Math Meets Biology: Characterizing Stomatal Clusters

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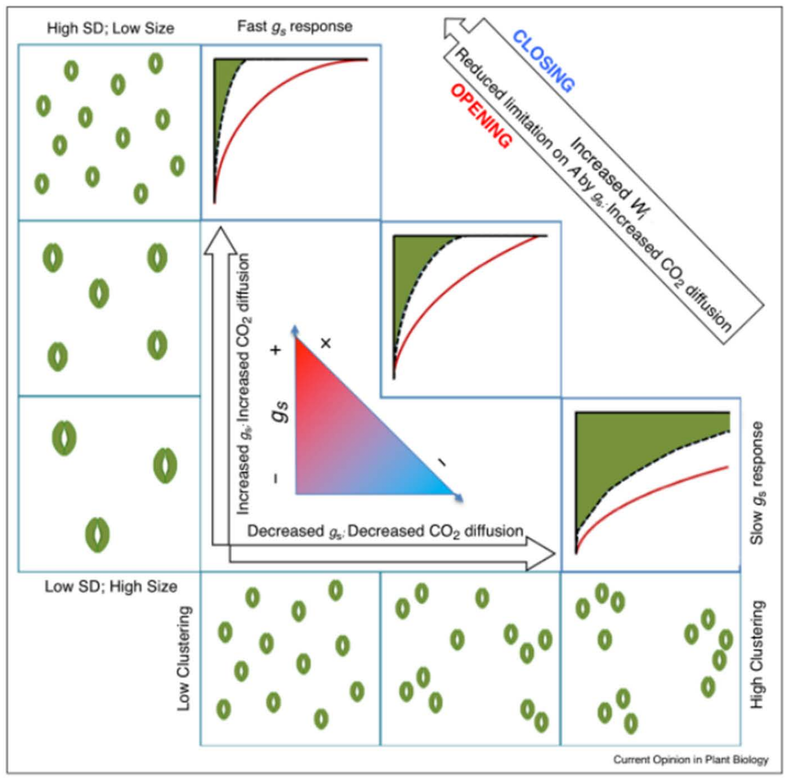
Background



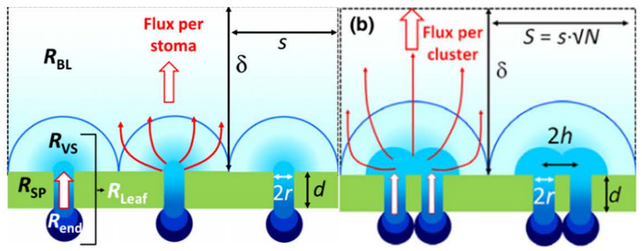


Figure 1. A chart depicting stomatal conductance's expected relationship with stomatal size, stomatal density, and stomatal clustering. [2] The images underneath the chart show how the diffusion gradients interact. [1]

Hypotheses and Objectives

- Create a script to compare clustering characteristics with low-resolution data.
- Clustering characteristics of samples taken from different locations will differ from one another.

Methods

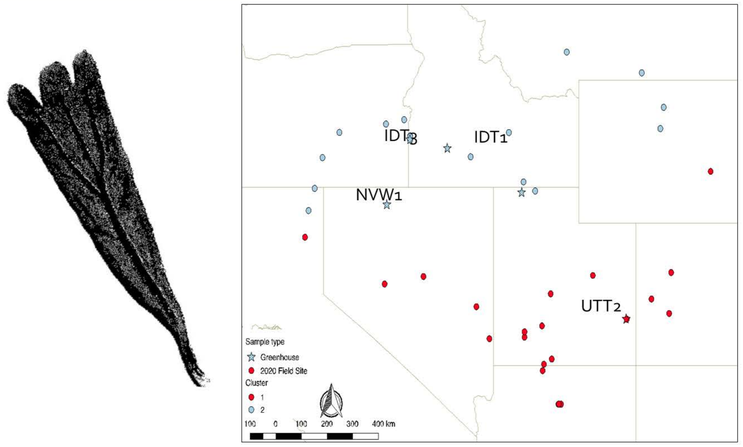


Figure 2. Image of sagebrush leaf (left) and map depicting sample population locations (right).

