Park Biodiversity Surveys

Gus Fruh Park

Emma Long Metropolitan Park

Bull Creek District Park

Liberal Arts and Science Academy Students

Instructor: David Walker

Fall 2024 – Spring 2025

Table of Contents

Gus Fruh Park Surveys **1-112**

Martinez, Dickinson-Sand, and Jones, Woody Plants 1-13

Roy, Venkatagiri, and Melillo, Woody Plants 14-24

Ervin, Kuranam, and Muller, Woody Plants 25-36

DiCarlo, DeLeon, and Tumolac, Northern Cardinal 37-53

Pai, Sharma, and Egler, Northern Cardinal 54-68

Tran, Garret, and Bracchini, Northern Cardinal 69-84

Cordova, Yan, and Yin, Arthropods 85-97

Vidal, Wu, and Zitkovic, Arthropods 98-112

Emma Long Metropolitan Park Survey **113-124**

Kassam and Stanley, Arthropods 113-124

Bull Creek Park Survey **125-138**

Casati, Gupta, and Shraga, Woody Plants 125-138

The Effect of Soil Grain Size on the Growth, Population and Diversity of Woody Plant Species in Gus Fruh Park, Southern United States of America

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Spring 2025

ABSTRACT: This study investigated the influence of soil grain size on woody plant diversity and abundance within Guh Fruh Park, in Austin, Texas, USA. The growth of plants on three different soils: Del Rio Shale, Tributary Terrace Deposits, and Edward Formation, were analyzed and collected through the line-intercept transect method, with three transect lines dedicated to each soil type. The finest grained soil was the Edwards Formation Limestone, and the courtesy grained soil was the Tributary Terrace Deposits. Contrary to the hypothesis that soils consisting of larger-grained particles will have a higher diversity and abundance of plant species, the data trended toward higher woody plant species richness and abundance being found on finer soils, like the Edwards Formation. This soil averaged 5.33 species and 22.67 plants per transect, while Tributary Terrace Deposits averaged only 3.33 species and 19 plants. However, these trends may not be statistically different as analysis by ANOVA tests that compared averages in plant diversity found no statistical difference ($p = 0.29$). Several additional variables, such as elevation, slope, and water availability possibly skewed the results. Repeated experiments should increase sample size, and reduce the impact of additional variables.

Introduction

Purpose

The purpose of this experiment is to analyze the effects of different soil types on the population and diversity of woody plants in Gus Fruh Park, Austin, Texas. This study will be focused on the Edwards Formation, Del Rio Clay, and Tributary Terrace Deposits.

Hypothesis

In Gus Fruh Park, areas upon bedrock made up of larger-grained particles will have a higher diversity of plant species because rougher soils tend to yield better growth of woody plants.

Site Description

Location:
Gus Fruh is located in Southwest Austin. The park's most eastern point borders Highway 360. The park is approximately 1 kilometer north of the intersection between Lamar Blvd. and Ben White Blvd. Gus Fruh borders the east edge of the Barton Hills Neighborhood. It is also approximately 3 miles southwest of the Capital. The park's western side runs alongside Barton Creek (Google Earth 2025).

Areal Extent:
The area of Gus Fruh is approximately 103.6 hectares of land. It consists of a cylindrical/oval shape at the base of the park, north of that, a rectangular shape, and at the top of that, a circular shape (Google Earth 2025).

Topography:
Topographic low- 146m
Topographic high- 213m
Topographic relief- 67m
There is a significant topographic relief between the highest points in the park and the creek. From the Barton Creek Greenbelt Trailhead, the elevation changes about 12m vertically over 100m horizontally. On the east side of the creek, there is a cliff about 30m higher than the creek bed. This increase in elevation occurs over just 10m of horizontal distance.
(Topo map explorer 2025)

Geology:
Edwards Formation and Georgetown Formation limestones, formed in the Cretaceous period, are abundant around the creek bed and cliffside. The vast majority of the park lies upon these

bedrocks. Tributary Terrace deposits and Alluvium, formed in the Quaternary period, fill the empty creek bed. A small portion of the park, mostly at higher elevations along the eastern edge, is comprised of Del Rio Clay, which came from the Cretaceous period. Many boulders and rock formations surround the creekbed, likely from erosion on the cliffs. The park is on the Edwards Aquifer recharge zone (USGS 1992).

Vegetation:
Roughly 95% of Gus Fruh Park is woodland, while the remaining 5% is creekbed and urbanized land (Google Earth 2025). A survey conducted on 2/17/2025 found that the vegetation found plant species included the Ashe Juniper (Juniperus ashei), the Evergreen Sumac (Rhus virens), and the Texas Live Oak (Quercus fusiformis).

Water Availability:
A survey conducted on 2/17/25 found that the water level in Barton Creek was 0 meters, as it had completely dried up. There was evidence that water had recently filled the creek before the study because dead plants filled the creekbed. There was evidence of flooding up to 6m above the creek bed due to the presence of bent land plants at that elevation level. There was also what appeared to be a creekbank at a corresponding elevation, further suggesting that water levels had been historically higher.

Urbanization:
The urbanization in Gus Fruh is moderate and includes picnic tables, man-made trails, trail signs, and trash cans. The nearest house to the creek is about 90 meters away. The closest street to the creek is about 100 meters away (Google Earth 2025).

History:
The Barton Creek area has a long history of pollution and overdevelopment, combated by climate activists from the 1960s through the 1990s (Barton Creek Time Stream). Mopac was completed in 1971 (Barton Creek Time Stream), and Highway 360 was completed around 1981 (Historical Aerials). In 1980, Gus Fruh was set aside for preservation (Austin City Records). Urbanization in the Gus Fruh area, such as hike and bike trails and houses, was built around 1973 (Historical Aerials).

Research Plan

Design of Study

This experiment utilizes the line-intercept method of data collection with fifty-meter transects. There will be nine transects, each only sampled once. Three transects will be placed on each type of bedrock and will be spaced far apart to eliminate random error. The map of the transect locations is included below. The transects on Del Rio Clay are labeled in red. The

transects on the Edwards Formation are labeled in black. The transects on Tributary Terrace Deposits are labeled in blue. Placing the transects on the different bedrocks will answer the question of which soil types are best for woody plant growth and diversity.



Background Information

The role of topographic and soil factors on woody plant encroachment in mountainous rangelands: A mini literature review

This source is an experiment on the role of topographic and soil factors on woody plants in mountainous regions. The study explains how soil type generally affects woody plants and describes how coarse-textured soils promote the solid growth of woody plants, while finer-textured soils diminish it (Kapos V). This supports the hypothesis that in Gus Fruh Park, areas with coarser-grained bedrock will have higher diversity in woody-plant species. The coarsest soil included in this study is the Tributary Terrace Deposits.

How do root and soil characteristics affect the erosion-reducing potential of plant species?

This source analyzes how plant roots in sandy soils compare to those in sandy loam and silt loam soils when it comes to erosion. It also compares the moisture and texture of the soil. The experiment was conducted with six field plots (length = 1.15 m, width = 1.00 m, and soil depth = 0.15 m) that were installed in Spring 2015 near the University Campus, Heverlee. The field plots were filled with sandy topsoil" (Vannoppen). The results of this study show us that plant roots are extremely efficient in reducing erosion rates in sandy soil. The soil detachment rates are 20% less in sandy soil than in other soil.

Of the three soil types present in the study on grain size's effect on plant growth in Gus Fruh, the one with the largest grain, and is, therefore, most similar to sand, is Tributary Terrace Deposits. This suggests that a similar effect may occur in this soil. Erosion significantly reduces fertility in soils, which reduces the growth of plants (Sulaeman, Westhoff). Assuming that the reduction in erosion at least somewhat applies to Tributary Terrace Deposits, this further supports the claim that the larger-grained soils in Gus Fruh will support better plant growth and diversity.

Exploring effects of geologic substrate on plant growth and fitness in the White Mountains, Eastern California

This source goes over the impact of soils from different geologic substrates on plant fitness and health. They examined the "physical and chemical properties of dolomite, shale, and granite-derived soils and their effects on plant growth and fitness through a plant survey and germination bioassay" (Amatya et al). This study was conducted at Crooked Creek Research Station in the White Mountains, California at roughly 3,000 meters in elevation in August 2021. Shale-derived soils seemed to provide a better habitat for both grass seeds and E. clokeyi plants than both granite and dolomite. On shale, E. clokeyi had a larger disc size on bloomed flowers, as well as a longer maximum leaf length across all plants. Granite slurries resulted in the highest germination rates as well as a marginally longer maximum stem length of germinants compared to the control. It is said that E. kingii plants were negatively affected by dolomite while responding well to granite and moderately well to shale. E. clokeyi did not show a strong dislike of dolomite but thrived on shale soils and tended to have lower fitness on granite soils. Differences in responses to substrate could be due to a plant's adaptations and phenology. Ultimately, it says that support for edaphic control in the White Mountains. All three geologic substrates affected plant growth and fitness differently. While there was no overall preferred substrate for both flowering plants, shale and granite soils generally fostered higher germination rates and plants with overall greater fitness. This supports the claim that the larger-grained soils in Gus Fruh will support better plant growth and diversity, as dolomite is a type of limestone, and shale is primarily composed of clay. The shale in the study in California found that shale did better at growing plants than dolomite did, and therefore it isn't unlikely that the larger-grained Del Rio clay in Gus Fruh will outperform the smaller-grained Edwards Formation limestone.

Materials

- 50-meter transect tapes
- Project notebook with data collection tables
- Pen
- Tape
- Flashlight
- Geologic map
- Gloves
- Phone Camera
- Phone GPS
- Native and Naturalized Woody Plants of Austin and the Hill Country by Brother Daniel Lynch.

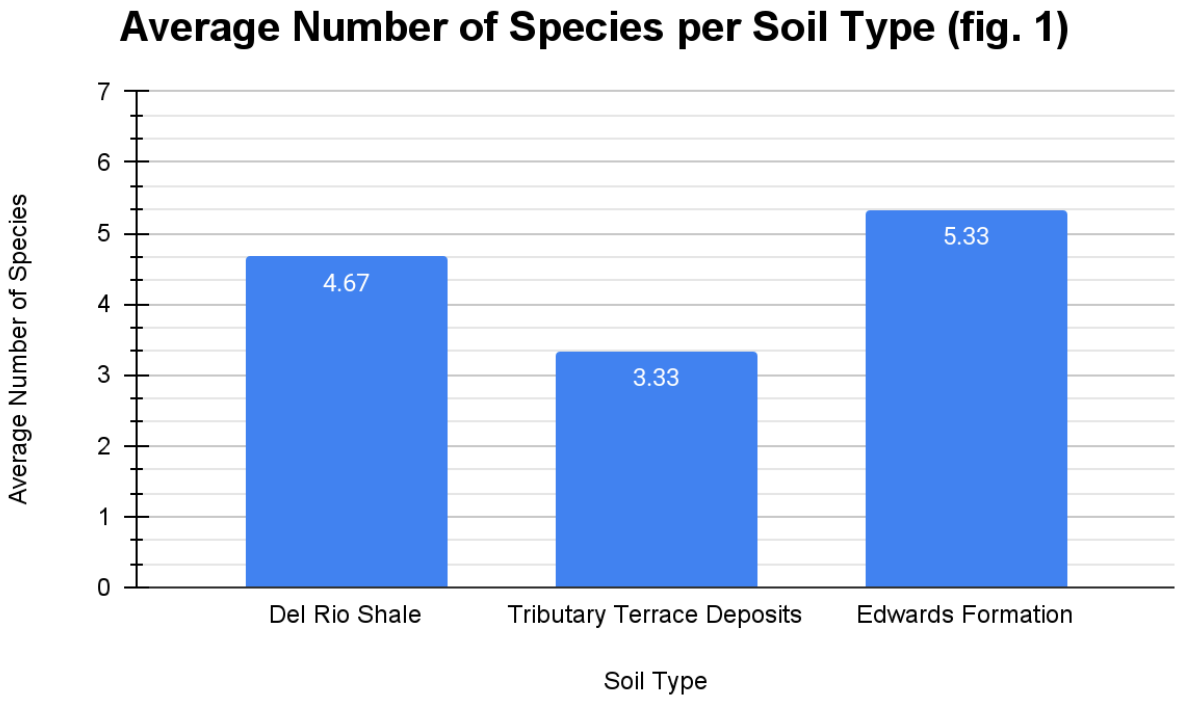
Procedure

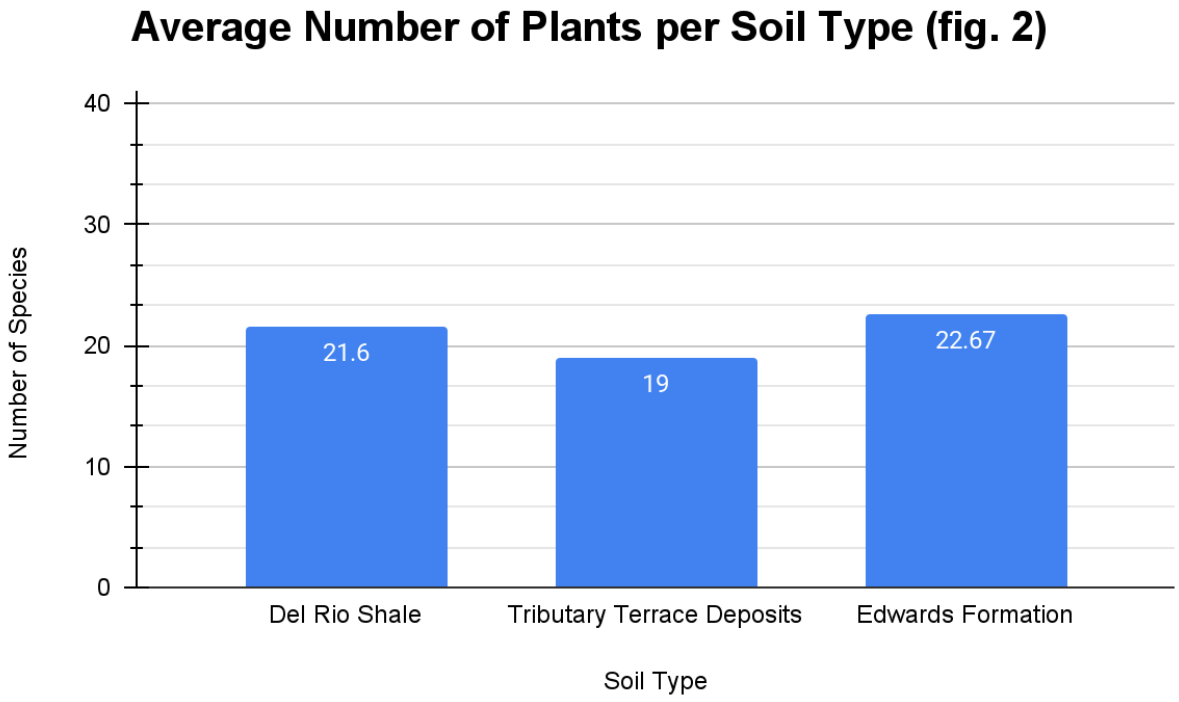
1. Obtain or draw a data collection table in which transect number, date and time, transect length (which will be 50 meters), and weather information can be recorded.
2. Go to the precise location of the transect, using GPS to verify your location.
3. Extend the transect tape over the correct location, making sure it is taut.
4. Walk along the tape and record the species that have direct overhangs. Record the name of the species or label it as an unknown to be identified at a later date (use the same naming convention for other unknown plants of the same species). Write down the range of the plant over the tape, stopping at the end of the plant, not as soon as overlap occurs with another. Record which intervals the plant falls into, which are 5-meter-long sections starting from zero meters.
5. Tape a representative leaf sample into the project notebook, unless the plant is Poison Ivy or a succulent, in which case a photograph of the plant should be printed out and taped into the notebook. Write down the leaf type and arrangement. Take notes on the bark of the plant and descriptions of any reproductive tissues that are visible. Record the type of woody plant encountered (such as a vine, tree, or shrub), as well as any other distinctive information.
6. To complete the analysis, first, key the unknown species using Native and Naturalized Woody Plants of Austin and the Hill Country (Lynch). Write down each step followed, marking the less confident choices so that if the plant is incorrectly identified, it is easy to find the mistake. When the plant shown in the book matches the sample in the notebook, write down the common and scientific name, underlining the latter. Cross out all uses of the word unknown, and write the common name underneath.
7. Analyze the statistics of each plant by completing four calculations. Calculate relative density by taking the total number of individuals of one species, dividing it by the total number of all individuals, and multiplying by 100. Calculate relative dominance by

taking the total intercept of one species, dividing it by the total intercept length of all species, and multiplying by 100. Calculate the relative frequency by taking the total number of intervals of one species, dividing it by the total number of intervals of all species, and multiplying by 100. Then, calculate the importance value by adding up all three numbers: the relative density, the relative dominance, and the relative frequency.

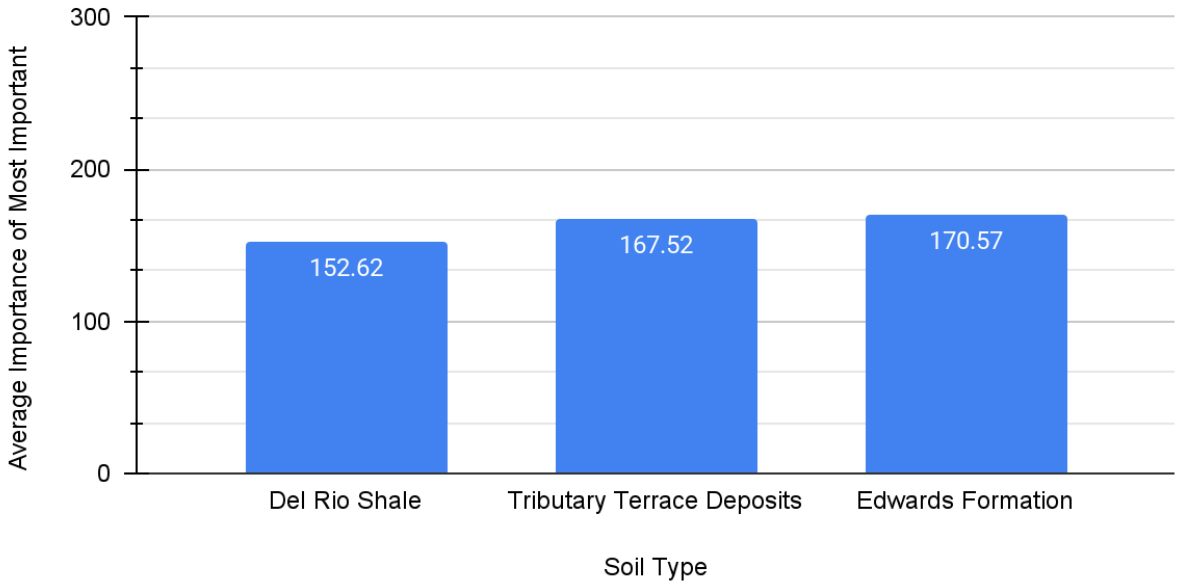
Conclusion

Results

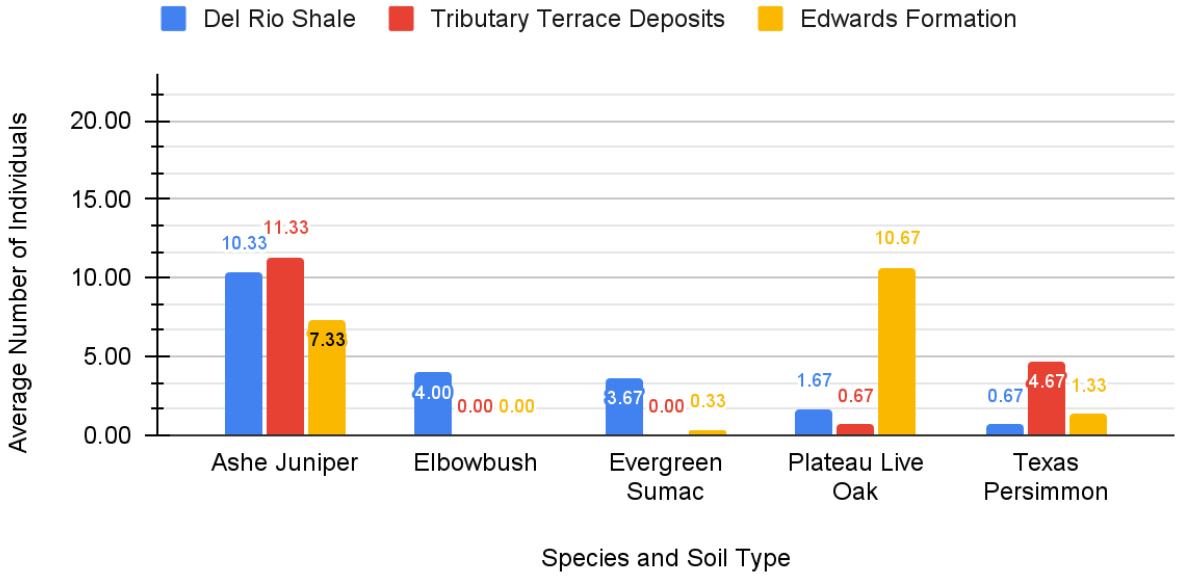




Average Importance of Most Important Species per Soil Type (fig. 3)



Average Number of each Plant Species per Soil Type (5 Most Abundant Species) (fig. 4)



The average number of species on Del Rio Shale was found to be 4.67. The average on Tributary Terrace Deposits was 3.337, and the average on Edwards Formation was 5.33 (fig. 1).

Despite the presence of a visible trend of higher diversity on finer soils, an ANOVA test comparing the results found no statistical significance in the differences ($p = 0.2856$).

On average, 21.6 plants were found on Del Rio Shale, and average abundance values on Tributary Terrace Deposits and Edwards Formation were found to be 19 and 22.67 respectively (fig. 2). This suggests a trend of higher abundance of plants being found on finer soils.

On average, the most important species on Del Rio Shale has an importance value of 152.62, the most important species on Tributary Terrace deposits had an importance value of 167.52, and the most important species on Edwards Formation Limestone had an importance value of 170.57 (fig. 3).

Elbowbush was only found on Del Rio Shale with an average abundance value of 4.00. Evergreen Sumac was found on Del Rio Shale with an average abundance of 3.67, and also on the Edwards Formation with an average abundance of 0.33. Ashe Juniper was found in all 3 soil types, with average abundances 10.33 (Del Rio Shale), 11.33 (Tributary Terrace Deposits), and 7.33 (Edwards Formation). Plateau Live Oak was most abundant on the Edwards Formation, with an average of 10.67, compared to 1.67 on Del Rio Shale and 0.67 on Tributary Terrace Deposits. Texas Persimmon was found primarily on Tributary Terrace Deposits with an average abundance of 4.67, but also on Del Rio Shale and Edwards Formation with average abundance values of 0.67 and 1.33 respectively (fig. 4). The differences between abundance averages on different soils of both Plateau Live Oak and Elbow Bush were compared. ANOVA tests found no statistically significant difference between the averages of either the Plateau Live Oak ($p = 0.18$) or the Elbow Bush ($p = 0.2577$).

Discussion

The hypothesis that this study was based on was that in Gus Fruh Park, areas upon bedrock made up of larger-grained particles will have a higher diversity of plant species because rougher soils tend to yield better growth of woody plants

The results of the experiment did not find evidence for this hypothesis, in fact, it somewhat suggested the opposite, that finer grained soils had higher diversity and abundance. In both measures of abundance and diversity, transects on Edwards Formation limestone (the finest grained soil) had the highest average figures, and transects on Tributary Terrace Deposits (the coarsest grained soil) had the lowest average figures. This suggests a flaw in the hypothesis, in that either it was false, or failed to account for a wide range of independent variables that weighed upon the results of the experiment. There were large elevation changes throughout the park, as well as changes in slope. Distance from water and how well each soil type preserved water also varied. Data was also collected at different times of year, which made plants found on earlier transects more difficult to identify as researchers struggled to find representative leaf samples in winter months.

If there was more time allotted for experimentation, more data could have been collected for evidence. Only 9 transects were used as data, thus a very minimal amount of evidence was collected. This resulted in the differences being statistically insignificant for data like species diversity ($p = 0.2856$) or abundance differences for specific species (e.g., Plateau Live Oak, $p = 0.18$, Elbow Bush, $p = 0.2577$). A future experiment would preferably take significantly more data.

Another potential flaw in the study that may reduce the usefulness of the data is that soil type is a very broad and complex variable. Though grain size is important, pH levels, moisture content, and density also impact how plants grow in a given soil. A better experiment would seek to reduce the variability of these alternative features. A multi-year study could also be conducted to account for changes in diversity and abundance over time. Additionally, a similar study could be conducted

A study was conducted on the adverse effects of high soil compaction on woody plant growth and yield. From the data conducted (Kozlowski, T. T. et al. 1999), the researchers found that highly compacted soil adversely affects the growth of plants by physical soil changes and plant physiological changes. Experiments of seedlings placed in highly compacted soil, demonstrated that the growth of the seedling by inhibiting seed germination and seedling growth by inducing seedling mortality. The study also found that seedlings placed on skid trails, where highly compacted soil is found (due to urbanization), result in a 40% decrease of those seedlings' growth. Highly packed soil could have skewed the data taken in the Gus Fruh experiment on soil density because there were varying levels of urbanization throughout the Gus Fruh park, with particularly high amounts near to the transects taken on Del Rio Shale.

A study was conducted on the difference in elevation and slopes in correspondence with the growth and diversity of woody plants. In the study, researchers surveyed the distribution of families, genera and species of woody plants in different elevations/slopes (Depression, Lower slope, Middle slope, and High slope). The researchers found that in general as the slope increased so did the diversity and growth of more woody plants. The results yielded that the lower slope had 105 species from 83 genera and 43 families while the high slope results yielded 149 species, 112 genera and 50 families (Hu, Gang, et al. 2023). This connects to the Gus Fruh experiment, as it proves slope is an additional independent variable that affects plant diversity and growth. The Gus Fruh data had varying levels of elevation, where in particular the transects on the Edwards Formation had the most severe slopes, and coincidentally also had higher diversity and abundance of species than other soil types.

A study was conducted which analyzed the influence that altitude has on the growth of morphological, anatomical, and wood density properties of the salpings of the Abies nordmanniana, a tree species in Turkey. Two altitude levels were chosen, 795m for low and 1350m for high. The study focused on Trojan fir saplings, examining their morphological (e.g., stem height, diameter, taper), anatomical (e.g., wood cell structure, tracheid dimensions), and wood density properties at different elevations (Özden, 2020). The study concludes that “the growth and development of fir saplings were better when they were grown at high-altitude than low-altitude.” In the Gus Fruh study, there were varying levels of elevation throughout the park, as Del Rio Shale had the highest elevation and Tributary Terrace Deposits had the lowest. Therefore, the independent variable of elevation could have further skewed the results.

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The Effect of Water Availability on Plant Abundance and Diversity

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Fall 2024

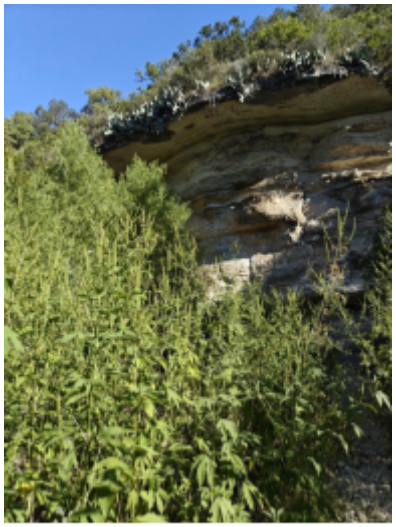
ABSTRACT: The purpose of this study was to determine the effect of water availability on plant abundance and diversity. The study was conducted in Gus Fruh park in Austin, Texas. Nine different 50m transects were placed in 3 different areas, close middle and far. On each transect, the species, length, and location of each plant was recorded using the line intercept method. A 50m transect measuring tape was laid and each plant which overhung the measuring tape was recorded. This study found that on average, close to water transects contained 10 different species, while medium and far transects contained 5.66 and 5.33 respectively. This suggests that water availability has an effect on plant diversity. This study also found that on average, close to water transects contained 55.33 woody plants, while medium and far transects contained 34.66 and 28.66 respectively. This suggests that water availability has an effect on plant abundance and diversity.

Introduction

Purpose
The project will deal with how the distance of plants from water affects the composition of plants at Gus Fruh park in Austin Texas. Gus Fruh park is located at a bend in Barton Creek with the land at the center being the farthest from water (USGS).

Hypothesis
Plant species near the water will have a greater species diversity and abundance than those farther away from water because species biodiversity and abundance generally increases when closer to water (Ferreira et. al).

Site Description
Location
Gus Fruh is located in southwest Austin directly east of the 360 and Loop 1 intersection (Google Maps, 2024). The Park is 3.19 km southwest of Zilker Metropolitan Park.


Cliff in Gus Fruh Park

Areal Extent
The park is 180 hectares with the western side defined by loop 360, northern side defined by loop 1, the southern side defined by the Barton Hills neighborhood, and the eastern side of the park is along the banks of Barton Creek (Google Maps, 2024).

Topography
There is a sizable difference in elevation throughout the park, the minimum elevation is roughly 140.2 meters, and the maximum elevation is roughly 237.7 meters. Near the crossing of the creek from the 360 entrance, there is a large cliff roughly 60.96 m high (USGS).

Geology
The geologic formations in Gus Fruh are fredericksburg group undivided, del rio clay formations, georgetown formation, and alluvium. Alluvium contains smooth pebbles with sand and gravel mixed in deposited during the quaternary period. Del rio clay is dark clay forming layered rocks with mega fossils of pelecypods. The georgetown formation is mostly limestone with some marl also containing marine mega fossils. The Fredericksburg group undivided edwards limestone which is exposed on trails at the park leading to the aquifer (USGS).


Alluvium found in the creek bed of Barton Creek.

Vegetation
The vegetation in the park is mainly small shrubs and some conifers, roughly 95% woodland and 5% grassland. Examples of

plants found here are Sugar hackberry, Oregon ash, Eggleaf silktassel, and Snow on the mountain.

Water Availability

Barton Creek runs through the park. The creek bed was dry up at the time of visit in September, 2024. Multiple creeks normally run through Gus Fruh. There is usually a large area dedicated to a pool, but it is also dry. Gray, sandy soil/clay, likely chalk-taylor clay, at the bottom of the creek bed.

Urbanization

The park is surrounded by a neighborhood, roads, and shopping centers. Trails have been paved throughout the park, and some stone rocks have been placed to be used as steps. Fences have been placed in areas of steep decline.

History

Gus Fruh was acquired in 1980, 1986, and 1992 by the City of Austin. Before it was acquired it was likely used as cattle ranching in the 1940's and by the 1950's was almost abandoned and had a telephone line running through it (*Historic Aerials*, n.d.).

This section of the Barton Creek Greenbelt was named after Dr. Edward Gus Fruh, a professor at the University of Texas at Austin for 12 years. Dr. Fruh served on the City of Austin's Environmental Board, and while doing so, he ensured that the water quality in Barton Creek met "swimming standards" (Slusher).

Research Plan

Design of Study

The study has nine total transects with 3 sets at different distances from the creek. The three transects in blue are along the creek bed within 40 m of the creek. These will receive high amounts of water due to their proximity to the creek. The three transects in orange are the intermediate data set. These are within 200m to the creek and may only receive water during heavy rains and flooding. The three transects in green are farther than 200m from the creek receiving none to minimal water from the creek. All nine transects utilize the line intercept method and are 50m in length.



An aerial view of the transects (Google Maps, 2024)

Background Information

This study was conducted by creating three 10m deep and 275m long transects. One was in a dry area, one was in a wet area, and one was in an intermediate area. The result they found was that "The driest/most heterogeneous transect had the lowest total species diversity, while the wettest/least heterogeneous transect showed the lowest beta-diversity." (Ferreira et. al) From this, they concluded that "Abundant PAW [Plant available water] in the top 4m of soil may favor

many species and increase species total diversity" (Ferreira et. al, 2009). This connects to our purpose of studying how plant composition and diversity changes based on how far away it is from water, as this study claims that dry areas have lower species diversity, while areas with PAW [Plant available water] favors many species and increases species diversity.

This study was conducted in the central Amazonian forests, between the Purus and Madeira Rivers in Central Amazonia. The study used eighty-eight 250 X 2 m plots placed along a 600-km transect, with different parts of the transect having a different amount of water availability based on their proximity to either river. The study concluded that "the hydrological conditions greatly affected the composition and biodiversity of the plants. There was a gradual change in species composition and abundance along the hydrological gradient, with there being greater abundance and biodiversity of plants in areas with more available water" (Moulatlet et al., 2014). This connects to our purpose of studying how plant composition and diversity changes based on how far away it is from water, as this study claims that drier areas have a lower abundance of species, with there being greater abundance and biodiversity of plants in areas with more water.

This study was conducted in the Okavango Delta in Botswana, the study used Vegetation sampling was conducted in four sites in 20 m × 10 m belted plots placed perpendicular to the river bank at 0–10 m, 10–20 m, 20–30 m, 30–40 m, and 40–50 m distance classes. At each site, 10–15 plots were sampled at each distance class. The study concluded that "The richness of the species was significantly higher at 0–10 m, as well as the composition and diversity of the plant species" (Tsheboeng, 2018). This connects to the purpose of studying how plant composition and diversity changes based on how far away it is from water, as this study claims that when plants are closer to a water source, the richness is significantly higher, as well as the composition and diversity of the plant species.

Materials

The materials for this study require a minimum of a project notebook**,** the woody plant field guide, a phone with GPS capabilities, the iNaturalist Seek phone app, and a 50 meter transect tape.

Procedure

1. Create a table with the transect number, date and time, transect length, and weather information
2. Travel to the transect location based on the transect map, verifying the location with GPS
3. Extend the transect measuring tape for 50 meters as straight as possible
4. Divide the transect into 10 imaginary sections
5. Record the common names of woody plants found that overhang the transect line. Record the range the plant intercepts the transect, length of the overhang to the nearest decimeter, and the intervals (imaginary 5m sections the plant covers). If two plants are overhang on top of each other, record both ranges such that they overlap.
6. Collect a leaf sample for each species encountered. Tape the sample to a back page of the notebook and attempt to identify the plant using the Seek app.
7. After collecting all the data, identify samples using a dichotomous key and list the steps used on the page with the sample.

8. After identifying each plant, write down common name, latin name (which should be underlined), leaf type, leaf arrangement, whether it's a tree, shrub or vine, and flowers or fruits which are present.
9. After recording the info about each species, create a data table either online or on paper with columns as species, number of individuals, relative density, intercept lengths of all recorded members of a species, sum of intercepts, relative dominance, number of intervals, relative frequency, and the importance value. The rows are a species present at the site.
    a. The relative density is the total number of individuals of a species divided by all plants identified multiplied by 100.
    b. The relative dominance is the total intercept length of a species divided by the total intercept length of all species multiplied by 100.
    c. The relative frequency is the total number of intervals a species is present divided by the total intervals a plant occurs multiplied by 100.
    d. The importance value is the sum of the relative density, relative dominance, and relative frequency.

Conclusion

Results

On average, close to water transects contained 10 different species, while medium and far transects contained 5.66 and 5.33 respectively. There was more plant diversity in close to water transects, although not a statistically significant difference ($p = 0.06$). However, there is no significant difference between plant diversity in far and middle transects.

On average, close to water transects contained 55.33 woody plants, while medium and far transects contained 34.66 and 28.66 respectively. There was more plant abundance in transects the closer they are to water, however the difference is not statistically significant ($p = 0.23$).

