# Interactive effects of drought and fire on co-existing woody and herbaceous communities in a temperate mesic grassland

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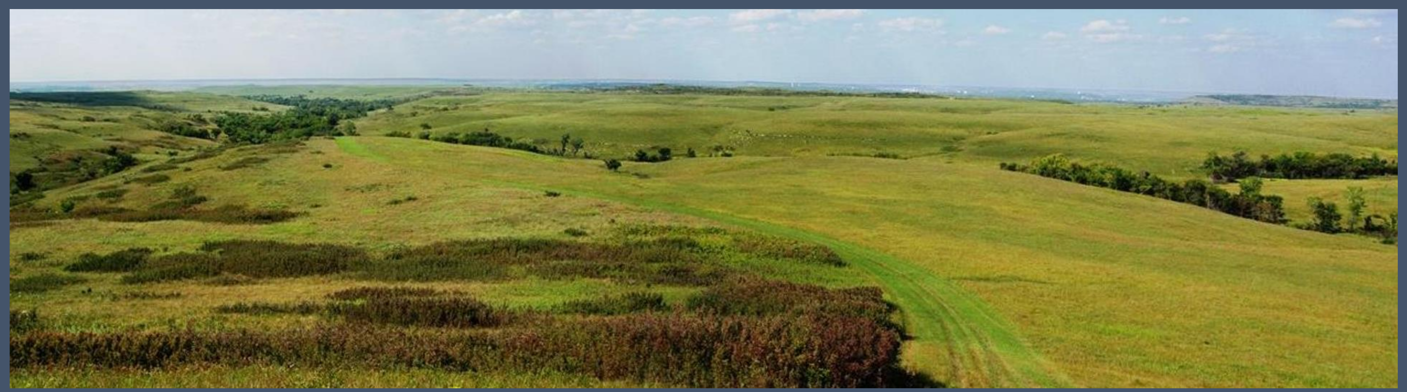
## Background and Objectives

Increased frequency and intensity of drought and woody encroachment are likely to have substantial and interactive effects on grassland carbon and water cycling in the future. However, we currently lack necessary information to accurately predict grassland responses to drought-by-fire interactions in areas experiencing woody encroachment. A more thorough understanding of these interactive effects on grass-shrub physiology would improve the effectiveness of demographic vegetation models and refine predictions of future changes in grassland ecosystem function.



**Main Objective**: Determine how experimental changes in water availability and fire frequency impact physiological and growth traits in an encroaching woody shrub (*Cornus drummondii*) and a dominant $C_4$ grass species (*Andropogon gerardii*) in a native mesic grassland in north-eastern Kansas, USA.

## Study Area and Methods

Konza Prairie Biological Station (KPBS) is a native mesic temperate grassland in north-eastern Kansas, USA. KPBS is a Long-Term Ecological Research (LTER) site and is split into experimental watersheds with varying fire and grazing treatments, many of which have been in place since the 1980's. Woody cover has been increasing at the expense of grass cover at KPBS over the past few decades, particularly in watersheds with burn frequencies >3 years.

**Study Design:** Passive rainout shelters were built over intact shrub-grass communities on watersheds with either 1-yr or 4-yr burn frequencies. Rainfall in drought shelters was reduced by ~50%. Changes in leaf-level physiology in a dominant $C_4$ grass and an encroaching clonal shrub in response to drought and fire have been monitored from 2019 – 2021. All measurements were taken on *Andropogon gerardii* ($C_4$ grass) and *Cornus drummondii* ($C_3$ shrub).