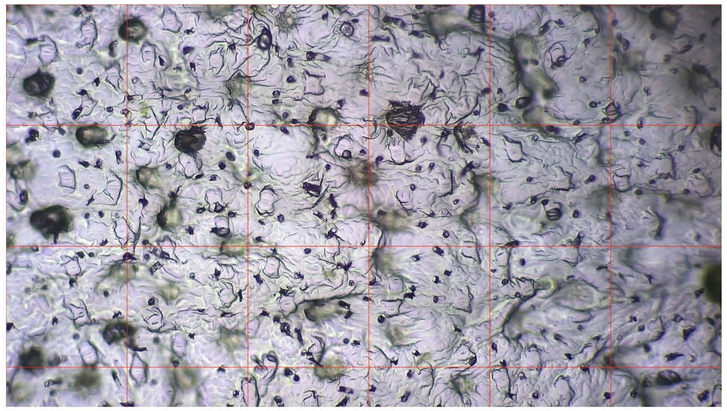
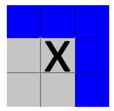


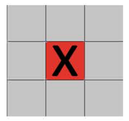
Figure 3. An example of leaf epidermis at 10x objective magnification.

A = True if



More than half of the cells surrounding the observed cell have fewer than the average number of stomata per cell

B = True if



Cell being observed has more stomata than the average for the image

Cell with more stomata than the average for that image

Cell with fewer stomata than the average for that image

Cell being observed = X

$$P(A|B) = \frac{P(B|A) \times P(A)}{P(B)}$$

Results

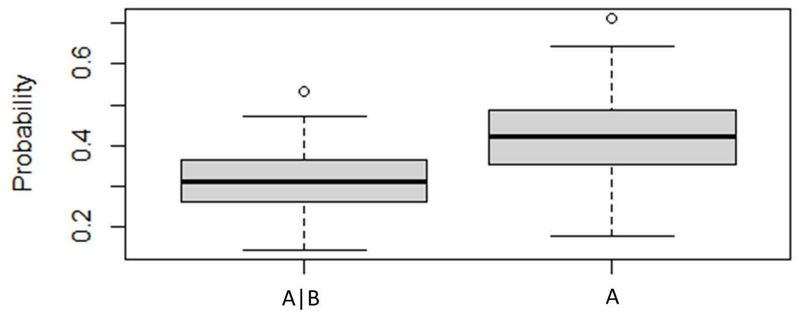


Figure 4. This graph depicts the probabilities of event A and event A|B occurring. A Welch's t-test showed a significant difference *($p < 0.001$).*

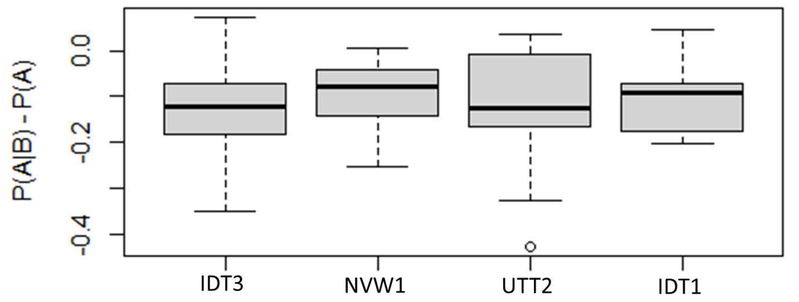


Figure 5. Box plot depicting the difference between the P(A|B) and P(A)(from left to right, IDT3, NVW1, UTT2, IDT1). A t-test between all the populations showed no significant difference, however the fact that the means are negative does suggest that the stomata are over dispersed.

Discussion

- Stomatal clustering is already optimized
- Sagebrush populations are nearing peak cluster efficiency
- Increases in water use efficiency (W_i) must come from stomatal size and density
- Future research can focus on other characteristics involved in W_i
- This is one of the first tools to quantify clustering characteristics using low resolution data

References

1. Drake, P.L., de Boer, H.J., Schymanski, S.J. and Veneklaas, E.J. (2019), Two sides to every leaf: water and CO_2 transport in hypostomatous and amphistomatous leaves. New Phytol, 222: 1179-1187. https://doi.org/10.1111/nph.15652
2. Lehmann, P. and Or, D. (2015), Effects of stomata clustering on leaf gas exchange. New Phytol, 207: 1015-1025. https://doi.org/10.1111/nph.13442

Acknowledgments

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