On average, about 44% of the plants in the close transect were drought tolerant, 24% in the middle transect, and 25% in the far transect (Fig. 3). While the close transect has a higher percentage of drought tolerant individuals than the middle or far transect on average, it is not statistically significant ($p = 0.12$).

On average, Ashe juniper had importance values of about 171 on the far transect, 87 on the medium, and 86 on the close (Fig. 4). While Ashe Juniper on average had a higher importance value closer to water, it is not statistically significant ($p = 0.11$). White shin oak was only found far from water and had an importance value of 65. Evergreen sumac was only found far from water with an importance value of 73. Plateau live oak had importance values of 22 on the transects farthest from water, 110 on the transects a medium distance from water, and 34 on the transects closest to water. Texas Persimmon had importance values of 6 on the transect farthest from water and 75 on the transect a medium distance from water. Heavenly bamboo had an importance values of 7 a medium distance from water and 99 on the transect closest to water (Fig. 4).

Figure 1. Average Number of Plant Species per Transect Site

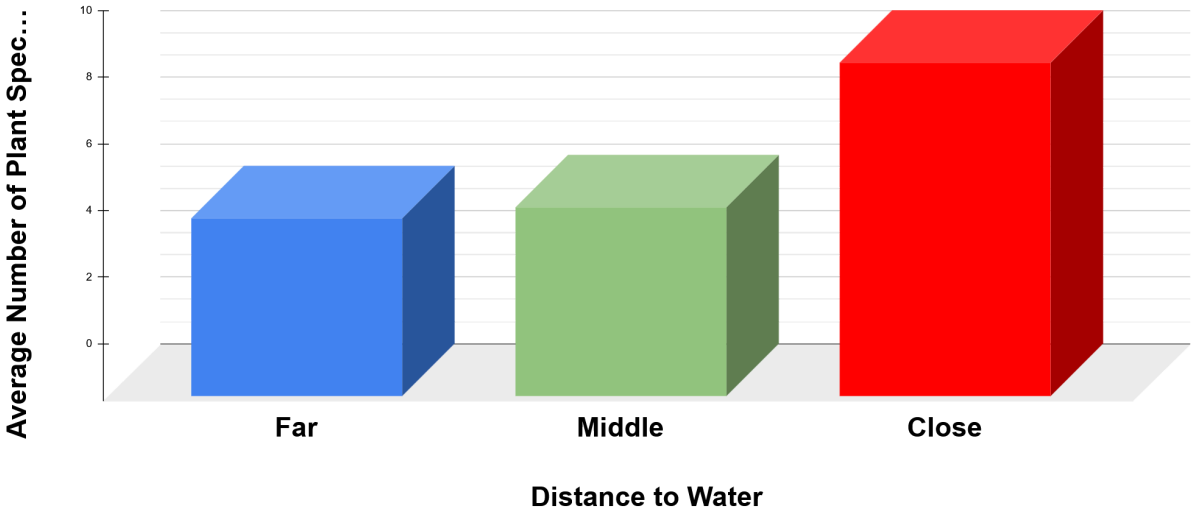


Figure 2. Plant Abundance vs. Water Availability



Figure 3. Percentage of Drought Tolerance vs. Water Availabilty

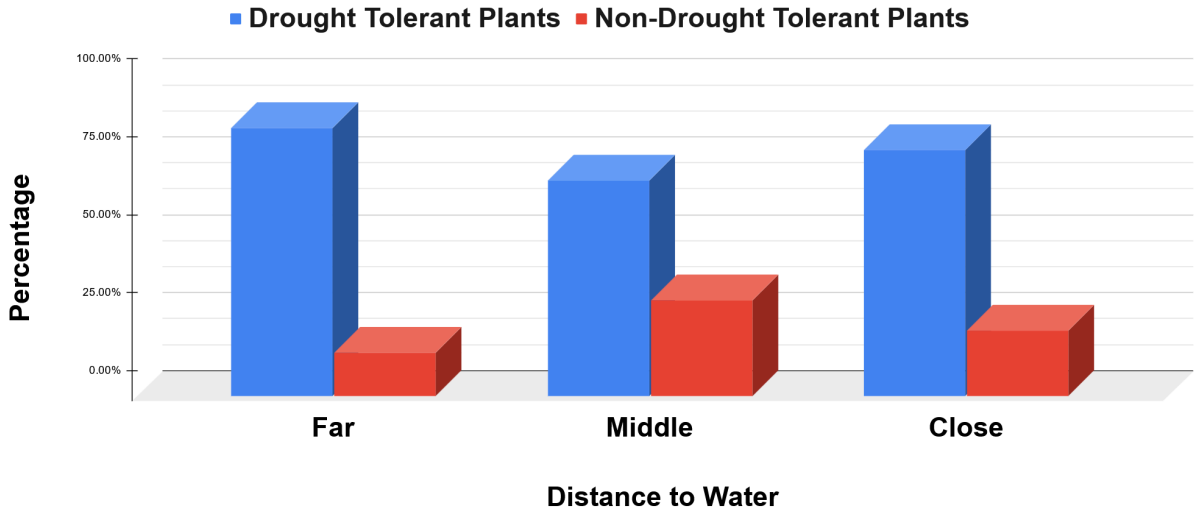
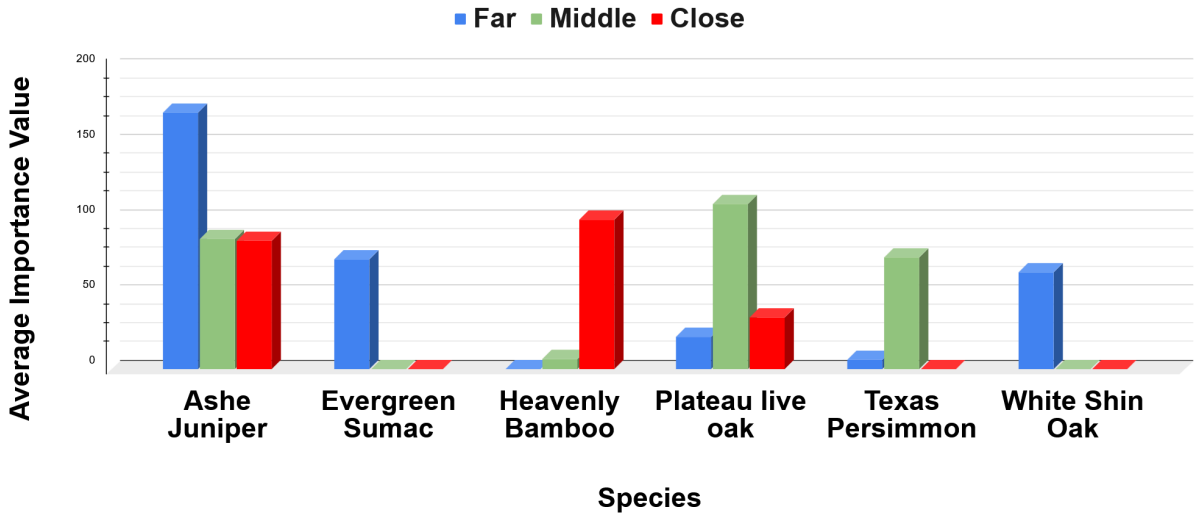


Figure 4. Average Importance Values vs. Water Availability



Discussion

The hypothesis for this study predicted that there would be higher abundance and diversity of plants closer to water. This hypothesis was supported by data and observations about drought tolerance, diversity, and abundance. The data in this study suggests that water abundance has an effect on the diversity and abundance of plant life in the area.

Fig 1 supports the idea that plant diversity will increase as the distance to water decreases. Fig 1 supports this idea as it displayed an increase in plant diversity in close to water transects compared to middle and far transects. Although the data is not statistically significant, given the small sample size, it is likely.

Fig 2 also supports the idea that plant abundance increases with closer proximity to water as it displays an increase in the average plant abundance the closer they are to water.

A related study was conducted in the Northern regions of China where 1039 quadrats were sampled at 184 sites using quadrat sampling and nested sampling design. 30 m x 30 m sites are split into 0.5 x 0.5 m sub plots and sampled for a number of species individually till the 30m x 30m site is fully surveyed. Region water availability was determined using the UNEP aridity index and water availability variables such as mean average precipitation. The results suggested that on average the number of species in quadrats with high water availability was higher than those in low water availability (Yao et al. 2021). This supports the finding that plant diversity is higher in sites closer to Barton creek at Gus Fruh park.

Another related study also focused on Northern China deserts focusing specifically on shrub and herb density. 433 sites were sampled divided into 15'x10' areas further divided into 3m x 3m sites. Each site was sampled for shrub and herb density then the shrubs were sampled for biomass based on leaf size. The water availability for a site was calculated using the precipitation and potential evapotranspiration rate for that site. The sites were divided into three groups by aridity and results suggested that species richness had a positive correlation with water availability (Guo et al. 2019). This supports the conclusion that increased water availability has a positive correlation with water availability in Gus Fruh park.

A study was conducted which aimed to see if the leaf turgor point, which is an indicator of plant drought tolerance, of plants affected how abundant they were in tropical environments with high seasonality. The study sampled 399 tree species and measured them using 1 ha plots. Tree abundance was measured as basal area per hectare. The results of this study showed that trees with lower leaf turgor points were more abundant in tropical environments with high seasonality (Song et al. 2023). This supports the finding that plants with low drought tolerance, such as Cedar Elm, are more abundant closer to water.

Although Fig 3. seems to contradict this finding since the percentage of drought tolerant plants is higher closer to water than in the middle, the ongoing drought likely killed many of the non-drought tolerant plants dependent on the water skewing the results.

Ashe Juniper, White Shin Oak, and Evergreen Sumac were all found primarily dominant far from water (Fig. 4). This is likely due to their high drought tolerance and ability to outcompete plants in low water environments. Although plateau live oak is also drought tolerant, it had the highest importance values in the middle transects (Fig. 4). This was likely due to the fact that Plateau Live Oak benefits more from partial shade unlike Ashe Juniper which thrives in full sun. Texas Persimmon shows a similar trend having high importance in the middle transects (Fig. 4). However unlike Plateau live oak it prefers full sun which is contrary to our data. Heavenly bamboo is an invasive species found primarily close to water (Fig. 4). Although it is drought tolerant, its spread likely due to the high amount of non-drought tolerant plants killed in the drought giving it space to opportunistically spread.

Species diversity likely increases with water availability because more water allows for plants to fill in more niches and produce a greater species diversity overall. However the middle and far transects (Fig. 1) did not show much difference in species diversity. This is likely due to the middle transect being too far from the creek to be either influenced by its water supply or the drought that killed many of the species unique to the area.

Because of the current ongoing drought in this area and changing weather between data collections, the number and diversity of woody plants could've been lower than usual. The fact that each data collection was done by 3 people may introduce bias, as it is sometimes subjective whether a plant is within a transect or not. The fact that there were only 3 data collections for each transect type introduced a large bias, and would've increased the standard deviation on many of our data points. Finally, the placement of each transect may not have been completely optimized to represent water availability.

If this study was redone, it could've helped to have more data collections and optimize the placement of the transects to more accurately represent water availability. In the future, other studies could look at the plant diversity outside of a drought.

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Effects of Elevation and Water Availability on Woody Plants' Biodiversity

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ABSTRACT: The purpose of this study was to determine the effects of elevation and water availability on the diversity of woody plant species, the hypothesis of which was that as proximity to water increases, biodiversity increases and that the elevation change wouldn't affect biodiversity as much as proximity to water. It was conducted at Gus Fruh Park in Austin, Texas (30.2449309°N, -97.7930615°W). Data was collected from nine transects, divided into three areas ranging from close to the creek to far away from it. A line-intercept method was used; the collected data for plant species were: importance value, drought resistance, and the average amount on each transect were studied to determine biodiversity in Gus Fruh. The data supports the original hypothesis. The mean average number of species in the transects close to the water was 6.67, but as distance increased, it dropped to 4.47. In addition, importance values in general increased as distance increases, which shows that those plants of one species are more dominant on the transects farther away from water. Also, the amount of drought tolerant plants increased as distance from water increased, which suggests more homogeneity in the transects farther from water and less biodiversity. All of this supports the hypothesis that as distance from water increases, biodiversity decreases.

Introduction

Purpose

The purpose of this study is to assess the effect of elevation from sea level and distance from Barton Creek on the diversity of woody plant species in Gus Fruh park, Austin Texas. This study will be conducted using the line intercept transect method on high relative elevation away from the creek, medium relative elevation closer to the creek, and low relative elevation adjacent to the creek.

Hypothesis

The hypothesis is that as distance to water increases, biodiversity decreases and that the elevation change wouldn't affect biodiversity as much as proximity to water.

Site Description

Location

Gus Fruh park is located in the Barton Creek Greenbelt, in west Austin TX. It is directly east of the intersection of Mopac and Capital of Texas Highway. It is located 6 km south west from the Texas Capitol building (Google Earth, 2025).

Areal Extent

The areal extent observed was about 133.47 ha (Google Maps, 2025). It is generally in a trapezoidal shape defined by Loop 360 and the neighborhood nearby.

Topography

The highest elevation at Gus Fruh is 213.36 meters (USGS, 1988). When approaching the creek, the elevation drops to a topographic low of 149.35 meters. The topographic relief of the area is 64.01 meters. The elevation climbs rapidly farther away from the creek, and is relatively flat in the creek bed compared to the forested hills.

Geology

As observed on February 15, 2025, the Barton Creek deposits alluvium on its creek bed, which is from the Quaternary period. Alluvium contains silt, gravel, clay, and smoothed stones formed from deposition by rivers. Another rock type found in the park is the Fredericksburg Group Limestone, formed in the Cretaceous period. This limestone is part of the Edwards formation, and is identified by limestone, dolomite, chert, a fine grain, and a medium gray to gray-brown color. The last formation found in Gus Fruh is the Del Rio Clay formation created by ocean deposition in the Cretaceous. This rock is a bedrock containing clay and pyrite, is blocky and is a medium gray color. (USGS Geologic Survey, 2025).

Vegetation

The composition of Gus Fruh is approximately 60% woodland, approximately 25% grassland and approximately 5% rock. In the Gus Fruh forest, some examples of vegetation are Ashe Juniper, Common Hedge Parsley and Cedar Elm.

Water Availability

The Gus Fruh is supplied by water from Barton Creek. Barton Creek at the time didn't have any water as of February 15, 2025. The area can flood up to 10 meters above the creek's normal boundaries as evidenced by smoothed rock, bent trees, and pieces of trash carried high in elevation when the creek floods and recedes.

Urbanization

The park is adjacent to Loop 360 and to a neighborhood. It has trails for hiking.
The park contains rip-rap to prevent erosion on the banks. In addition, Barton Creek contains a pollution issue. Some observations include trash bags, plastic bags, and tires. There are also hooks on the rock face for rock climbers, people frequently take their dogs on walks on the trails and people set up hammocks.

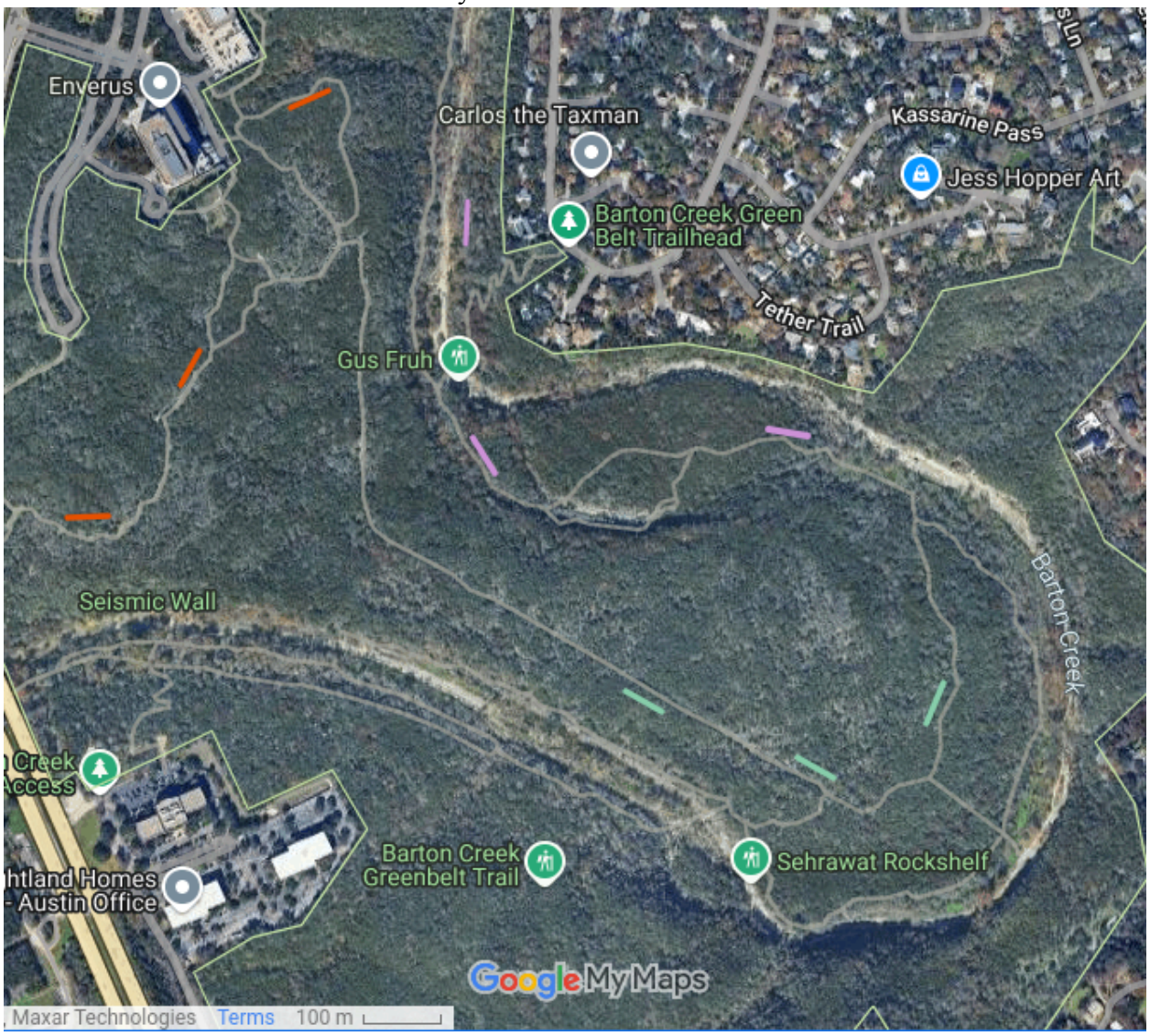
History

The Gus Fruh Park was first acquired in 1980, and then later on in 1986 and 1992 acquired again (Austin City Records, 2025). Between 1954-1958 the nearby neighborhood was developed, while the land around the creek was not used for any purpose since it remained untouched (Historic Aerials 2025). In 1973 the loop 360 was finished, and in 1981 a neighborhood developed closer to the creek (Historic Aerials 2025). At the same time, though, there was a growing movement to protect the environment, with the growing environmental movement nationwide. April 22 was declared as Earth Day, and the residents made demands for a park, including the Office of Environmental Resource Management in 1972, ballot initiatives to protect green spaces in 1975, and a building moratorium to help protect nature in 1979. Afterwards though, some results were mixed, with attempts to establish pollution controls failing in the 80s, but also a Parkland Dedication Ordinance. In the late 80s though, there would be some backlash towards proposed developments on the land.(Barton Creek Time Stream, 2025). The creek has a history of flooding, such as during Memorial Day in 2015, or in 2019 when the creek rose above the flood stage (Austin American-Statesman 2019).

Research Plan

Design of Study

Of the nine transects, they will be spread throughout the park, and figure out the diversity in each one to analyze biodiversity. We're using the line intercept method. On the map the red are high elevation, the green are middle elevation, and the purple are low elevation. The red transects are located approximately 200 meters above sea level on the west side of the park. The northernmost transect is 158 meters from Barton Creek, the southernmost transect is 137 meters away, and the central transect is 292 meters away from Barton Creek. The green transects are located approximately 162 meters above sea level on the south east side of the park. The southernmost transect is 112 meters away from Barton Creek, the northwest transect is 109 meters away from Barton Creek, while the easternmost transect is 144 meters from the creek. Lastly, the purple transects are located closest to the creek at lowest elevation. The easternmost transect is 49 meters from Barton Creek, the southernmost transect is 38 meters from the creek, and the northernmost transect is 18 meters away from the creek.



Background Information

- A study near the Okavango Delta in Botswana tested the influence of the distance to water on riparian vegetation. The survey was conducted on four sites with 20m x 10m plots placed near the river bed with changing distances by 10m and at each site an indicator species was tested to determine the characteristics of the species. The results showed that the plants closest to the river would have a higher richness while the other intervals didn't have much variability (Tsheboeng 2018). This supports the hypothesis that plants will be more diverse close to water on transects closer to Barton Creek.

- A study in Southwestern Ethiopia tested the biodiversity of home-grown plants based on wealth and elevation. The study measured with 3 altitudinal gradients(1459-1750 m, 1750-2050 m, and 2050-2542 m). Only woody plants with a diameter of at least cm and a height of 1.5 cm were measured. In the study, P, the level of significance between altitudinal gradients, was less than 0.05(Jegora 2025). While some differences were noted based on the altitudinal gradients, they weren't very sizable. Instead though, there was more biodiversity based on wealth in the homegrown plants.Since there's no real difference with large gradients, it's unlikely to be really affected with the gradients at Gus Fruh. This does not support the idea that elevation will have an effect on the biodiversity of woody plants and rules that out as a possible theory.

- A study across the drylands of China surveyed 184 sites to test the impact of water availability and energy availability on the diversity of plants. The study tested annual herbs, perennial herbs, and woody plants using nested sampling. Samples for grassland started at $0.5m^2$ x $0.5m^2$ quadrats and moved up to $30m^2$ x $30m^2$ quadrats, while arid desert samples started at $1m^2$ x $1m^2$ quadrats to $100m^2$ x $100m^2$ quadrats. Every plant's scientific name and category (annual, perennial, woody) were noted. Next, a linear mixed-effects model was used to evaluate the relationship between diversity and the water and energy variables. The study found that water availability significantly increased the diversity of plant species, while an increase in energy availability led to a decrease in plant diversity. However, when water was controlled for, the energy seemed to have absolutely no effect on plant diversity (Yao 2021). This study supports our hypothesis that areas with more water availability in our park–namely close to Barton Creek–will experience a greater species diversity, granted that water availability in arid or semi-arid climates would have more impact than water availability in temperate climates.

Materials

- Transect Line (50 meters)
- Tape
- Scissors
- Dichotomous Key (Lynch 2012)
- iSeek Naturalist App

Procedure

1. Lay out a 50 meter transect line with 30 meters of overhang
2. For 5 minutes, write down each woody plant species in spotted in the notebook
3. Write down each species observed (if unknown, mark it as such, ex: Unknown A).

4. Mark which intervals the species were in.
5. Mark the intercept lengths for the species.
6. Take a sample of the plant and keep it in the notebook.
7. When in class, identify the species with a dichotomous key.
8. Confirm with the iSeek Naturalist app.
9. Calculate the relative density, which is the total number of a specific species divided by the total number of all species, times 100.
10. Calculate the relative dominance, which is the total intercept length for a specific species divided by the intercept length for all species, times 100.
11. Calculate the relative frequency, which is the total number of intervals for a specific species divided by the total number of intervals for all species, times 100.
12. Find the importance value, which is the sum of the relative density, relative dominance, and relative frequency.

Conclusion

Results

In the data observed, a clear correlation is highlighted by the change in the number of drought tolerant plants as the plants got further away from the creek. In the transects low in elevation and close to Barton Creek on Fig. 3, there is an average number of 16.00 drought tolerant plants versus 3.67 drought susceptible plants. On the medium distance and elevation transects, there was an average of 23.67 drought tolerant plants and 3.33 drought susceptible plants. In the large\ distance/high elevation transects were statistically significant with a P value of 0.047. Here there was an average of 21.67 drought tolerant plants versus 4.00 drought tolerant plants.

There was a slight increase, then general decrease in the diversity of the plants as the data samples got higher in elevation and farther away from Barton Creek. From low elevation/close to water In Fig. 1, on the low elevation close to the creek, there was an average 6.33 species, with a standard deviation of 2.52. For the medium elevation and distance from the creek, there was an average of 6.67 species, with a standard deviation of 2.86. On the large distance from the creek and high elevation transects, there was an average of 4.67 species with a standard deviation of 1.70.

The T-Tests conducted on the drought tolerance sheet shows that the number of drought tolerant plants was significantly different in higher elevation/far from water transects compared to the population of non-drought tolerant plants ($p<0.047$). Meanwhile, in close to water and medium distance transects, the difference between drought tolerant and drought susceptible were not statistically significant ($p<0.067$ and $p<0.090$ respectively). In our data there were no samples of Texas Live Oak in our low elevations while in the medium and high elevation we found samples. This is different from the trend observed among the other species and we found more at the high amount going against our hypothesis.

Fig. 1 Number of Unique Species on Transects vs. Standard Deviation

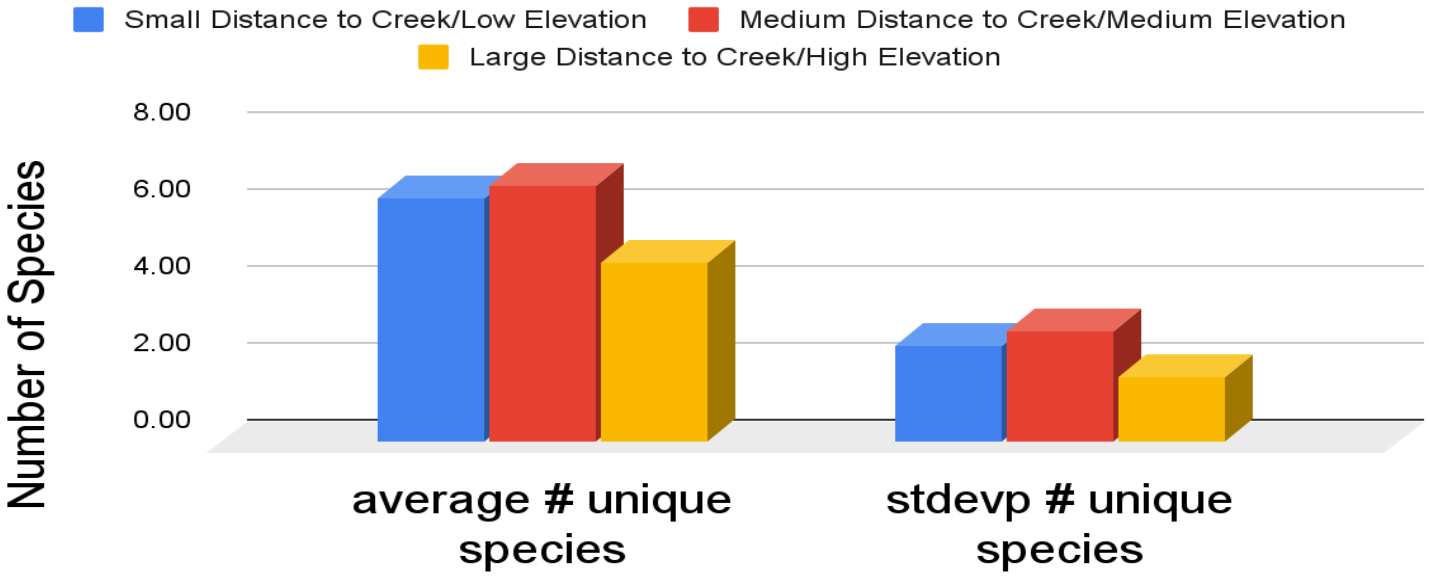


Fig. 2 Average Importance Value of Plant Species across Transects

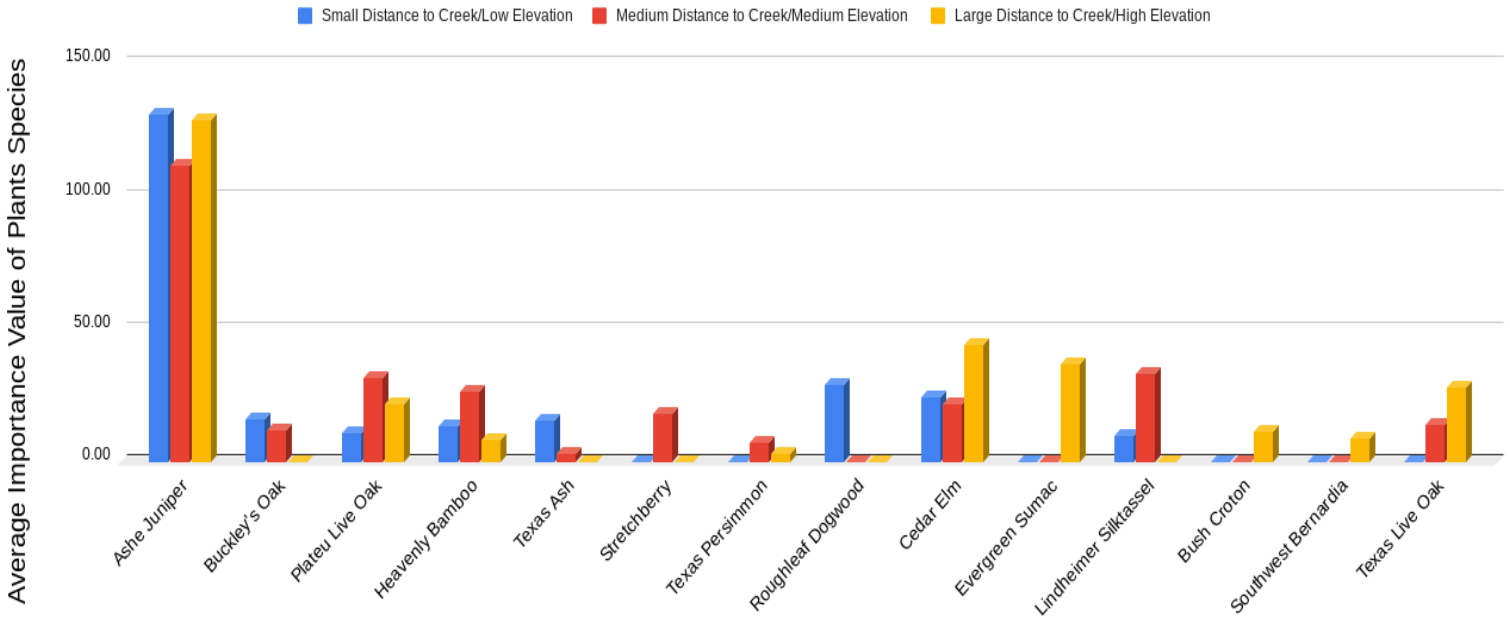
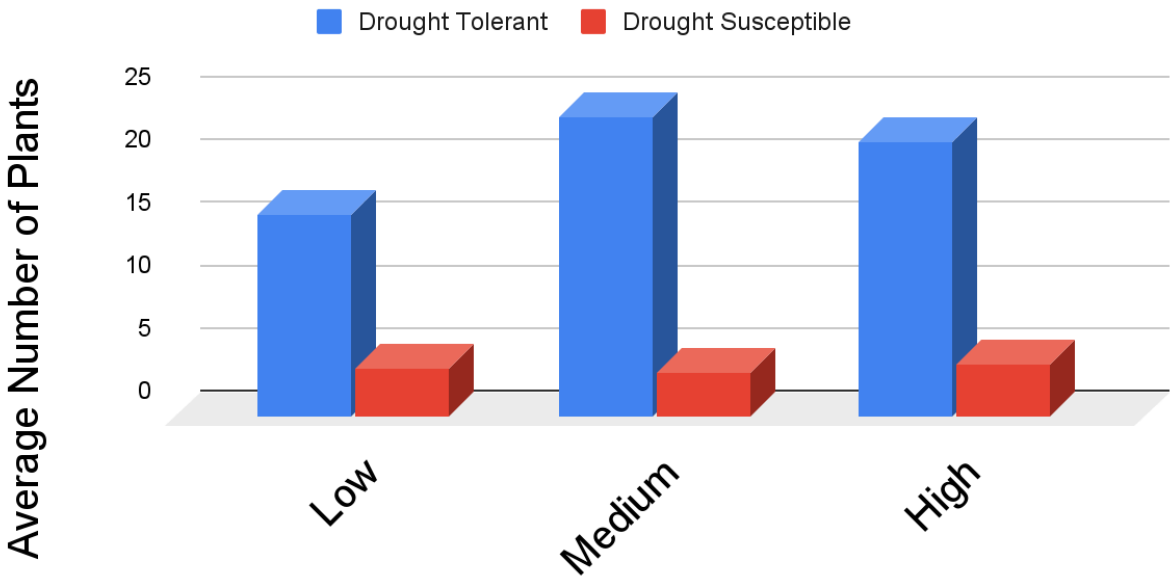


Fig. 3 Average Number of Drought Resistant vs. Drought Susceptible Plants



Discussion

The hypothesis is that as distance to water increases, biodiversity decreases and that the elevation change wouldn't affect biodiversity as much as proximity to water.

Our data does support our hypothesis. The hypothesis stated that the general trend would be a decrease in biodiversity as elevation and distance from the creek increase. The biodiversity tends to slightly increase in the middle transects, with an increase in both the average number of species (mean=6.67) and the importance values for each individual species, but after that the number of unique species drops in the transects far from Barton Creek and higher in elevation (mean=4.67), which supports the original hypothesis created. Our species importance values tend to be higher on the farthest transects. A higher importance value tends to demonstrate less biodiversity since a single species has greater importance in the transect, so this supports the hypothesis. The ratio of drought tolerant to drought susceptible species also increases on the farthest transects, which highlights a decrease in biodiversity as there would be more of the same type of plants. This supports the hypothesis.

A study was conducted in Shaanxi Province, Northwest China, on 31 pairs of congeneric species in several different plots in semiarid, temperate, and continental monsoon, and the area has a relatively stable climate between 9^{O}C and 11^{O}C. The study was conducted in three 50x50m plots in two different areas. From each target species, 3-5 specimens were collected from each plot. Results suggested that there were significant differences in traits among 18 special congeneric species in six general under different soil water availability. This does support the hypothesis since it demonstrates that the availability of water(which would be affected by distance from a creek for example) ends up having a significant effect on the traits, and as a result, their biodiversity. The study demonstrated a safety vs. efficiency tradeoff, which was said to affect co-occurrence negatively with less water availability.

A study was conducted in Kruger national park (KNP) in South Africa, surveying plant species coverage on 60 50x50m plots located in three distinct habitats: (i) at perennial rivers, (ii) at seasonal rivers with water available only in the rainy season, and (iii) on crests, at least ~ 5 km away from any water source. History of fires, climate, and vegetation characteristics were all assessed and accounted for in the data collected. The study found lower diversity of shrubs in crest plots and in perennial river plots than in seasonal river plots (9.4 ± 5.5, 9.5 ± 5.5, 12.0 ± 6.4 species richness respectively) (Hejda 2022). This supports that grasses are largely dominant in areas far (~5 km) from a waterbody and are present on perennial rivers, while areas near seasonal rivers are more specially diverse. While the section of Barton Creek in Gus Fruh park appears seasonal (the creek bed was dry during the data collection), Gus Fruh doesn't have the large distances from water sources that are present in KNP.

