

Water Availability Impacts on Saguaro Cactus Branching

Mikayla Brown and Joseph Herrel

New College of Interdisciplinary Arts & Sciences, Arizona State University – West Campus, Phoenix, AZ 85069

Introduction:

- Saguaro can hold well over a ton of water within itself (Drezner, 2003).
- The Sonoran Desert receives an annual rainfall of 3-20 inches every year.
 - In the winter precipitation tends to be lower, while in the summer many monsoons add to a greater precipitation (Enzi, 2019).
- Many studies have found that cacti branching can be attributed to both geography and summer rainfall (Lin, 2020).
- It is possible that human disturbances can affect the amount of water a cactus may receive.
 - Disturbances including: agricultural development and man-made water sources.
- We hypothesized that cactus branch growth is greater in areas with higher water availability than in areas with lower water availability

Methods:

To test the hypothesis that saguaro branching is impacted by water availability, four individual saguaros were observed at four locations around Phoenix, Arizona. The locations chosen for these measurements were: Estrella Mountain Regional Park, The Salt River, Saguaro Lake, and Theodore Roosevelt Lake. The following sequence of events was conducted for each site:

- Individual Saguaros were identified and chosen at random based on their estimated proximity to the nearest water source.
- Soil moisture readings were taken at the base of each cactus, using a soil moisture probe. Each reading was repeated 3 times and the average was recorded in the data tables below.
- The number of branches (arms) the Saguaro had was observed and recorded, as well as any notable nearby plant species or observations regarding the landscape features.
- The GPS location of the individual was recorded, and the distance from the water source was calculated using an online Coordinate Distance Calculator.
- Measurements were then graphed and statistically analyzed using Pearson's Correlation.



Hypothesis and Research Questions:

Saguaro cactus branch growth is greater in areas with higher water availability than in areas with lower water availability.

- How does proximity to a water source affect a Saguaro cactus' branch growth? Is total branch number affected by the availability of water?



Results:

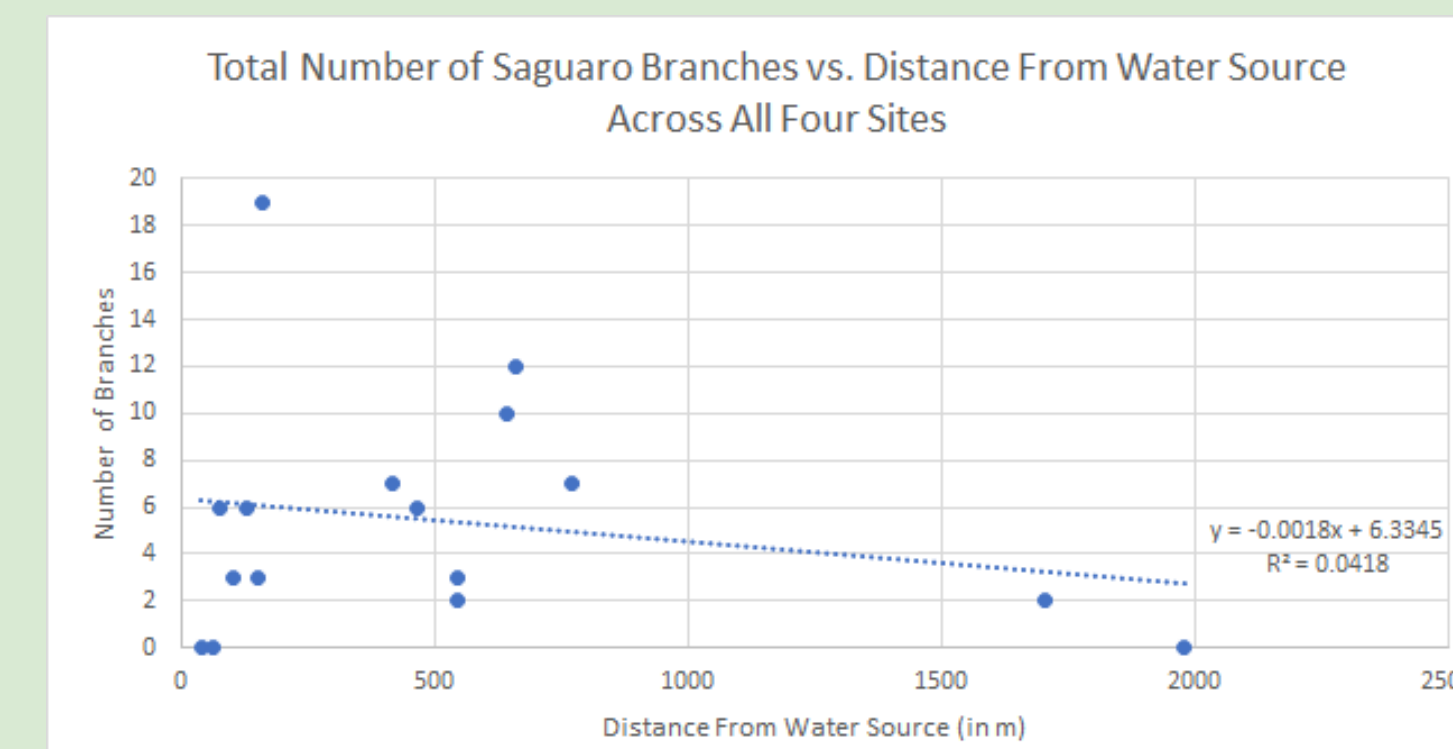
Measurements showed a slight negative relationship between total number of Saguaro branches and distance from the nearest water source. Additionally, a slight positive relationship was observed between soil moisture content and total number of branches. Statistical analysis using Pearson's Correlation was performed and are listed for each graph below.

