The Effects of Distance from Water on Plant Density in Central Texas

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ABSTRACT: The purpose of this study is to research woody plant species in Mary Moore Searight Park, Austin, Texas. The question that the study aims to answer is how does the proximity to water affect plant density, and the hypothesis was that as distance from water increases the plant density will decrease. A total of 9nine 50-meter line intercept transects were taken at <10m, 500m, and 800m from the nearest water source, Slaughter Creek, with 3 at each distance. For each intersecting plant, the intercept range, intercept length, and intervals intersected-1 interval is every 5 meters-were recorded. Each unique species had a sample taken, and unknown species were identified with a dichotomous key. The results found that Ashe Juniper had the largest importance value. The average number of species was significantly lower in the 800m transects compared to the 500m and <10m. Finally, the average abundance for Ashe Juniper increased as distance from water increased but for all other species average abundance decreased. However, the majority of these results were counted as insignificant from P/T tests. Our results indicate that Ashe Juniper thrives in arid environments, which may cause the decrease in biodiversity.

Introduction

Purpose

This study aims to research woody plants in Mary Moore Searight Park, Austin, TX. The question addressed by the study will be how does water proximity affect plant density.

Hypothesis

The study's expected outcome is that as distance to water increases, the plant density will decrease in Mary Moore Searight Park. This is because plants require water to survive, so areas with less access to water will struggle to support more plants.

Site Description

Location

Mary Moore Searight Park is in South Austin, around 6.74 kilometers west from the southernmost tip of McKinney Falls State Park to the northernmost tip of Mary Moore Searight Park (Google Maps, 2024).

Areal Extent

The area of Mary Moore Searight Park when outlined in a parallelogram is around 116 hectares (Google Maps, 2024).

Topography

The minimum elevation in the park is around 183 meters and the maximum is roughly 200 meters, with the park being flat overall (USG, "Esri", 2014).

Geology

The majority of the rock in Mary Moore Searight Park is Kau, or Austin Chalk. It is a white limestone made of chalk and marl, and it is 85% $CaCO_3$. It was formed in the Cretaceous period (USGS, "Pocket", 2019). The rock deposited around Slaughter Creek is Qt, or Fluviatile Terrace Deposits, consisting of small, polished stones as well as sand, silt, clay, and gravel. Fluviatile Terrace Deposits were formed in the Quaternary period (USGS, "Pocket", 2019).

Vegetation

The vegetation within the park is roughly 80% woodland and 20% grassland. Three example tree species found during an initial field visit in February, 2024 were Ashe Juniper, Red Oak, and Japanese Privet.

Water Availability

The main water source for Mary Moore Searight Park is Slaughter Creek, which runs through the southern end of the park. As observed on February 18th, 2024, the creek was ~½m deep, at a steady speed, and with flooding could reach ~3m. The evidence suggesting this is the damage to plants and roads in the direction that the creek flows.

Urbanization

The park has multiple trails going through it and there are parking lots and roads going into the park and there is a recreational area at the heart of the park. There are multiple neighborhoods bordering the park and there is also an elementary school bordering the park. Some parts of the park are also surrounded by fencing.