A study was conducted in various continental (n=195) and island (n=105) locations across the world in 2010, surveying pteridophytes (spore-reproducing plants, i.e. ferns) and seed-bearing plants. The study accomplishes this by using the Checklist of world ferns by Hassler and Swale from 2004. The study collected data on the number of pteridophyte and other vascular plant species in selected locations and the abiotic factors–mean annual precipitation, days with precipitation > 1mm, etc.–associated with those regions of the world. The results of this study

suggest that there is a strong positive correlation between pteridophyte presence and seed-bearing plants ($r=0.68$, $p<0.001$), namely in the tropics where water availability is high. Pteridophytes relative proportion to all vascular plants were found to increase in montane (8% proportion) and tropical moist broad-leaf forests (6.8% proportion), and decrease in desert (1.4% proportion) and Mediterranean climates (2.1% proportion) (Kreft 2010). This study supports the hypothesis that species diversity in pteridophytes increases in correlation with increased water availability, and by extension diversity in seed-bearing plants, which are positively correlated with pteridophytes abundance. However, the water availability metrics measured in this study likely would not differ significantly in Gus Fruh due to the geographical constraints of the park.

The data collection had some issues that could have affected it. One reason was that after a while, the heat could have impeded data, due to the fact that it made the collectors more tired and weakened our attention abilities . In addition, there was a chance that, by working alone, there were some species that were missed. Moreover, more species could have been collected from more transects if there were more people and more time. Getting more species would have allowed for more representative data and become able to establish a more accurate conclusion. The park also wasn't incredibly large. If more studies were conducted in additional parks to gain more data , more data could have been collected for a more accurate conclusion.

In the future, the study could be conducted over more time than just a semester, and the groups could be larger than just three people. In addition, there could be more room for multiple transects than just nine. More variables could have been looked at than just the three used for the stats, charts, and graphs. The study could also have been conducted in other parks to increase the sample size of the data.

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Analyzing the Effects of Urbanization on Northern Cardinal Populations in Gus Fruh Park

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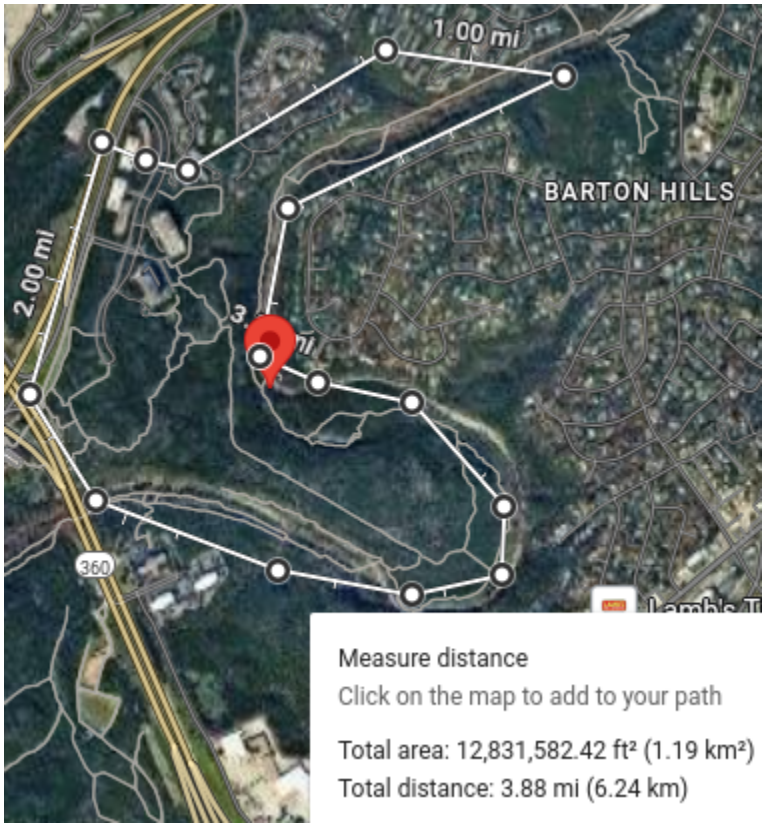
Liberal Arts and Science Academy, Austin, TX
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ABSTRACT: The purpose of this study was to evaluate the effects of urbanization on Northern Cardinal populations. The study was conducted in Gus Fruh Park, Austin, Texas. Three researchers were each assigned one transect and took data on bird songs, calls, and sightings in addition to temperature, weather, and other activity. An Emlen Strip Transect method was utilized to calculation population estimates for each transect, and data was collected on each transect on six separate occasions. It was determined that the average estimated population of Northern Cardinals was highest around the transect a medium distance from urbanization, as opposed to a lower average in the transect closest to urbanization and a lowest estimate in the transect farthest from urbanization. This does not support the hypothesis. It is possible that cardinals favor more urbanized areas or that there wasn't enough of a difference in urbanization between the different study areas.

Introduction

Purpose
The purpose of this study is to compare the populations of Northern Cardinals near the highway, near the neighborhood, and far from both in order to observe the effect of urbanization on the population of Northern Cardinals in Gus Fruh, Austin, TX.

Hypothesis
There will be fewer Northern Cardinals near the neighborhood and the highway, while towards the center there will be more. By urbanized, humans are living, and or frequently using that area. Like the two examples we've already given. This is due to the noise pollution, movement, mortality, and other disturbances caused by urbanization.



Site Description
Location
Gus Fruh is located in central Austin. It is located 0.8 km southeast from the Southern Mopac Expressway (Loop 1) & Loop 360 intersection (Google Maps, 2025). The physical variable being studied is the distance from the highway that borders the park on the west.

Areal Extent
Gus Fruh is a roughly crescent-shaped park approximately 119 hectares in area (Google Maps, 2025).

Topography
Gus Fruh has a maximum elevation of 212m and a minimum elevation of 158m (Living Atlas). Towards the creek, the elevation drops sharply, creating a large cliff face and a small, flat area surrounding the creek. The land atop the cliff is mostly flat.

Geology
Gus Fruh contains limestone, and siltstone from the Cretaceous period. At the creek bed, alluvium is deposited continually. The park is around 50% Del Rio Shale and 50% Fredericksburg Group Undivided, with the former more prominent around the north and south and the latter in the middle (USGS, 2025).

Vegetation
Gus Fruh is almost entirely woodland. It is abundant in large trees, which provide shade and shelter for organisms in the park. There is extremely lush greenery around the riverbed. In the creekbed, there are tall, fast growing plants. One of the many trees found in Gus Fruh are Oak

trees or *Quercus* species known for their hardwood, and acorns. One common plant that contributes to the lush greenery is called *Nandina domestica* or more commonly Heavenly Bamboo. It is fairly common around Austin and has small red berries with alternate, bipinnately compound, semi-evergreen leaves. Another common plant many are aware of is Poison Ivy aka *Toxicodendron radicans* known for containing 3 leaflets with alternate leaves on the stem.

Water Availability

As observed on 2/15, water is usually readily available at Barton Creek, which runs through the park, roughly following the east border. However, during times of drought, the creek can run dry. The creek is prone to flooding as evidenced by bent vegetation within 2-3m upwards of the creek's typical water level and a swing constructed above the creek.

Urbanization

Gus Fruh is bordered to the west by a highway and to the east by a neighborhood. Dirt and stone paths are present throughout the park. The sides of the riverbed have been reinforced with bricks, with the addition of the occasional pipe to deposit water. There are posts and benches present for human recreation.

History

Gus Fruh was acquired piece by piece by the city of Austin in 1980, 1986, and 1992 (Austin City Records). Gus Fruh has historically been used for recreation including hiking, cliff climbing, and swimming when the water level is adequate.

Historically, there has been a struggle for the protection of Barton Creek starting as early as the 1950s. From the 1950s to the 1960s, in the time following World War II, as some groups noticed the natural beauty of Barton Creek, they began to grow concerned that new developments in the area would negatively impact it, forming the Audobon Society to protect the creek. Some attempts were made to urge city leaders to purchase land in the region, but they achieved limited results. Regulations were put into place to prevent the harming or alteration of creeks, but these were rarely followed or enforced. In 1969, the Austin Environmental Council was founded for the protection of Austin's natural heritage.

The 1970s came with growing awareness and involvement concerning the protection of Barton Creek. From 1969 to 1971, Mopac was being constructed, possibly opening the door for further development in the Barton Creek area. Around the same time, ambitious plans for a "Barton Creek Park" were drafted, which called for the area stretching 13 miles west from Zilker Park to be untouched with development. While awareness continued to grow surrounding the importance of protecting creeks in Austin, laws and ordinances about development around creeks continued to be passed and subsequently broken. From 1978 to 1979, anti-development groups such as the Zilker Park Posse and the Save Barton Creek Association were formed to oppose the developments in the area. The city started to make slow progress towards purchasing Barton Creek parkland as approved by Austin voters.

In the 1980s, politically savvy and vocal environmentalist groups began to emerge to combat the rapid development in green spaces. More pushes were made for the city to purchase Barton Creek land. In June of 1990, an "all-night" hearing about the controversial Barton Creek

Development that was to take place caused more than a thousand citizens to speak out for the protection of the creek. The media started to cover the growing opposition for the proposition, further uniting citizens. Groups such as Earth First! began practicing civil disobedience to protest the development. In August of 1992, the Save Our Springs ordinance, the strictest water ordinance ever, was passed, endorsed by Austin voters by a 2-to-1 margin. The purchase of a Barton Creek Wilderness Park was also approved by the voters to protect endangered species. This marked a huge victory for those advocating for environmental protection.

Barton Creek continues to be threatened with development, but it is now protected by many ordinances and laws that will continue to be upheld.

Research Plan

Design of Study

The Emlen strip transect method will be used to collect data (see #3 under "Procedure" for details). Each researcher has a transect that will be walked down 6 times, meaning 18 sets of data in total, 6 per transect. Because the study is on how urbanization affects Northern Cardinals, the selected transects naturally reflect this.



Transect 1 (cyan) has a length of 828 meters, following along the creek more upstream, closer to the Capital of Texas Highway. This transect has a few office buildings as well as a highway nearby, acting as a middle ground in terms of urbanization. The transect is accessed via the Capital of Texas entrance to the park, requiring a small walk up the transect before starting data collection. The transect transitions from being near a major highway to running along the stream.

Transect 2 (green) is 936 meters long, running along the canyon next to Transect 1. This transect is positioned around the middle of Gus Fruh, relatively far from neighborhoods and other office buildings, making it the least urbanized transect, though the start of the trail is notably close to some moderately large office buildings. It starts ~150m away from the start of Transect 1, but due to the cliff, requires entry from the Via Fortuna entrance to the park. Transect 2 starts at the north end at an intersection between different offshoots of the Via Fortuna trail section of Gus Fruh and ends at a clearing closer to the creek.

Transect 3 (blue) is 991 meters in length, and it runs along the trail around 226 meters southwest of the Barton Creek Greenbelt Trailhead. It begins at the point at the trail that runs along Barton Creek on the west side, at the point where it opens up to the trail connecting to the Barton Creek

entrance on the east side. It ends at the Save Barton Creek Association. Transect 1 is bordered to the west by a large cliff face and to the east by Barton Creek. It is closer to the neighborhood and farther from the highway, making it somewhat urbanized.

57.878% is the percentage of the total study area being assessed.

Background Information

The Northern Cardinal (*Cardinalis cardinalis*) is a medium-sized songbird that lives in North America. The Northern Cardinal is often most recognizable by its color, the tuft of fur on its head, or its large, conical beak. Males are bright red in color while females are a light brown or buff color, both with a black mask around the recognizable bright orange beak (Texas Breeding Atlas, Cornell Lab of Ornithology, Encyclopedia Britannica).

The Northern Cardinal is found throughout eastern and central United States, some of southeastern Canada, and most of Mexico. This bird does not migrate, so it can be found in any of those locations year-round. Its preferred environment encompasses a wide range, including deciduous forests as well as urban areas.

The Northern Cardinal is a crepuscular bird, most active during dawn and dusk. In the dawn, it can be heard singing its dawn chorus along with other bird species active in early daylight hours. Its song is a long string of high-pitched sliding chirps, often ending in a long trill. It is distinctive from the Carolina wren in that it is less uniform and often varies from song to song. Its call is a high-pitched metallic squeak, not to be confused with the warmer imitation calls of the Northern mockingbird.

The breeding season of the Northern Cardinal is from May to July, but they also mate in March. During mating season, males offer food gifts to females and become extremely aggressive towards other males, sometimes even attacking their own reflections. Females build cup-shaped nests out of twigs and line the nest with soft material found while foraging.

The preferred diet of the Northern Cardinal consists primarily of seeds and fruit such as dogwood, wild grape, and corn. It may also supplement its diet with insects such as crickets, moths, and cicadas. Because of this plant-based diet, the Northern Cardinal is a ground foraging bird, searching for food on or near the ground. During breeding season, it is known to forage in pairs, but it can form fairly large flocks in fall and winter. Sometimes, it has been known to forage with other bird species.

A study by Santos et. al. (2024) The study was carried out in a fairly large metropolitan area of João Pessoa, Northeast Brazil, which is a hot and humid region. The percentage of urbanization was measured through aerial photos, and the varying species of birds were sampled between June 2014 and May 2015 using the Mackinnon method. The study found that the number of species dropped significantly and in a non-linear manner as the percentage of urbanization increased, affecting forest and non-forest birds equally.

A study by Francis et. al. (2011) showed that the frequency of a certain bird species' call directly correlates with how much the noise of the highway affects that species. The study was conducted in the San Juan Basin in New Mexico, in an area dominated by woodlands. After isolating potential noise pollution to the highway, several bird nests were monitored for disturbances in

addition to several species of bird vocalizations being recorded. The study found that the highway tended to affect larger birds with lower frequency calls more than smaller birds with higher frequency calls. Because the Northern Cardinal is a smaller bird with a higher frequency call, the expectation is that, while the number of detected birds should decrease closer to the highway, it should be a relatively insignificant effect, with the little effect present possibly being attributed to other disturbances caused by the highway, such as movement, pollution, and mortality caused by cars.

A study conducted by Pena et. al (2023) in Belo Horizonte, Brazil noted that more urbanized areas had less birds, mainly due to noise pollution, building height and vegetation of the urban areas. The researchers conducted three 20 minute visits in 60 sampling sites distributed throughout the streetscape of the study area, in total only including 68 out of the 73 bird species. The more noise there was, the less birds were found alongside foliage. Therefore, more birds should be found near the center of the park.

Materials

- Binoculars
- Project Notebook (for notetaking)
- Merlin (To aid in identifying birds)
- Mapmyrun (to track hiking distance, and speed)
- mymaps.google.com (for transects)

Procedure

1. Three transects were marked, each measuring between 0.8 and 1.2 km, inside Gus Fruh Park, Austin TX.
2. The time, weather conditions, and other possible affecting factors are noted down by each researcher.
3. One researcher per transect walks in one direction along the transect (see transects above) at roughly 1 km/hr, marking in a table when seeing a bird or hearing a bird's song or call including the estimated distance. Disturbances such as human activity and other animals are also kept track of. (see table to the right)
4. The data was analyzed using several different formulas. The full detection strip (hereafter F.D.S.) is calculated as

Date 2/13/05 **Starting Time** 7:46 AM **Ending Time** 8:46 AM **Hike Speed** 1 km/hr
Transect Number 1 **Transect Length** 1 km. **Bird Species** Carolina Wren
Weather 75F **Beaufort Number** 3 **Wind Direction** NE **Sky Condition Code** 2

	5 m. strips							30 m. strips			
Detection Cues	**0-5**	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**	**35-65**	**65-95**	**95-125**	**Total**
Song	||||	||	|			|					8
Call	||	||||	|||||		|		|	|			14
Vision	||||	|||			|||||						12
Total	10	9	6	0	6	1	1	1	0	0	34

Human Activity:
Planes: 5
Hikers: 12
Dogs: 2
Bikers: 0
A construction crew was working repairing Yager Lane and the noise made it difficult to hear on the last half of the transect.

Other Animal Activity:
Raccoon tracks found
Other birds: Red-tailed Hawk, Downy Woodpecker

Problems:
Confusing Carolina Wren with Cardinal

the distance interval past which the number of bird detections drops by more than 20% of the previous average detections per interval. The population estimate of the area tested by the transect is calculated as the strip transect width times the number of detections in the F.D.S. divided by the F.D.S. width, all divided by the area being tested by the transect in hectares. This gives a rough estimate for how many birds there are in the area per hectare.

5. The coefficient of detectability is the total number of detections divided by the estimated total population in the area, which gives a rough percentage of how many birds the researcher is able to detect. (see equations below)

$$\text{P.E.} = \left[\frac{\text{Strip Transect Width}}{\text{Full Detection Strip Width}} \times \text{\# of detections in Full-Detection Strip} \right] \Big/ \text{Area being tested by transect (in hectares)}$$

$$\text{C.D.} = \frac{\text{Total number of detections}}{\text{Estimated total population for area being tested by transect}}$$

Conclusion

Results

On average, the population estimate of cardinals over all six datasets was higher for the transect nearest to urbanization and decreased as proximity to urbanization decreased. Transect 1 (medium distance from urbanization) had an average of 15 birds. Transect 2 (farthest from urbanization) had an average of 12 birds. Transect 3 (closest to urbanization) had an average of 10 birds (Fig. 5). The difference between transects 1 and 2 was not statistically significant ($p = 0.02$), but the differences between transects 1 and 3 ($p = 0.07$) and transects 2 and 3 ($p = 0.24$) were statistically significant.

The percentage of calls out of total vocalizations was similar for the transects near and a medium distance away from urbanization, with a value around 56.2% (Fig. 4a, 4b). With an average of 169 songs and 98 calls for nearest. While the transect in between close and far has 119 songs and 150 calls. However, in the transect closest to urbanization, the percentage dropped to 36.7% (Fig. 4c). With 119 songs and 156 calls. There was a weak correlation between humans v.s Calls and Songs (Fig. 6a, 6b).

There was little to no correlation between P.E. and temperature ($R^2 = 0.001$) (Figure 2), or between P.E. and human activity ($R^2 = 0.005$) (Figure 3).

Figures

Figure 1: Urbanization V.S P.E per data set

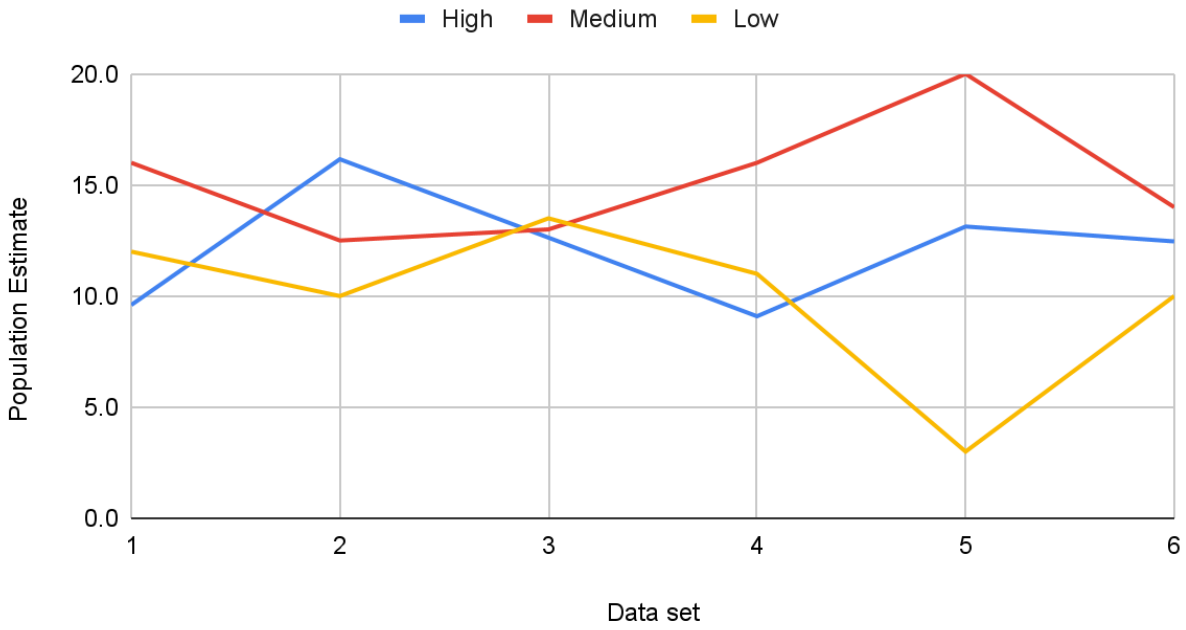


Figure 2: P.E vs. Temperature

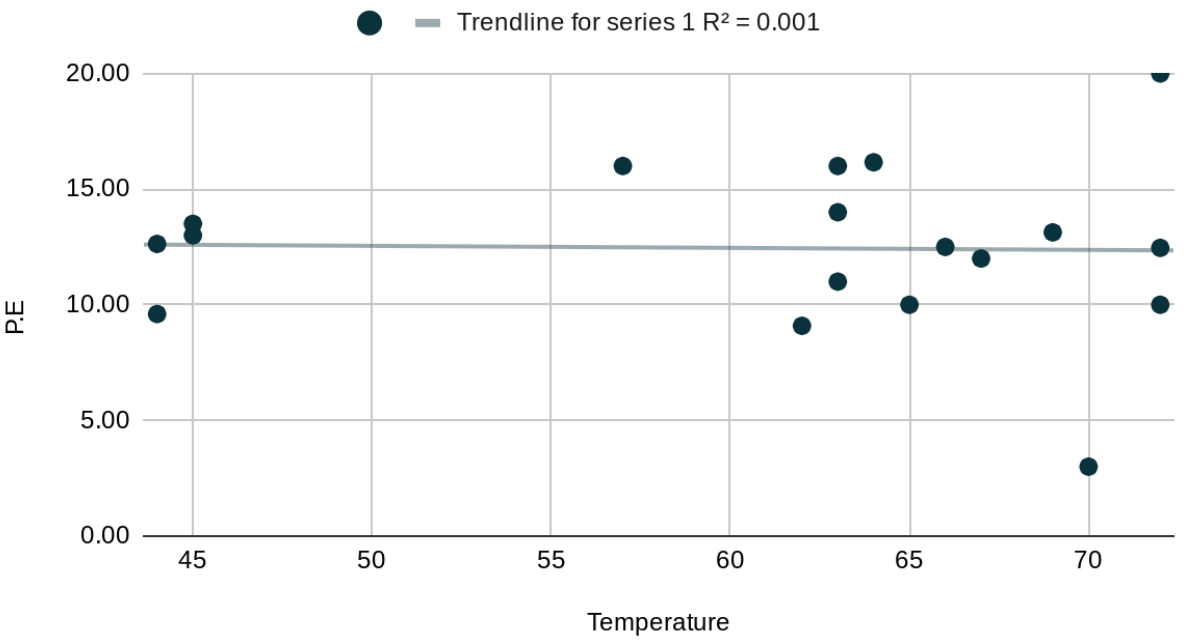


Figure 3: Pop. Estimate vs. Human Activity

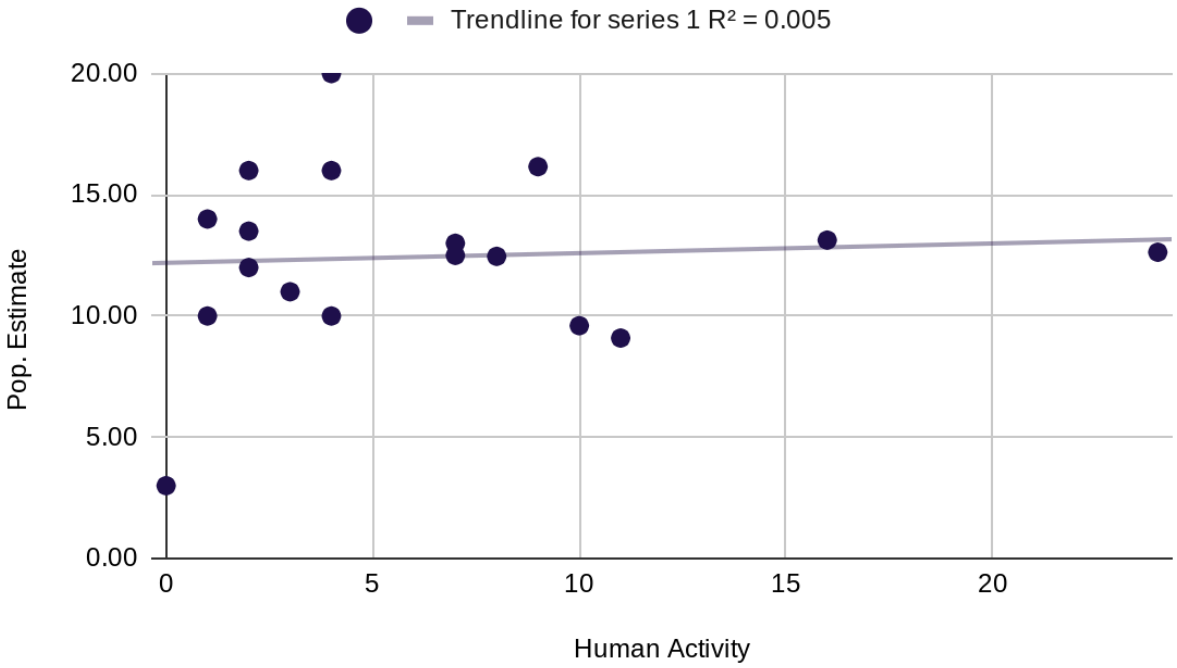


Fig. 4a: Medium Urbanization: Song/call percentage

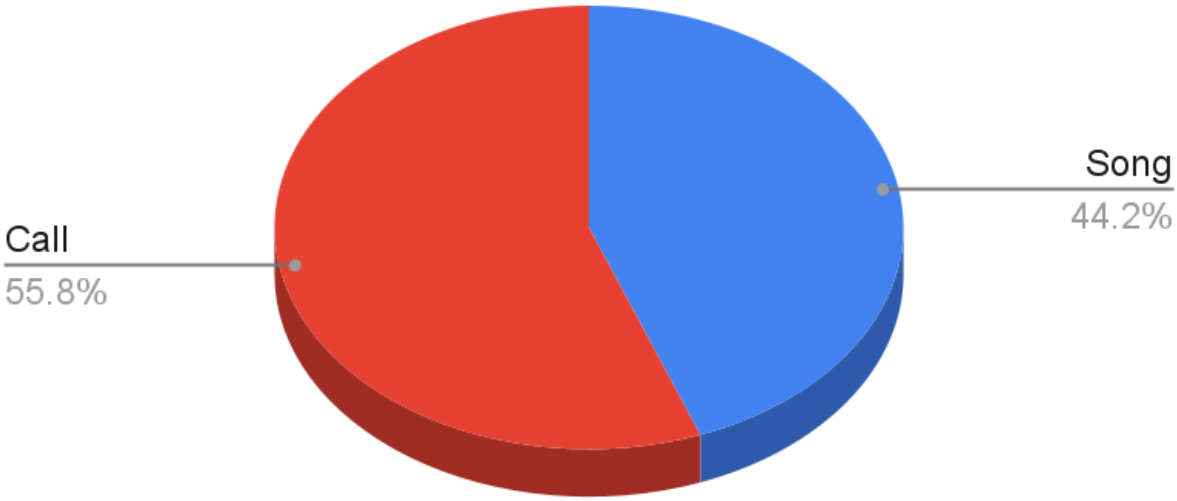


Fig. 4b: Low Urbanization: Song/call percentage

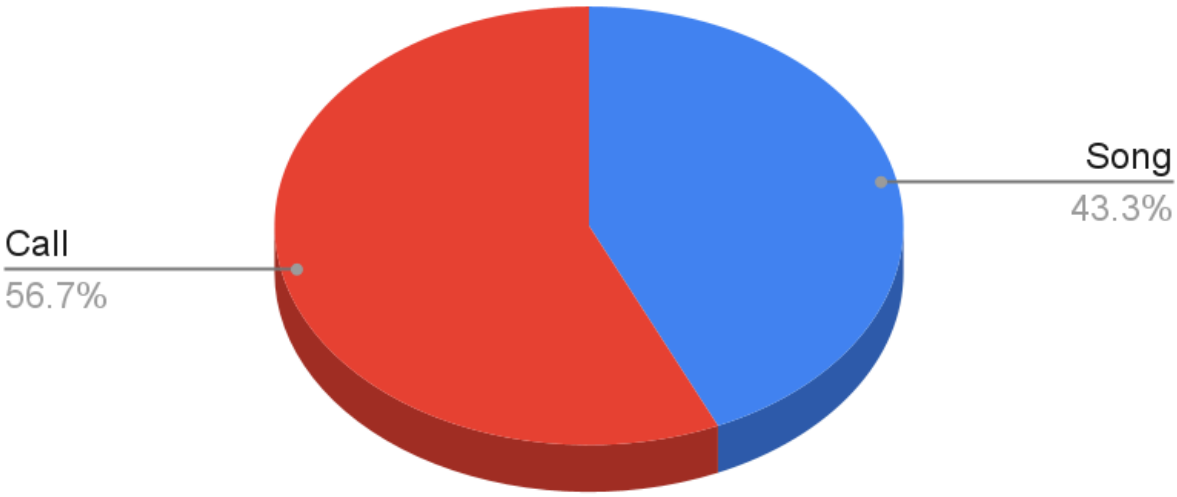


Fig. 4c: High Urbanization: Song/call percentage

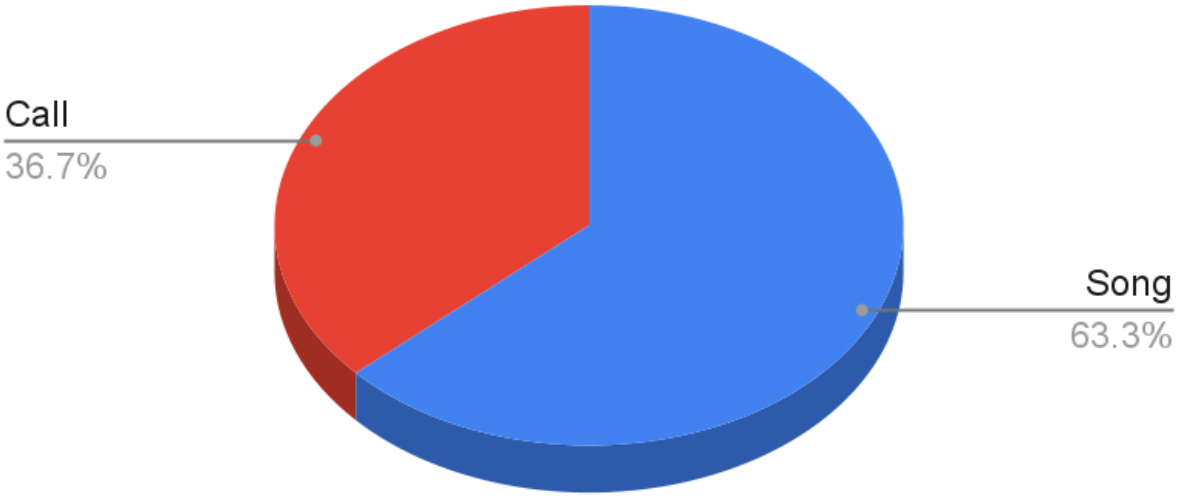


Figure 5: Urbanization V.S Average P.E

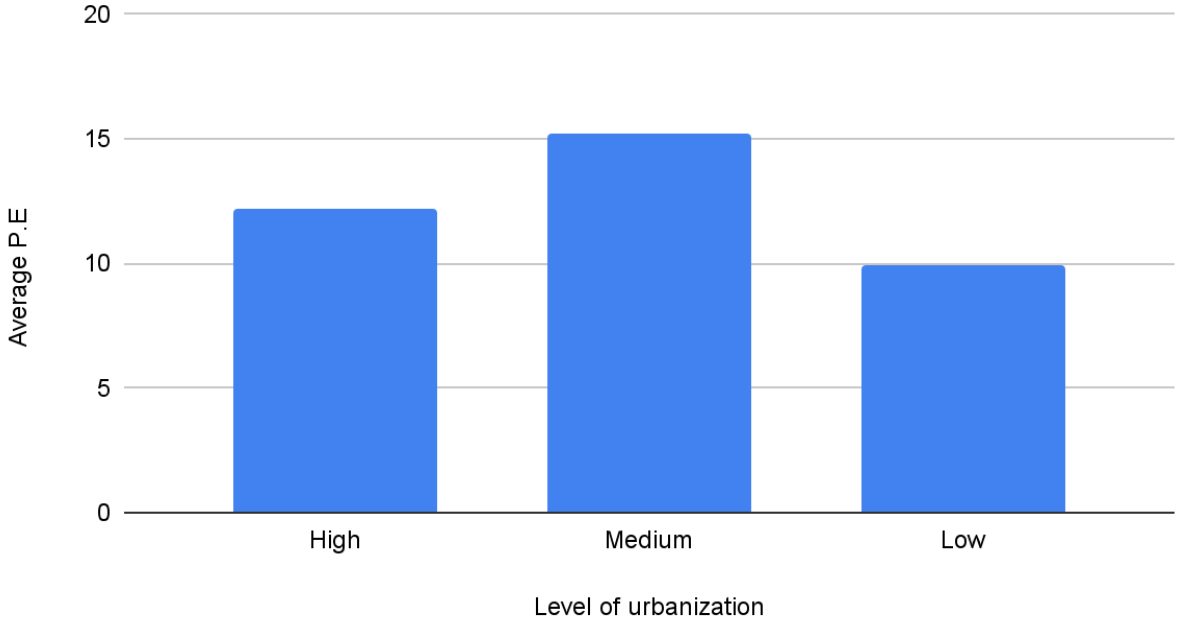


Fig. 6a - Model of humans vs. songs on all transects

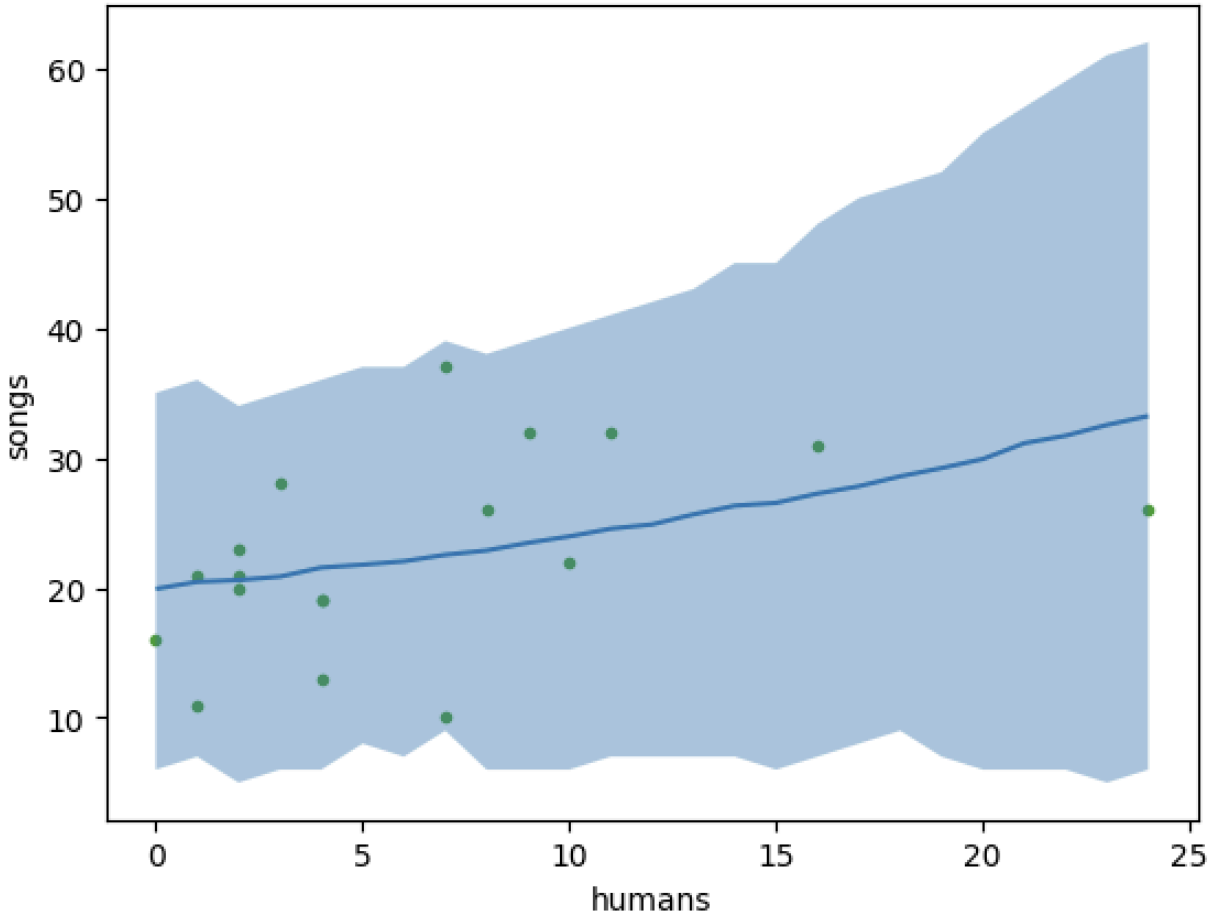
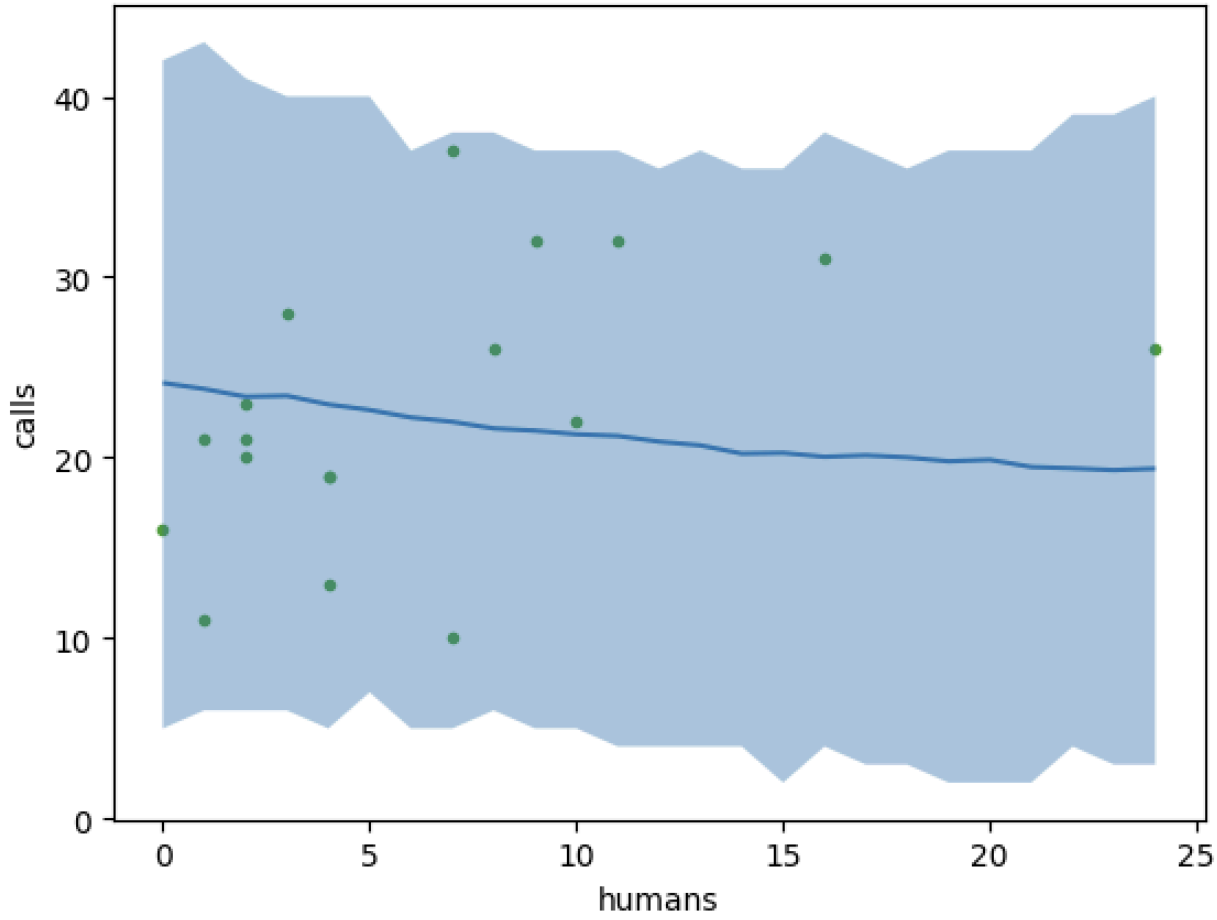


Fig. 6b - Model of humans vs. calls on all transects



Discussion

The hypothesis proposed was that there would be fewer cardinals close to urbanization and more further away but the data, for the most part, says the opposite (Fig. 5). In general, data supports no correlation between urbanization and cardinal population estimate; if anything, fewer birds were estimated to be present on the transect furthest from urbanization.

