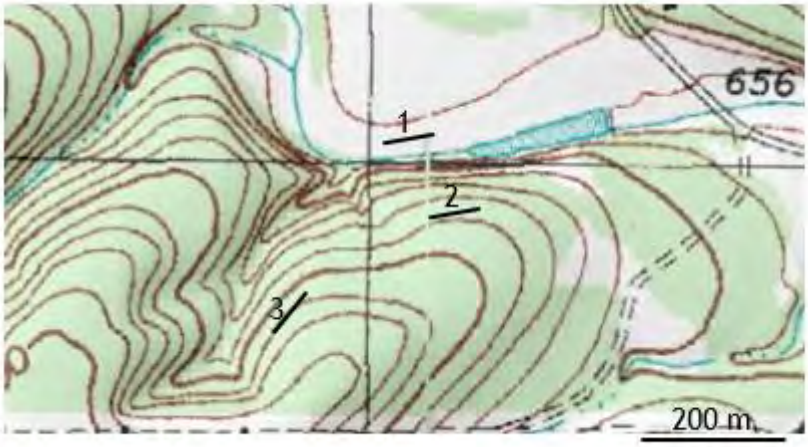
5. Collect samples of any new species observed and record the common name, Latin name, whether the leaf is simple or compound, leaf arrangement, bark description, and a description of the fruit or flower.
6. Calculate the Relative Density, Relative Dominance, Relative Frequency, and Importance Value for each data set.
7. Repeat steps 2-6 with the other transects.

Works Cited:

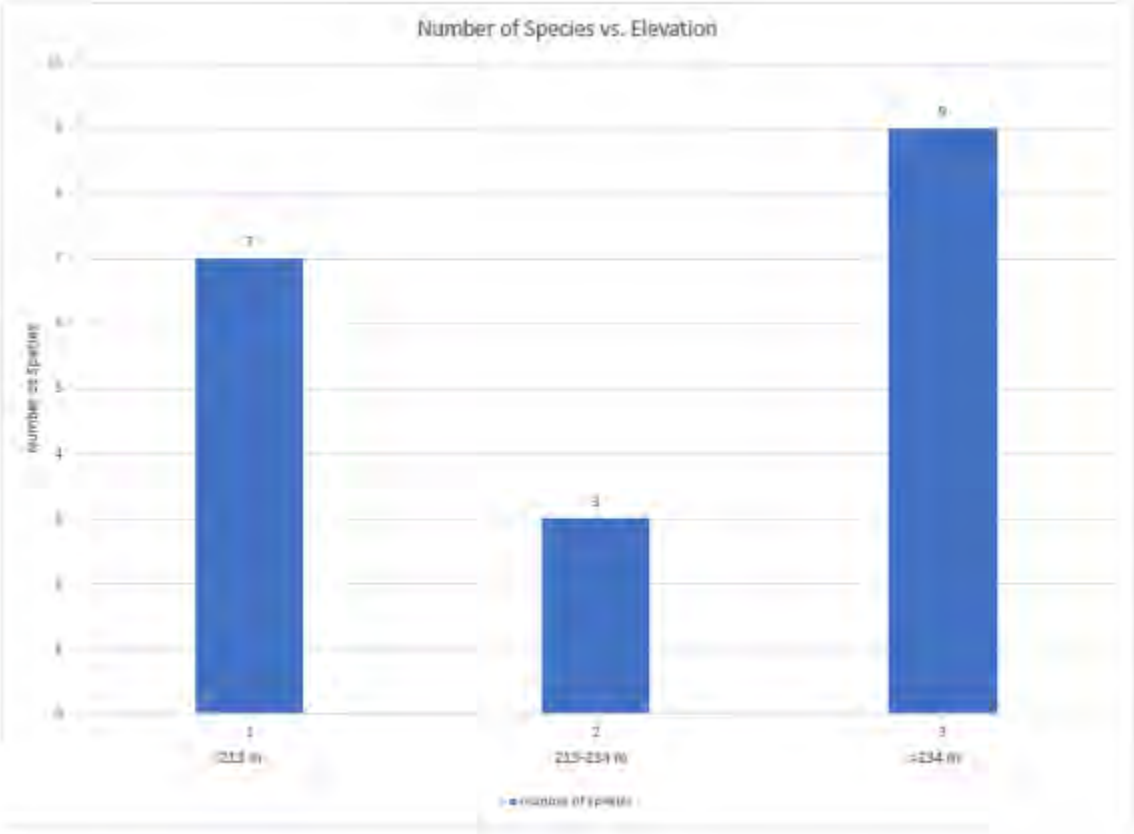
Yu, Hua. "Distribution of Vascular Plant Species Richness and Endemic Richness along the Elevation Gradient in Hubei Province, China." *International Institute for Earth System Science*. Web. 29 Feb. 2016.

