How Does Woody Plant Encroachment Impact Soil Water Chemistry and Hydraulic Conductivity?

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Background

Woody Plant Encroachment (WPE) is an increasing concern for grassland ecosystems because it can alter soil hydrological properties and water cycling. How water moves through soil and is stored changed depending on the grass or shrub dominated root system. Grasses have dense, shallow roots which allows for higher soil porosity. However, woody shrubs have deeper roots that can create preferential flow paths. Woody encroachment is a growing problem at Konza Prairie Biological Station. Here, there are long-term burning manipulation experiments that help show the rate of woody encroachment. The Shrub Rainfall Manipulation Plots (ShRaMP) compares soil and water dynamics in woody and grass dominated plots while providing an opportunity to study hydrologic impacts. Plots 1-7 are one year burns while 8 - 14 are four year burns with a total of 14 shelters.

Methods

- At Konza Prairie Biological Station, I did 4 different tests of the minidisk infiltrometer at 14 different shelters.
- Each shelter had a different cover of woody versus grassy vegetation.
- I did two duplicate tests in the grassy area and two duplicates in the shrubby area.
- Measured the pressure at four different tensions: -6,- 4,-2, and -0.5.
- Measured water infiltration for an average of 10 minutes for each pressure.

Learning Objectives

- Compare infiltration rates between grassy and shrubby vegetation to assess how vegetation type influences soil hydraulic conductivity (K).
- Assess how drought treatments influence soil infiltration dynamics across plots.
- Evaluate whether differences in fire return intervals (1-year vs. 4-year burns) influence soil infiltration capacity.
- Investigate how woody plant encroachment (WPE) impacts surface-layer hydrology compared to findings from deeper soil studies.

Results

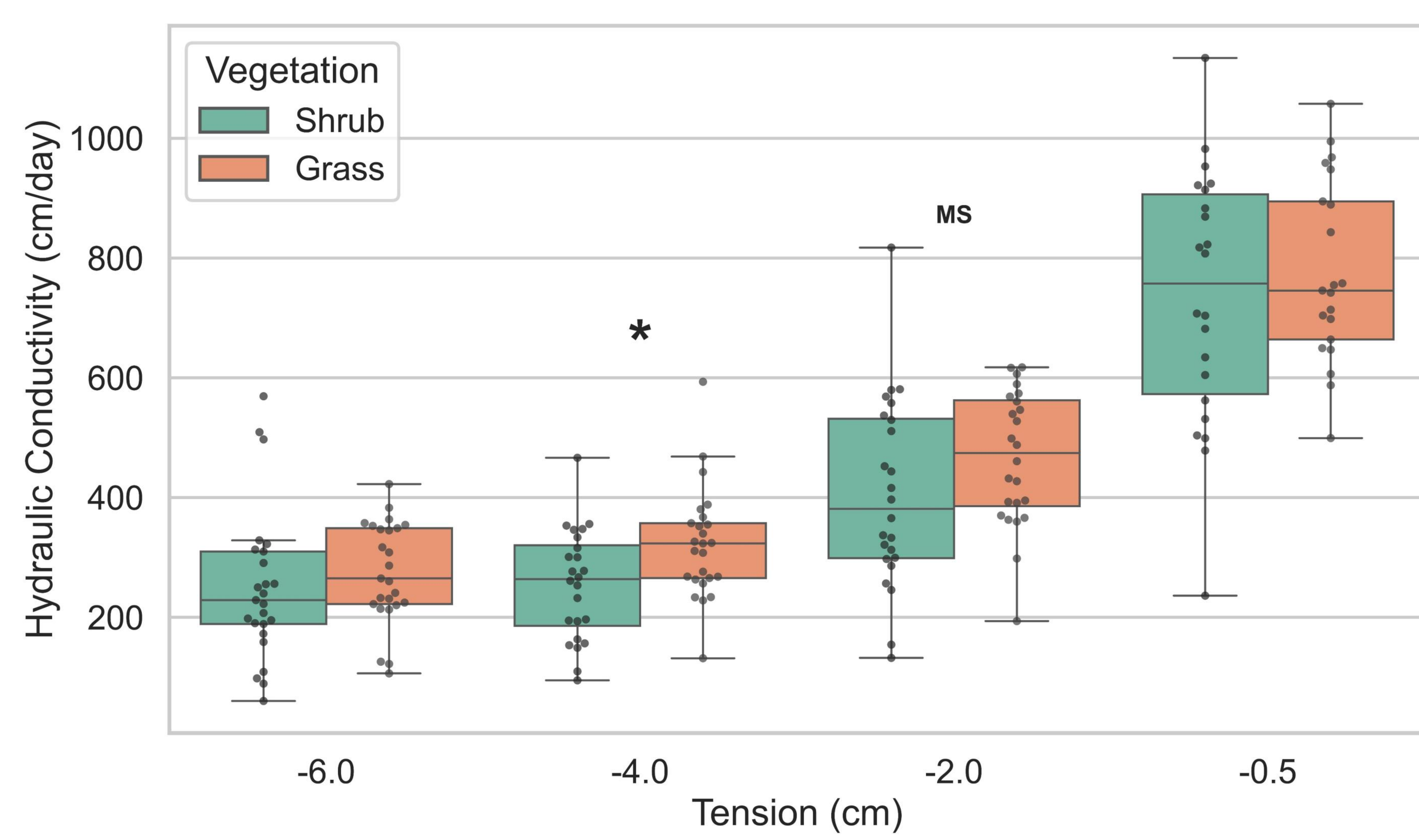

Figure 1: *Comparison of hydraulic conductivity in shrubs and grasses across different soil water tensions. Boxes represent the interquartile range (median ± IQR), individual points are jittered, and significance between treatments at each tension is indicated by asterisks () for p < 0.05 and MS for marginal significance (0.05 ≤ p < 0.1), based on the Mann–Whitney U test.*