A study by Møller et al. analyzed the correlation between urbanization and bird population density in several locations throughout Europe. The study found that some bird species, such as the house sparrow and the feral pigeon, had become accustomed to urbanization, and the populations of these bird species had increased to pre-urbanization levels. This supports the findings of the Northern Cardinal population, suggesting Northern Cardinals may have become accustomed to urbanization in a similar manner.

A study by Levaeu et al. was conducted in three cities in South America: La Paz, Bolivia; Mar del Plata, Argentina; and Osorno, Chile. Data was taken on bird populations using 100 x 50 m transects. An inverse correlation between bird population richness and impervious cover (buildings and pavement) was discovered. This directly contradicts the findings on Northern

Cardinals, but this is likely because none of the transects in the current study contained impervious cover. Rather, the more urbanized transects were simply closer to neighborhoods and areas with impervious cover.

A study by Hugo et al. was conducted on bird species in South Africa. The richness of avian species was analyzed in relation to 2001 census data of the population of humans. It was discovered that human activity which leads to increasing heterogeneity of habitat was beneficial to populations of common birds, but not rare birds. Common birds were found to be more flexible to human activity than rare birds. This supports the results received about Northern Cardinal populations in relation to urbanization, as Northern Cardinals are very common birds throughout Austin and southeast America.

According to these studies, cardinals may have been found to favor being near urbanization due to being common birds with a long history of human contact, likely accustomed to the effects of urbanization. There was not much significance in temperature or human activity on the population estimates (Fig 2, and Fig 3), showing that urbanization had a more pronounced impact on bird population density than these factors.

A correlation between urbanization and percentage of songs out of total vocalizations was found (Fig. 4). A possible explanation may be that songs travel over longer distances than calls, which may be more beneficial in urban environments, where birds may be more spread out.

There is a strong possibility of error. Because bird data was collected in the morning around 6 to 8 AM, researchers may have miscounted due to fatigue. If the study was to be conducted again, more transects would have to be done across a wider time period and area to increase the amount of data and possibility of statistically significant results. In addition, more researchers may have walked along the same transect to minimize possible bias due to researchers' different abilities to detect birds.

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Effect of Urbanization on Northern Cardinal Populations in a City Greenbelt

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Liberal Arts and Science Academy, Austin, TX
Fall 2024

ABSTRACT: The purpose of this study was to measure the Northern Cardinal populations in urban suburban and rural areas of Gus Fruh Park in Austin, Texas. The study focused on the abundance of cardinals in relation to the urbanization gradient. The hypothesis was that cardinal populations would be greater on the urban transect in comparison to the rural one. To conduct this study, researchers marked 3 transects in 3 areas inside the park, with one in an urban area, one in a suburban area, and one in a rural area. Over the span of 6 weeks, data on Northern Cardinal populations were collected on each transect, using an Emlen strip transect method. The results from the data concluded that the hypothesis was supported, suggesting that cardinals are more abundant in areas that are higher on the urbanization gradient. This is likely due to factors including year-round food and patches of vegetation suited for nesting that increase survival rates of Northern Cardinals in urban areas.

Introduction

Purpose

This study aims to determine how the location of nearby urbanization affects the bird population in Gus Fruh Park located in the Barton Creek Greenbelt, Austin, TX.

Hypothesis

The hypothesis is the population of Northern Cardinals will be more abundant and centralized in urbanized areas due to their inclination toward houses and urban parts of forests.

Site Description

Location

Gus Fruh Park is located in southwest Austin, specifically South Lamar (Google Maps). It is located 5.43 km southwest of downtown Austin (Google Maps). It is also located at the intersection of Mopac Blvd and Loop 360, across from Barton Creek Square Mall (Google Maps).

Areal Extent

The park's shape is defined by Mopac Blvd on the North and Loop 360, the rest of the park is defined by the shape of Barton Creek(segment between Loo 360 and Zilker Park) and urbanization such as houses and offices (Google Maps, 2024). The area of the park is 190 hectares (Google Maps).

Topography

The maximum elevation of the park is 212.14 meters (USGS). The minimum elevation is 146 meters (USGS). There are many cliffs present in the park along the creek and the elevation slopes down close to the creeks.

Geology

Inside the park, visitors can find small caves, formed by erosion from water. The rock types include Fredericksburg Group undivided from the Cretaceous Era. It includes Edwards limestone, dolomite, and chert (USGS, 2024). This makes it part of the Edwards Aquifer recharge zone. There is also the Del Rio Clay and Georgetown Formation from the Cretaceous Era. This rock contains limestone and fossils and is calcareous and gypsiferous (USGS, 2024). The creek bed has alluvium, from the Quaternary period, which consists of rounded pebbles, gravel, silt, and sand.

Vegetation

The park is home to several kinds of vegetation, including small shrubs, flowering plants. Some species include the Texas Ash (*Fraxinus albicans*), the Eastern Cottonwood (*Populus deltoides*), and the Western Soapberry (*Sapindus saponaria*) tree. It consists of 90% woodlands and 10% of tall grass in the dried up creek (Google Maps, 2024).

Water Availability

As of September 14, 2024, Gus Fruh is experiencing a drought, leading to its river having a lack of available water, showing exposed roots of trees that are visible due to erosion in the sides of the river when water levels were higher. Scattered throughout the park are small, but vital waterfalls that provide habitats for small creatures, along with serving as the primary source of water during the drought. These waterfalls start at higher elevations, flow down rocks, and feed into the currently dried river.

Urbanization

This park is part of the Barton Creek Greenbelt system in downtown Austin that follows the Barton Creek. It is surrounded by urbanization in the form of neighborhoods and businesses. Many trees have been cut down to make way for a trail throughout the park. Along the trails are scattered pieces of trash, including glass, plastic water bottles, and assorted belongings. This has caused arthropods to clump up in areas where trash is the most abundant. There are homeless people living in the secluded areas of the park. Throughout the park, one can find signs telling visitors where the trails go.

History

Gus Fruh, established in the early 2000s, is a natural formation, formed by the flow of Barton Creek. It has been shaped over many years, carving out limestone. Gus Fruh From the creation of the park in 1937 until the present day, several features have changed. This includes installing a parking lot and infrastructure around the Loop 360 entrance in 1985. The park is named after Dr. Edward Gus Fruh, a professor of Civil Engineering at the University of Texas at Austin. He was focused on environmental resources and water quality. He improved water quality in Barton Creek.

Research Plan

Design of Study:

The Emlen Strip Transect method will be used. Three transects will be placed within the park. One will be surrounded on both sides by urbanization, the second one will have urbanization on one side and forest on the other, the third one will be surrounded by forest.

Transect One (orange) is the transect with urbanization on both sides. Transect 1 is 815 meters long and runs along the north side of the Barton Creek streambed. It begins 190 m after taking a right while entering through the Spyglass entrance, behind the Barton Hollow Condominiums. It is surrounded by an urbanized area 40 meters to the north, and another one located 60 meters to the south. The Transect ends when the creek begins to bend towards the south (Google Maps).

Transect Two (purple) has urbanization on one side and woodlands on the other. Transect Two is 890 meters long and runs along the streambed. It begins at the intersection of the main Gus Fruh entrance and the stream. 40 meters north of the transect there is urbanization in the form of a neighborhood. On the south, there is a thick forest. The 1st half of the transect is relatively straight. The 2nd half starts with a little strip of forest to the north, and it slightly bends along the creek where the urbanization gets closer. The end is on the creek, 60 meters Northeast of the Janet Wells Byers Memorial Bench (Google Maps).

Transect 3 (yellow) has no urbanization within 200 meters and is 800 meters long. It is part of the Via Fortuna Access trail which is 350 meters off the park entrance at the Enverus office building. The Transect starts off with a slight bend, and then the rest is completely straight. It is completely surrounded on both sides by thick forests, and is very shady. The Transect ends when the trail makes a sharp turn to the north (Google Maps).



Background Information

The northern cardinal (Cardinalis cardinalis) is a unique North American bird species known for its red plumage in males. Both sexes feature a crest and a thick, orange bill, with males having bright red feathers and a black face mask, while females have a brown body with reddish wings and tails (Northern Cardinal). The cardinal measures 8-9 inches in length with a 12-inch wingspan, and inhabits a variety of environments including woodlands, suburban areas such as gardens, and desert washes. They have been expanding their range more northward in more recent years (Cardinalis Cardinalis (Northern Cardinal)). 90% of their diet consists of seeds, grains, and fruits, along with insects, especially when feeding young. Cardinals are non-migratory and territorial during breeding season, and both sexes will sing. Males vocalize year-round except in the deepest winter. Cardinals are monogamous, and often mate for life, with females building nests and incubating on average 3-4 eggs for 11-13 days. Both parents feed the nestlings that fledge after 9-11 days, and typically produce 2-3 broods per year (Northern Cardinal). Cardinals have been extremely successful alongside human development, and have benefited from the change in landscape, and specifically backyard bird feeding. This has resulted in an abundant population that is estimated to be at 100-120 million individuals (Cornell Lab of Ornithology).

A study was conducted to find "Are urban forests ecological traps for understory birds? An examination using Northern cardinals" by Leston and Rodewald shows that northern cardinals have a strong preference for urban forest habitats, mainly those near residential areas. Cardinals were found to be 1.7 to 4 times more abundant in urban forests compared to rural forests, depending on the season(F.V. Leston et al.) This research suggests that cardinals are well-adapted to urban environments, taking advantage of the resources available near human housing and tending to stay in these areas year-round. Urban areas provide cardinals with

consistent food sources, including bird feeders put up by houses and plants with berries, as well as good nesting sites in areas of residence. **This supports the hypothesis that Cardinal populations will be more abundant in slightly urban parts of the forest.**

This study examines the effects of urbanization on bird communities in Tucson, Arizona, investigating how bird species richness and abundance change along an area from the city center to the surrounding desert. The research reveals that bird species' richness decreases with increasing urbanization, with fewer species found in highly urbanized areas compared to less developed or natural desert habitats. However, the abundance of birds increases with urbanization, meaning that while there are fewer species in urban areas, the number of individual birds is higher. Native bird species richness declines as urbanization increases, but exotic species richness remains pretty constant across the urban through rural path. The study identifies three distinct bird communities along the urban gradient: desert specialists, urban avoiders, and urban adapters/exploiters. (Jenkins) While homes and urbanization create new habitats and food sources that benefit some species, particularly those that can adapt to human-modified environments, it also results in the loss of specialized desert bird species that cannot thrive in urban settings. **This shows that birds are overall attracted and populations are greater in urban forest areas, even if the types of species decrease.**

Another study was conducted in Pennsylvania by ecologist Sara Gagné to answer the question: "What characteristics of forest bird species make them more or less vulnerable to urbanization?" (Gagné) To do the study, they used the point count method and took data on 58 species of forest birds. Gagné found out that not all birds are negatively affected by urbanization, she actually found that "Our study found that 32 percent of the species were actually positively affected by the impacts of urbanization. Those were technically forest birds, and it was a positive and somewhat heartwarming result." (Gagné). The reasoning for this is that those birds eat seeds and fruits. Northern Cardinals also eat food like seeds and small fruits (Cornell Lab of Ornithology). Since Northern Cardinals have beneficial characteristics, they will be able to survive in urban areas. **This supports our hypothesis that birds will be abundant in urbanized areas.**

Materials

- Notebook/note-taking device
- Black/blue pen
- Cell phone
- Bird identification (Merlin Cornell Lab of Ornithology—Home)
- Google Maps (Google)
- Distance mapping app (MapMyRun)

Procedure

1. Prepare a data chart (shown in first image below) with a ruler and pen. Record only the details above the chart that you are able to.
2. Retune your ears to the Northern Cardinal's (*Cardinal cardinalis*) song and call
3. Enter park through Spyglass Access or Gus Fruh Access and make your way to your transect's starting point using Google Maps to pinpoint the location. This should be just before sunrise.
4. Start the Map My Run app to track speed and distance traveled.
5. One should walk at a consistent pace (0.8-1 km/h) through the transect.
6. Take data of birds about the path based on song, call, or visual; make sure to have a cell phone with the Merlin bird identification app in case of uncertainty of bird sounds and visuals. If a song is heard and you see the bird after, only mark the song.
7. Estimate the distance from the bird to your location, making sure that distance is measured perpendicular to the transect. You must be accurate within a 5 meter range up to 35 meters, and be accurate within a 30 meter range from 35-125 meters.
8. Additionally, record any type of human activity, animal activity, or any difficulties faced.
9. At the end of the Transect, select "Stop" on the Map My Run app.
10. Use data to calculate Full Detection Strip (see below). This is a representation of the most accurate data collected along the transect.
11. Use Full Detection Strip (FDS) to calculate Population Estimate (PE) (see below). This is an estimate of bird population in the study area per hectare.
12. Calculate Coefficient of Detectability (CD). This is a comparison of how many birds were detected by the experimenter vs. the number predicted using the FDS.

Example data table

	5 m. strips							30 m. strips			
Detection Cues	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-65	65-95	95-125	Total
Song	IIII	II	I			I					8
Call	II	IIII	IIIII		I		I	I			14
Vision	IIII	III			IIIII						12
Total	10	9	6	0	6	1	1	1	0	0	34

Calculations

FDS = When the birds per strip drops 20% from previous average

$$PE: = \frac{\text{Strip Transect Width}}{\text{FDS width}} * \text{\# of detections in Full-Detection Strip Area}$$

$$CD: \frac{\text{Total number of detections}}{\text{Estimated total population for area being tested by transect}}$$

Example

Full Detection Strip = 10 m.
# of Detections in FDS = 19
Strip Transect Width = 125 m.

Population Estimate = $\frac{125m.}{10m.}$ x 19 birds = 237.5 Carolina Wrens / 25 Hectares = 9.5 Carolina Wrens / Hectare

C.D. = 34 / 237.5= .14

Conclusion

Results

In Figure 6, we can see on average, urban transects contained an average of 12.01 birds per hectare, while suburban and rural transects contained 10.12 and 5.12 birds per hectare respectively. This data set was significant with an ANOVA test ($p=0.005$). The T-Tests conducted showed that the rural vs suburban ($p=0.0331$) and the rural vs urban ($p=0.0006$) transects were significant. The T-Test conducted on the urban vs suburban ($p=0.3549$) was not significant.

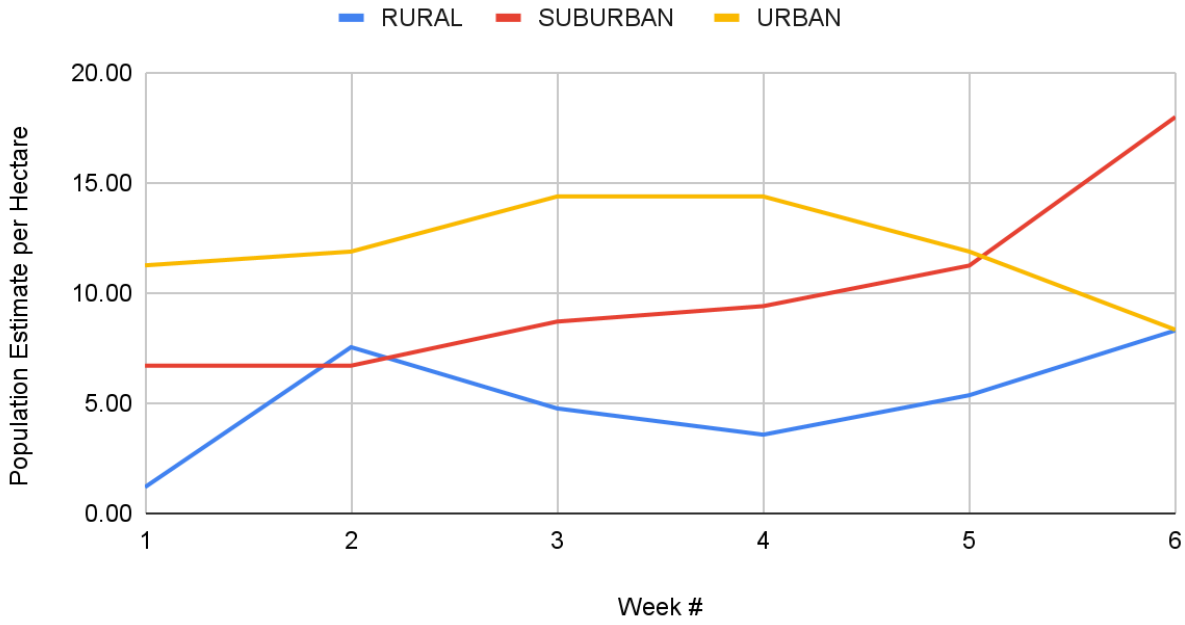
In Figure 1, we dive deeper into the data and see how consistent our data was. All 3 lines represent different transects with the population estimates from each week graphed. The 3 lines mostly maintained the order seen in the averages except for some points. For example on Week 2, the rural transect recorded 7.54 birds per hectare, and the suburban transect's PE was .84 birds per hectare lower. Week 6 was the other wonky one because we went on different days and there was rain. Suburban (went while wet) had the most with a study-high 17.98 birds per hectare. The second-most was the urban (went while drizzling) with 8.33 birds per hectare, and rural (went while sunny) remained last with 8.30 birds per hectare.

In Figure 2 we can see that there is a slight positive correlation of there being more human interruption creating a higher population. The line of best fit shows that at 0 interruptions there should be around 7.15 birds per hectare whereas at 20 interruptions there should be 11.77 birds per hectare. The r^2 value was .154 which strays away from the linear value of 1. This is because the plot contains a lot of outliers with low human interruptions and high PE's. Some contained very low values for both. The high interruption and high PE part of the graph (top right) had fairly linear values though. Rain could also affect the amount of human impact

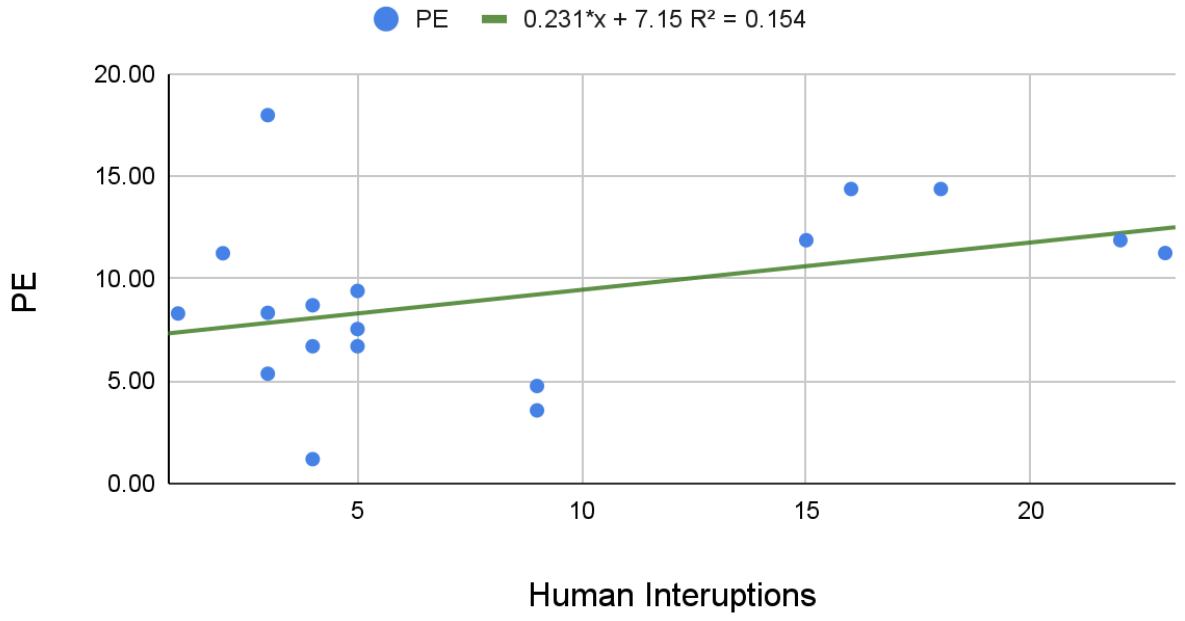
In Figure 3 we can see that the urban transects detect significantly more birds closer by than farther. In the 0-5m, 5-10m, and 10-15m strips the average detections were 8.8, 10.3, and 6 respectively. Then the values dropped off in the 15-20 m, 20-25 m, 25-30 m, 30-35 m, 35-65 m, 65-95 m, and the 95-125 m strips with average detections of 1.8, 1.8, 0.7, 1.2, 1.2, 0.5 and 0 respectively. Suburban transects detected significantly more birds in 0-25 m strips then the rest. In the 0-5 m, 5-10 m, 10-15 m, 15-20 m, and 20-25 m strips the suburban transect detected 8.3, 7.3, 9.8, 6.8, and 3.8 respectively. The 25-30 m, 30-35 m, 35-65 m, 65-95 m, and 95-125 m strips with 1.5, 1.0, 1.2, 1.0, and 0 average detections respectively. The detections for the rural transect remained consistent throughout the study. With there being average detections of 3.3, 2.8, 4, 2.8, 2, 3, 2.5, 3.7, 3.3, 2.8 in each of the detection strips.

Figure 4 shows that out of the detections, what percentage were song, call, or visions. The urban transect (recorded by Sharma) detected a pretty even split of song, call, and vision with 31.4%, 25.3%, and 43.3% respectively. The suburban transect heard a lot of calls with 73.5% and not as many visions and songs with 20% and 6.5% respectively. The rural transect had 55.5% class, 42.3% songs, and because of the dense vegetation only 2.2% visions. We did an ANOVA test on the percentage of calls and found the data set was significant ($p=0.0021$). After T-Tests were conducted, the rural vs urban ($p=0.000456$)and urban vs suburban ($p=0.000000492$) were significant. The rural vs suburban ($p=0.1389$) was not significant.

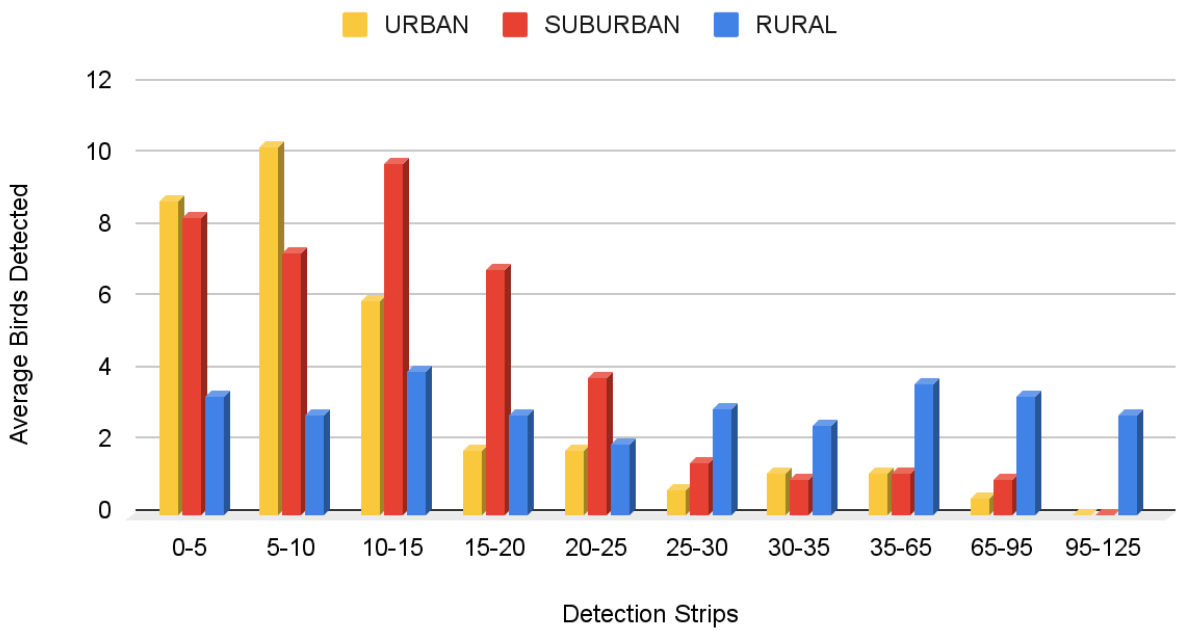
(Fig. 1) Population Estimates (Birds Per Hectare) by Week



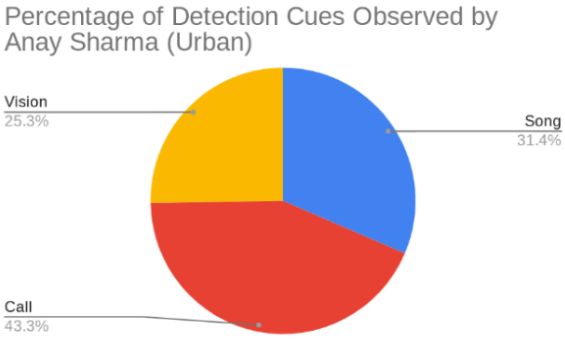
(Fig 2) PE vs. Human Interuption

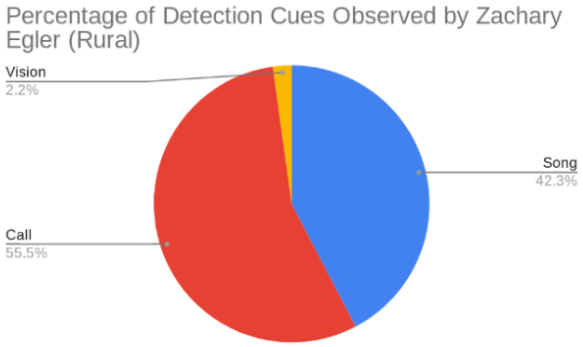


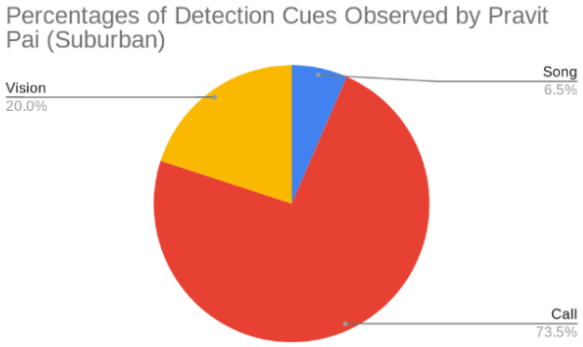
(Fig. 3) Average Birds Detected Per Detection Strip



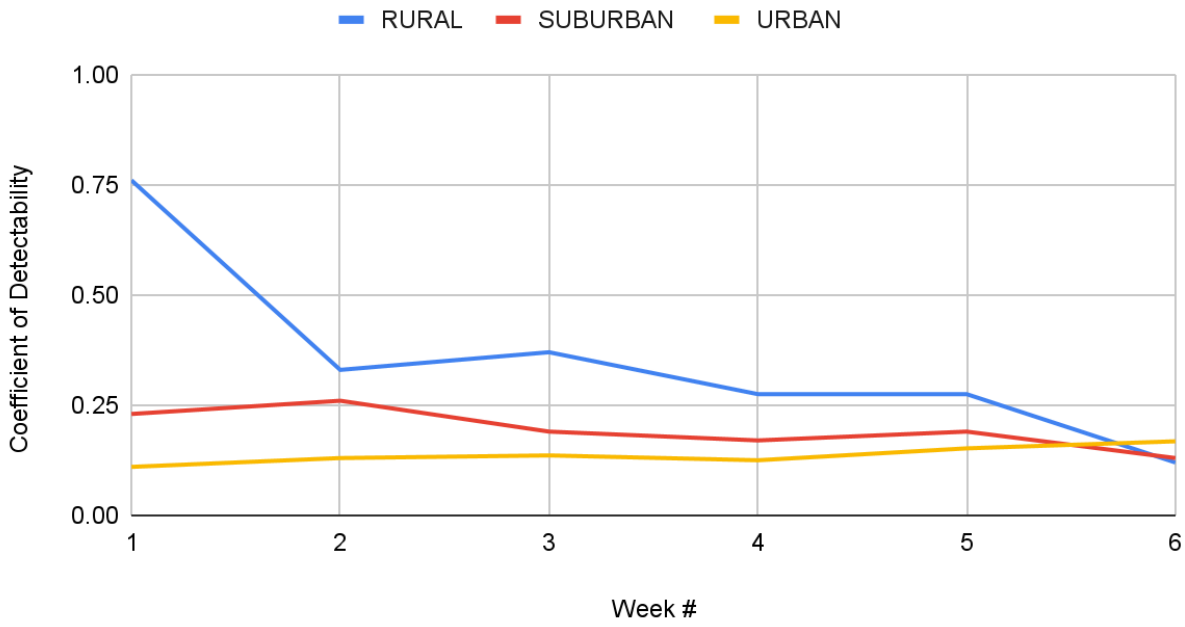
(Fig.4) Percentage of Detection Cues Observed



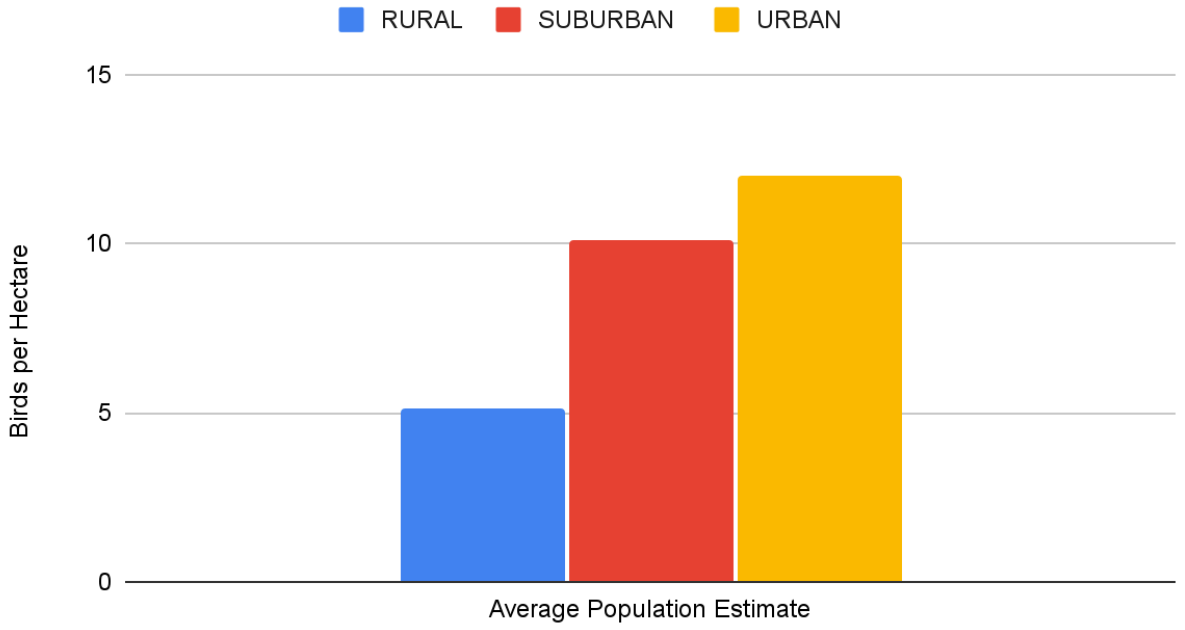




(Figure 5) Coefficient of Detectability vs Date



(Fig. 6) Average Population Estimates From Different Transects



Discussion

The hypothesis is was the population of Northern Cardinals will be more abundant and centralized in urbanized areas due to their inclination toward houses and urban parts of forests.