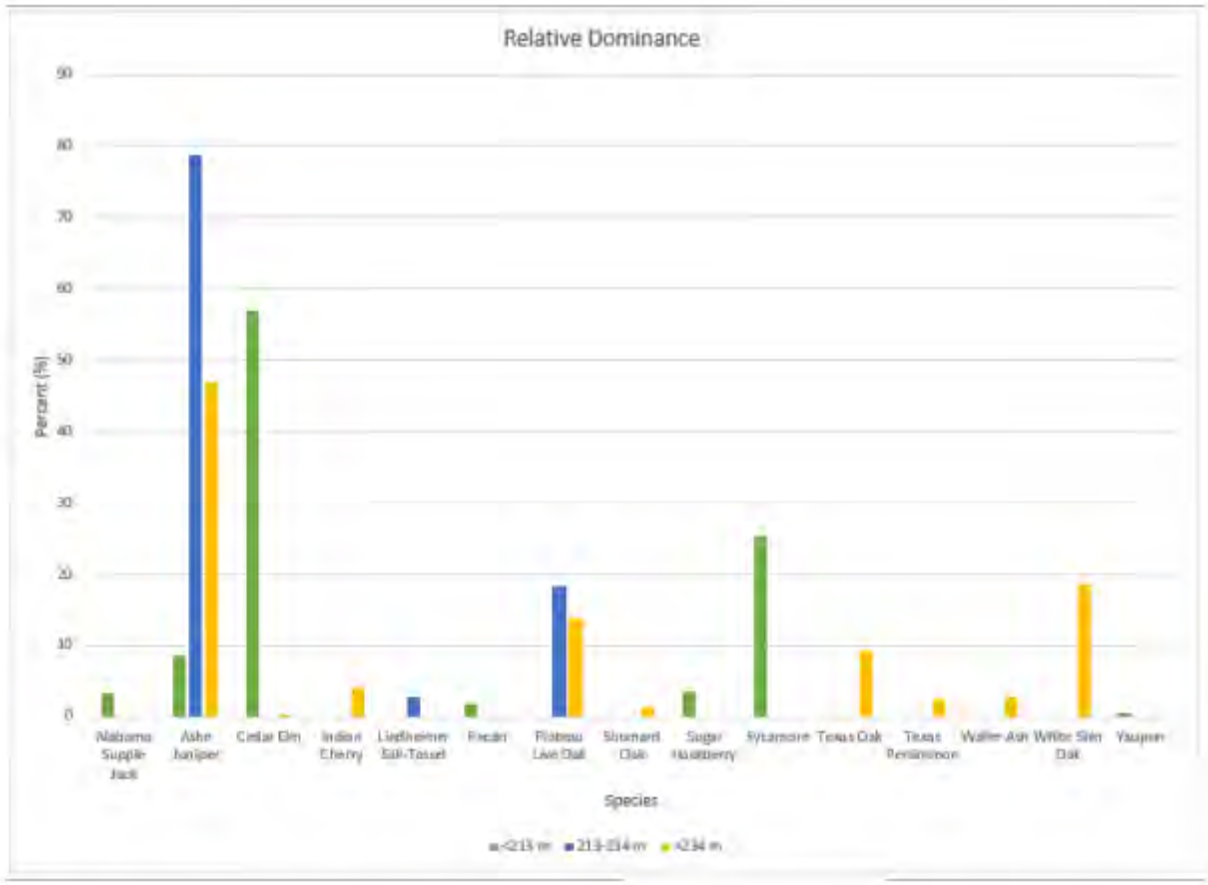
Bruun, Hans Henrik, Jon Moen, Risto Virtanen, and Lauri Oksanen. "Effects of Altitude and Topography on Species Richness of Vascular Plants, Bryophytes and Lichens in Alpine Communities." *ResearchGate*. Journal of Vegetation Science, n.d. Web. 29 Feb. 2016.