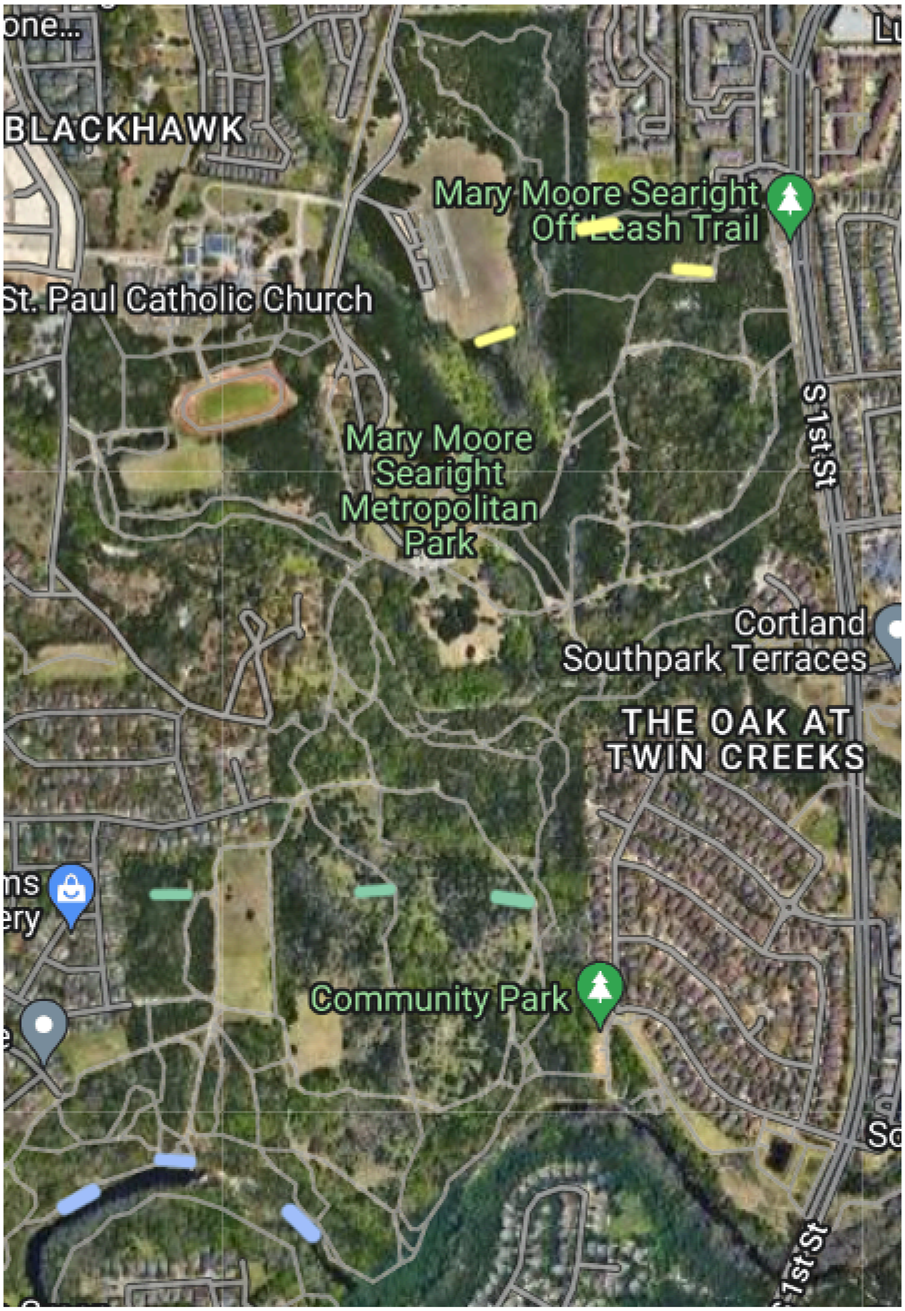
History

Mary Moore Searight Park was originally owned by Mary Moore Searight. The City of Austin purchased 35.6 hectares of the park through a Texas Parks and Wildlife Preserve grant, and Searight donated another 83.4 hectares (Olivieri). The park was acquired from 1988 to 1991 (Austin City Records).

Research Plan

Design of Study

The study will use the line-intercept method to record plant populations, with 50m long transects. There will be 9 transects taken, with one set of data recorded at each transect. 3 transects will be located adjacent to Slaughter Creek, 3 transects will be located ~200m from Slaughter Creek, and 3 transects will be located ~400m from Slaughter Creek. There is another small creek in the middle of the park, so some of the transects had to be located more north.