**Parameters Measured:**

- Photosynthetic rate
- Pre-dawn and midday leaf water potential ($\Psi_{leaf}$)
- Aboveground biomass
- Leaf water potential at turgor loss point ($\pi_{TLP}$)

## Results: Impacts of Burn x Drought Treatments on Grass and Shrub Physiology

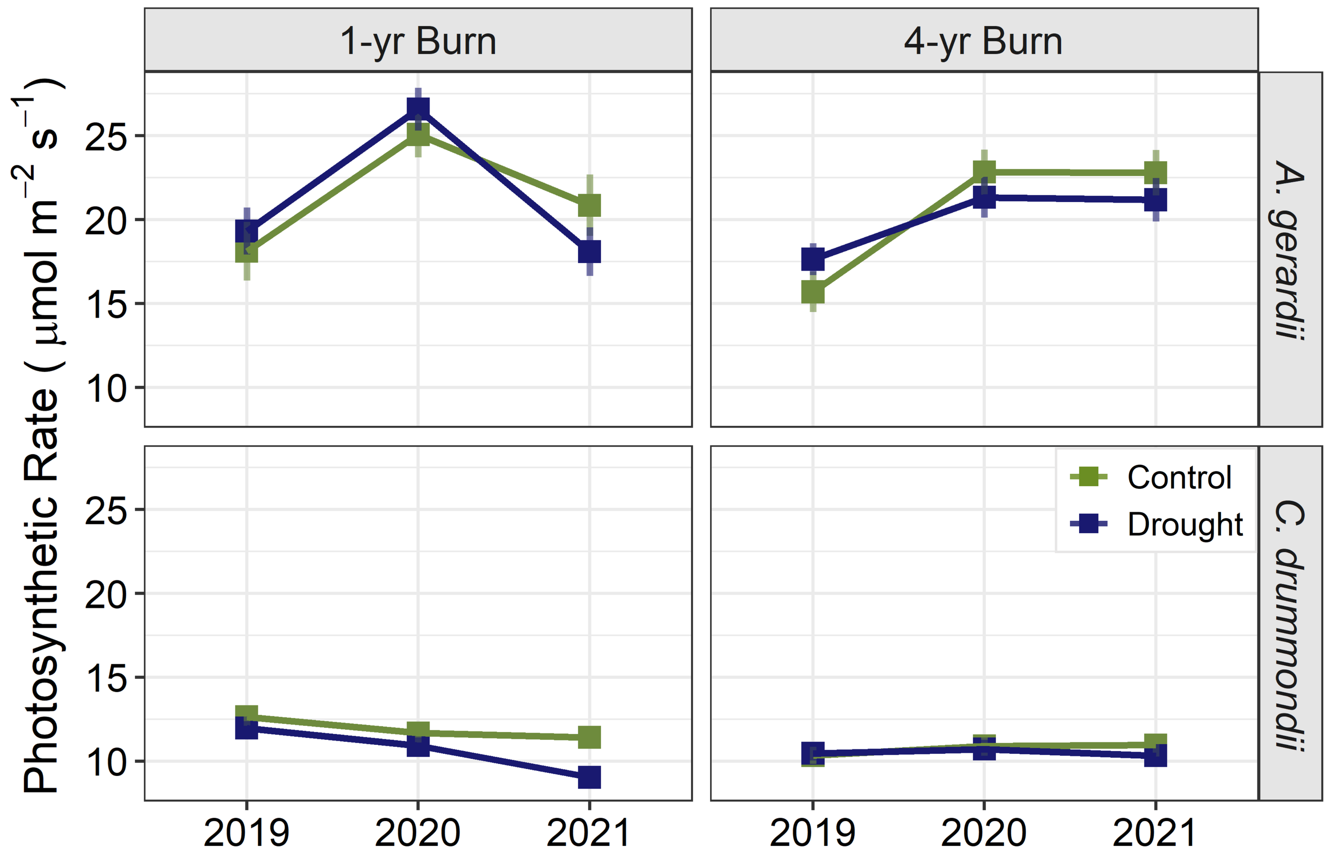



**Figure 1:** Photosynthetic rates for *A. gerardii* and *C. drummondii*, averaged across each growing season for the years 2019-2021. Bars represent standard error.