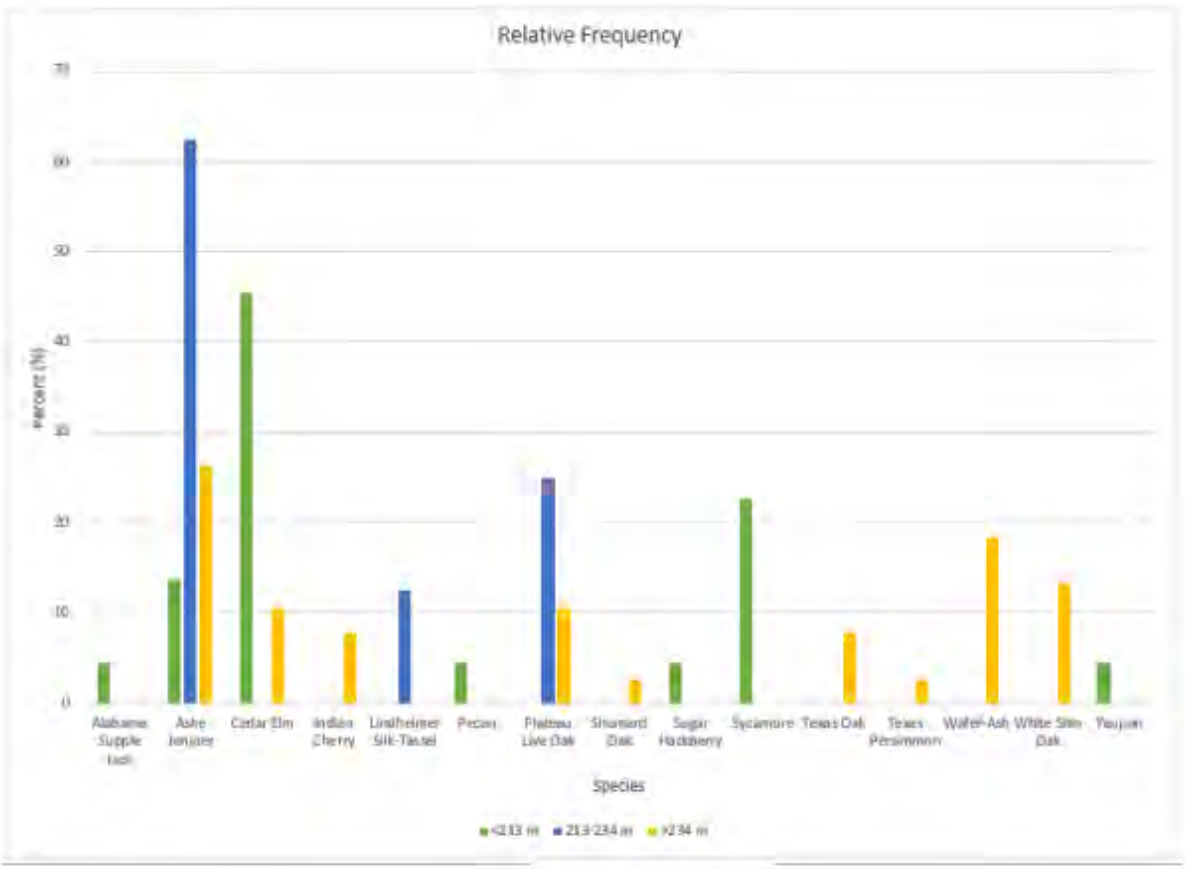
Akhtar, Naveed, and Erwin Bergmeier. *Species Richness, Alpha and Beta Diversity Of Trees, Shrubs, and Herbaceous Plants in the Woodlands of Swat, Pakistan.* n.d. Web. 29 Feb 2016.

