**Soil nitrogen availability increases the positive effect of normal growing season aridity on water use efficiency across a precipitation gradient in Texas**

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**Background/Question/Methods**

Terrestrial biosphere models commonly predict leaf photosynthesis based on positive relationships between soil nitrogen, leaf nitrogen, and photosynthetic capacity. While positive empirical relationships between soil nitrogen and leaf nitrogen are common, recent work leveraging photosynthetic least-cost theory indicates that interactions between aboveground climate and soil nitrogen may be a more reliable predictor of leaf nitrogen allocation than soil nitrogen alone. Specifically, the theory predicts that increasing aridity will increase leaf nitrogen allocation, which will allow individuals to maintain photosynthesis at lower water use. It also predicts that soil nitrogen availability should increase the positive effect of aridity on leaf nitrogen allocation and water-use efficiency. However, few direct tests of this theory exist, and it is unknown whether normal growing season aridity or a given growing season’s aridity is a better indicator of these nitrogen-water use tradeoffs. To test the theory, we measured leaf nitrogen and water-use efficiency at 25 sites scattered across a precipitation and soil nitrogen availability gradient in Texas. Normal growing season aridity was estimated by calculating the standardized precipitation evapotranspiration index using 15-year climate normal data. Growing season aridity was calculated using the same index with weather data from the month leading up to each site visit.

**Results/Conclusions**

There was no effect of normal or growing season 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 growing season aridity, soil nitrogen, and functional type. This interaction indicated that leaf nitrogen per leaf mass generally increased with growing season aridity, and that the positive effect of aridity on leaf nitrogen per leaf mass generally increased with soil nitrogen. Variance in water-use efficiency was best explained through a three-way interaction between normal growing season aridity, soil nitrogen, and functional type. This interaction indicated that increasing normal growing season aridity generally increased water-use efficiency, and that the positive effect of aridity on water use efficiency generally increased with increasing soil nitrogen. Patterns for both leaf nitrogen per leaf mass and water-use efficiency were observed in C3 graminoid, C3 forb, and C3 leguminous species, but not C4 graminoid species. These results support patterns expected from photosynthetic least-cost theory, providing additional context to understanding nitrogen-water use tradeoffs across different environmental contexts.