Estrella Mountain Regional Park

	Distance to water source (in m)	Number of branches visible	Soil moisture content at Saguaro base	Notes (important features, nearby plant species, overall health of the plant)
Saguaro 1	1705.91	2	0.4%	few plants near this cactus, some drought deciduous brush plants nearby (nothing within 1m of saguaro base)
Saguaro 2	1979.493	0	1.2%	rocky area with little plants nearby, some grasses at base
Saguaro 3	466.71	6	0.5%	other saguaros nearby, creosote bush, and scattered drought deciduous bushes
Saguaro 4	547.18	3	2.2%	close to saguaro 3, same notes

Saguaro Lake

	Distance to water source (in m)	Number of branches visible	Soil moisture content at Saguaro base	Notes (important features, nearby plant species, overall health of the plant)
Saguaro 1	129.6	6	1.3%	Near a rocky area only a few shrubs at the base of the cactus
Saguaro 2	547.4	2	2.1%	This cactus is near a road and is surrounded by many plants
Saguaro 3	772.6	7	1.2%	Near many nursing plants on flat ground
Saguaro 4	659.5	12	1.5%	Near the road around many shrubs



Graph 1: Scatter plot showing the relationship between Saguaro branching and proximity to a water source.

- High variability was observed in the total number of Saguaro branches and their proximity to water sources.
- Although a slightly negative relationship is shown here, the data is not statistically significant.
 - Pearson's Correlation: $r = -0.2044$, $P = 0.45$