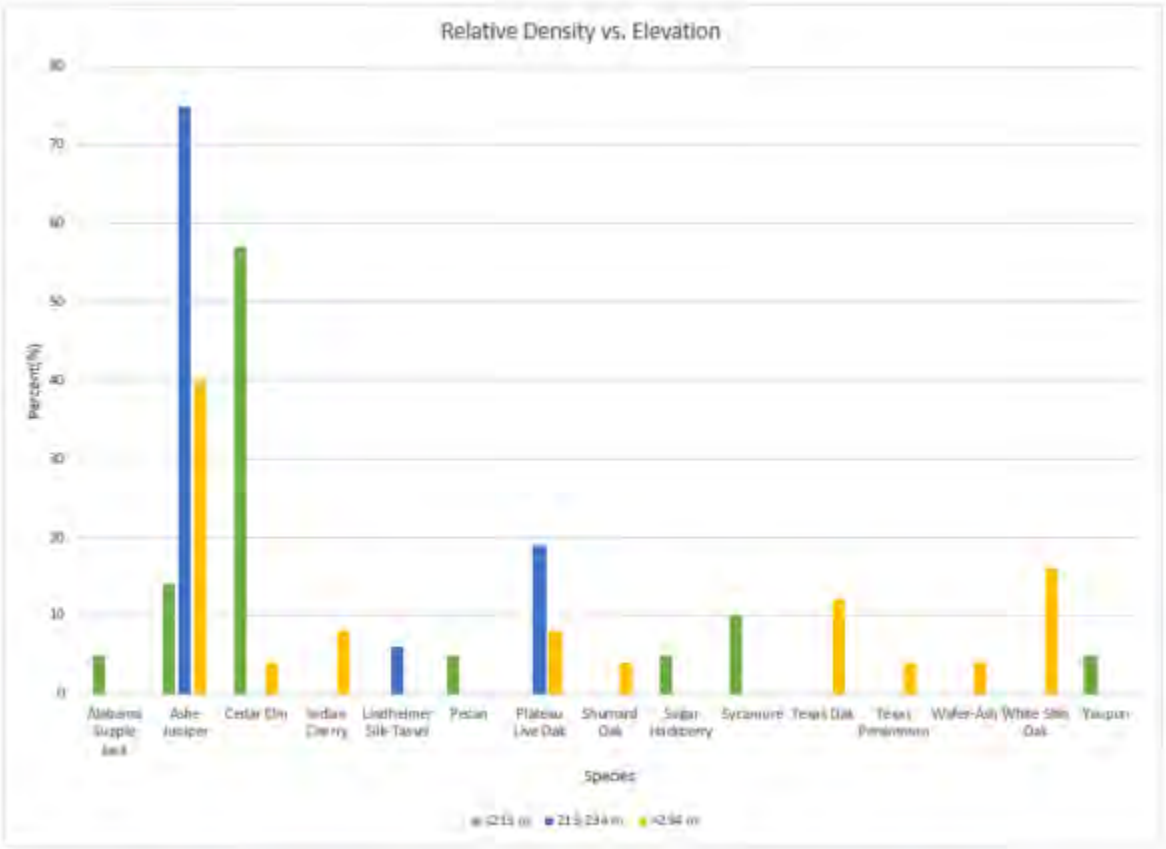


