**Soil nitrogen availability increases the positive effect of long-term aridity on water use efficiency across a precipitation gradient in Texas**

Evan A. Perkowski\*1, Nicholas G. Smith1

1Department of Biological Sciences, Texas Tech University, Lubbock, TX

**Background/Question/Methods**

Terrestrial biosphere models commonly predict leaf photosynthesis based on positive relationships between soil nitrogen, leaf nitrogen, and photosynthetic capacity. While there is a strong consensus for positive relationships between soil nitrogen and leaf nitrogen, recent work leveraging photosynthetic least-cost theory indicates that aboveground climate may be a stronger determinant of leaf nitrogen than soil nitrogen. It has been reasoned that this might be driven by aridity, where plants increase leaf nitrogen allocation to maintain photosynthesis at lower water use. Yet, we do not fully understand whether these patterns are driven by short-term or long-term aridity, and how soil nutrients or plant functional type might modify expected photosynthetic least-cost responses to climate. In summer 2020 and 2021, we measured leaf nitrogen and water-use efficiency at 25 sites scattered across a strong precipitation and soil nutrient gradient in Texas. Long-term aridity was estimated by calculating the standardized precipitation evapotranspiration index using 15-year climate normal data, while short-term aridity was calculated using the same index with weather data from the month leading up to each site visit. We hypothesized that increasing aridity would increase water-use efficiency and leaf nitrogen, and that the effect of aridity on these traits would increase with soil nitrogen.

**Results/Conclusions**

There was no effect of aridity, soil nitrogen, or functional type on leaf nitrogen per leaf area. These patterns were driven by similar directional effects of aridity, soil nitrogen, and functional type on leaf nitrogen per leaf mass and specific leaf area. Variance in leaf nitrogen per leaf mass was driven by a three-way interaction between short-term aridity, soil nitrogen, and functional type. This interaction indicated that leaf nitrogen per leaf mass generally increased with increasing aridity, and that the positive effect of aridity on leaf nitrogen per leaf mass generally increased with soil nitrogen. These patterns were observed in C3 graminoid, C3 forb, and C3 leguminous species, but not C4 graminoid species. Variance in water-use efficiency was best explained through a three-way interaction between long-term aridity, soil nitrogen, and functional type. This interaction indicated that increasing long-term aridity generally increased water-use efficiency, and that the positive effect of aridity on water use efficiency generally increased with increasing soil nitrogen. These patterns were also observed in C3 graminoid, C3 forb, and C3 leguminous species, but not C4 graminoid species. These results support our hypothesis, providing additional context to understanding how nitrogen-water tradeoffs vary across different climatic and soil resource environments.