Background information
A study was conducted in Hututu settlement, Trans Nzoia County, Kenya, examining the influence of water proximity on land cover, tree species distribution, and tree functions in agro-ecosystems. Results indicate that water proximity moderately affects land cover, with their . Eucalyptus, the primary tree species, shows similar distribution patterns. Tree functionality is indirectly impacted by water proximity, favoring less managed trees near water courses. Additionally, proximity to buildings positively correlates with woody land cover classes, while fruit trees are commonly planted near houses (Berntsson and Winberg, 2013). These findings correlate with the hypothesis.

Another study examined the effects of water availability on *Shepherdia* × *utahensis* shrubs at the Utah Agricultural Experiment Station’s Greenville Research Farm, in North Logan, Utah. Cuttings from the same clone plants were propagated, then grown to the same height and shoot number. Then, 96 of them were transplanted, and watered at 8 different volumetric amounts. The study found that the proportion of visibly wilted leaves increased as substrate volumetric water content decreased, and that plant mortality increased from 8% to 58% when the substrate volumetric water content decreased from $0.25\ m^3 \cdot m^{-3}$ to $0.05\ m^3 \cdot m^{-3}$ (Chen et al., 2022). This supports the hypothesis that plant density will be higher when closer to a water source.

A study investigated how the fitness and geographic spread of Barbarea vulgaris R. Br. (Brassicaceae) were affected by abiotic variables, particularly the availability of water and nutrients. Research was done on the positive relationships that exist between plant growth, flower output, water availability, and nutrients (potassium, phosphorus, and nitrogen). The evaluation takes into account the population's density and fitness distribution in space. They measured the amount of water and nutrients available to the population as well as the number of flowers, plant height, and projected density for each individual. The findings show that while blossom quantity and plant height peak in the perimeter and plots closest to the wetland, density is maximum in middle plots and those at a medium distance from the wetland. There are no regional trends in the availability of water, nitrogen, or potassium (TenBrock, 2015). So this study supports the hypothesis as the plant height peaked when it was near water.

Materials
- Transect Tape
- Project Notebooks
- Scissors
- Tape
- Pen
- Phone
    - Seek App (iNaturalist)
    - Google Maps

- Dichotomous Key (Lynch, 1981)

Data Collection Procedure

1. Prepare a blank data collection table in the project notebook. Above it, record the transect number, date and time, transect length, and weather information.
2. Travel to the desired study location in the park. Use google maps phone to ensure the correct location is reached.
3. Stretch the 50 meters transect line as straight as possible in the desired study area.
4. Move along the transect line and record the woody plant species found that overhang the transect line in the field data table with a pen. Record the common name of the woody plant and intercept range and length to the decimeter. Record the intervals that the woody plant is found.
5. Next collect a representative lead sample from each species encountered. Press and tape the sample in the back of the project notebook on the unnumbered pages. A good lead sample will include many leaves attached to the branch, so that leaf arrangement can be seen. While in the field, record the lead type and arrangement, a description of the bark , and a description of the fruit and/or flower for each plant on its corresponding sample page. Also record whether the woody plant is a tree, shrub, or vine. Sample pages should include this information.