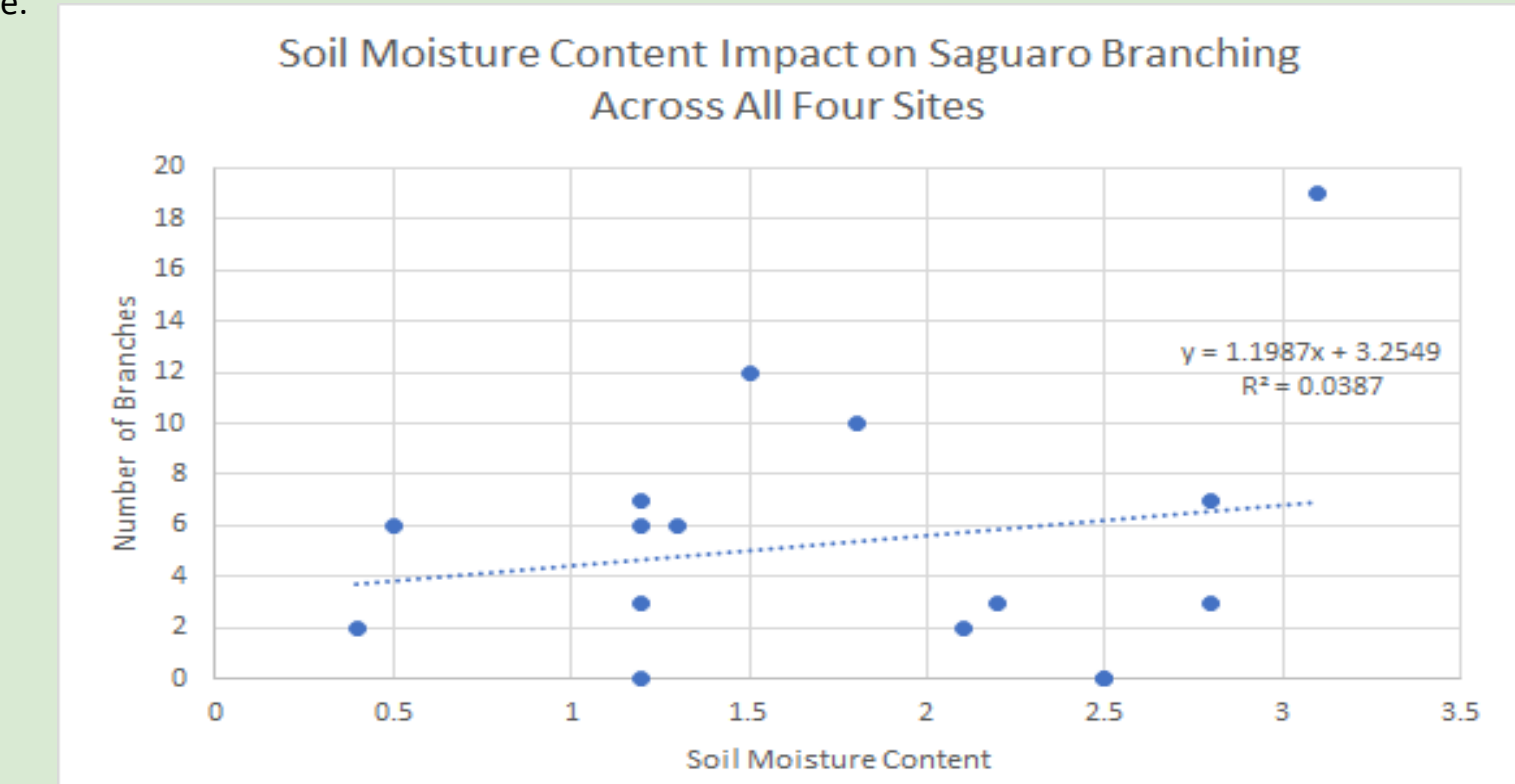
Salt River

	Distance to water source (in m)	Number of branches visible	Soil moisture content at Saguaro base	Notes (important features, nearby plant species, overall health of the plant)
Saguaro 1	76.50	6	1.2%	Surrounded by many nursing plants, near the trail
Saguaro 2	101.19	3	2.8%	Human litter was next to the cactus and there was many other plants at its base
Saguaro 3	40.10	0	2.5%	Lots of horse droppings around this plant as well as nursing plants at its base
Saguaro 4	158.80	19	3.1%	Very little plants around it

Theodore Roosevelt Lake

	Distance to water source (in m)	Number of branches visible	Soil moisture content at Saguaro base	Notes (important features, nearby plant species, overall health of the plant)
Saguaro 1	64.1	0	2.5%	Near a highway and close to the water, lots of gravel is nearby.
Saguaro 2	153.4	3	1.2%	Near a service road, surrounded by plants and rocks
Saguaro 3	418.4	7	2.8%	Off the side of a road in a little ditch surrounded by rocks and plants
Saguaro 4	643.6	10	1.8%	This cactus is in a barren rocky area

- Soil moisture content at the base of each individual Saguaro plotted against the number of branches showed a slightly positive relationship.
- This relationship was not determined to be statistically significant.
 - Pearson's Correlation: $r = 0.1967$, $P = 0.47$



Graph 2: Scatter plot showing the relationship between soil moisture content and Saguaro branching.

Discussion and Conclusion:

- **Evidence supported no statistically significant differences between saguaro cactus branching and proximity to the nearest water source or soil moisture content.**
 - The data collected did not yield statistically significant results. The Pearson's Correlation Coefficient yielded a value between no association present (0) and an inverse association between variables (-1) for graph 1, and a value between no association present (0) and positive association between variables (1) for graph 2.
- **Sources of variation not accounted for during experimentation.**
 - There could have been several unaccounted for sources of variation in this experiment, unable to be addressed using the methodology conducted here. It is possible that annual rainfall in specific areas farther from the natural water source could have allowed for greater water availability at larger distances. Additionally, anthropogenic changes to the desert landscape could account for variation in growth.
- **Age and weathering factors are out of our control.**
 - The age of the saguaro cacti could have an impact on branching that was unaccounted for. Saguaros have been shown to grow in height before any branching occurs. There was no definitive way to determine each individual's age in this experiment. Potentially some of the branchless individuals observed could have been juveniles. Additionally, weathering and physical alterations could have removed branches from Saguaros (either by being broken off or burned off).
- **Future research direction.**
 - Further study of this matter would require exploration of sources of water availability and growth variation including: age of each individual Saguaro cactus, average precipitation received in each area annually, and potential anthropogenic inputs of water.



References:

Enzi, Julianna J., William D. Pechey, and Katharine L. Gerst. "A Decade of Flowering Phenology of the Keystone Saguaro Cactus (*Carnegiea Gigantea*).*" American Journal of Botany* 106.2 (2019): 199-210. Web.
 Taly Dawa Drezner. "A Test of the Relationship Between Seasonal Rainfall and Saguaro Cacti Branching Patterns."*Ecography (Copenhagen)* 26.4 (2003): 393-404. Web.
 Jianfeng Lin, Dagang Zhao, Chunyu Guo, Zhaofan Zhang, Yamin Su. "Numerically Modeling the Effect of Flexibility on Flow around Marine Engineering Structures: Using the Shape of the Saguaro Cactus."*Journal of Coastal Research* 36.3 (2020): 628. Web.