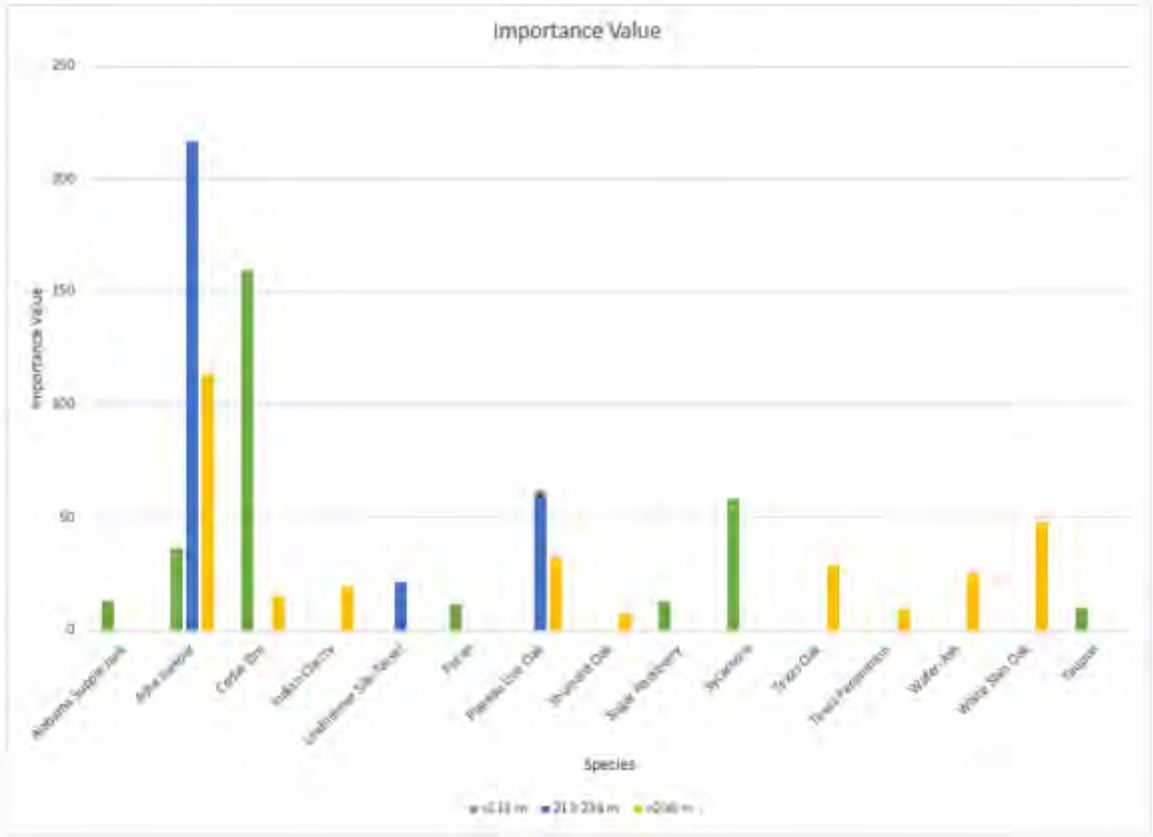
Contour interval: 20 ft.