Data Analysis Procedure

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

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

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

Importance Value Relative Density + Relative Dominance + Relative Frequency

Conclusion

Results

On average, the Ashe Juniper importance value on the transects <10m from the water was 161.67, while in the transects 500m and 800m out from the water, Ashe Juniper an importance value of 143.33 and 253.33, respectively (Fig. 1). Although the average importance value of Ashe Juniper increased from 161 to 253 from close to far distance from water, the result was not significant ($p = 0.17$). The next most frequent species-being Plateau Live Oak - had an average importance value of 75, 21.67, and 37.67 across <10m, 500m, and 800m transects respectively (Fig. 1). Despite the difference in importance values the result wasn't significant ($p = 0.3417$). The average number of species at close, medium, and far distances to water were 5, 5.3, and 1.7 (Fig. 2). The difference between close and far and the difference between medium and far were significant ($p = 0.03$, $p = 0.01$). So the average number of species in the transect <10m, and 500m were significantly higher than that of the 800m transects by 3.3 and 3.6 species. So, the farther away from 500m the less species are present, but from <10m and 500m the average number of species is the same. The average abundance of woody plants at close, medium, and far distances to water were 25.7, 23.3, and 30.7 respectively. The difference between close and medium was very insignificant ($p=0.64$), and the difference between close and far and medium and far were insignificant ($p = 0.13$, $p = 0.21$) On average, the relative frequency of the Cedar Elm on the transect 500m out from the water was 22.33%, while on the transects <10m and 800m out from water, had a relative frequency of 1.39% and 0%, respectively (Fig. 4). Although the difference of the average relative frequency on the <10m and 500m transect was 20.94% and 22.33% on the 500m and 800m transects, the results were not significant ($p = 0.09$, $p = 0.07$).

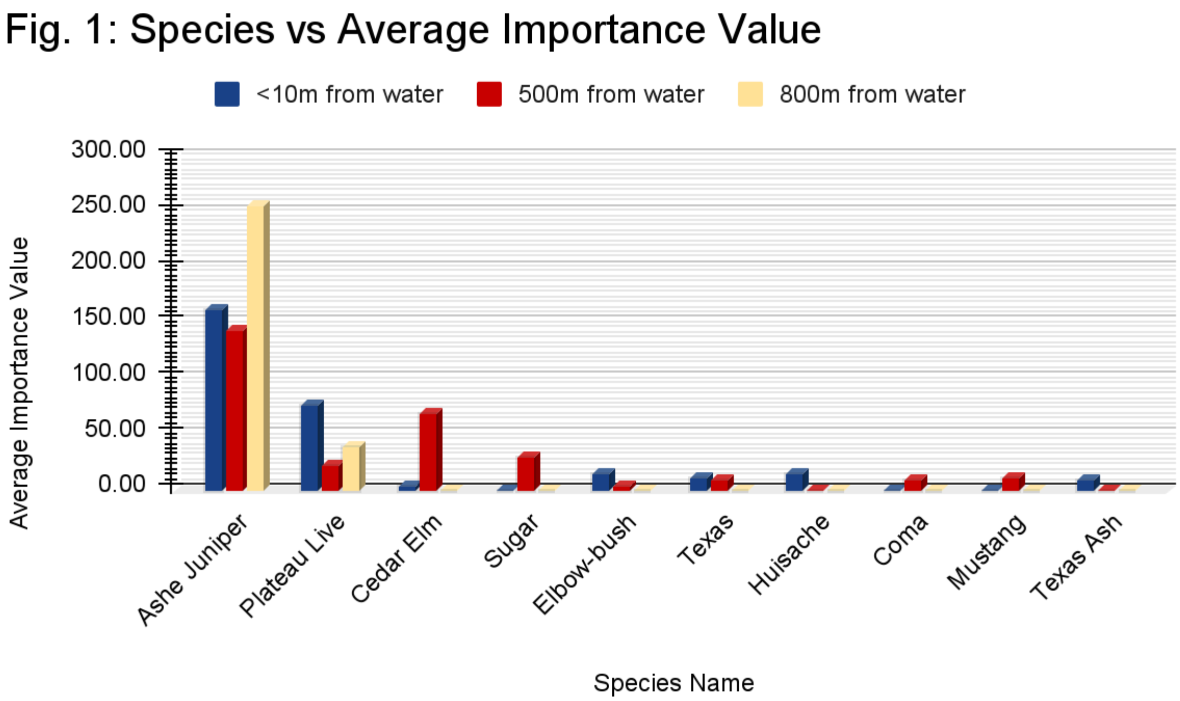


Fig. 1: Species vs Average Importance Value
<10m from water
500m from water
800m from water
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Average Importance Value
Ashe Juniper
Plateau Live
Cedar Elm
Sugar
Elbow-bush
Texas
Huisache
Coma
Mustang
Texas Ash
Species Name