Slight drought effects were observed in the 2021 growing season, whereby photosynthetic rates were lower in drought shelters than in control shelters (with the exception of *C. drummondii* in the 4-year burn treatment).

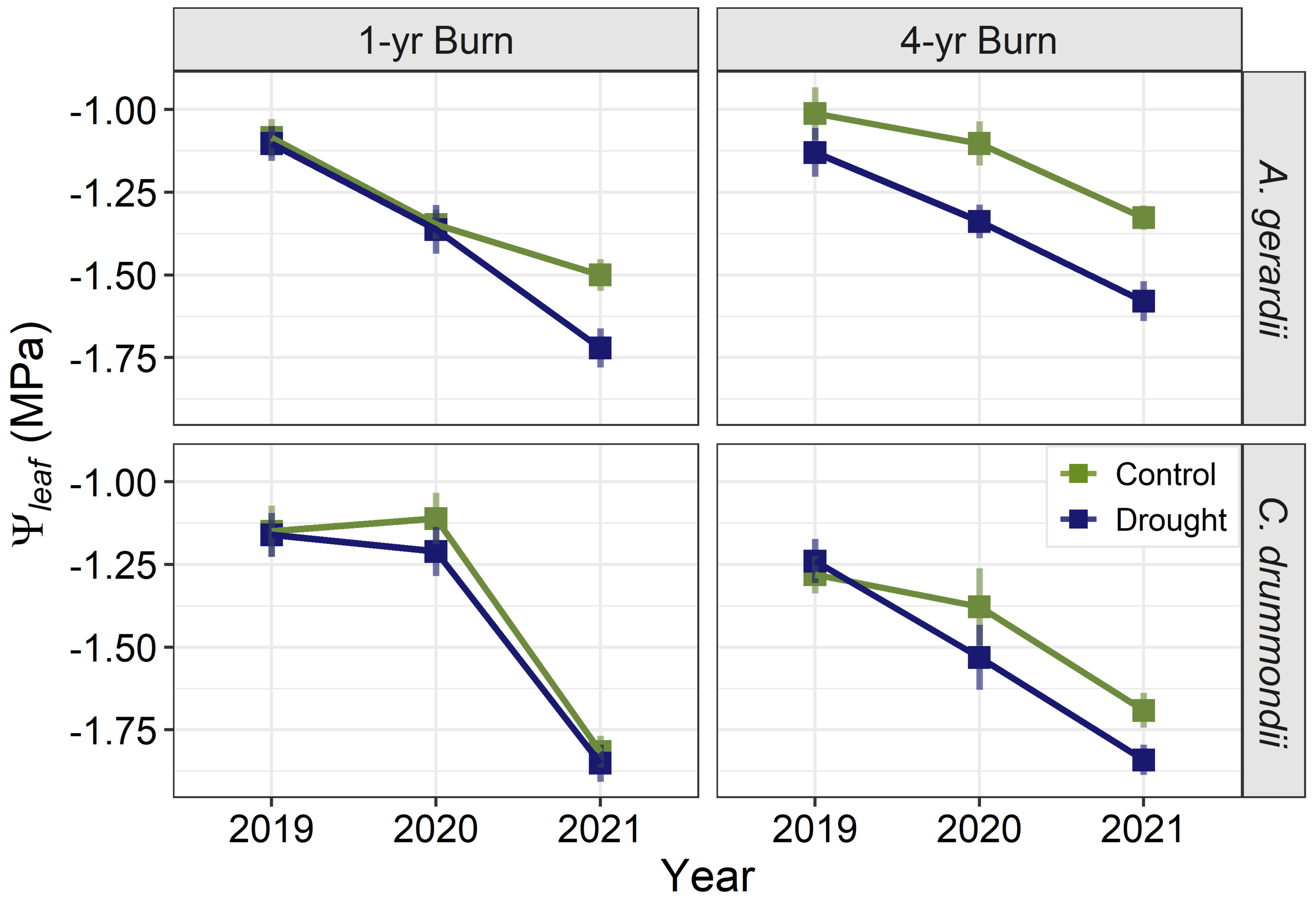



**Figure 2:** Midday leaf water potential ($\Psi_{leaf}$) for *A. gerardii* and *C. drummondii*, averaged across each growing season for the years 2019-2021. Bars represent standard error.