The results of this study suggest that there are more birds per hectare in urban areas than in rural areas. More specifically, the data illustrates that more Northern Cardinals can be heard on further away detection strips in the rural transect compared to more urbanized ones. This is likely due to the absence of loud noises from society found in more urban and suburban areas, making it easier to identify birds at a further distance. By contrast, urban and suburban areas have more birds on closer detection strips. This could be because the data also suggests that Northern Cardinal sightings are much more common in urban areas than rural ones. Because the forest is less dense around more urbanized areas for hikers and buildings, it makes it easier for birds to be spotted. The dense vegetation and uncleared grounds make it more difficult to spot birds in rural transects because it is difficult to spot them in the trees.

In addition to sightings, Northern Cardinals specifically favor urban areas. A study was conducted that included in three large cities in Myanmar where the scientists detected birds in areas differentiating in their urbanization levels (Downtown–urban, University Campus–suburban, Paddy Field–agriculture, Hill–forest) What they found was, "The urban environment favors species that can utilize small, discontinuous patches of vegetation", along with, "Omnivores were more abundant in the city center than all other functional groups… Insectivores were also predominant in the city center" (Reale, Blair, 2023). Northern Cardinals are omnivores, which explains why their population was far more abundant in very close detection strips in the urban transect where the vegetation is lighter near the trails as opposed to thick, woody forests further away.

Another study was conducted in the Bay Area in regions: one urban (San Francisco, CA) and one rural (Point Reyes, CA). They captured 162 white-crowned sparrows from the urban area, and 96 from the rural area. Scientists used MARK analysis to see if habitat had any affect on survival. They found that urbanization increased the survival rate. This is believed because of the "year-round food resources in urban habitats compared to fluctuating food resources in rural habitats" and the fact that "seasonal changes and environmental events, such as drought, affect rural areas more than urban areas" (Phillips et al., 2018). This supports the hypothesis that there are more birds in urban areas because of the increased conditions of survival.

Another study was conducted in north-central Florida. The study focused on two rural areas (a farm in Marion County and Austin Cary Forest) and two urban areas (Gainesville and Ocala). Using passive mist nesting, 80 birds were collected from 10 rural and 10 urban sampling points. A commonly used test based on 5 personality traits was conducted to measure the differences. The study revealed that the cardinals were more neophilic than their rural counterparts and had lower levels of stress hormones (corticosterone). This data was backed up by the fact that "urban forests were found to have nearly three times the amount of fruit and nearby bird feeders compared to rural areas, providing cardinals with ample food sources" (Huang et al., 2020).

Multiple possible errors happened. One problem encountered was the ability to collect data at the same time. Schedules were busy and the tight morning window made it hard to synchronize each data collection. This could have made the data more accurate as seen in Week 6 when the transects had different conditions (Fig. 1). Another error was during the first data set where all of us walked at fast speeds This can be seen in Week 1 where the data didn't follow the order we saw in the averages (Fig.1, Fig. 6).

Improvements that could have made the study more accurate could have been going on the same day each week to ensure that he weather and temperature was the same for each transect.

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The Effects of Urbanization on the Northern Cardinal Population in Gus Fruh Park

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Fall 2024

ABSTRACT: The goal of this study was to evaluate the extent that urbanization had on the Northern Cardinal population in Gus Fruh Park, Austin TX. The study included walking transects close to one kilometer in length and tallying when there was either a visual, or audio detection on six different occasions. The study included three separated transects one located in close proximity to urbanization having urbanization on both sides, one a medium distance only one side next to urbanization, and another was located in a more secluded area. The study also included using The Emlen Strip Transect Method to calculate bird population estimates on six different occasions, for each transect. After analyzing the data, it supports that the Northern Cardinal population in Gus Fruh Park increases in urbanized areas. In addition, more detections were made via call in higher urbanization areas. Overall the study supports that Northern Cardinals populations benefit from urbanization. However, it would be interesting to further research the extent of this benefit to see if Northern Cardinals populations still grow in a heavily urbanized area such as downtown.

Introduction

Purpose

The purpose of this study is to assess the effects of urbanization, specifically residential development, on the Northern Cardinal population in Gus Fruh Park, Austin, TX.

Hypothesis

The Northern Cardinal population in Gus Fruh Park, Austin, TX, will decrease the closer in proximity it is to residential urbanization. This is due to the decrease in natural landscape, pollution left from urbanization, and the noise pollution that occurs.

Site Description

Location

Gus Fruh is located in central west Austin. It is right by the intersection of loop 360 and Mopac. It is also south-east of Barton Creek Square and just above south lamar (Google Maps). The park is 13.24 km northeast of Austin-Bergstrom International Airport.

Areal Extent

Gus Fruh is 212 hectares. The perimeter of the park is 11.75 km. The western side of the park is framed by Texas 1 loop and Texas 360 loop. The rest of the park is shaped by the creek and Barton Hills neighborhood (Google Maps).

Topography

The highest point in Gush Fruh is 213 meters. The lowest point of the park is 152 meters. The topographic gradient is 61 meters (Topo Map Explorer).

Geology

Gus Fruh park has multiple underlying geological formations, for the majority of the park the underlying formation is the Fredricksburg Group Undivided formed in the cretaceous period. Towards the upper left of the park there is both Del Rio Clay and Georgetown formation, and the Eagle Ford Group and Buda Limestone Undivided which were both formed in the cretaceous period. The Fredricksburg Group Undivided, mainly contains various types of limestone, layered in sheets, that can be porous. The Del Rio Clay and Georgetown formation contains multiple rock types, mainly forms of pyrite, limestone, and can contain mega fossils deeper into the formation. Lastly, the Eagle For Group and Buda Limestone Undivided formation contains incredibly thin, brittle shale and limestone as well as containing certain fossils left over from the cretaceous period (USGS).

Vegetation

There was a large amount of vegetation in Gus Fruh, such as Ragweed, Poison Ivy, and Ashe Juniper. The coverage of the park was around 90% if there was water in the creek, but due to the overgrown vegetation in the creek and on the trails it was closer to 98% coverage.

Water Availability

The Barton creek flows through most of Gus Fruh and is the main source of water. The creek is dried up and looks like it has not been filled in quite a while (as of September 7th, 2024). There is a large amount of Ragweed filling the creek. There is evidence of the creek flooding up to five meters, such as significant erosion and trails being raised a large amount above creek bed.

Urbanization

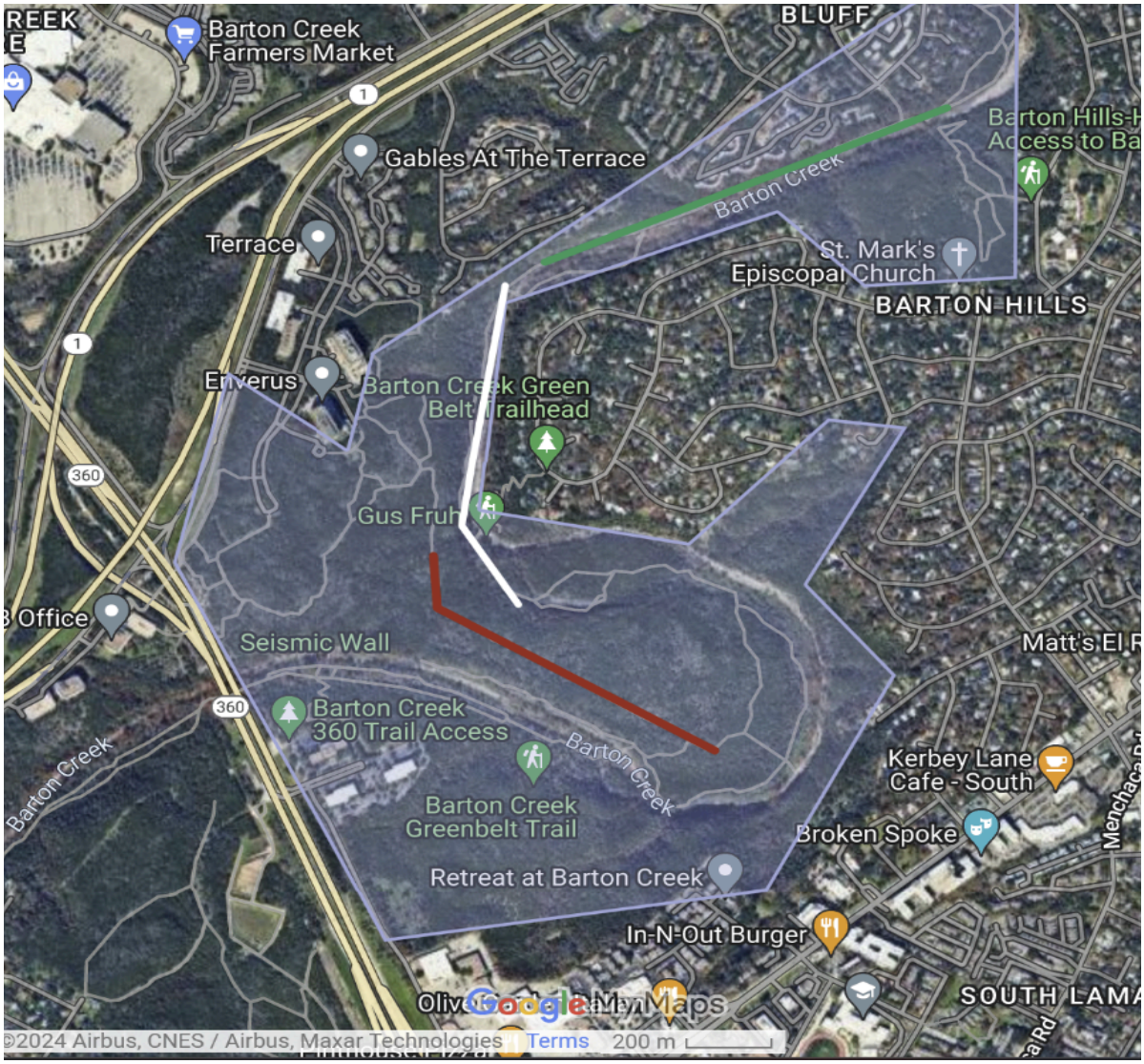
Gus Fruh park contains a medium level of urbanization. Surrounding the entire park, there is an incredible amount of urbanization such as highways towards the west and north, residential areas surrounding the north and east, large office buildings towards the northwest, and etc. However, throughout the actual park, the amount of urbanization is limited to trails, some sewage pipes, and multiple trash cans for disposing of litter. There are a large number of people either running, walking, or biking most days of the week (Fascinating Life Sciences).

History

The Texas government bought Gus Fruh in multiple purchases, 1980, 1986, 1992 (Austin City Records). During these times the area surrounding the park began to be urbanized with houses and roads as the park itself remained mainly unchanged. However, as the 20 century came to an end and the 21 began, urbanization surrounding the park exploded as more roads and buildings were developed (Historic Aerials - NETR Database). Gus Fruh itself mainly was left unchanged, but certain trails have become more visible and entirely new ones have been made.

Research Plan

Design of Study



The study will use Emlen strip transects to collect data on each transect on 6 separate occasions that are spaced out at least a week apart. Transect one (shown in red) is 800 meters long and follows a trail starting roughly 50 meters east of the Gus Fruh entrance. It continues along the trail until there is a 90 degree turn left. The transect is mostly visible from the aerial view, if you zoom in, but is covered by trees in some places. The transect begins at an elevation of 177 meters and gradually descends to around 161 meters. This is the only transect that does not directly follow the creek and it sits into between where the creek takes a u-turn and doubles back. This transect is the least urbanized and has no houses near any part of the trail.

Transect two (shown in white) is 900 meters long and follows a trail starting around 200 meters south on the trail by the Gus Fruh entrance. It continues north along the trail and takes a 30 degree turn 230 meters in. It ends around 700 meters past the turn in a north-eastern direction. The trail is almost completely covered by trees and only visible in some parts of the aerial photo. Because the trail follows the creek, the transect keeps its elevation very consistent, from 155 meters to 158 meters. This transect is urbanized a moderate amount with neighborhoods and houses on one side of the transect.

Transect three (shown in green) is 800 meters long and follows the same trail as transect two. This transect is a completely straight line and ends at the Flats. It begins 50 meters after the end of transect two. This trail is mostly covered with trees and the trail is only visible in parts of the aerial photo. This transect is the most urbanized with neighborhoods and houses on both sides of the trails. It also ends at a pretty popular spot for people so there might be more visitors.

Background Information

The male Cardinals appear bright red with a small dark mask around the bright red beak and eyes. Female Cardinals appear a pale brown with a bright red beak and small bits of red on the wings. Other field marks are the tuft of hair sticking straight up on the top of the head. The geographic range stretches from the north east USA all the way down to Mexico. The farthest West they go is Nebraska. Cardinals prefer forest, wetlands, and shrublands. The Northern Cardinal hops on the ground and small bushes looking for insects, berries, and seeds. The adult's diet is mostly seeds while the young are fed insects. Males are aggressive attacking any males trying to invade the nest. When courting each other they will move their heads back and forth while singing softly. The birds will try to find mates in the spring. The nest is built by the female and is placed anywhere between 0.9 - 3 meters. Females build the nest well hidden in bushes or trees. The song is a series of quick metallic chirps. The calls are spaced out chirps (Cornell Lab of Ornithology, 2024).

A study in the Netherlands was conducted on the clutch amount of Great Tits over their distance to a highway. They used 10 transects and many nesting boxes to take data over the clutch size. The study showed that Great Tits that nested in louder areas had smaller clutch sizes (Halfwerk et al., 2010). This supports the hypothesis that Northern Cardinals will have a smaller population when on transects closer to urbanized areas.

A study in suburban areas of Southeastern U.S.A. was conducted over the dangers of domestic cats on bird populations. They tested 60 cats using animal-borne video cameras. The study showed how domestic cats can pose a significant threat over certain animal species as on average the cats killed 2.4 animals during a seven day period (Loyd et al., 2013). This connects to the hypothesis as domestic cats will be far more common in urbanized areas and can threaten the native bird population.

According to a study conducted in Minas Gerais, Brazil in 2017 birds were found to share less diversity in urban environments than those found in forest (Pena et al., 2017). The scientist used 60 points with a 50 meter radius to conduct the study. Each point had 3 20 minute visits during the breeding season. The times when this was conducted would be 30 min after sunrise and would after the first 3 hours of daylight. This could lead to less population in the Northern Cardinal population living in Gus Fruh. The lack of genetic diversity weakens the population to diseases.

Materials

- Binoculars
- Merlin Phone App (Cornell)
- MapMyRun Phone App
- Project Notebook
- Cornell Lab of Ornithology

Procedure (Emlen Strip Method)

- Prepare a data field chart
- Ensure that researcher able to recognize chosen bird's song and call
- Walk to transect starting point
- Begin run survey on MapMyRun
- Conduct census by walking very slowly and pausing briefly every once in a while
- In your data field chart, record species' detected from song, call, or vision, and distance (make sure to only record on the first detect).
- Also record the types and amounts of human activity, animal activity, and any other issues
- Once researcher has completed walking their transect, end \run on MapMyRun and show it to teacher in class
- Calculate the values of full detection strip (distance up until the average number of detections drops by 20%), population estimate ((Strip transect width/full detection strip width x # of detections in full-detection strip)/area being tested by transect in hectares), and coefficient of detectability (Total number of detections/Estimated total population for area being tested by transect)
- Repeat this procedure at least 6 times at least a week before

Example Data Table:

Method of Detection	0-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-65m	65-95m	95-125m	Total
Song	0	2	0	0	0	0	1	1	1	1	6
Call	2	2	2	1	2	1	3	0	0	0	13
Vision	2	0	0	0	0	2	0	0	0	0	4
Total	4	4	2	1	2	3	4	1	1	1	23

Other data and calculation recorded below.
F.D.S.: 10m
# of Detections: 8
P.E.: 3.88 per hectare
C.D.: .23

Conclusion

Results

Over the course of six weeks, six different sets of data were collected on each transect (Fig. 1). On average, the low urbanization transect had a cardinal population estimate of 1.89, while medium and high had 7.65 and 12.92 respectively (fig. 2). There were significantly more Northern Cardinals on the high and medium urbanization transects compared to the low ($p = 0.0093$, $p = 0.0001$). However there was not a significant difference between the high and medium transects ($p = 0.2997$). In the high urbanization transect 69.4% of detections were from calls, while in the medium and low urbanization transects 57.8% and 53.7% (Fig. 3, 4, 5).

The average number of disturbances (e.g. hikers, dogs, bikes) during the data collection period was 7.38 on the low urbanization transect, while the medium and high urbanization transects averaged 28.00 and 27.17 (Fig. 6). The difference between the high and low and between the medium and low transects was statistically significant ($p = 0.0189$, $p = 0.0010$) while the difference between the high and medium was not ($p = 0.2996$). In addition, when taking population estimates in relation to the average temperature, there was no correlation suggested (Fig. 7).

Figure 1. PE of Each Data Set

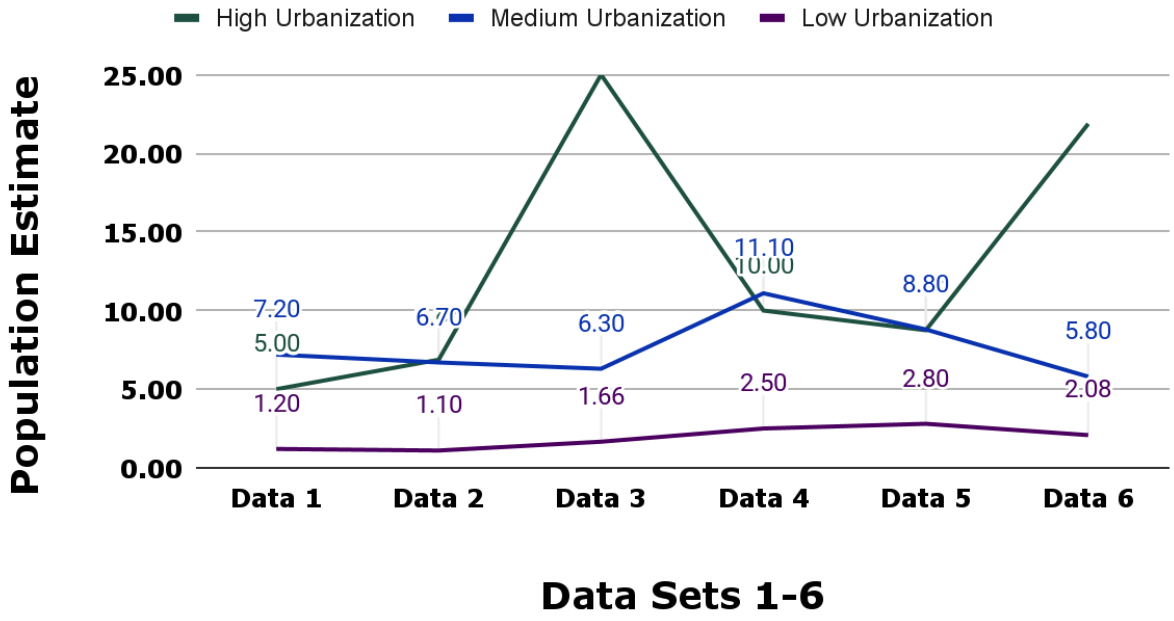


Figure 2. PE Average vs. Urbanization

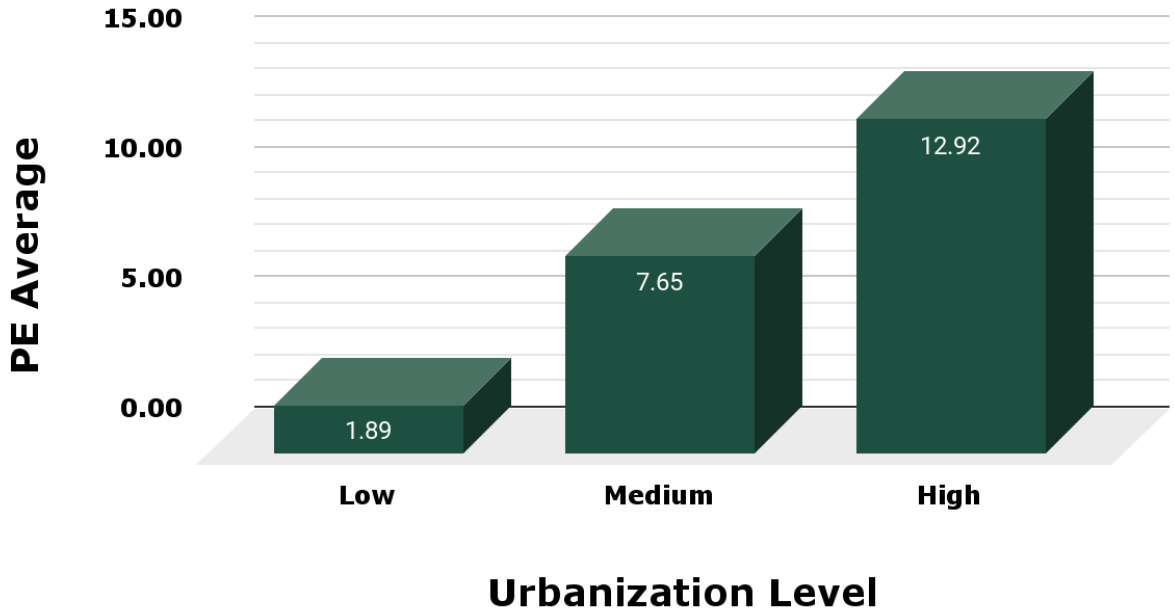


Figure 3. Percent Detections in High Urbanization

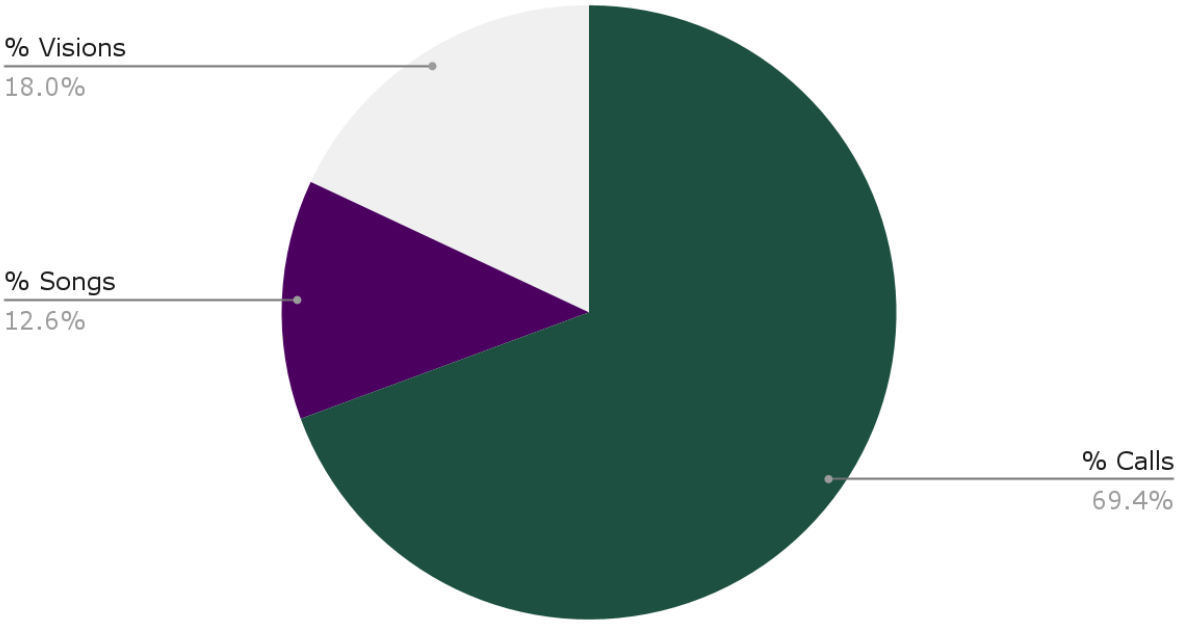


Figure 4. Percent Detections in Medium Urbanization

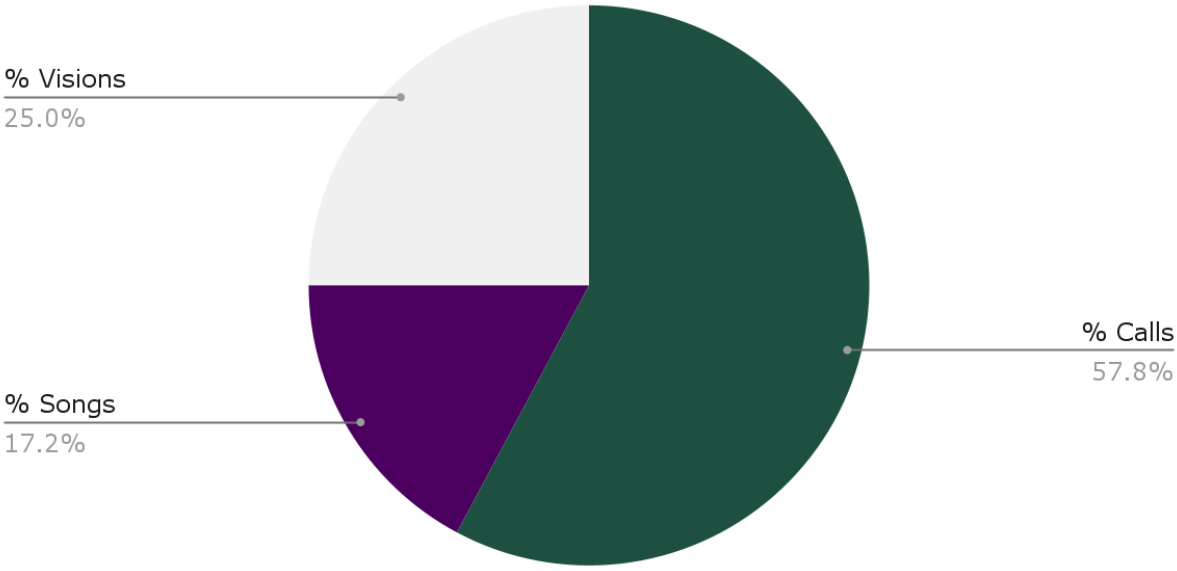


Figure 5. Percent Detections in Low Urbanization

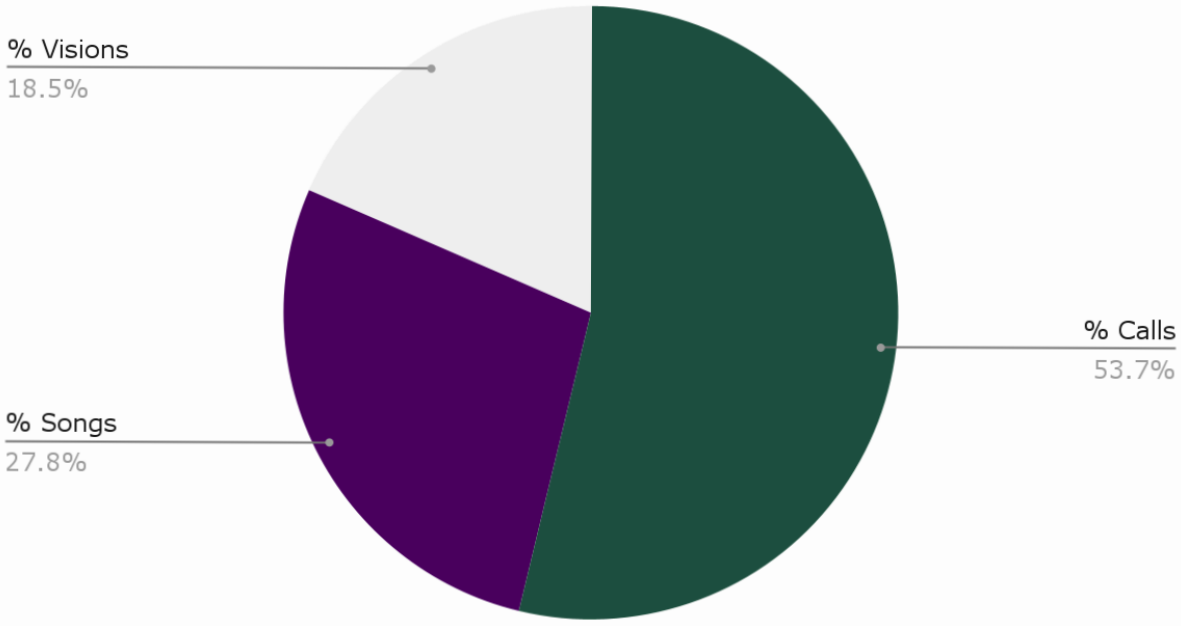


Figure 6. # of Disturbances vs PE Average

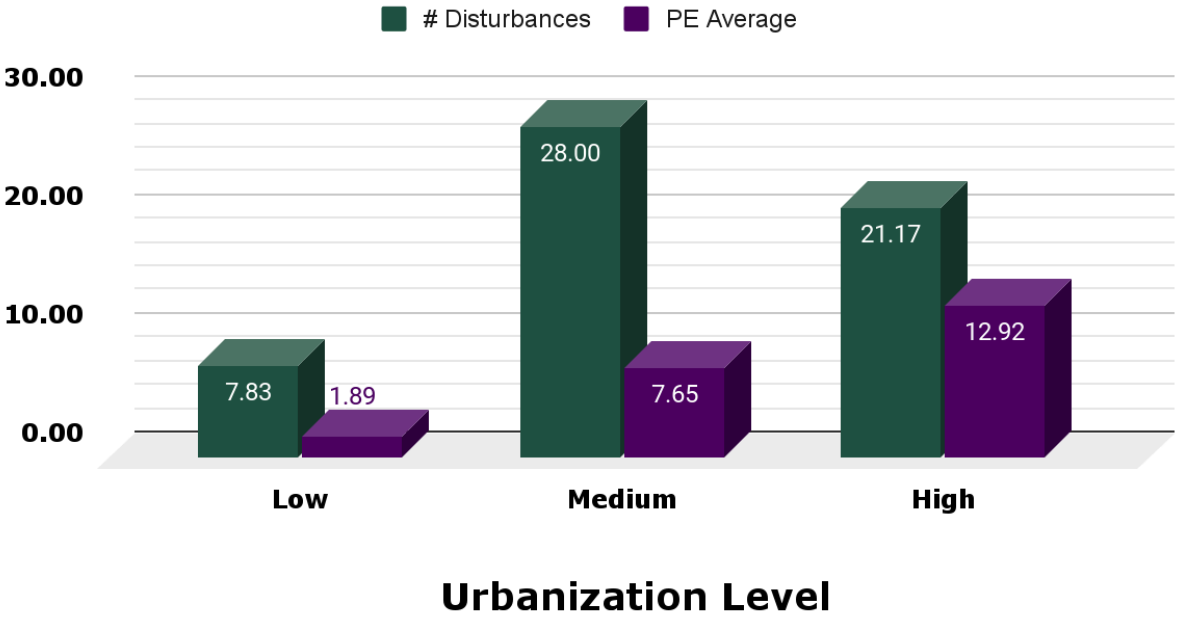
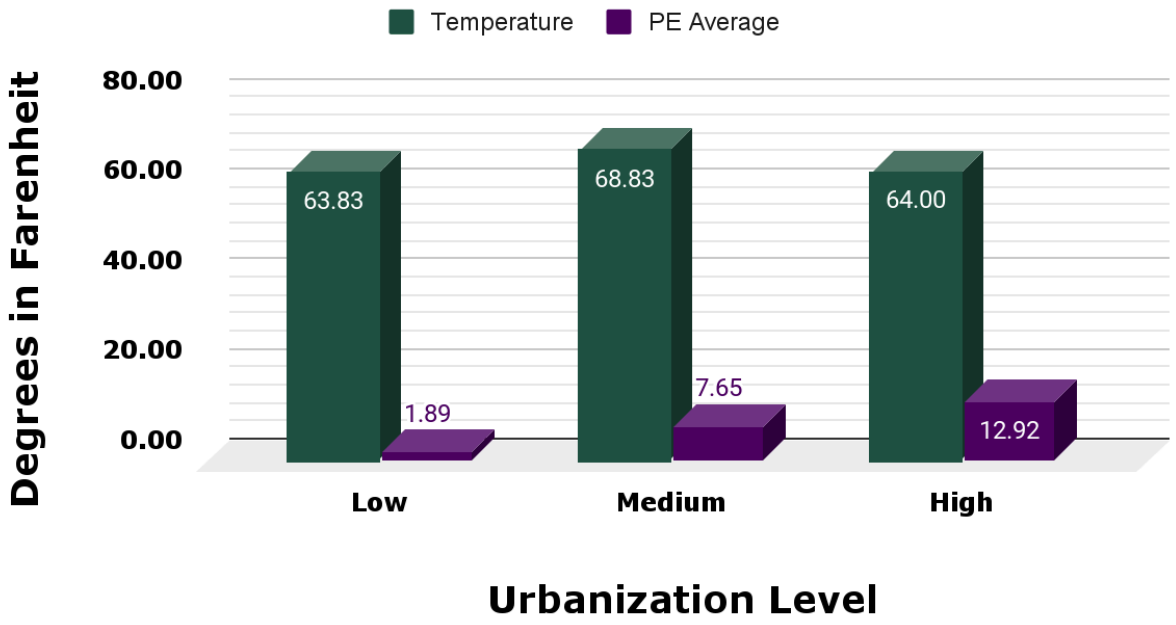


Figure 7. Temperature vs PE Average



Discussion

The hypothesis was that the Northern Cardinal population in Gus Fruh Park, Austin, TX, will decrease the closer in proximity it is to residential urbanization. This is due to the decrease in natural landscape, the increase of pollution left from urbanization, and the increase of noise pollution that occurs. The results of the experiment show quite the opposite. A larger number of Northern Cardinals were found in closer proximity to urbanization. The average population estimate for high urbanization was 12.92 per hectare. This transect was surrounded on both sides by urbanization. The average population estimate for medium urbanization was 7.65 birds per hectare. This transect only had one side close to urbanization. The average population estimate for low urbanization was 1.89. This transect was the most isolated from urbanization (Fig. 8). This means that the cardinals find it better to live either in or next to urban areas. The experiment conducted is also supported by the other studies below.

A related study was conducted over 58 forest bird species by analysing the "Second Pennsylvania Breeding Bird Atlas". Surveys were conducted between 2004 and 2009 in a grid of over 4000 blocks, each block approximately 25 km^2, in the survey, paid, and trained researchers would take results based on sound and sight for 6 minutes and 15 seconds. After analysing the survey's data their study supported that many bird species, specifically those that were grain eating or omnivores, were benefited in increasingly urbanized areas (Gagne et. al.). This supports the results that were gathered from the current study.

In a study conducted in Pecs, Hungary. There were several points where a person would spend 10 minutes on the point. Every bird heard and seen within 50 minutes was reported. This study reached the result that birds were more common in urbanization areas instead of rural areas. The results of this study relates to the Northern Cardinals experiment as more birds were found closer to urbanization. The birds prefer the urban areas due to bird feeders, short grasses to find insects easier, gardens, and buildings to help build nests.