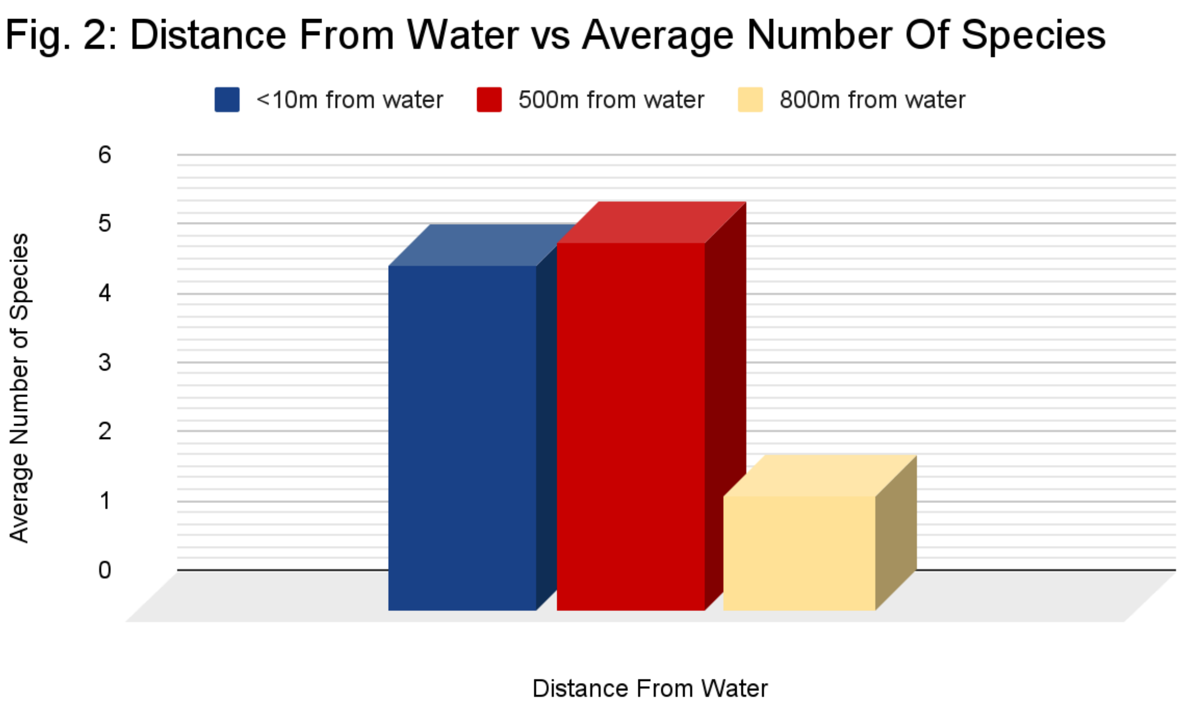


Fig. 2: Distance From Water vs Average Number Of Species
<10m from water
500m from water
800m from water
6
5
4
3
2
1
0
Average Number of Species
Distance From Water