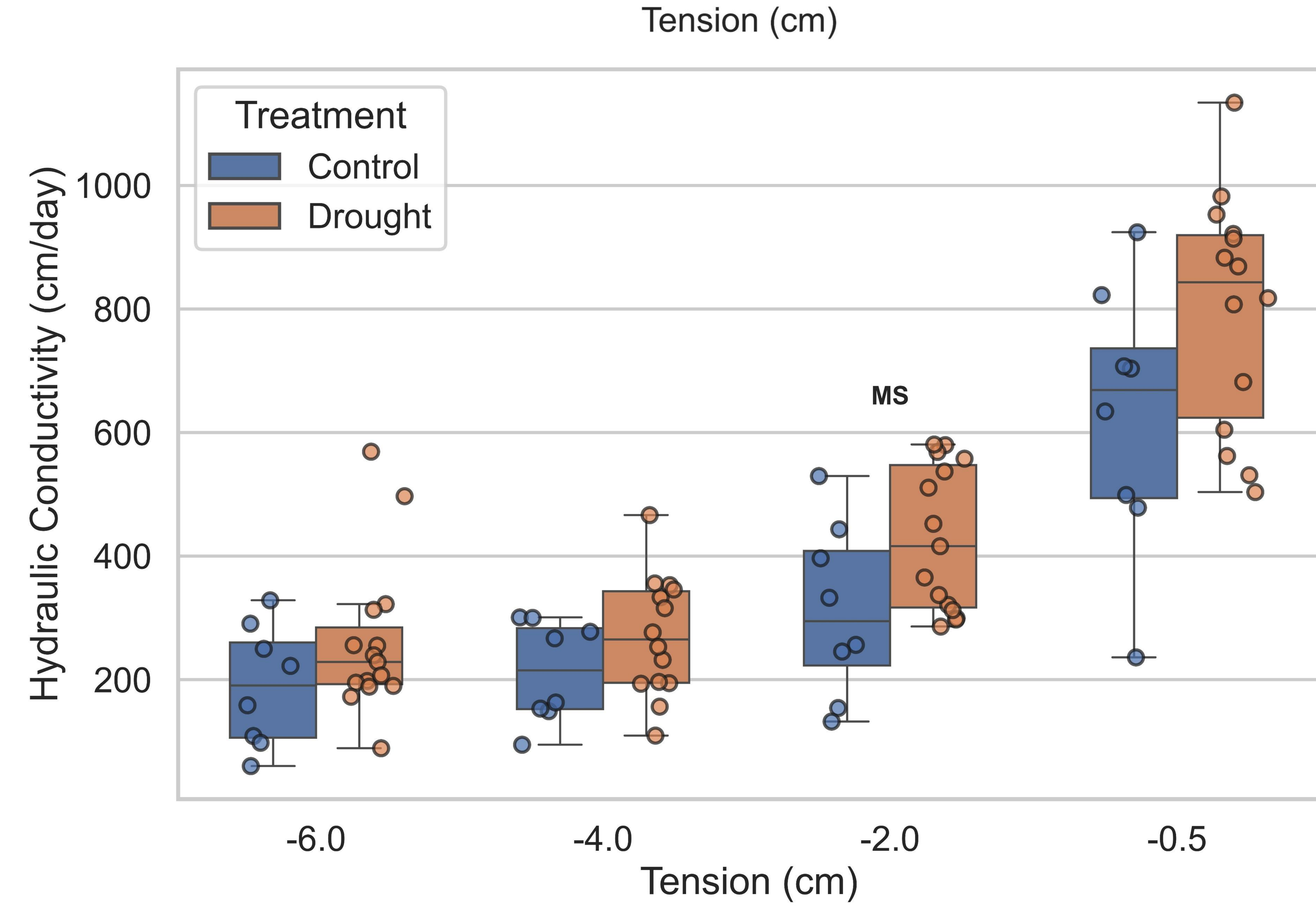

Figure 2: *Comparison of hydraulic conductivity in shrubs under Control and Drought treatments across different soil water tensions. Boxes represent the interquartile range (median ± IQR), individual points are jittered, and significance between treatments at each tension is indicated by MS for marginal significance (0.05 ≤ p < 0.1), based on the Mann–Whitney U test.*

Discussion

- Grassy vegetation exhibits higher mean K values than shrubby vegetation, with statistically significant differences observed at tensions of -4 and –2, grass soils conducting more water (Fig. 1).
- Significant differences were found between drought and control shelters for shrubby vegetation, with drought soils conducting more water, plant responses may enhance macropore connectivity (Fig. 2).
- The fire return interval (1 vs. 4 years) does not appear to alter soil infiltration capacity, likely due to root systems stabilizing hydraulic behavior across fire regimes, due to long-lived woody roots and persistent soil crusts that endure repeated burns.
- Previous studies indicate WPE enhances K through deeper root systems, but this study focused on the surface layer where this effect is not visible.

References

Caplan, Joshua S., et al. "Decadal-scale shifts in soil hydraulic properties as induced by altered precipitation." Science advances 5.9 (2019): eaau6635.