In a study held from 2004-2014, Northern Cardinals were studied in a rural-to-urban Ohio, USA. 10 ha grids were created in various urban density areas and were traversed in 50 meter intervals. Females were target banded to determine population estimates. This happened 50 times in the months of July to August. Their results suggested that urban areas had a smaller evolutionary force that it exerted on the female cardinales. This resulted in more cardinals surviving to reproduce and urban areas did have a higher average population estimate than rural areas.

The study did have a couple possible problems. For instance, each transect has only six data sets taken from it. This limit in available data obviously hindered the results. In a future study on bird population in relation to urbanization, an increase in data would benefit it. In addition, having multiple people take data sets will obviously create differences for any number of reasons. For example, certain researchers could have been more adept at distinguishing between bird calls. Also, as time went on, data collection improved throughout everyone taking data - researchers most likely improved in their ability to distinguish Northern Cardinals by sight and sound.

If the study was redone, each transect would be located in different locations. For example one in a neighborhood, another one on the edge of a city and the low urbanization transect in a forest away from urbanization. There would be a large data pool, and preferably a single trained scientist collecting data.

Overall, the data found in this study as well as the results from various other studies support that Northern Cardinal population increases in higher urbanization areas. Some possible reasons for this are the abundance of bird feeders found closer to urbanized areas. Another reason might be that there are a smaller number of predators closer to urbanization. In addition, the idea that being a resident species was a factor that benefitted bird populations' success in urban areas. The data also supports that Northern Cardinals call more while in higher urbanization. Northern Cardinals use their call to warn anyone messing with their territory which would make sense with the higher number of disturbances also found in urbanized areas.

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The Effects of Sunlight Exposure on Arthropod Biodiversity and Abundance in Gus Fruh Park

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ABSTRACT: Arthropod biodiversity and abundance are commonly affected by sunlight exposure present in habitats. Various organisms suffer from UVB radiation, while others are attracted to it. Researchers set out to gather data on arthropod diversity and abundance present in Gus Fruh Park, Austin, Texas, periodically collecting data on 3 transects in each low, mid, and high exposure environments. They hypothesized that the increase in biodiversity and abundance occurs as exposure to an environment decreases. Researchers would incrementally search sections of a 50-meter transect, catching as many bugs as possible in the designated time limit. Data suggests that arthropods truly are more diverse as exposure in an environment decreases. Low exposure transects present an average diversity of 4.67 arthropod orders, as opposed to the mid and high 3.33. Abundance data suggests a trend of abundance increasing from high, low, to mid exposure, 6.33, 8.33, and 13.00, respectively. However, the abundance of data acquired was most likely due to bias present from researchers' increasing experience throughout the study, and therefore presents inconclusive results. Therefore, it’s likely that diversity is inversely correlated with exposure levels, and future research performed around arthropod abundance should most likely be conducted by experienced researchers for less biased results.

Introduction

Purpose

The organism that is planned to be studied is Arthropods. This will be conducted in the central east portion of Gus Fruh Park, Austin, TX, where the team will examine how different habitats and sunlight exposure affect the concentration and types of arthropods present.

Hypothesis

The population of arthropods will be inversely proportional to the amount of exposure and, by extension, soil quality and moisture. Multiple articles in Nature.com's scientific journal support this.

Site Description

Location

Gus Fruh is located in South Austin, 0.8 kilometers east of the intersection of 1 Mopac Highway and 360 Capital of Texas Loop (Google Maps, 2025). It's directly west of Barton Springs.

Areal Extent

Gus Fruh is rectangular and was calculated as roughly 217 hectares (Google Maps, 2025).

Topography

The highest point was 212 meters, and the lowest was 149 meters on February 23. (Topography Explorer, 2025). The elevation decreases as the park approaches the creek. It also has a sudden elevation increase in the form of a cliff along the creek.

Geology

The park is mainly composed of Edwards Limestone (Kfr), Fluviatile terrace deposits (Qt), Alluvium (Qal), Del Rio Clay (Kdg), and Eagle Ford Formation (Keb) (USGS). Kfr, Kdg, and Keb were formed in the Cretaceous period, containing various sands, silts, and clays. Qt and Qal, formed in the quaternary period, being dominant in the area is most likely due to the area's creek and fluctuating water level, leading to younger grainy river deposits forming over most of the park. There are noticeable overhangs on top of cliffs with boulders in the valley below the cliffs.

Vegetation

During a visit on February 23, 2025, Gus Fruh Park was observed to be mostly composed of woodlands. It was roughly 90% woodland and 10% grassland. Ash Juniper, Common Chickweed, Heavenly bamboo, and green-tufted stubble moss were all observed throughout the survey.

Water Availability

The only major water source observed on the February 23, 2025, visit was a creek. The transition from alluvium to soil is 3.66 meters from the creek, which allows us to infer that the river has reached a peak of roughly 3.66 meters deep. The creek was empty during the visit, with little to no evidence of past flooding.

Urbanization

The trailhead that the team accessed Gus Fruh from was located adjacent to the Barton Hills neighborhood. Throughout the survey, the team observed mile markers, artificially dug trails, and wooden posts. In addition, litter and rock graffiti were found near the creek. Lastly, multiple rock formations were placed by human hands with pipes and other water features under them.

History

Gus Fruh was established in 1980, 1986, and 1992. Historically, the area was named Town Lake without the use of any dams (History of Austin Creeks). Later, in December of 1975, hike and bike trails were created in the Gus Fruh area(History of Austin Creeks). The river used to be 20 meters wide in 1937, but now is only 10 meters in width (Historic Aerials).

Research Plan

Design of Study

The timed transect method will be used for data collection. There are three 50-meter transects each in Grasslands (Green), Woodlands (Blue), and Creek beds (Orange) for a total of 9 transects. Data will be collected once for each transect.



Background Information

A study was conducted in various parts of South Dakota across woodlands and corridors between woodlands and rivers to determine the abundance of arthropods as prey for birds. Surveys were conducted within 200 meters of a mist net used to catch migrant birds, and branch-clipping, pitfall trap, and sticky trap methods were used to catch arthropods. Results suggested that arthropods were sufficiently diverse and abundant in corridors and woodlands (Avian Conservation & Ecology 2021). This result demonstrates an abundance of arthropod populations in shaded areas like the woodlands we plan to observe because of the diversity of ecological

niches and microhabitats. This supports the hypothesis that arthropods will be more abundant and diverse in the woodlands than in more exposed areas. The study concluded that wooded areas had more arthropods because there were more diverse microhabitats for them to inhabit.

A study was conducted in a laboratory to determine the effects of constant exposure to adult Folsomia candida. They found that constant exposure to UV-B increased the mortality of Folsomia candida. There was also a reduction in egg viability and an increase in development time (Holford, 2024). This supports the hypothesis that arthropods will be more abundant in shaded areas like the woodlands, as they would have less exposure to harmful UV-B rays. Even though the organisms were inhabiting soil and leaf litter, they were still affected by UV radiation (Holford, 2024). The shade from trees in the woodlands would provide a second layer of protection from the UV rays because leaves provide extra protection in addition to the soil, rocks, and fallen leaves that are the only source of protection found in the creek bed.

A study was conducted in Lexington, Kentucky, in which researchers studied the effects of UV-B radiation, a common component of sunlight, on the two-spotted spider mite *Tetranychus Urticae* Koch and the aquatic copepod *Cyclops serrulattus*. The researchers isolated these two arthropods to a certain area of either leafage for the mite or water for the copepod and exposed portions of the defined areas to radiation. Both organisms demonstrated avoidance of the UV-B radiation-exposed areas and generally chose to exclusively occupy the non-radiated area. This result supports the hypothesis that arthropods will be more abundant in areas with less exposure to sunlight. This would translate to the woodland and grasslands within Gus Fruh, as the dry creek beds can't provide as much shade when arthropods are above ground without large woody plants to do so.

Materials

- Field Guide (Borror 1970)
- iNaturalist Seek Phone App
- 50 Meter Transect Line
- Collecting Net
- Storage Box
- Forceps
- Cotton Balls
- Ethanol
- Acetone Fingernail Polish Remover
- Dichotomous Key
- Project Notebook

Procedure

During the survey, the team will follow these directions:
Data collection procedure:
1. Prepare 7-10 killing jars each with a cotton ball saturated with acetone or ethyl acetate (fingernail polish remover) in it.
2. Travel to the study location in Gus Fruh using Google Maps.
3. Stretch the 50-meter transect line in the study area.

4. Make a note of the transect number, transect category (based on variable), date, time, weather, and ground cover in the project notebook.
5. For every 10 m interval, sweep the vegetation along the 10-meter section with the collection net. Then, follow up with a visual inspection using forceps for 5-10 minutes. If at least 2 arthropods are not found in the first 10-meter section, adjust the placement of the transect and restart data collection. Transfer specimens to the killing jar and pause the time when doing so.
6. Label each killing jar with the name, the date, and the transect number.
7. At home, sort the specimens from vegetation and put them in a freezer. Combine specimens from the intervals of one transect into a single container. Label the container with the name, the date, and the transect number.

Preparation of Specimen Collection:
1. For each data set, key all collected arthropods to order, group the individuals based on similarities in appearance, and make sure its use is consistent for all the arthropods collected by every group member during the project. Record each specimen in the project notebook with a description of each morphospecies when first encountered.
2. Prepare one individual of each morphospecies for the collection
Preservation of Insects:
Once insects have been killed, they should be removed from the killing jar immediately. The insects should be separated from the vegetation and placed in a freezer until they are preserved. Put soft-bodied insects into alcohol. All others should be pinned as described below:
Select the appropriate size pin for the insect. Insects should be placed on the pins such that the tops of the insects are a uniform distance from the top of the pin. Insects that are too small to pin should be glued to points, which can subsequently be pinned.
Spreading Insects: The wings of Odonata and Lepidoptera should be spread so that the veins of the wings can be seen. Push the pinned specimen into the groove of the spreading board until the base of the wings is level with the board on each side. The wings are then spread, and paper strips are placed over them.

Labeling Insects:
1) the order label
2) the morphospecies label
3) the locality label. The locality label contains the state and county, the park location, the transect category, the date, and the name of the collector of the specimen. Locality labels should be typed in 4-point Arial font and cut to the smallest size possible.
4) For pinned insects, one order label is placed at the top of the column of all the specimens within that order and a morphospecies label and a locality label are placed below the specimen, with the morphospecies label on top.
5) Affix all three labels to each vial.

Conclusion

Results

On average, low exposure transects contained 4.67 different orders of arthropods, while mid and high exposure transects both contained 3.33 (Fig. 1). There were slightly more orders found in low transects than on mid and high transects, but the differences were not statistically significant ($p = 0.40$). On average, mid and high transects present the same number of arthropod orders. Mid transects' standard deviation is 1.53, while high exposure transects have a standard deviation of 0.58. On average, low exposure transects contained 8.33 arthropods, mid exposure contained 13.00, and high exposure transects contained 6.33 (Fig. 2). There were more arthropods found in mid transects than on low and high transects, but the differences were not statistically significant ($p = 0.42$). The standard deviation of low and high transects is 1.15, while mid transects have a standard deviation of 10.15. On average, Coleoptera, Orthoptera, Hemiptera were more abundant the less exposure present in their environment. High transects contained higher abundances of Diptera, while mid transects contained higher abundances of Araneida (Fig. 3). There were more Araneida found in mid transects than on low and high transects, but the differences were not statistically significant ($p = 0.30$). The average abundances of both Hymenoptera and Isopoda were generally consistent across all three exposure level transects (Fig. 3). Araneida and Hymenoptera had the greatest number of morphospecies (Fig. 4).

Fig. 1: Order Diversity vs. Exposure

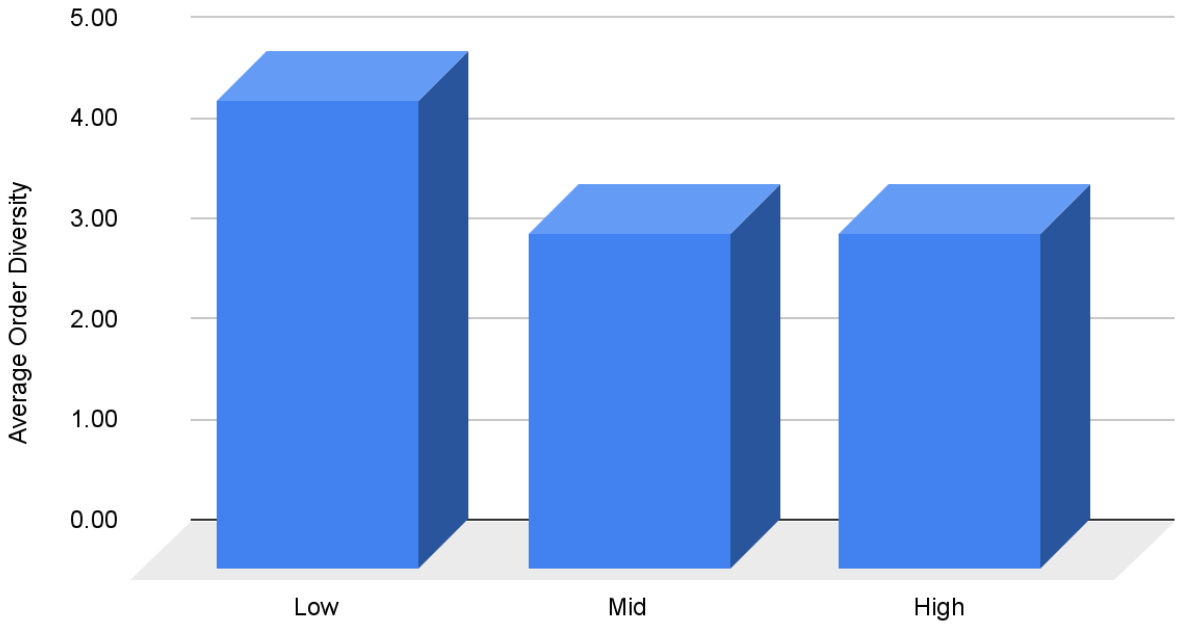


Fig. 2: Average Abundance vs. Exposure

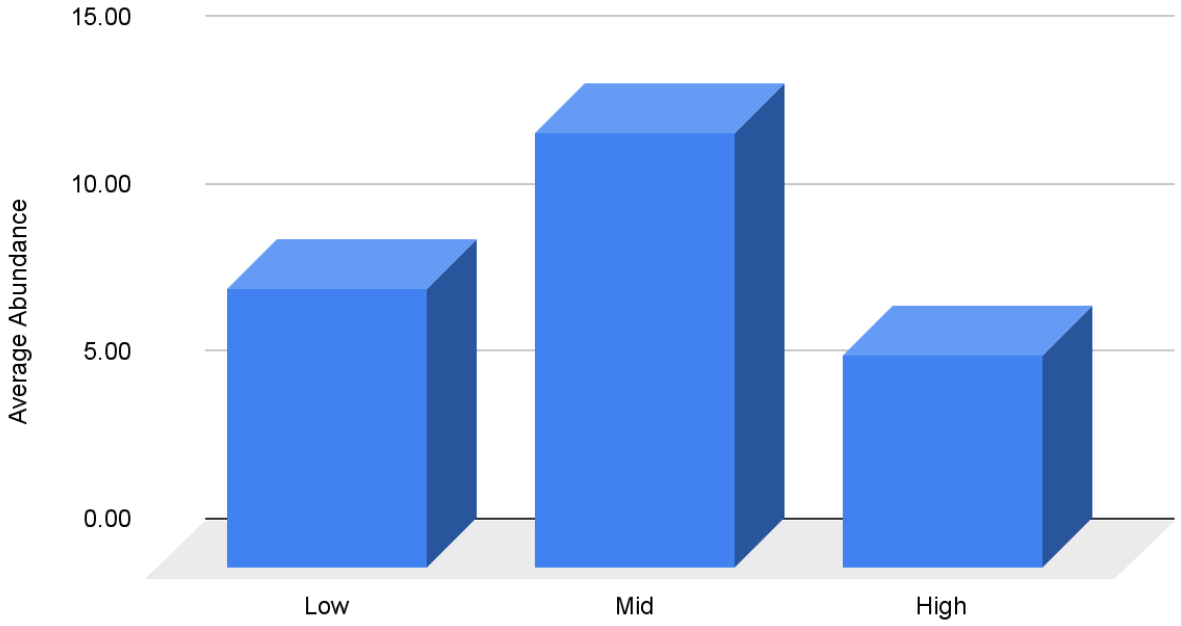


Fig. 3: Abundance by Order vs. Exposure

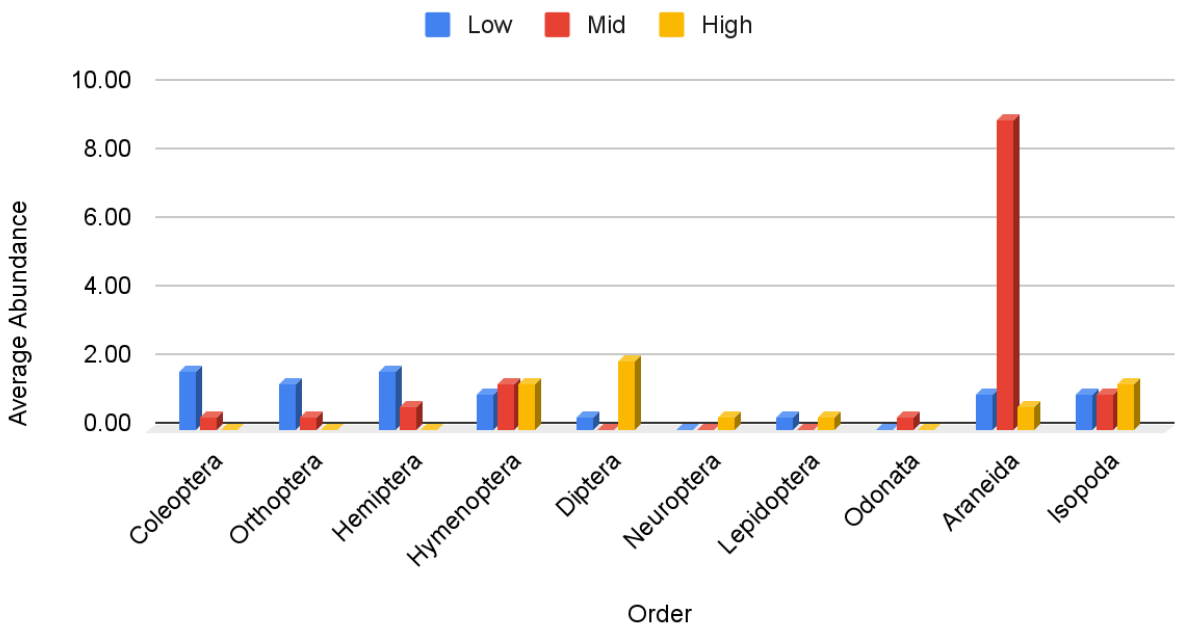
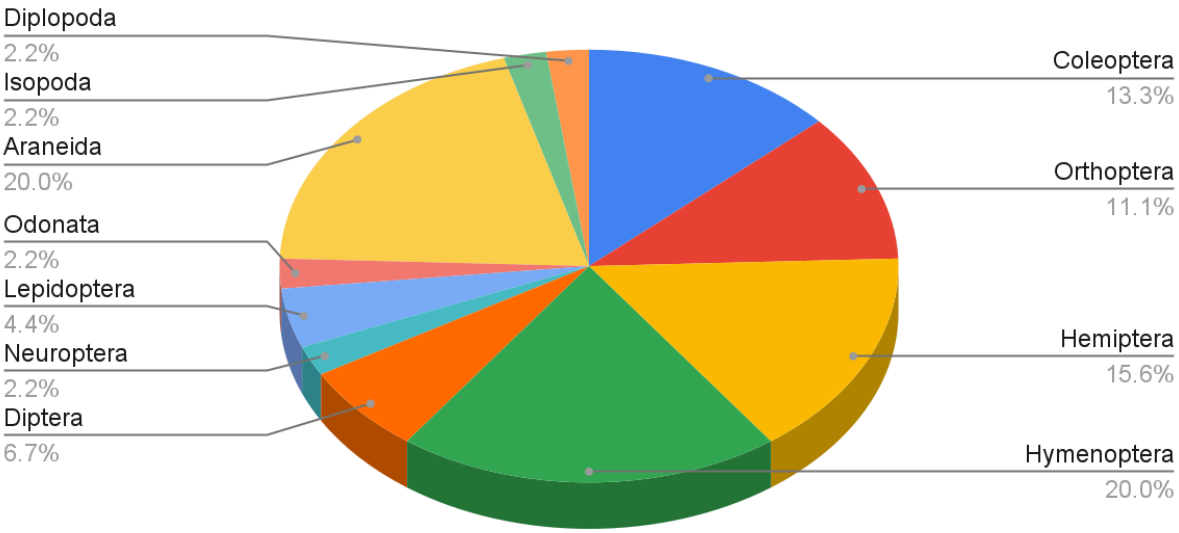


Fig. 4 Total Morphospecies Diversity by Order



Discussion

We hypothesized that the population of arthropods would be inversely proportional to the amount of exposure and, by extension, soil quality and moisture. Multiple articles in Nature.com's scientific journal support this. Increasing levels of biodiversity in relation to the decreasing exposure levels prove this hypothesis. However, results surrounding abundance present biased and therefore inconclusive results, not suggesting this hypothesis.

Biodiversity increased as exposure lowered, probably due to the increased cover from radiation, leading to greater occupational space and variety of possible ecological niches. This is supported by a study conducted in 2021 in the Appalachian area, which suggests that the amount of shade (lower exposure), specifically shade from trees, is directly proportional to arthropod biodiversity (Landsman et.al, 2021). Biodiversity data had a high standard deviation in the mid exposure transects, likely due to speculative placement during initial planning. The transects were not surveyed before being chosen, instead being chosen through aerial view, meaning smaller differences aside from exposure could have affected the biodiversity of arthropods surveyed. The most significant outside factors that could lead to deviation include Transect 3's river bed grassland fusion habitat, as well as Transect 1, which consisted entirely of a homogenous tall grass, housing a large abundance of spiders as opposed to other mid exposure transects.

The abundance of arthropods increased from high to low to mid exposure levels. This is in direct correlation to the order surveying took place, with each member surveying each exposure category at the same time (i.e, each high exposure transect was surveyed, then each low exposure, then each mid). This trend is most likely due to researchers improving over time. Coleoptera, Orthoptera, and Hemiptera were more abundant as exposure decreased, likely due to their reliance on cover from radiation and ability to occupy the wide variety of niches presented by the environment. Diptera were more abundant in high-exposure transects than other categories, most likely due to diptera's common exhibit of positive phototaxis, meaning an attraction to sunlit environments and the UV present in exposure. Araneida were extremely more abundant in mid-exposure transects, most likely due to the anomalous mid-exposure transect, Transect 1, which presented a large population of spiders.

Isopoda and Hymenoptera had a relatively equal abundance throughout the transect categories. Hymenoptera's consistency is likely due to its resistance and generalist nature, supported by a Lake Forest College study conducted in 2016, which found Hymenoptera being resilient to habitat disturbance and therefore able to handle different microhabitats without much issue (Arthur, 2016). Araneida and Hymenoptera were the orders with the most abundant unique morphospecies. This is most likely because Araneida and Hymenoptera tend to be larger on average compared to other orders of arthropods in Texas, as well as resting in easier-to-see locations compared to others, such as flying organisms. This is supported by a study in 2012 that found that Arianeida were abundant along transects in the northern hemisphere, at a similar time to the time collection took place (Rogers, et. al., 2012).

During this study, several problems occurred that could have interfered with the data collected. First, time constraints due to external obligations led to researchers having to collect data during different times of day, and therefore various weather's and times of day. Also, some had to leave

preemptively from the research site, leading to other researchers not having as much help as they usually would, which could lead to a potential bias. Next, timekeeping was not very precise, with researchers using a mobile phone's built-in timer function, and various human errors led to margins of error inconsistent throughout data gathering. Another large bias is the increasing experience of researchers. Abundance data is exactly correlated with the chronological conduct of research, suggesting a large bias. Future research should try to coordinate the times of day to be more consistent and less variable, as well as use previously experienced researchers to eliminate the bias of increasing data gathering aptitude.

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Effect of Soil Type on Arthropod Diversity in Austin's Gus Fruh Park

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ABSTRACT: A study of arthropod diversity and activity was conducted within Gus Fruh Park, Austin, TX. Three distinct soil types - shale, limestone, and alluvium - were studied, with three data collections in each area. Each data collection involved a timed collection of arthropods on a 50-meter transect, utilizing forceps and bug nets. It was hypothesized that the alluvial environment would result in the greatest diversity, and the shale environment in the least. This hypothesis was supported by the data, with a total morphospecies count in the alluvium environment of 17, and 16 found in the limestone, while the shale environment only included 12 distinct morphospecies. The average number of organisms located on each transect was notably higher on the alluvium and limestone environments than in the shale environment. Though the hypothesis was supported, the results were not entirely known to be significant - the average organism count showed a p-value of 0.392 under ANOVA; additionally, alternate factors, such as time of day/year and vegetation diversity on transects, may have confounded results. Still, the knowledge gained during this experiment provides a solid base for future, larger-scale studies.

Introduction

Purpose

The purpose of this experiment is to assess the impact of soil type as influenced by water formations and faulting on the distribution of arthropod species in Central Texas. The experiment will be conducted in the Gus Fruh area of the Barton Creek Greenbelt in Austin, TX over several weeks in the Spring of 2025.

Hypothesis

The hypothesis is that arthropod diversity increases in moist, fertile soil as compared to shallow, dry, and less nutrient-heavy soil. Alluvial soil will have the most diversity, followed by limestone, and then shale with the lowest diversity.

Site Description

Location

Gus Fruh is located in Southwest Austin, near Zilker Park. It is 0.92 km east from the intersection of Mopac and 360, 6.03 km away from the State Capitol, and 1.5 km away from Barton Creek Mall (Google Maps).

Areal Extent

The research area is approximately 144 hectares in extent (Google Maps). The park consists mostly of a large, ellipsoid zone at the bottom, with small areas jutting out near the west end; a long, thin, winding area following Barton Creek extends to the north.

Topography

The elevation of the research area ranges from approximately 134 m to 207 m, or 440 to 680 ft (USGS, 1988). The gradient of the park area is mostly decided by the flow of the creek, when it exists; north of the trailhead, the west side of the creek is a sheer cliff, with the east side being decently gradual, while this is reversed south of the trailhead. The lowest point in the research area exists in the creek bed.

Geology

The two most notable base formations in the Gus Fruh area are Fredericksburg Group undivided Cretaceous limestone (Kfr) and Del Rio Clay, also known as the Georgetown Formation (Kdg) (Pocket Texas Geology Map, 2007). Most visible rock formations are made of limestone, including large parts of the creek bed; quaternary alluvium is found surrounding them. High incidence of fallen limestone boulders shows faulting and erosional behavior, especially in the shale walls adjacent to the creek. The stark cliff in the park is likely due to a combination of

the Balcones fault, which runs straight through the park, and erosion from continual river water (Historical Topo Map Explorer).

Vegetation

Overall, the Gus Fruh area is approximately 85% Woody Forest, 10% Rocky Shrubland, and 5% Grassland. Notable plants in the woody area include the Ashe Juniper, Chinese and Tree Privets, Firethorn, and many Joint-Toothed Mosses, alongside small populations of Twisted Leaf Yucca and Texas Blue Prickly Pear. In the shrubland around the creek bed, the main vegetation is composed of Switchgrass and Comb Bushmint.

Water Availability

The main water formation in the area is Barton Creek. During the visit on February 23, 2025, the creek was entirely drained; however, there is evidence that the creek has reached much greater heights in the past, with evidence of flooding up to 7-9 meters above the streambed in the surrounding vegetation and soil. Much of this water percolates down into the Edwards Aquifer, as this creek is part of its recharge zone; most of the creek's water comes from rain, especially during flash floods, and evidence of rapid downwards flow towards the creek is visible even at higher elevations in the park.

Urbanization

Majority of Gus Fruh is adjacent to the neighborhood Barton Hills, having many well developed trails running through much of the park (Google Maps). Notable human interaction within the park includes a tire swing by the creek, multiple guard rails, benches, tables, and an artificial stone wall to prevent soil erosion from the creek. The latter half of these features (guard rails, benches, tables, and wall) were notably dated, indicating this has been an urbanized park for quite a while. One of the most notable features are the multiple rock climbing walls present in the park.

History

In the late 1800's, Barton Creek's springs were a common stop on the Chisholm, and in 1907, Andrew Zilker bought the land, and 11 years later, in 1918, he gave the land over to the city. Over 50 years later in 1976, the City of Austin finally decided to start on preservation efforts, finishing their work in the mid 1980's (Barton Creek Time Stream). The area of Gus Fruh was obtained in three sections by the City of Austin in 1980, 1986, and 1992 (Austin City Records). Other history in Gus Fruh includes the dates of creation of the trails, such as the very first one being present since 1985, and other trails slowly becoming more defined. Gus Fruh last was flowing as a true river in late winter of 1991, and only barely flows now with heavy rainfall. However, if heavy rainfall occurs for a long period of time, flooding can occur, raising water level 2-3 meters above the usual (SOE).

Research Plan

Design of Study

The study will primarily be using a timed transect method, with each project member observing three 50-meter transects once each over the course of the study, for a total of nine data collections. Three transects will be located in and around the alluvium and terrace deposits surrounding the Barton Creek bed (labeled in black), three will be located on Edwards limestone cliffs (labeled in blue), and three will be located on the outskirts of the research area atop Del Rio shale (labeled in yellow).



Background Information

A study was conducted in Meru Betiri National Park, in Indonesia, evaluating the diversity and abundance of arthropods in different environments, such as paddy fields, orchards, forests, and savannahs. Conducted in the same manner, that is a transect of 100 meters, each section being 25 meters long, utilizing pitfall traps to collect data, after being left out for three days, over an unknown period of time. The results show that orchards have the least diversity, with only 7 orders, while forests have 9. These orchards are planted on loamy and clay soil, while forest soil mostly consists of peat soil, *supporting the hypothesis that arthropod diversity will be at its lowest on shale, while peat soil/alluvium and other types of soil rich in organic matter will have the highest diversity.*

A study regarding the effect of soil parameters on the interconnection between soil arthropod activity and fungal activity was conducted in Ontario, Canada. The soil in a 100 m^2 plot was divided into 10-meter layers, with sampling in each layer being conducted four times over one year. The data showed that soil arthropods are most abundant in the higher layers of soil and in the litter, and that the most notable factors on arthropod diversity were water content, temperature, and pH in the litter zone. Due to the fact that soil dries most in the hottest areas of the year, cold and moist environments were often desired by microarthropods, although there is a large variety as to the exact most desired soil content based on the species. Additionally, fungal health was found to be positively correlated with greater arthropod diversity, as fungi increased soil health, and lower-pH soil was found to be most amenable to both arthropods and fungi. That is relevant since moist, cool areas usually have lower soil pH. This supports that, due to various factors, cool, moist soil allows for the most diversity amongst arthropods and has the most richness in nutrients. *It is accordingly hypothesized that stream deposits in the study area will be the most cool and moist and have the highest richness in nutrients.*

A study was conducted in South Africa, to assess the influence of variables such as soil type at different spatial scales of different biotopes on arthropod diversity. The two areas most directly compared were the coastal Zululand and the interior Midlands. They studied 72 sites in total, over a large geographical area, utilizing pitfall traps, hand-collection, and soil sample extraction. The results showed that biodiversity was much higher in the Midlands, with higher elevations and moist humic soil containing large amounts of nutrients. *This supports that organic, peaty soil will have the highest biodiversity as compared to dry, rocky soil.*

The alluvium and terrace deposits in the study area are close to water, don't dry easily, remain cool, and have lots of organic material both dead and alive around them, making them very similar to the peaty soils studied above. Limestone is less amenable, being much drier than alluvium, but still contains organic matter and some levels of moisture. The shale is farthest from

the water, dries very easily, and is least nutrient-rich, and has the highest pH of the three studied zones.

Materials

The materials used for this project are:

- a field guide (Borror & White, 1970);
- iNaturalist's Seek phone app;
- a collecting net;
- a 50-meter transect line;
- killing jars;
- cotton balls;
- ethanol;
- acetone fingernail polish remover;
- forceps;
- a collection box.

Procedure

Data Collection

1. Prepare 7-10 killing jars by saturating a cotton ball with acetone and closing it firmly into the jar, then allowing it to rest for a small amount of time.
2. Travel to the desired transect for this data collection; get as close to the marked location as possible. Bring net, killing jars, forceps, and any other items thought necessary for the collection of arthropods.
3. Stretch the transect line across your study area, taking care to allow time for disturbed organisms to go back to regular movement before starting your collection procedures.
4. Collect arthropods on each 10-meter interval of the transect tape:
    a. Take a predetermined, constant amount of time (5-10 minutes) on each interval.
    b. If <2 arthropods are found within the first 10 meters, do not continue with this transect and reassess placement of transect.
    c. While moving collected arthropods to killing jars for preservation, pause interval timer.
    d. Label all killing jars with name, date, and transect number.
5. Place killing jars in freezer for preservation. Do not mix insects from different transects

Analysis

1. Preserve insects by pinning them or using alcohol.
2. Use field guide (and included dichotomous keys) to organize collected insects by order.

3. Within order, note distinct morphological differences between insects in order to create a distinct set of morphospecies for each order.
    a. Make sure morphospecies labels are consistent between all organisms in an order.
    b. Make sure morphospecies characteristics are denoted in at least one project notebook within group.
4. Label insects with order, morphospecies, name of collector, date, teacher, and location found.
    a. Softer insects (Those in groups Isopoda, Phalangida, Araneida, Acarina, Scorpionida, Chelicerates, Diplopoda, Chilopoda, Protura, Collembola, Diplura, Thysanura, Ephemeroptera, Isoptera, Plecoptera, Phthiraptera, Thysanoptera, Trichoptera, Siphonaptera) must be preserved in alcohol or mounted on slides.
    b. All others should be pinned with a straight alignment, with the pin to the right of the midline in the thorax; smaller, more precise pins should be used for smaller insects, other than orders Lepidoptera, Hymenoptera, Diptera, and Odonata.
    c. If they are too small to be directly pinned, glue the insect to a point, which can then itself be pinned.
    d. The wings of Lepidoptera and Odonata should be spread.

Conclusion

Results

The alluvium transects contained the highest diversity in organism morphospecies, at 17 total morphospecies across every transect. Limestone came in a close second, with 16 total morphospecies, while the shale transects contained 12 morphospecies collectively (Fig. 4). The data for total organisms per soil type yielded slightly different results, with limestone containing the highest average organisms per transect, at 8.67, followed by alluvium at 8.33 organisms per transect and shale at about 5.00 organisms per transect (Fig. 2). Another significant trend that was measured across soil type was the percentage of obviously winged organisms as compared to the total population of arthropods. Alluvium contained the highest proportion, at 48% of the total population, while limestone came in second at 35% and shale in last at 27% (Fig. 5). Other significant trends, seen in specific orders on specific soil types, included; the abundance of Araneida on limestone transects, at 4.33 per transect when compared to the averages of 0.67 and 0.33 on the alluvium and shale transects respectively (Fig. 1); the variation in Lepidoptera morphospecies on limestone transects, at around 1.67 per transect (Fig. 3) while alluvium and shale contained on average 1.00 and 0.67 morphospecies per transect; and the variation in Hymenoptera morphospecies on alluvial soil, at 1.33 unique species per transect (Fig. 3) as compared to 0.67 and 0.33 averages of morphospecies on limestone and shale transects.

Although statistical analysis were conducted for the averages of total organisms across each soil type, average morphospecies of lepidoptera, average morphospecies of hymenoptera, average organisms of araneida, and the proportion of winged arthropods, none yielded a significant p-value ($p = 0.39$, $p = 0.56$, $p = 0.37$, $p = 0.50$, and $p = 0.54$, respectively).