Fig. 3: Distance From Water vs Average Abundance

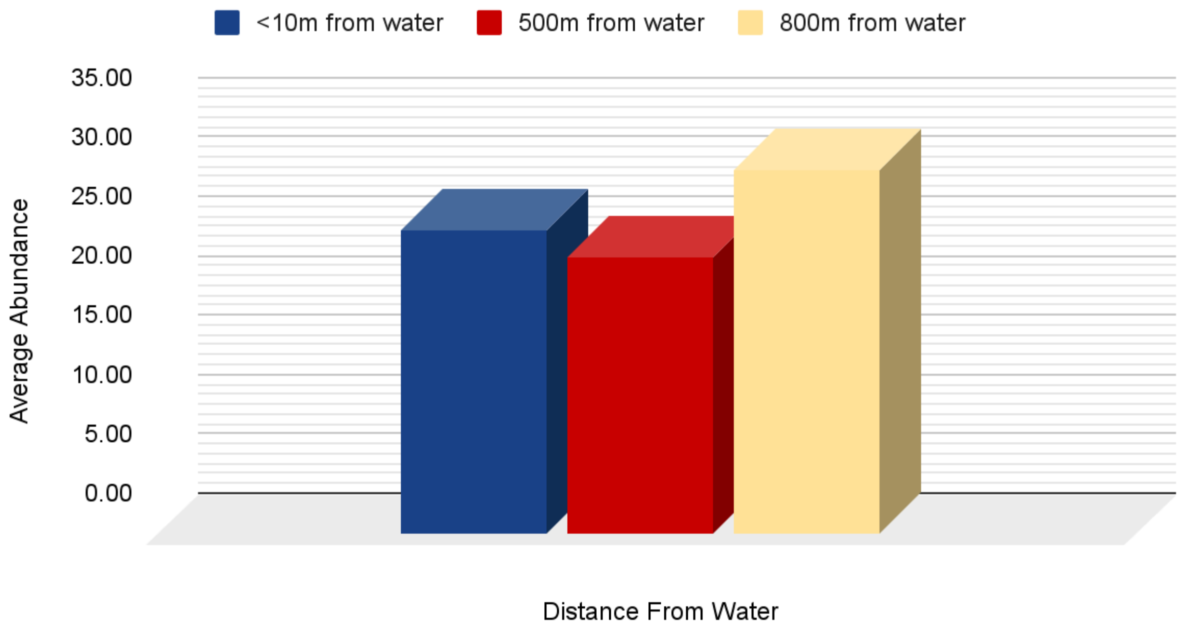
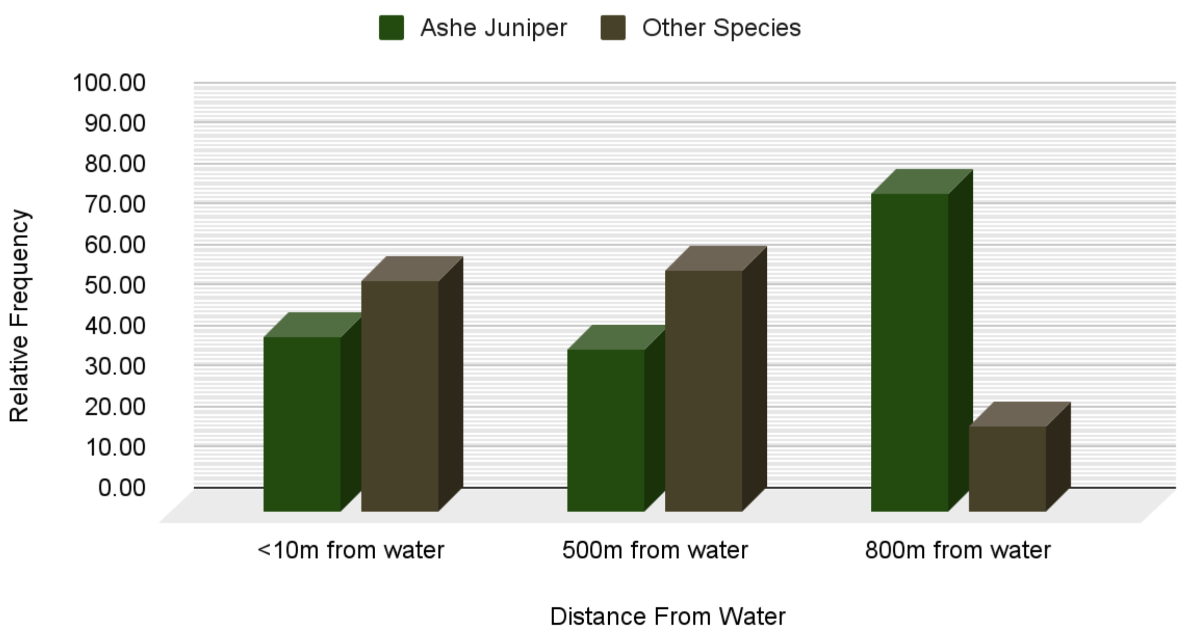