Water potential values were generally lower in drought shelters compared to control. For both species, this trend was more pronounced in the 4-year burn treatment. Drought effects were strongest in 2021, and $\Psi_{leaf}$ were lower overall during the 2021 growing season.

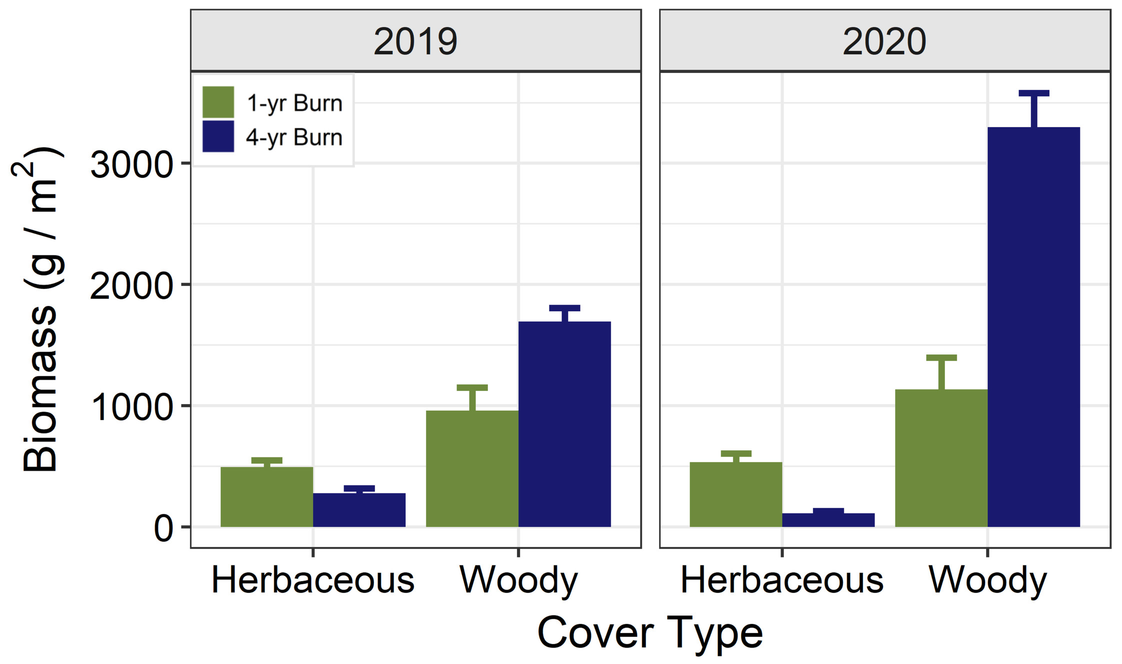



**Figure 3:** Woody and herbaceous biomass for the years 2019 and 2020. Herbaceous biomass represents aboveground net primary productivity (ANPP) collected by clipping live aboveground biomass in September of each year. Woody biomass was determined by measuring stems in a 1.5 x 1.5 m quadrant of each shelter, then using established allometric equations for *C. drummondii* to estimate aboveground biomass. Woody biomass was higher in the 4-year burn treatment (where shrub islands were larger in stature) compared to the 1-year burn treatment.