Relative Dominance
Percent (%)
90
80
70
60
50
40
30
20
10
0
Alabama Supplejack
Ashe Juniper
Cedar Elm
Indian Cherry
Lindheimer Silk-Tassel
Pecan
Plateau Live Oak
Shumard Oak
Sugar Hackberry
Sycamore
Texas Oak
Texas Persimmon
Waller Ash
White Shin Oak
Yaupon
Species
<2.13 m
2.13-2.54 m
>2.54 m


Relative Frequency
Percent (%)
0
10
20
30
40
50
60
70
Alabama Supple Ash
Ashe Juniper
Cedar Elm
Indian Cherry
Lindheimer Silk-Tassel
Pecan
Plateau Live Oak
Shumard Oak
Sugar Hackberry
Sycamore
Texas Oak
Texas Persimmon
Wafer-Ash
White Shin Oak
Yaupon
Species
<2.13 m
2.13-2.34 m
>2.34 m


Relative Density vs. Elevation
80
70
60
50
40
30
20
10
0
Percent(%)
Alabama Supple Jack
Ashe Juniper
Cedar Elm
Indian Cherry
Lindheimer Silk Tassel
Pecan
Plateau Live Oak
Shumard Oak
Sugar Hackberry
Sycamore
Texas Oak
Texas Persimmon
Wafer-Ash
White Shin Oak
Yaupon
Species
<215 m
215-234 m
>234 m


Importance Value
250
200
150
100
50
0
Importance Value
Species

Conclusion

The data taken the diversity and frequency of woody plants in St. Edward's Park in northwest Austin at various altitudes does not support the hypothesis that there is more diversity in the plant species at medium elevations. In fact, the trend in the data is quite the opposite. The transect in the medium elevation, 213-243 m (700-800 ft.), only contained 3 different species of woody plant while the transect at the low elevation, under 213 m (700 ft.), contained 7 different species, and the transect at the high elevation, above 243 m (800 ft.), contained 9 different species. The high diversity in the low elevation could be due to the fact that it was in close proximity to water, and the high diversity in the high elevation could be due to a high number of woody plants that prosper in only high elevations.

In all transects, Ashe juniper is present, and it is the most abundant species recorded with an average importance value of 122. This is most likely because Ashe juniper thrives in droughts, therefore having fewer requirements to grow and prosper in the area[i]. According to a study done in conjunction with Texas A&M University, it was found that since Ashe Juniper could persevere through wildfires, droughts, and soil erosion, they would overgrow the weaker plants that were wiped out by the natural disaster, therefore increasing their spread across the area. The prominence of Ashe Juniper in the area could be due to a drought in the area several years ago.

Cedar elm was the species of most importance for the low altitude, and this could be because the data taken at the low elevation was taken in an area that was in very close

proximity to water, and was on an area with softer clay soil. According to the Northeastern Area State and Private Forestry, Cedar Elm is more likely to thrive in areas with abundant water and thick clay soils[ii]. It is also less likely to survive without access to water, thus dying out in the higher elevations during a drought and making space for the Ashe Juniper in areas that are not close to water (the mid-elevation and high-elevation data sets), while the Cedar Elm will prosper near the water (low elevation data set).

There is a relatively low amount of species overlap in the different elevations, with all species except Plateau Live Oak, Ashe Juniper, and Cedar Elm being present in only one of the data sets. This means that most species were somewhat isolated in their respective areas, and this could be limited by the reproductive methods of the plants. The pollen from the plants can only travel so far, and this could limit the extent of the population of the species[iii].

A problem in this study was the lack of multiple transects at each elevation range. Since there is only one data point for each grouping, the trends could be caused by any number of external factors like proximity to urban areas, proximity to water, or soil type. To improve the results, it would be beneficial to take more data at these similar altitudes.

[i] Smeins, F. E., and S. D. Fuhlendorf. "Texas Natural Resources Server."*Biology and Ecology of Ashe Juniper «*. Texas A&M University, n.d. Web. 17 May 2016.

[ii] Stransky, John J. "Ulmus Crassifolia Nutt." *Ulmus Crassifolia Nutt*. Northeastern Area State & Private Forestry, n.d. Web. 18 May 2016.

[iii] Hou, Yan, and Anru Lou. "Population Genetic Diversity and Structure of a Naturally Isolated Plant Species, *Rhodiola Dumulosa* (Crassulaceae)."*PLoS ONE*. Public Library of Science, n.d. Web. 18 May 2016.