Fig. 4: Ashe Juniper & Other Species vs Relative Frequency



Discussion

This study's hypothesis was that as distance to water increases, the plant density would decrease. The results showed that abundances somewhat increased as distance to water increased, which does not support the hypothesis, but the data was also insignificant. This may be due to how Ashe Juniper thrives in arid environments. However, we found that the average number of species at different distances to water decreased when comparing the <10m and 800m transects and the 500m and 800m transects. This means the biodiversity of the park decreased from <10m to 800m and 500m to 800m, which does support our hypothesis.

The most abundant plant within the study was Ashe Juniper, and from Fig. 4, the relative frequency of Ashe Juniper is seen to increase as the distance from water increases, which does not support our hypothesis. However, all of the other species collected are seen to have a decrease in relative frequency as distance from water increases, supporting our hypothesis. A few of the species that had a decrease in average frequency as distance from water increased were Elbow-Bush,Huisache, Texas Ash, Japanese Privet, White Shin Oak, and Southern Red Oak. It's possible that the high amount of Ashe Juniper biases the overall data, making the abundance appear to increase as distance to water increases, even though the abundance of other species decreases.

A similar study was conducted on the northern edge of a 5000-ha farm located in Salta Province, Argentina. A total of 16 plots were sampled, with half 15m from water and half 200m from water. The densities of saplings, shrubs and young trees, and adult trees were recorded in separate categories. It was found that the density of saplings and adult trees increased when at a greater distance to water (|d| = 7413 saplings/ha, |d| = 167.5 adult trees/ha) (Trigoet al.). This supports our finding of higher plant density at greater distances to water in Mary Moore Searight park.

In another study, the researchers conducted an experiment where they planted seedlings in containers and manipulated plant density by removing above-ground parts of randomly selected plants at 60 days post-planting, creating three different densities. They then deprived some seedlings of water and gave some excess to mimic plant conditions near streams/rivers. The study found a negative correlation between plant density and the time it took for seedlings to wilt or die under low water conditions. This means that seedlings survived lack of water significantly longer when planted at lower densities or when density was reduced. This can be related to this study, the seedlings that had no water access are similar to the 500m and 800m away from water transects. So, this study refutes our data taken at Mary Moore Searight Park of distance from water increasing results in an increase of plant density (Honda et al.).

Another study was conducted on the effects of water availability on the growth of young starfruit (Averrhoa carambola) plants. In this study, young star fruit plants were selected and in a controlled environment, they were subjected to different levels of water stress by withholding varying amounts of water. It was found that the plant vegetative growth was inhibited with the reduced water availability. Leaf water potential, relative water content, and the canopy transpiration were all reduced with increasing soil water stress, a deficiency of water within the soil. The leaf photosynthesis rate was also reduced when the stomatal resistance, caused by a water deficiency, was higher than 3.5scm -1. This does not support our results as in Fig. 3, we see that our data shows that plant density is the highest when we are the furthest away from water. However, this study shows that due to water deficiencies in soils, soils far away from water sources, plant growth is inhibited and plant density is lower than the plant density in the non-deficient soils (Ismail et al.).

Finding suitable transect locations was difficult. This was due to urbanization which was avoided due to possible influence on biodiversity, as well as the multiple water sources which had to be considered when taking distance from water.

This study could be improved by increasing the number of transects taken or by increasing the length of the transect taken. Additionally, a faster method of recording data, such as aerial photo data, could help increase the amount of data.

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