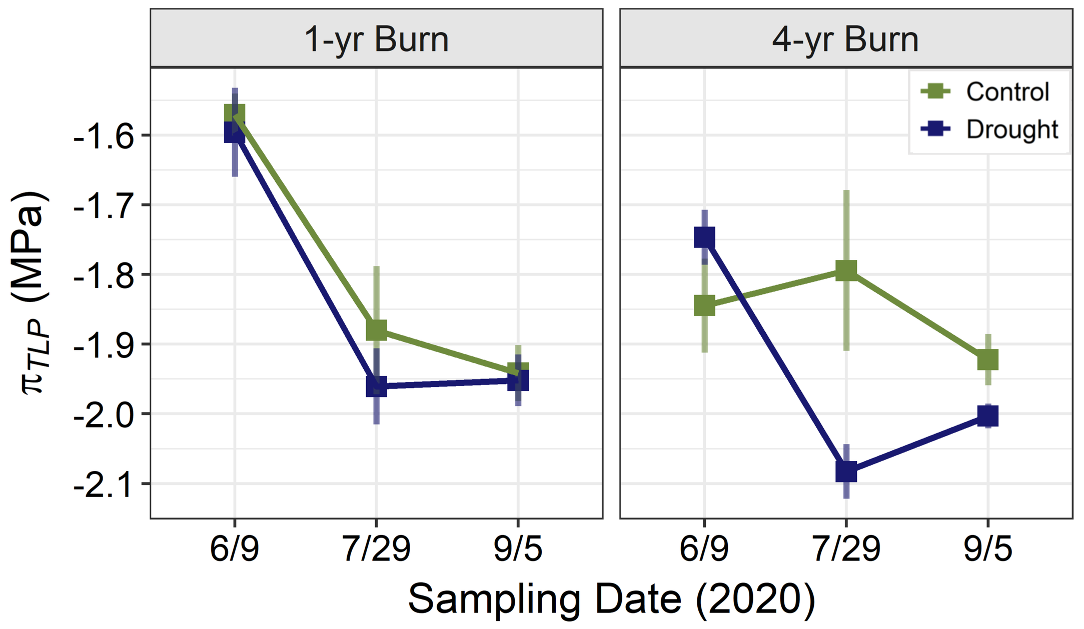



**Figure 4:** Water potential at leaf turgor loss point ($\pi_{TLP}$) for *C. drummondii* during the 2020 growing season. Osmotic potential was measured using a VAPRO vapor pressure osmometer, and values were used to calculate $\pi_{TLP}$ using an established equation for woody species (Bartlett et al. 2012*). $\pi_{TLP}$ values were generally lower in the drought shelters compared to control shelters, and this trend was more pronounced in the 4-year burn treatment. $\pi_{TLP}$ declined by >0.3 MPa over the course of the growing season, indicating that *C. drummondii* was able to adjust to tolerate increasing water stress (i.e., lower midday $\Psi_{leaf}$; Fig. 2).

## Summary and Future Directions

Long-term studies of co-existing grass and shrub communities are useful for informing management of woody encroachment during drought, and to help identify whether multiple external pressures (drought + fire) are needed to reverse grassland-to-shrubland transitions in temperate grasslands. Three years of experimental drought has resulted in modest impacts on leaf-level physiology in dominant grass and woody shrub species in tallgrass prairie. Lower photosynthetic rates, $\Psi_{leaf}$ and $\pi_{TLP}$ in drought shelters indicate that both species are beginning to experience water stress in the drought treatment, particularly in shelters that are also burned less frequently (4-yr burn). The effects of the rainout shelters on soil moisture after four years are observable, but not particularly strong. As these treatments continue to establish in future years, we expect to see greater impacts of water stress on leaf-level physiology, and potentially negative impacts on *C. drummondii* ability to resprout following fire in the less frequently burned treatment.

## Contact Info and Funding

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**Funding:** U.S. Department of Energy (DOE TES Award DESC0019037), Konza Prairie Biological Station, and Kansas State University.

*Bartlett MK et al. (2012) Rapid determination of comparative drought tolerance traits: using an osmometer to predict turgor loss point. *Methods in Ecology and Evolution*, 3(5): 880-888