Fig. 1 ~ Average Organisms by Order vs. Soil Type

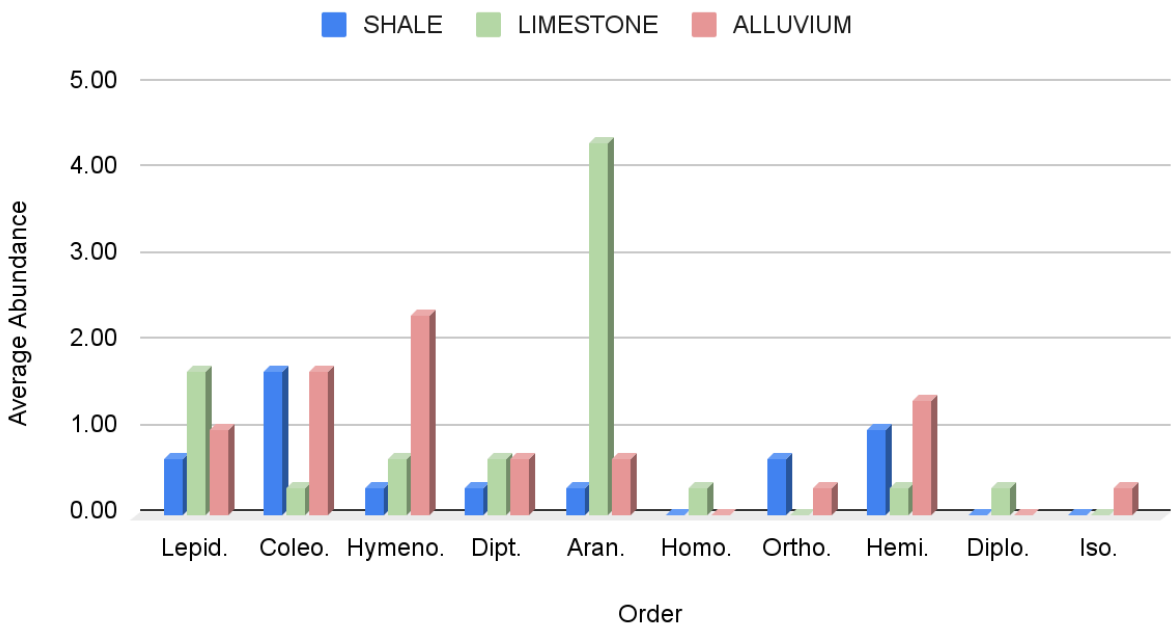


Fig. 2 ~ Avg. Total Organisms Across Orders vs. Soil Type

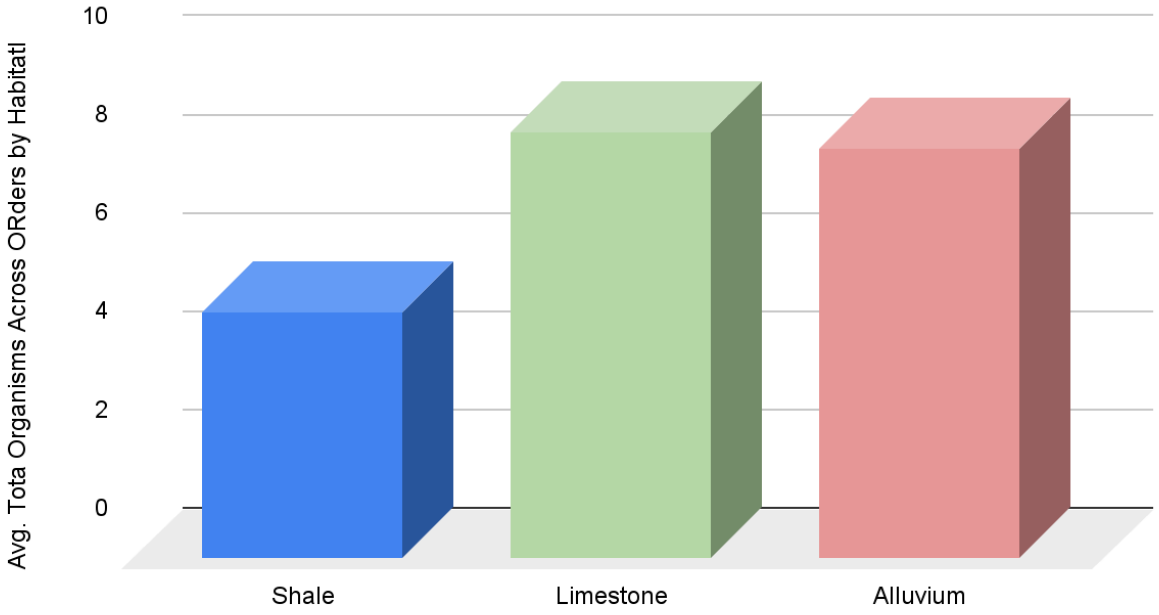


Fig. 3 ~ Avg. Morphospecies by Order vs. Soil Type

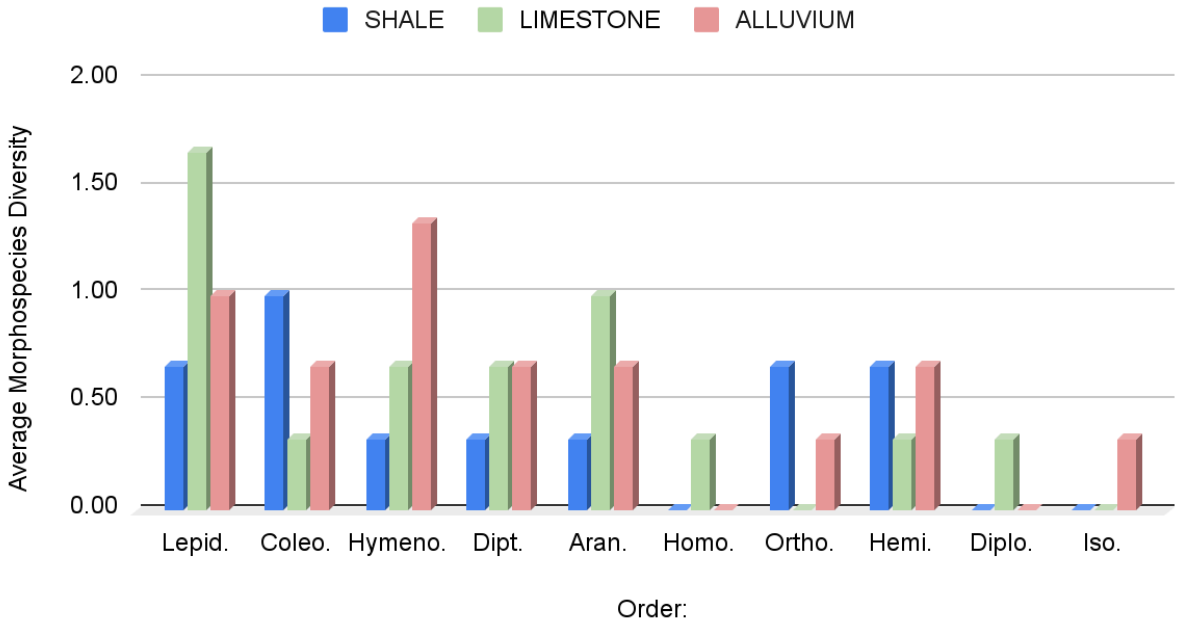


Fig. 4 ~ Total Morphospecies Across Orders vs. Soil Type

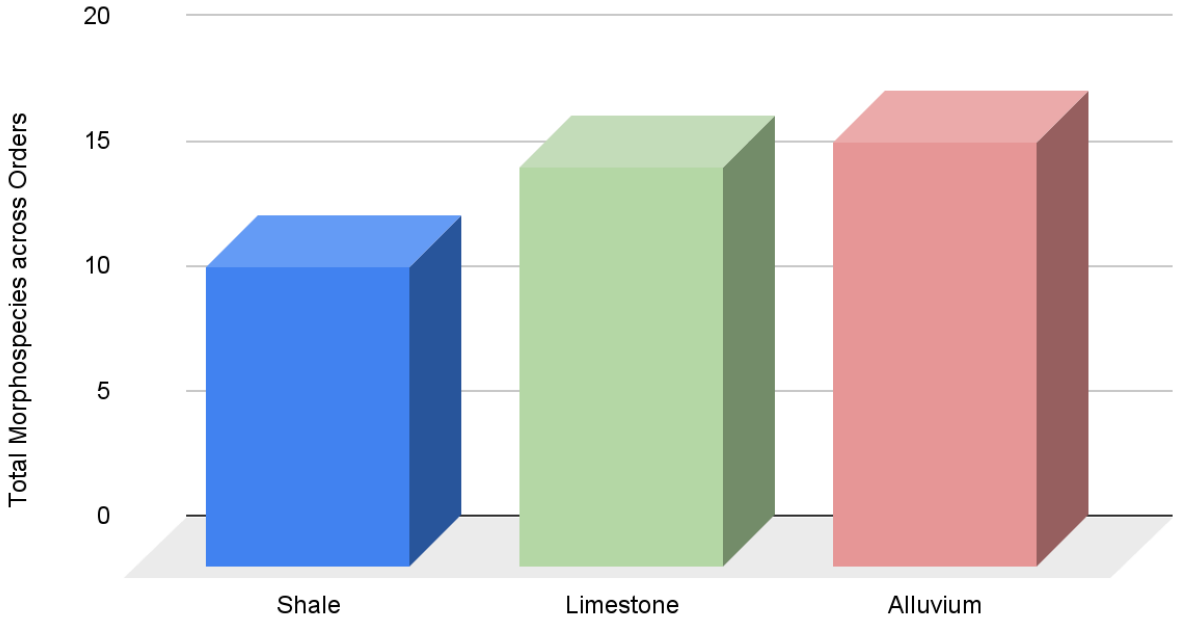
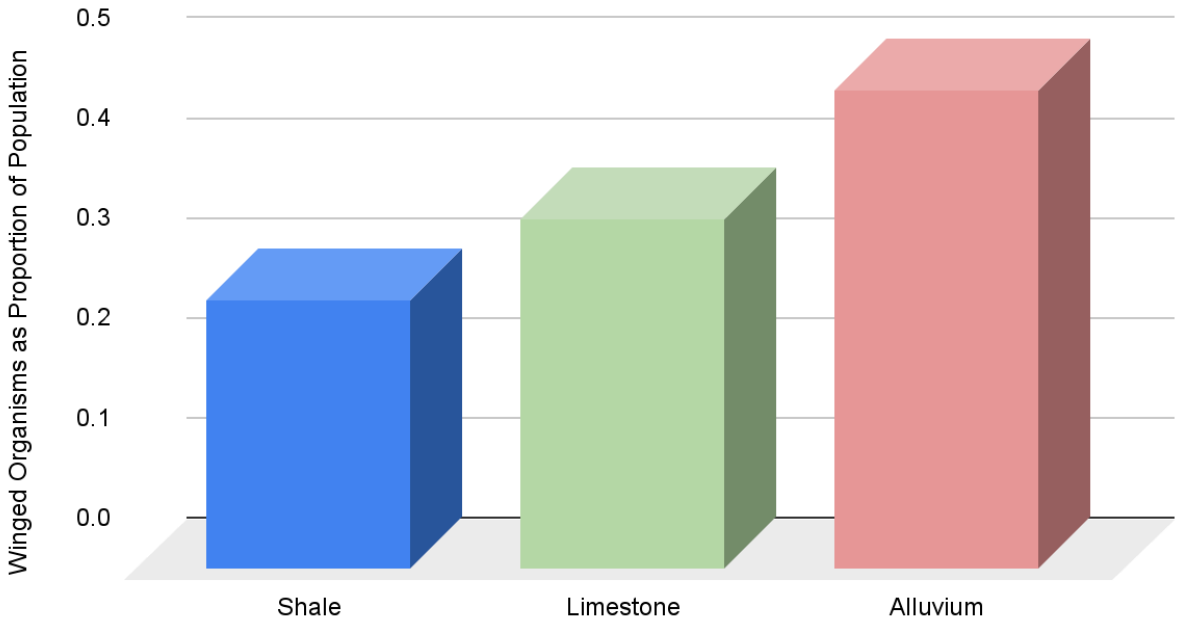


Fig. 5 ~ Percent Winged Organisms vs. Soil Type



Discussion

The hypothesis posited that arthropod diversity would increase in moist, fertile soil as compared to shallow, dry, and less nutrient-heavy soil. That entailed alluvial soil having the highest diversity, followed by limestone, and then shale with the lowest diversity. This hypothesis was mostly supported by the experimental data; although there were high p-values in the data to designate these differences, likely due to the limited amount of data collected on the field, there was still a notable difference between the shale transects versus the limestone and alluvial transects, with substantially lower organism abundance and morphospecies diversity observed in shale. The study results, alongside the referenced sources, suggest that these environments are the most amenable soil types for arthropod activity, exhibiting high amounts of organism-level, order-level, and morphospecies-level diversity when compared to shale transects. However, the sources (as described below) indicate that soil type itself may not be the most direct factor resulting in this diversity; instead, the correlation may result from alternate factors, both themselves impacted by soil type and entirely separate, such as vegetation diversity, elevation changes, and human activity affecting trailside areas.

A similar study to this one, conducted by C. F. G. Thomas and E. J. P. Marshall in 1998, utilized suction and pitfall trapping in order to study the existence of a correlation between the diversity and spread of arthropod taxa and the diversity of vegetation within an area. They found a strongly significant ($p = 0.002$) positive correlation. While each transect had heavy vegetation surrounding them, the alluvial transects had a great variety in plant species due to its proximity to both the creek bed and forested hill areas. The limestone transects exhibited similar diversity; while very vegetated, the shale transects did have less diversity in their types of plants, with the area being more cultivated due to more frequent human movement there. *This study coincides with an alternative explanation for the findings in this study, being that soil type and other activity - including human activity - affected floral diversity, which in turn was the primary driver of the differences in arthropod abundance.*

Another study, by I. Yekwayo, and T. Mwabvu, observed effects on flightless arthropod diversity from environmental factors, such as rocky vs non rocky soil types, and the presence of vegetation. While they found no direct correlation between these factors, previous studies had, and their results had slight differences between their study areas. For example, the study had found that in rocky areas, the amount of unique flightless arthropods was the greatest compared to non-rocky areas. This was also true with the abundance of arthropods, as they had collected more arthropods in areas with less vegetation, which would be true in the Gus Fruh environments of limestone. *This supports the idea of both abundance and diversity increasing in limestone environments, as reflected in the data collected.*

A third study conducted by J. G. Gilgado et. al. investigated the effect of several factors, mainly focusing on elevation differences, in Swiss National Park. They note how, as the elevation increases, the composition of the soil goes from developed soil to a more rocky soil, similar to the data collected in this study. In the six groups of arthropods they were looking at, as the elevation increased, abundance and diversity of the arthropods decreased. Similar to this study, their environment reflected the limestone this study observed, with the elevation of the

study by Gilgado. *This further supports the fact that as we go from alluvium to shale, both the abundance and diversity of arthropods will decrease.*

A major issue in the study conducted was that, due to the design and time constraints of the project, the amount of data gathered was highly insufficient for significant findings. Each person only collected data in each area once; this increased the influence of human error on the project structure. Additionally, the collection procedures, with only the use of a net, forceps, and killing jars, resulting in difficulty in both finding and capturing organisms; as such, the reported numbers were likely lower than the actual numbers, and skewed towards more visible and flightless arthropods, with those being more easily capturable. This was most seen in the extremely high incidence of Araneida in the limestone transect, as the common presence of a bright red, flightless mite - very visible against leaf habitats - led to skewed counts towards that arthropod, due to large groups of it able to be captured quickly. Additionally, the high incidence of oak pollen in the study area impaired certain group members from conducting capturing procedures as effectively as possible. A possible reason as to why the amount of Lepidoptera was so much higher on the limestone could be because of timing, as we collected data on that transect during their migration season. Another possible reason for this could be because the limestone transect was much more open when compared to the forested alluvium and shale transects, making it easier to chase down and catch Lepidoptera.

If this project were to be done again, it would more likely be done in the fall, with similar temperature conditions but little to no oak pollen; additionally, it may be prudent to extend the time spent at each transect in order to allow a more comprehensive organism collection. If possible, the use of traps such as pitfall or suction traps may be useful, although monetary considerations do make this difficult. Finally, controlling for time of day and time of year - instead of spreading out the investigations over a month or more - would help eliminate confounding variables.

Future studies done in this area could control for soil type and instead study the influence of vegetation diversity and abundance within one area; additionally, studying the impact of the creek on the alluvial and limestone transects when the creek is filled and not dry may result in a more complete understanding of arthropod activities in the Gus Fruh park.

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Order Abundance and Diversity in Arthropods in Relation to Water Availability

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Spring 2025

ABSTRACT: This study investigated how proximity to Turkey Creek influenced arthropod abundance and diversity in Emma Long Metropolitan Park, Austin, Texas. Using timed transect sampling, researchers compared arthropod populations in six 50-meter transects: three in close proximity to water and three further from it. Results indicate that areas closer to water yield a greater number of *individual* arthropods but fewer morphospecies, whereas areas further from water had fewer individuals but significantly higher morphospecies diversity. Orders *Isopoda, Hymenoptera,* and *Lepidoptera* were more abundant near water, while *Coleoptera* was more prevalent in drier transects. These findings suggest that, while proximity to water can lead to an increase in order abundance, it may also decrease order diversity. Results partially contradicted the original hypothesis, indicating a far more complex relationship between arthropod population dynamics and water availability than initially posited. Potential areas for error throughout the research process may include the lack of broader sampling and controls on variables such as human activity, collection bias, and weather.

Introduction

Purpose

The purpose of this study is to survey and describe the effect of elevation change and consequent proximity to bodies of water (Turkey Creek) on local arthropod species biodiversity and population size in Emma Long Metropolitan Park.

Hypothesis

We hypothesize that the abundance of arthropods is greater closer to Turkey Creek due to water availability and more vegetation.

Site Description

Location

Emma Long Metropolitan Park is located in North-West Austin, 5 kilometers southeast of the intersection of State Highway 360 and the Colorado River (Google Maps, 2025). It is surrounded by the Colorado River.

Areal Extent

Emma Long Metropolitan Park is roughly triangular in shape and is an estimated 465 hectares in area (Google Maps, 2025).

Topography

The topography of the area is uneven and hilly, especially considering the site is on an offshoot of the Balcones fault. The area near Turkey Creek experiences significant terracing, with the area sloping towards the body of water due to cross-cutting and erosion. The highest point in the selected park area is 270 meters, with the lowest point in the selected park area being 183 meters (USGS Topographic Map).

Geology

As noted before, the area near the river experiences significant terracing, revealing older types of rock due to erosion and superposition. Rock formations in the park include Upper Glen Rose Limestone and Lower Glen Rose Limestone, both formed during the Cretaceous period, which forms the hard bedrock of the park, as well as the Fluviatile terrace deposits, which form a clay soil in the woody areas and which were formed in the Quaternary period and finally Alluvium deposits in and around the creek bed, which were also formed in the Quaternary period and appear to be small, smooth rocks (USGS Geologic Map).

Vegetation

Pertinent vegetation in the area includes the presence of Ashe juniper and other woody plants; yucca growing near the creek bed, Lindheimer's Silktassel, tree privet, as well as traces of invasive bamboo stalks. Additionally, the vegetation near the creek is leaning in the general

direction of the creek's current, implying flooding occurs. I would estimate the park is 70% woodland and 30% grassland (concentrated by the Colorado River).

Water Availability

Emma Long Metropolitan Park is crosscut by Turkey Creek, which measures 1.5-2 meters in depth, however, signs showed flooding could reach up to 10-15 meters in depth, when observed on 16 February 2025. The creek was dammed naturally, most likely either by the stream collecting branches or by organisms within the creek, potentially including beaver.

Urbanization

Emma Long Metropolitan Park is partially urbanized, with large swaths of undeveloped woodland, however, most especially near the Colorado River, it is significantly developed with large clearings that are used for camping, picnics, and other recreational activities. Moreover, there is a two-lane road and several motorbike/mountain bike trails throughout the park. There are also several trails within Turkey Creek, as well as minor pollution. There is also Austin Fire Station 47 on the outskirts of the park. Finally, there is a boat ramp, which is paved and attracts many mariners.

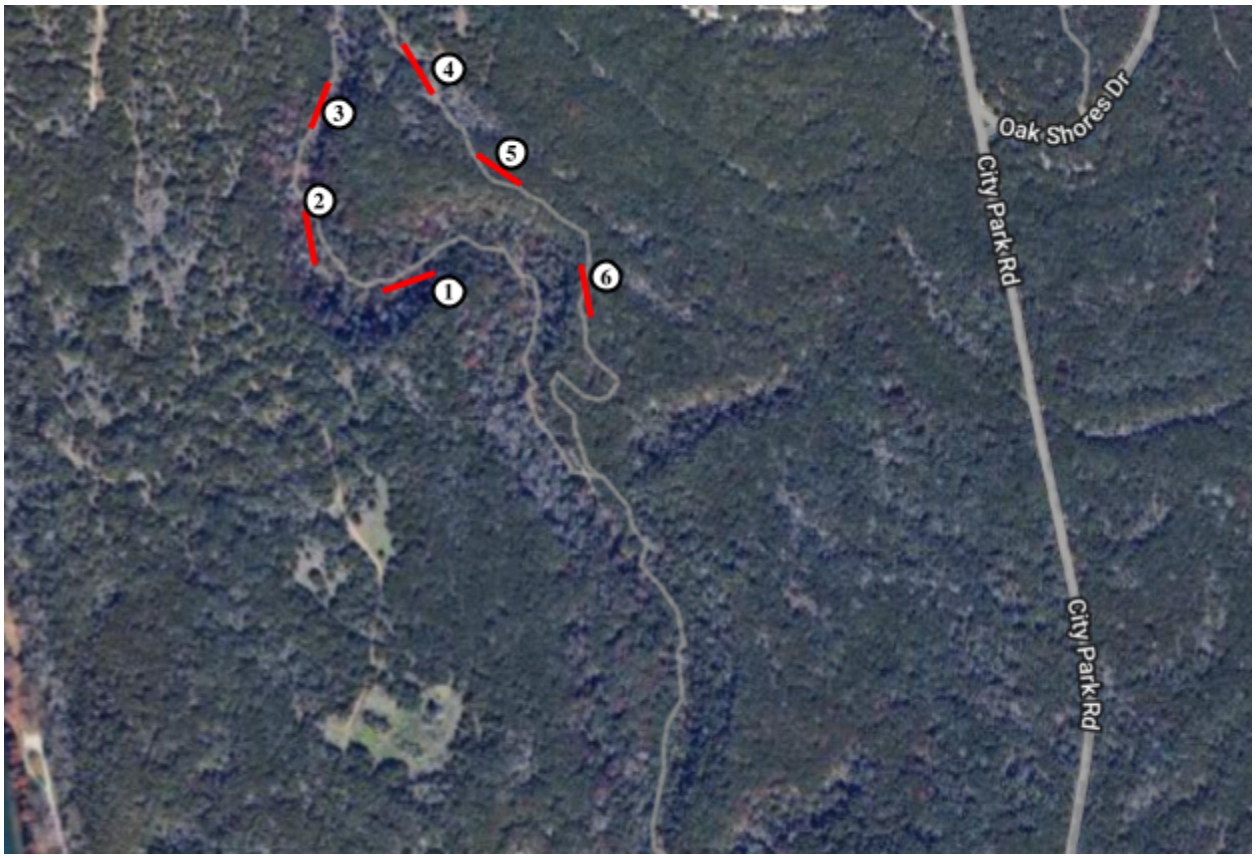
History

Emma Long Metropolitan Park was acquired by the City of Austin in 1939 (Austin City Records). It was originally known as City Park until it was renamed in 1984 by Mayor Carol Keeton Rylander after the first female Austin City Councillor Emma Long (City of Austin). The City has since established roads within the park, including a parking lot and picnic area. Aerial photography shows clear differences between 1937 to 2022, with the surrounding area becoming much more developed, and the official park borders becoming much more pronounced. As well, it is also clear that large swaths of the park bordering the Colorado River have been cleared from their native woodland, as well as large trails and roads being created and crosscutting the park (Historic Aerials).

Research Plan

Design of Study

When trying to find information regarding the local biodiversity, researchers plot transects along the Turkey Creek trail, both in very near proximity to the creek and at a further distance from the creek. This will, in turn, give us a data set that effectively compares the two different areas and how water availability factors into the biodiversity of arthropod species in the area. Researchers will implement the timed transect method and collect data along each transect for 10 minutes. Each transect will be 50 meters in length and is around 50 meters away from the start and ends of the transects in front of and behind it, with three transects (#4-6) on the branch of the trail that parts from the creek, and three (#1-3) that are parallel to the creek. Data will be collected one time along each of the transects, with three transects assigned to each member of the group. Attached below is a picture of the numbered transects and the planned locations of each.



Background Information

A study was conducted on terrestrial arthropods and mollusks in a cool mesic region—specifically Northwest Ohio. Water-seeking behaviour was measured by surveying the number of organisms at an artificially-moistened water source versus a dry, control area. Results found that the artificially-moistened water source had about double the number of organisms than the dry, control area (Becker, 2021). These results suggested that terrestrial arthropods and

mollusks in cool mesic regions seek and abut water-rich areas over drier areas. This supports the hypothesis that arthropods will be more abundant within Emma Long Park in transects closer to Turkey creek.
Another study was conducted on soil arthropods in an aspen stand—a group of aspen trees—in Saskatchewan, investigating the impact of both water abundance and season on said soil arthropods. Surveys were conducted by creating twenty-four groups of five boxes, which were indented into the ground—creating microclimates for soil arthropods—and surveying the populations weekly, with bimonthly soil sample collections. Results found that mites and springtails responded positively to water addition—with springtail abundance being directly correlated with water abundance—whereas ants and other arthropods responded negatively to water addition (Chikoski, 2006). These results suggest that some soil arthropods are water limited. This supports the hypothesis that arthropods will be more abundant within Emma Long Park in transects closer to Turkey creek.
An additional study was conducted on arthropods in an urbanised, mesic region—specifically a parking lot in Raleigh, North Carolina. Surveys were conducted by supplying some trees—in which the arthropods resided—with a wet and dry water pillow, providing animal-available water—and measuring, weekly, the number of arthropods on each pillow 8-9 hours later (McCluney, 2017). Results suggested that in urbanised areas, arthropods had greater water seeking behaviour. This supports the hypothesis that—given Emma Long Park is urbanised—arthropods residing within the park are more likely to be residing in areas with higher water concentrations.

Materials
Common Insects of Texas (Abbott, 2020)
iNaturalist Seek Phone App
50 Meter Transect Line
Collecting Net
Killing Jars
Storage Box
Forceps
Cotton Balls
Ethanol
Acetone (or Ethyl Acetate) Fingernail Polish Remover

Procedure
<u>Collection Procedure</u>
1. Use GPS to ensure correct transect location, use pins and other means of location.
2. Stretch the transect tape 50 meters and let sit for 5 minutes to allow organisms to settle.
3. Note transect number, date, time, conditions, transect category, ground cover in project notebook.

4. Under a 7 minute timer for each 10 meters, move along the transect and collect at least 2 bugs per 10 meters. If at least 2 bugs cannot be found in 7 minutes, move on to a new location. Once an amount of time is decided, it must stay constant through all data collections.
5. Sweep vegetation with the net and inspect closer with forceps. Use the "net technique" procedure to collect bugs with the net.
6. As data is collected, put specimens into jars and pause the timer during this time.

Net Technique

Utilize the following technique to capture flying arthropods using a net:

Swing the net rapidly towards the specimen, then—if the specimen is caught—continue swinging to utilise centrifugal force to ensure the specimen is at the bottom of the bag. Then, inver the bag so that the bag hangs over the rim, ensuring the specimen cannot fly out. After, place the bottom part of the bag containing the specimen into the killing jar to stun it, and after a few moments and ensuring the specimen is stunned, remove the bag from the jar and place the insect into the jar with the lid of forceps to avoid reflexive stings.

Preservation Procedure

1. Prepare 6 killing jars (labelled with name, date, and transect number). In each jar should be a cotton ball soaked with ethyl acetate.
2. Once home, place the specimens in the freezer. Researchers may consolidate arthropods from a single transect into the same jar.
3. Take the jars to school (on the next school day), and place them in the class freezer—ensuring labels are clear and identifiable.
4. Key each arthropod to the specific order, and then—based on appearance—to the morphospecies. Once defined, this morphospecies should remain consistent across notebooks.
5. Either pin or vial the arthropod. Vials should be used for organisms without a strong exoskeleton that are too unstable to be pinned. All other organisms should be pinned, and if the organism is too small to be pinned, it may be glued to a point—which is then pinned.
6. All specimens recorded must be properly labelled in the collection, and all additional specimens of an already recorded and labelled morphospecies should be stored in a labelled container in the freezer and turned in upon completion of the project.

Conclusion

Results

Overall, it was found that with higher water availability, an increase in abundance of arthropods occurred; conversely, lower water availability yielded a smaller average abundance (Fig. 1). On average, transects with a closer proximity to water, ergo higher water availability, yielded roughly 7 organisms, but contained only 2.33 morphospecies. This was statistically significant ($p = 0.047$). Transects with low water availability yielded 4.33 organisms but 3.67 different morphospecies in average (Fig. 1, Fig. 3). By order, *Isopoda* experienced a notable spike in abundance with closer proximity to water, as did *Hymenoptera* and *Lepidoptera*. Conversely, *Coleoptera* experienced a statistically significant spike at a lower water availability with an average of ~1.66 organisms collected on high water availability transects and 0 organisms collected on low water transects ($p = 0.0075$) (Fig. 2).

Fig. 1: Average Abundance by Water Availability

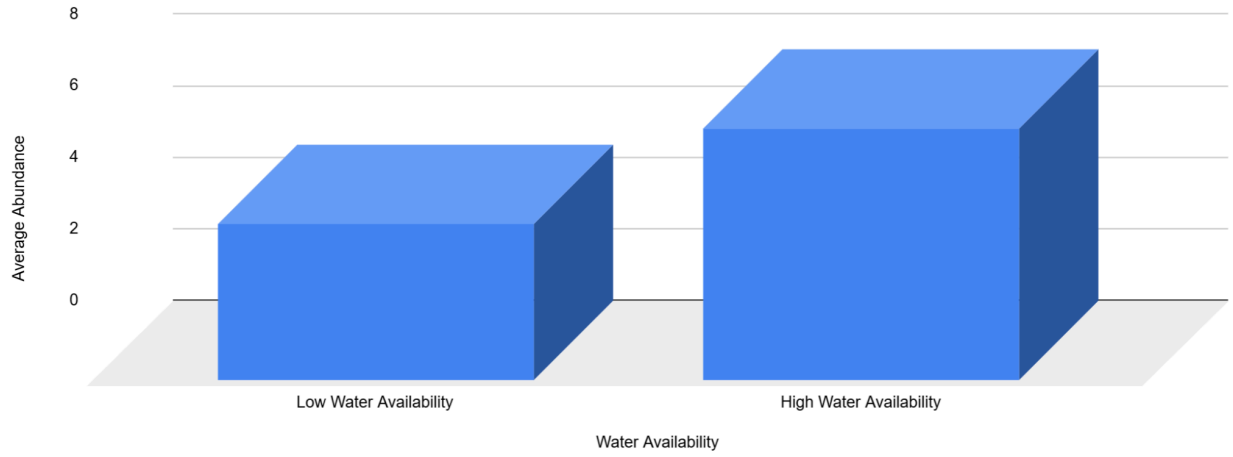


Fig. 2: Abundance by Order vs. Water Availability

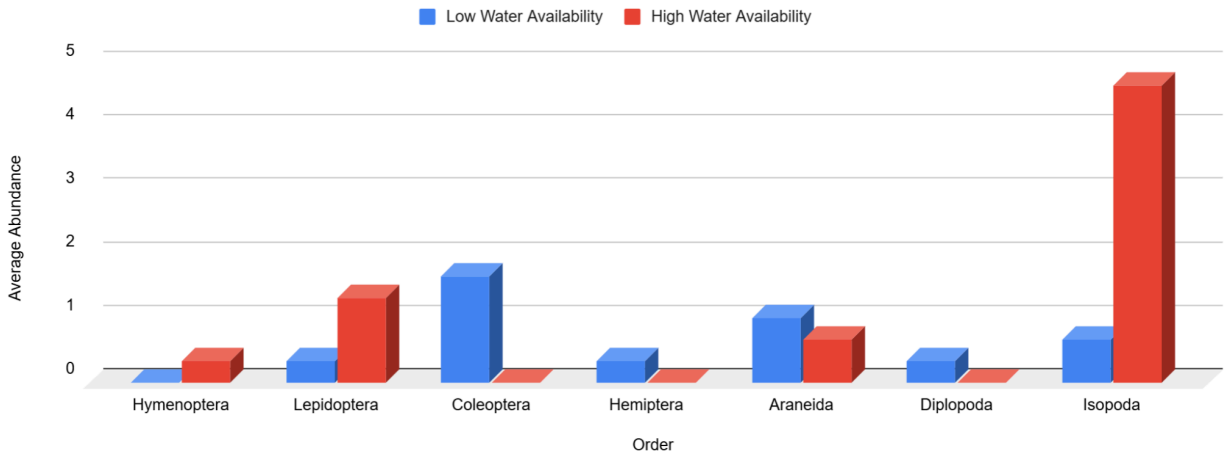


Fig. 3: Morphospecies Diversity per capita vs. Water Availability

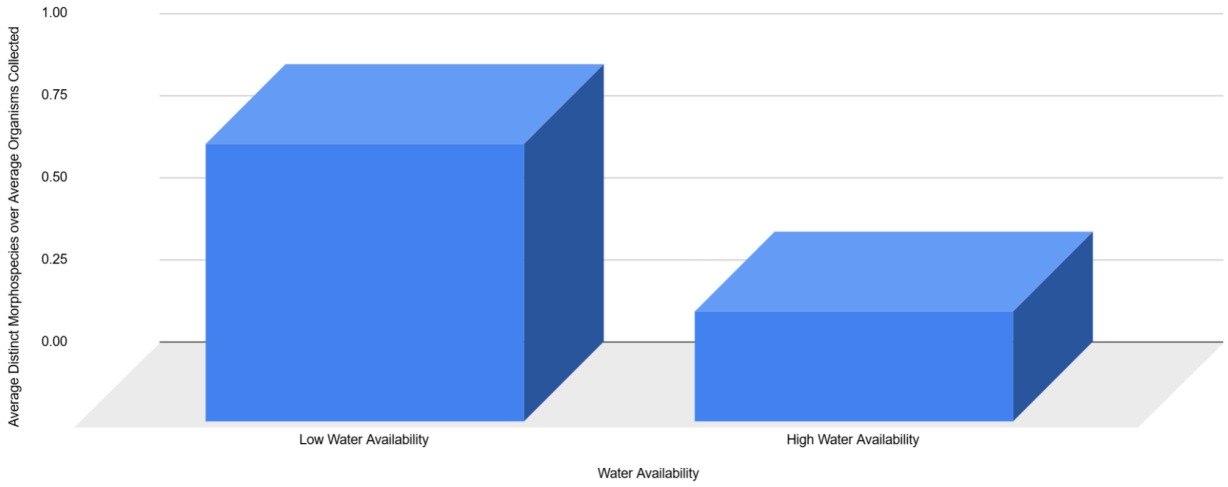


Fig 4: Morphospecies Diversity (Average) vs. Water Availability

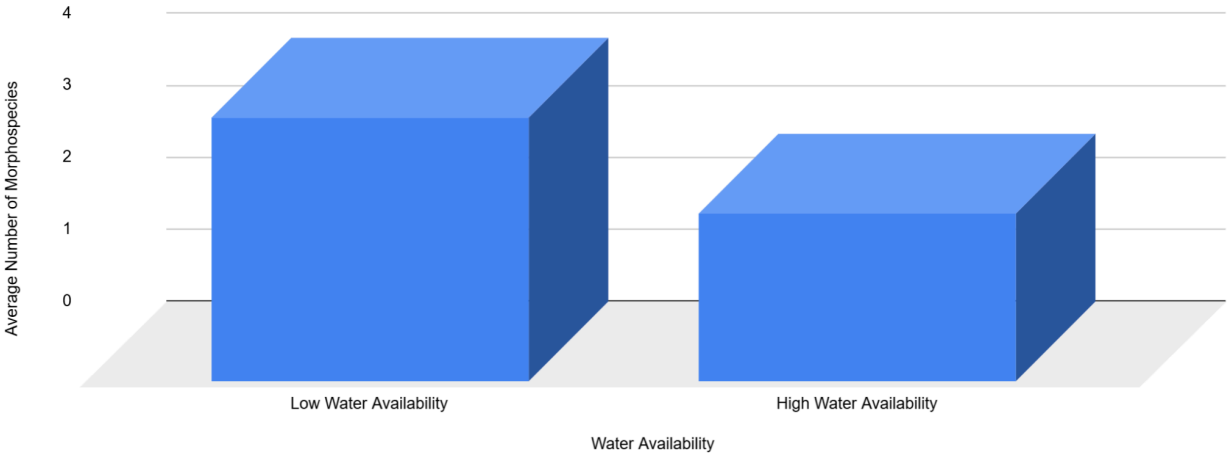
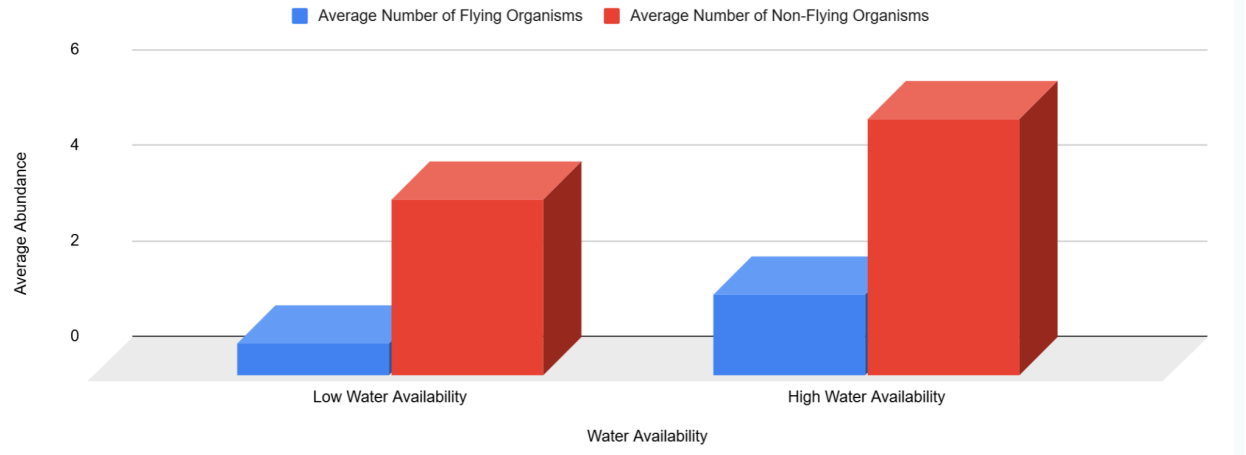


Fig. 5: Organism Morphology vs. Water Availability



Discussion

It was hypothesised that there would be a far higher abundance of arthropods at transects with higher water availability due to more factors such as hydration, vegetation that could provide sustenance as well as shelter, and other organisms that predatory arthropods would be able to exploit for food. Overall, this hypothesis was not supported by the data collected. (Fig. 1) In areas with higher water availability, more organisms were found in orders *Isopoda*, *Hymenoptera*, and *Lepidoptera* than in areas with lower water availability.

While the number of organisms in high water availability areas was greater than the number of organisms in low water availability areas, it is important to note that the difference was not statistically significant, therefore, the hypothesis was not supported. Moreover, low water availability areas had higher diversity of morphospecies—in a statistically significant manner—which is important to note as well. It is believed, however, that a larger study might yield more statistically significant results with more data points and could, potentially, support the hypothesis—given the study was hampered with only six data points. Running water and flooding could potentially negatively impact arthropod diversity in high water availability areas. In addition, the transects closer to water were much more frequently utilized by hikers; Human impact could reduce arthropod abundance significantly. Furthermore, areas with high water availability, or that were in the general creek bed, had little to no tree canopy or cover over them, and by extension an absence of brushy plants, fallen leaves, and shale (mostly alluvium deposits in drier areas), whereas areas with lower water availability offered all of those factors, which could allow protection from predators such as birds or other insectivorous organisms.

While it is important to note there is a large difference in *Isopoda* abundance (Fig. 2), this was primary due to a single transect yielding fourteen organisms—a statistical outlier. Moreover, the difference in the number of flying organisms (Fig. 5) was not significant, with both high and low water availability areas primarily consisting of non-flying organisms. This is, however, also because it was more challenging to capture flying organisms than non-flying organisms, potentially skewing our results.

Research suggests that there is a statistically significant correlation between access to water and abundance of order *Coleoptera* (Fig. 2). This suggests *Coleoptera* prefers environments with lower water availability. A related study examined the dehydration dynamics in terrestrial arthropods (in re water balance, &c)--including *Coleoptera*, across a number of environments. (Benoit et al., 2023) The study showed a number of behavioural and physiological adaptations that terrestrial arthropods made to survive in lower-water availability environments, including reduced respiratory water loss, shifts in cuticular hydrocarbon types, and behavioural shifts towards humid climates. These findings support the conclusion that terrestrial beetles have perhaps adapted to lower-water availability environments.

Moreover, another related study focused on the habitat selection of the darkling beetle *Eleodes hispilabris* (Coleoptera: Tenebrionidae) in environments with lower-water availability (McIntyre et al., 1997). Said study found that *E. hispilabris* often selects environments with direct sunlight and lower temperatures and have adapted to survive in arid environments. These findings further support the conclusion that terrestrial beetles have adapted to lower-water availability

environments. It must be noted, though, a number of factors impacted the findings and introduced variables that suggest uncertainty with the data.

Furthermore, the morphospecies diversity between transects was statistically significant. This suggests there is more morphospecies diversity in areas with lower water availability. One related study analysed the influence of rainfall patterns on arthropod diversity in arid environments. (Fischer et al., 2022). Over a six-year period the study found short-term rainfall influenced diversity more than seasonal rainfall patterns Moreover, the study observed increased diversity in detritivorous arthropods. This supports the conclusion that water availability affects diversity, though—not necessarily in the way the data suggests.

Data was impacted by a number of factors including: temperature, humidity, precipitation, researcher's hunger and rest levels, and researcher's general distaste for wasps—all of which were variable by transect collection date. On the second collection day—with collections for transects five and six—it was significantly damper than the first and third collection days. Researchers were also obligated to readjust the second transect by ~50 feet due to the trail making that area inaccessible. For future research, it would be preferable to collect data from the transects simultaneously—eliminating interday factors—as well as collect over a longer period, to allow for more data points and less error. Finally, it would be important to have collection researchers who are not scared of wasps—which potentially impacted this study's results.

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Effects of Water Proximity on Woody Plant Biodiversity in Bull Creek Park

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Spring 2025

ABSTRACT: A study was conducted in Bull Creek Park, Austin, TX to investigate the effects of water proximity on the biodiversity of woody plants. The hypothesis was that the population and diversity of woody plants will decrease as the distance from the creek increases. The study was located in different sites with 50m transects at close, medium, and far distances from the water, all parallel to the creek. This particular study aimed to find the total biodiversity and population size in relation to distance from water, recording each species as well as the intercept range of each specimen. The relative dominance, relative frequency, relative density, and importance value were all calculated within each data set and compared these values across all ranges to determine any significant changes in biodiversity and species type. Results indicate an inverse relationship between distance and biodiversity, as a larger variety of species were found closer to water, as well as a more densely populated transect, supporting the hypothesis. Further studies on the adaptations of plants in proximity to water would help to provide great understanding for the results found.

Introduction

Purpose

The study seeks to evaluate how the population and biodiversity of woody plants vary in type in relation to the distance from a body of water at Bull Creek in Austin, TX.

Hypothesis

The project hypothesis is that the population and size of woody plants will decrease as the distance from the creek increases. This is based on the assumption that plants closer to water sources have more consistent access to moisture through their root systems, especially in times of cold and/or drought. A constant water source allows for greater survival and growth rates, while those further away experience more drought stress and competition for limited resources. This leads to stimulated rates of new plant growth, increasing the rate of reproduction, and in turn, plant mutation. This leads to increased plant types and biodiversity.

Site Description

Location

The location of Bull Creek is in Northwest Austin and is around 4.66 km Southwest of Anderson High School, and 12.08 km Southeast of the Texas Capitol (Google Maps, 2025).

Areal Extent

Bull Creek's aerial extent is best described as a large wavy shape of ovals combined together, spanning around the wavy creek it's named after. The perimeter is about 7.82km and the area is roughly 128 hectares (Google Maps, 2025).

Topography

The topographic high peaked at 276.75 meters, found all numbers to hundredths, and the low, at 109.73 meters (USGS, 1988). Overall, the park did not have a large variation in elevation with high peaks of mountain, but had mostly flat, sometimes hilly, terrain instead. The majority of the instances of elevation drop were caused by the large creek.

Geology

Because Bull Creek is characterized by a creek, it possessed characteristics that showed evidence of sediment depositing via streams of water. It was observed that there were several cases of Alluvium; loose clay, silt, sand, or granite that had been deposited by the running water during the quaternary period. There were also interesting cases of hole-filled Edwards limestone near water sources. This limestone is known for its holes due to being highly soluble, and this solubility allows for slightly acidic rainwater to cause small holes on the surface.

Additionally to the rocks found in the creek, there were also Eagle Ford Group and Buda limestone deposits formed during the Cretaceous period, as well as Del Rio clay and 'Georgetown formation' from the Cretaceous period (USGS, 1988). The rocks found in or nearby creeks had become round and smooth from their time tumbling down the creek, and were very small.

Vegetation

The vegetation of Bull Creek was lightly wooded at around 70%, with a 30% flatland where the majority of the land is creek, and surrounding the creek is limestone that inhibits plants from growing atop it. The woods were mostly Ashe junipers, a common plateau live oak in the area, Cacti in areas of the park with less water availability, Texas Live Oak, Texas Persimmon, and Virginia Wild Ryer. It was observed that trees and plants closer to larger water sources were smaller and greener, in comparison to their less-water-abundant counterparts that were often found to be dead with little leaves.

Water Availability

Bull Creek's main water source is a creek flowing through the middle of it, which deposits into Lake Austin. Found on the first field visit on February 24th, 2025 the creek had an estimated depth of 3.66 meters and flowed southwest. Due to the knocked-over plants on the side of the creek area, the river, and the trails, mixed with the plants on the flood bank, all pushed over pointing east, the river shows signs of flooding every rain. The estimated height of flooding in Bull Creek is 2.9 meters, as shown by how far out the plants around the river bed were pushed over.

Urbanization

Bull Creek is stationed within extreme proximity to both a main street road to the northwest, as well as many residences blocking it in at all angles, but neighborhood density is especially high south of the Creek. Because of this, the creek often displays signs of human contact such as litter in its main populated areas, as well as sound pollution from the nearby large roads. There are an abundant amount of bike and hike trails, as well as a Trailhead sign built-in Bull Creek. Because of the Creek's history of flooding, there is a flood gauge and manmade flood pipe, helping to guide over-abundant water away from popularized areas.

History

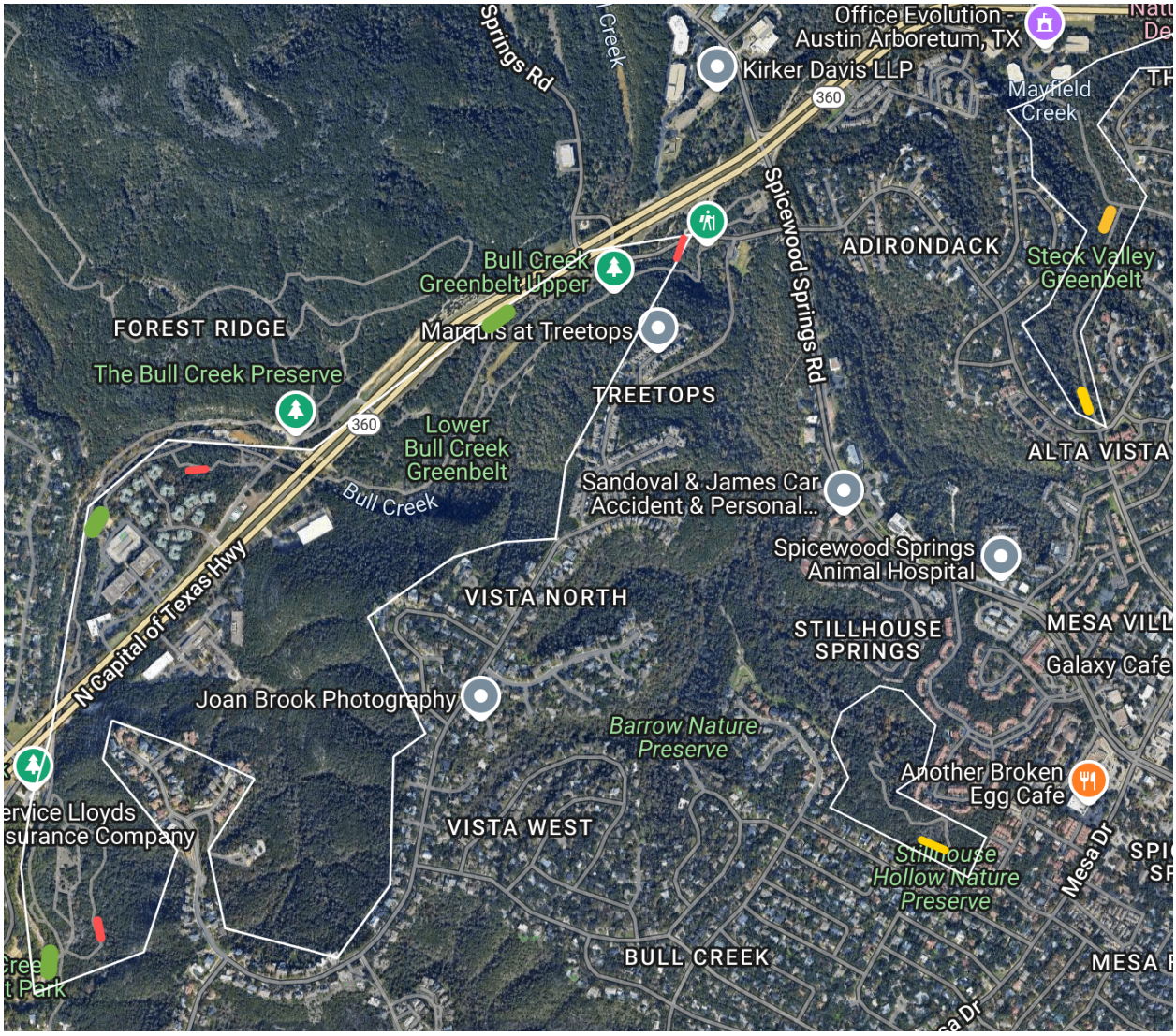
As mentioned under urbanization, Bull Creek has in the past, experienced erosion and flooding. Because of that, prevention measures have been made by humans such as pipelines to protect the sides of the creek from flooding, and a vertical flood gauge to indicate change in water levels. The flooding prevention was done in 1984 with the Old Lampasas Dam built to offset the frequent flooding, though this dam has since been damaged and has not stopped flooding as well as it used to (austintexas.gov, 2024). Additionally, the major road nearby, N Capitol of Texas

Highway, was built in the Preserve in 1980 (Google Earth, 2025). In the 1800s, Bull Creek served as a “commerce highway” for wagons, and has parallel wagon tracks carved in the limestone bed as evidence. At the midpoint of the trail on the west side of 360, there used to be a sawmill & gristmill atop pilings over the creek that used water for power. Bull Creek is the northern segment of the Edwards Aquifer, as well as the Trinity Aquifer, and is one of Austin’s 66 creek watersheds that contribute to the city's drinking water supply.

Research Plan

Design of Study

The data collection of this experiment will be done through 3 sets of 3-line intercept method transect lines to allow for clear and distinct data without any case of random error to trash the entire experiment. This method will help collect the needed information for the purpose question by allowing for distinct transect lines near the creek and away from it. The line intercept transect lines will be 50m each, with a 30m minimum plant overhang. The first set of lines will be done near the creek at different points to allow for a base understanding of the vegetation, this transect line is labeled on the below map in green. These transects will be placed around 5 meters away from the water source. The next transect lines will be done a medium distance away from the water to view the vegetation there, labeled in pink and 100-300 m from the water source - I have an idea for a slight adjustment of the third pink transect. Speak to me in class about this.. The third set of transect lines will be a new area even further away from the creek to get a more rounded view of the vegetation difference between the creek and dry land, labeled in yellow. These far from water, yellow transects will be around 1400m away from the creek source. One will be recorded in Stillhouse Hollow Nature Preserve, as well as two in Steck Valley Greenbelt.



Background Information

Riparian zones are critical sites between land and water sources, often characterized by distinct vegetation patterns which are influenced by proximity to the water source. A study conducted by David Rolbiecki (2025) examined the diversity and community structure of a riparian forest along Denton Creek in Grapevine, Texas. The study recorded the location, size, and frequency of 1,300 trees across 25 species and 14 different families. Rolbiecki's research found that tree richness and density were higher as they got closer to the water source. This conclusion **supports the hypothesis about plant populations and traits in relation to water proximity, These findings are relevant to Bull Creek, as both areas share similar environments and species.**

Another study by Gaolathe Tsheboend (2018) investigated the influence of distance from surface water on riparian plant species composition and distribution in Botswana. They measured

20mx10m plots perpendicular to the riverbank in 10m increments from 0-50m to compare species diversity, richness, cover, and basal area between distance classes. While the environments are different, the concepts of species richness and diversity were still proven consistent with the hypothesis. Their results supported that these aspects increased greatly as they measured closer to the river by 10-meter increments compared to sites further away. This study highlights the importance of surface water availability in maintaining species diversity, reinforcing the expectation that Bull Creek will exhibit similar patterns.

Lastly, a study by Zeng et al.(2019) visualizing the effect of distance from a river on tree cover, and richness, as well as shrub cover, further emphasizes the inverse relationship between distance and plant density and diversity. They measured 6 variables, the effect of distance from the river in relation to groundwater availability on tree cover, tree richness, shrub cover, shrub richness, herb cover, and herb richness in the riparian desert area of the Tarim River of Northwest China. The lack of other water sources in the area emphasizes the results of the study, clearly showing a negative correlation between distance from water/groundwater availability and tree cover/richness, supporting the original hypothesis about size and frequency declines as one travels further from the water source.

Materials

- Transect measure (50m)
- Woody Plant Field Guide ("Native and Naturalized Woody Plants of Austin and the Hill Country", 1981 | ArchivesSpace Public Interface)
- iNaturalist Seek Phone App
- Scissors
- Tape

Procedure

1. Select three distinct areas at various distances from the water sources to set up 3 line-intercept transects in each desired area. One near, one intermediate, one further away.
2. Lay out transect measure parallel to the creek at a desired distance (50m).
3. Record all woody plants that touch the line, noting species, number of leaves, leaf surface area, color, intercept range, and number of individuals on data sheets.
4. Photograph each plant species and record physical attributes in the journal (color variation, dryness, fragility).
5. Take a sample of the plant and put it into field journal.
6. Repeat for each transect group.
7. Consult the *'Native and Naturalize Woody Plants of Austin and the Hill Country'* plant keying guide for all unknowns
8. Change unknowns to found plants and write all important information into the page the plant is pasted into.
9. Compile data sets into a table.

10. Calculate relative density by dividing the number of species recorded in each transect by the total amount of species recorded for each data set times 100.
11. Calculate relative dominance by dividing the total intercept length of a species by the total intercept length of all species times 100.
12. Calculate relative frequency by total # of intervals of that species within a transect by total # of all species in an interval times 100.
13. Calculate importance value by adding relative density, relative dominance, and relative frequency together.

Conclusion

Results

As per several studies conducted in Bull Creek, Austin Texas, based on water as an encompassing variable, on average, transects close to water (≤5m) contained 27.40% Hydrophyte (not drought adapted) types, 39.73% Xerophytes (drought adapted,) and 32.88% Mesophytes (somewhat drought adapted,) while medium (100m-300m) and far transects (>1400) contained 1.61%, 85.48%, 11.29%, and 14.81%, 33.33%, 51.85%, respectively (Fig. 1).

Given these percentages (found from # of mesophytes out of # of total plants, etc), it is observed that there were significantly more drought adapted plant types found on transects of subjectively far and medium proximity to water than on close transects. There was also a distinct decrease in the diversity of plants in comparison to their distance to water, with a result of 11.3 avg distinct plant types found close to water, and 2.6 far, seen (Fig. 3).

Four ANOVA tests were run across the results, the first being the importance value of Cedar Elm across all 3 distances and data sets, with a result of Cedar Elm being distinctly higher in far from water data sets in comparison to the other two sets. This resulted in a statistically insignificant p variable (p=0.0931).

2 separate ANOVA tests were conducted on the difference in abundance of Mesophytically, Xerophytically and Hydrophytically adapted plants within medium proximity from water, which yielded a statistically insignificant value (p= .995). The 2nd ANOVA test run on abundance was conducted on a similar basis, with the difference being a difference in abundance of Mesophytically, Xerophytically and Hydrophytically adapted plants within a far proximity from water, yielding a statistically insignificant value (p=0.77), both ANOVA tests were noted *Figure 1*.

Lastly, an ANOVA test was run on the total diversity of plants in correlation to their distance to water, the separate groups being in relation to close, medium and far distances from water. The result produced a statistically insignificant value of (p= 0.15) but was close to proving significant in an around 85% accuracy value, noted *Figure 3*.

Figure 1: Water Availability in Areas vs Plant Water Adaptations

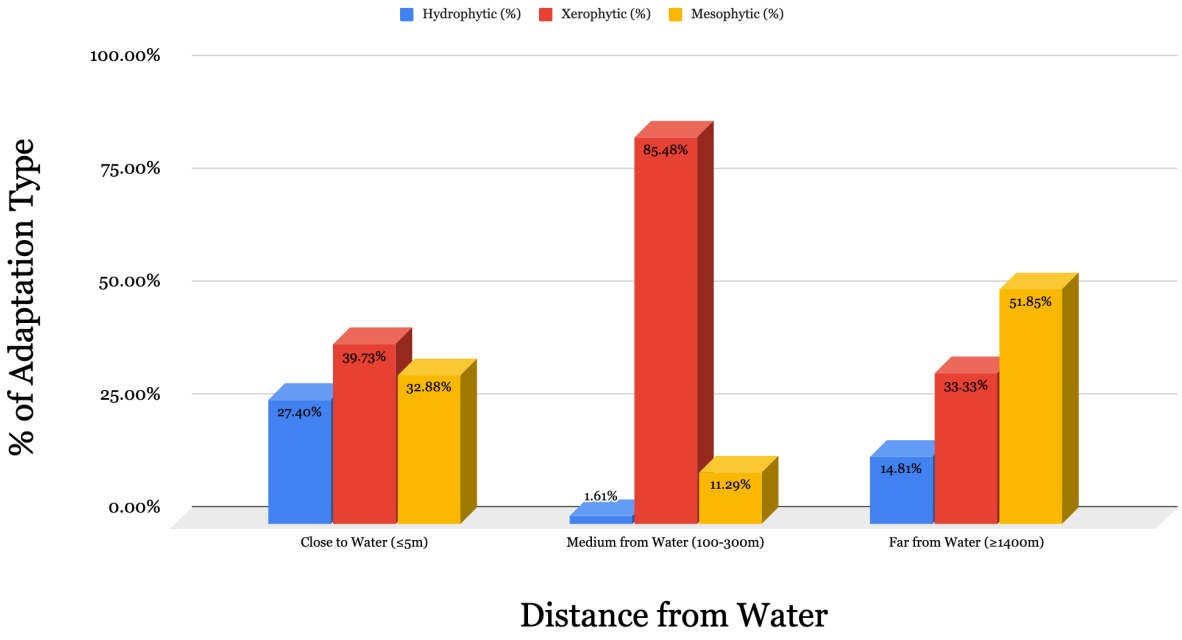


Figure 2: Avg Importance Value By Distance

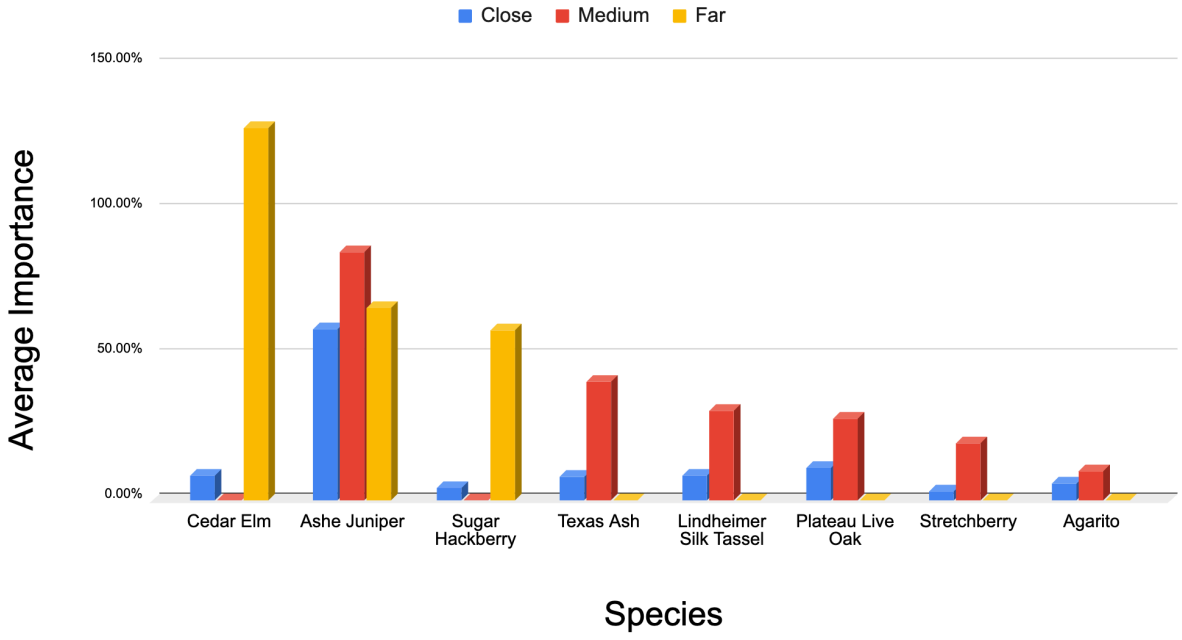
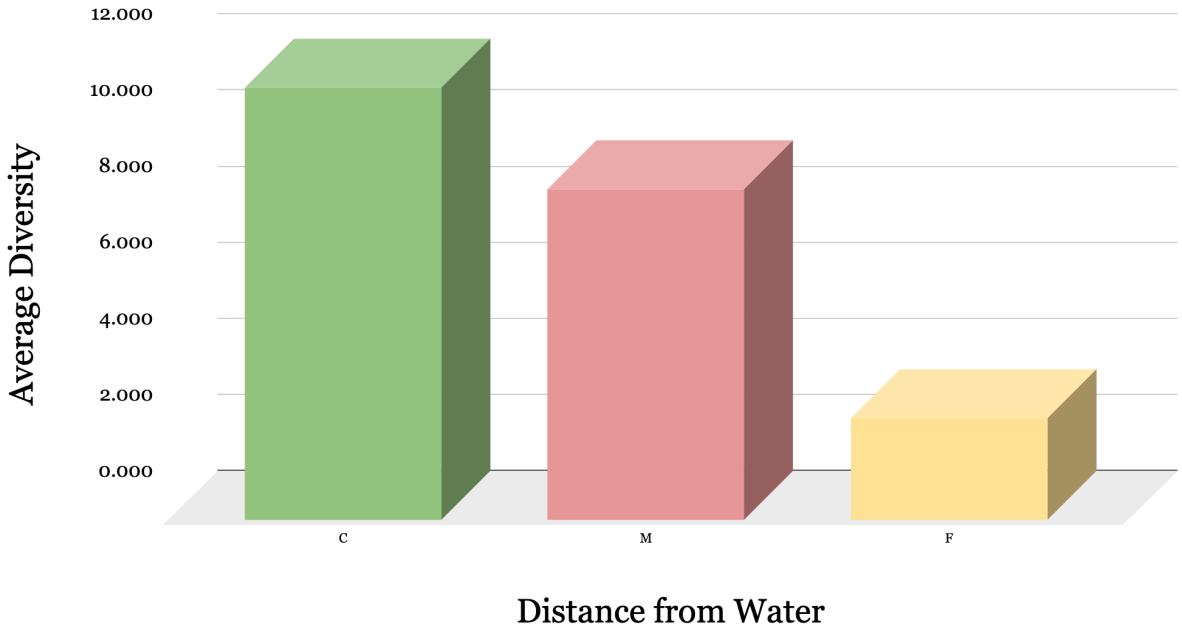


Figure 3: Diversity vs. Distance from Water



Discussion

The project hypothesis is that the population and size of woody plants will decrease as the distance from the creek increases. This is based on the assumption that plants closer to water sources have more consistent access to moisture through their root systems, especially in times of cold and/or drought. A constant water source allows for greater survival and growth rates, while those further away experience more drought stress and competition for limited resources. This leads to stimulated rates of new plant growth, increasing the rate of reproduction, and in turn, plant mutation. This leads to increased plant types and biodiversity.

Observed in *Figure 1*, which displays water availability in areas close to water (≤5m), medium from water (100-300m), and far from water (≥1400m) vs their enhanced or developed plant water adaptations, a clear difference between plants adapted to survive droughts (xerophytic and mesophytic,) was observed in areas ≥1400m and 100-300m from water.

A related study was conducted on the particular matter of drought tolerance in plants, and their physiological and molecular responses across a wide range of plant species and phylums. Biological tests were conducted in this study, and it was observed that plant cells in dry and water-lacking climates express various mechanisms to withstand and reverse the cellular effects of drought stress. Across the study, similar results prevailed- indicating that developments in plants with lacking water access, such as stomata closure- a crucial mechanism plants employ to reduce transpiration and cope with drought stress resemble the same adaptations of Mesophytes and Xerophytes in Central Texas (reduced surface area to conserve water, higher water vapour potential outside stomata, and reduced water vapour potential gradient.)
(Haghpanah et al., 2024) This supports the finding of higher drought-resistant adaptations in plant species within furter proximity from water sources in Bull Creek.

In essence, as per Fig. 1, the encompassing idea of plant's gaining and developing adaptations over time which allow them to better retain and store water in Texas's dry/arid climate is supported by the data in Fig. 1, which exhibits the amount of drought adapted plant types increasing as the distanced they reside becomes further from water, and the abundance of plants which are not resistant to drought (also known as Hydrophytes,) decreasing.

Observed in *Figure 2,* which compares the average importance value of 10 given plants (preemptively selected based on their characteristics of possessing the highest level of abundance comparatively to all plant species taken) to proximity to water, there was a spike in plant populations when it came to the far distance on the data set. This is primarily due to the lack of diversity in the populations far from water, later noted in *Figure 6*.

A related study was conducted in the Okavango Delta, Botswana which observed the relationship between diversity of plants and their distance from surface water on riparian plant communities. In this study, it was found that within riparian plant communities found along river banks exhibited heightened habitat heterogeneity and diverse ecological processes and are often rich in plant species diversity (Tsheboeng, 2018). The information contained in this particular study supports the finding of higher abundance and diversity in plant species within close proximity to water sources in Bull Creek.

The ANOVA test for Fig. 2 is comparing the average importance value for Cedar Elm recorded in each transect, separated into close, medium, and far. The ANOVA test for this data set was the most significant within the study with a P-Value of .0931. The reason behind the massive spike in Cedar Elm in far distance to water, when compared to other transects, is the tolerance in heat and stress the tree has. This tolerance allows for the tree to have a far distance from water while also supporting itself with drought resistant tactics.

A study conducted in the Edwards Plateau of Central Texas (Kukowski et al., 2009), also studied the effect of plant survival in relation to distance from a water source. This study found that although cedar elm experienced the highest percent loss in stem hydraulic conductivity compared to other species during an unusually dry year ~ 90%, the plants continued to survive without mortality rates until a more extreme drought 2 years later. The study expresses the resilience of Cedar Elm in scarce water conditions and environments, enabling it to thrive in more distant zones. With the provided proof, there is a high chance that the importance values compared in each range show a direct relationship between the distance from the water source and the importance value.

Separately, the two ANOVA tests that ran over the difference in abundance of Mesophytically, Xerophytically and Hydrophytically adapted plants had largely varying results in the experiment, seen *Figure 1*. One of these tests showed a jump in xerophytic plants in the medium distance from water, which matches up with this type of plant being able to retain water for longer periods of time in comparison to other plants. Examples of these plants commonly found in Texas are cacti, agaves, and Texas sage, most of which were found at some point in the study.

The other test was ran over the farthest distance to water in comparison of these plant types, the result was far different to the medium distance one, where the plants had an almost 'staircase'

increase from hydrophytic to mesophytic, the increase is strange, as transects furthest from water would be expected to have the largest increase in xerophytic plants. However, the paper "Adaptations to Water Availability", by Maria Marrow from the College of Redwoods, produced a further understanding of Mesophytic plants that lined up with this study. Mesophytic plants are built for neither warm or cool conditions, making them questionable for these conditions, however, they have a competitive advantage to xerophytes because they invest energy in growth and reproduction rather than specialized water-saving structures (Morrow, 2019).

The final ANOVA test was done over the diversity of plant types in each distance from water, where, similarly to the prior ANOVA test, a 'staircase' of the overall amount was the result. The most plant diversity being close to water transects makes sense as more water resources allows for more plants that are weaker to survive. Similarly, there being a massive drop in far distance total diversity also lines up that only larger strong woody plants could properly survive in a dryer climate with a low overall constant resource of water.

In a source which evaluated similar variables as *Fig 3 and Fig 2,* "Soil water availability shapes species richness in mid-latitude shrub steppe plant communities" evaluated water availability within soil specimens and their relationship to species richness in given plant communities. Within this study, it was found that the spatial and temporal distribution of soil water for dryland plant species richness directly affected biodiversity patterns in plant communities (Robbins 11 et al., 2018). This supports the finding of increased biodiversity and abundance in plant species within close proximity to water sources in Bull Creek.

The main issue that likely affected the results of this study was the time of year that the study was done in, as many of the plants had smaller budding leaves which led to possible misinterpreting of which plant is in the area. Another case of human error that could have impacted these results is skipping smaller plants or assuming that clusters of plants were the same one due to the general abundance of plants in each transect.

Should another study be conducted over this topic, it would find better results done in another time of year when plants are not freshly budding. Additionally, an environment for each transect section that has no other water sources nearby that are not the main water source being used for the experiment would largely strengthen weaknesses in the current study, as plant types and total diversity per section would be strictly based on the large water source being used. A final revamp of the study for better results would be for the study to take place in a more organic area that isn't so close to a busy road area, as this possibly affected results of the experiment when it came to the overall diversity of plants.

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