# Modeling Good Behavior: Translating Individual Plant Communities into Fire Forecasts

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## Background

### Grasslands Cover



40 % World   26 % U.S.A

- **More U.S. homes are affected by grassland fires** and shrubland fires than by forest fires in the United States. (Radeloff et al., 2023)
- More homes are at risk due to the Wildland- Urban Interface (WUI) continually expanding
- Despite this, **grassland fire behavior remains understudied.**

- Events like the Marshall Fire demonstrate how grassland fuels can lead to devastated communities.
- **Current fire modeling in Boulder County uses standard grassland fuel models that assume homogeneity,** resulting in uniform fire behavior predictions.
- Bouder County Grasslands are generally characterized by the GR2 grassland fire fuel model.
- Species Richness is a characterization of plant heterogeneity and may affect fire behavior.
- By better understanding variations within grasslands, we can **prioritize wildfire management areas, fuel reduction efforts, and grassland conservation efforts.**

## Research Question

Do different grassland vegetation types along the Front Range produce distinct fire behavior?

## Methods

**Field Collection**
- We collected Biomass data from 78 sites across Boulder County representing diverse grassland communities.
- Two quadrats were placed at each site, avoiding previously sampled areas.
- We measured plant and litter heights (three of each per quadrat).
- We clipped and bagged all standing vegetation and plant litter.
- Samples were oven-dried and weighed to determine dry biomass.
- This study analyzes 2023-2024 data.

454 Biomass samples from 78 Sites

X3 height measurement

50 CM

75 CM

Smooth Brome Patch

**Data Analysis**
- We characterized height and biomass distribution for each vegetation type in R.
- We simulated hypothetical plots generating 50 standardized datasets per community type.
- We input the simulated plots into the BEHAVE fire model to calculate rate of spread and heat per area.

| Keep Constant within Behave | |
|---|---|
| Slope | 5% |
| Wind | 40 MPH |
| 1 hr Fuel Moisture | 0.01 |
| Dead Fuel Moisture of Extinctio | 0.15 |
| Dead Fuel Heat Content | 80 |
| 1Hr Fuel SA/V | 2000 |
| Live herbaceous fuel load | 0 |

## Results



Figure 1. This figure shows the varying levels of species richness across four general vegetation types. Smooth brome and Prairie Dog colonies have lower species richness.



Figure 2. This figure shows Biomass and Height variability across different plant communities compared to the GR2 model (Dashed Lines). **Smooth brome fields tend to have taller average height and larger total fuel load. Prairie Dog colonies have a very low average height and total fuel load compared to other communities. Few communities align with fuel model expectations.** (Dashed Lines indicates GR2 fuel model)
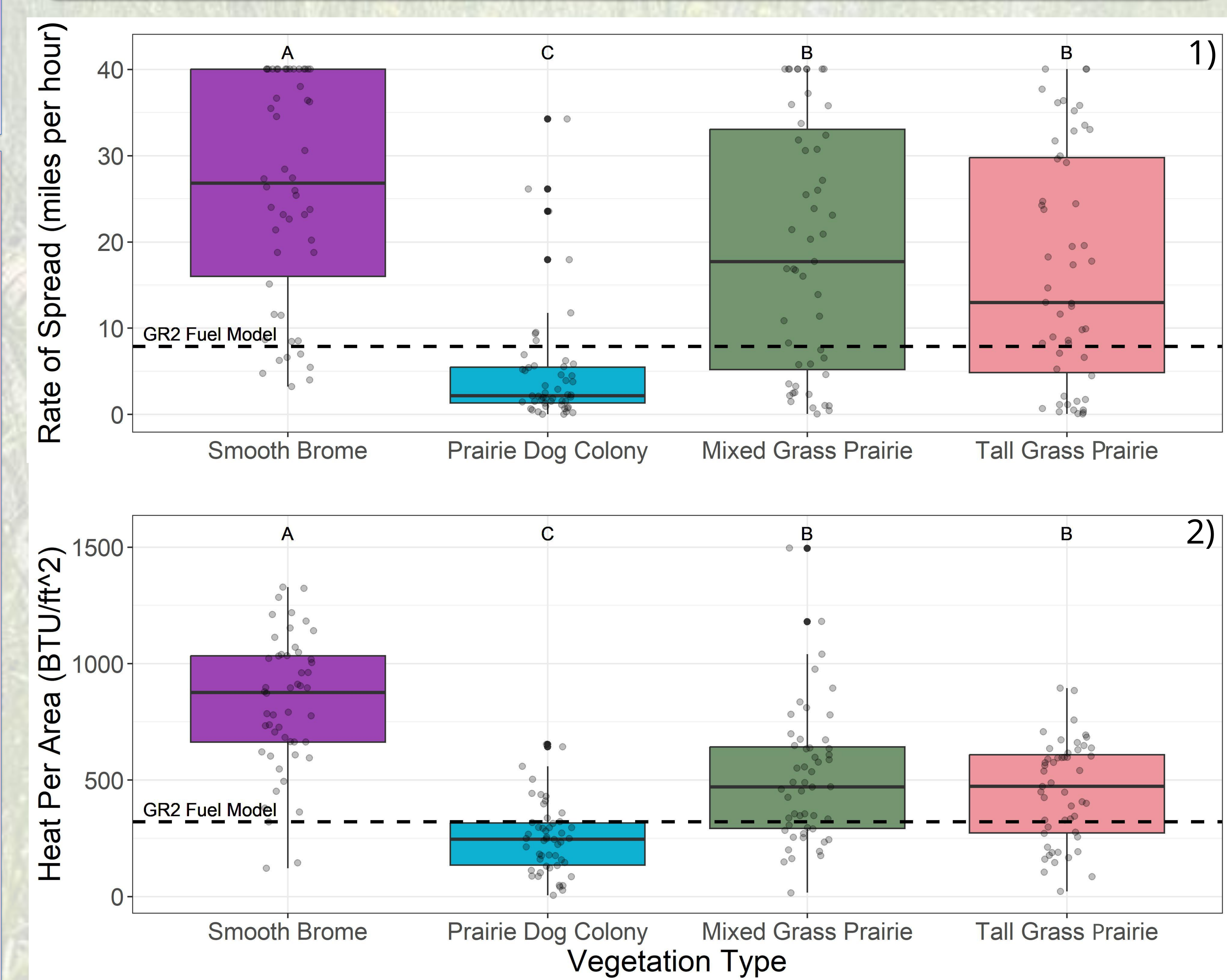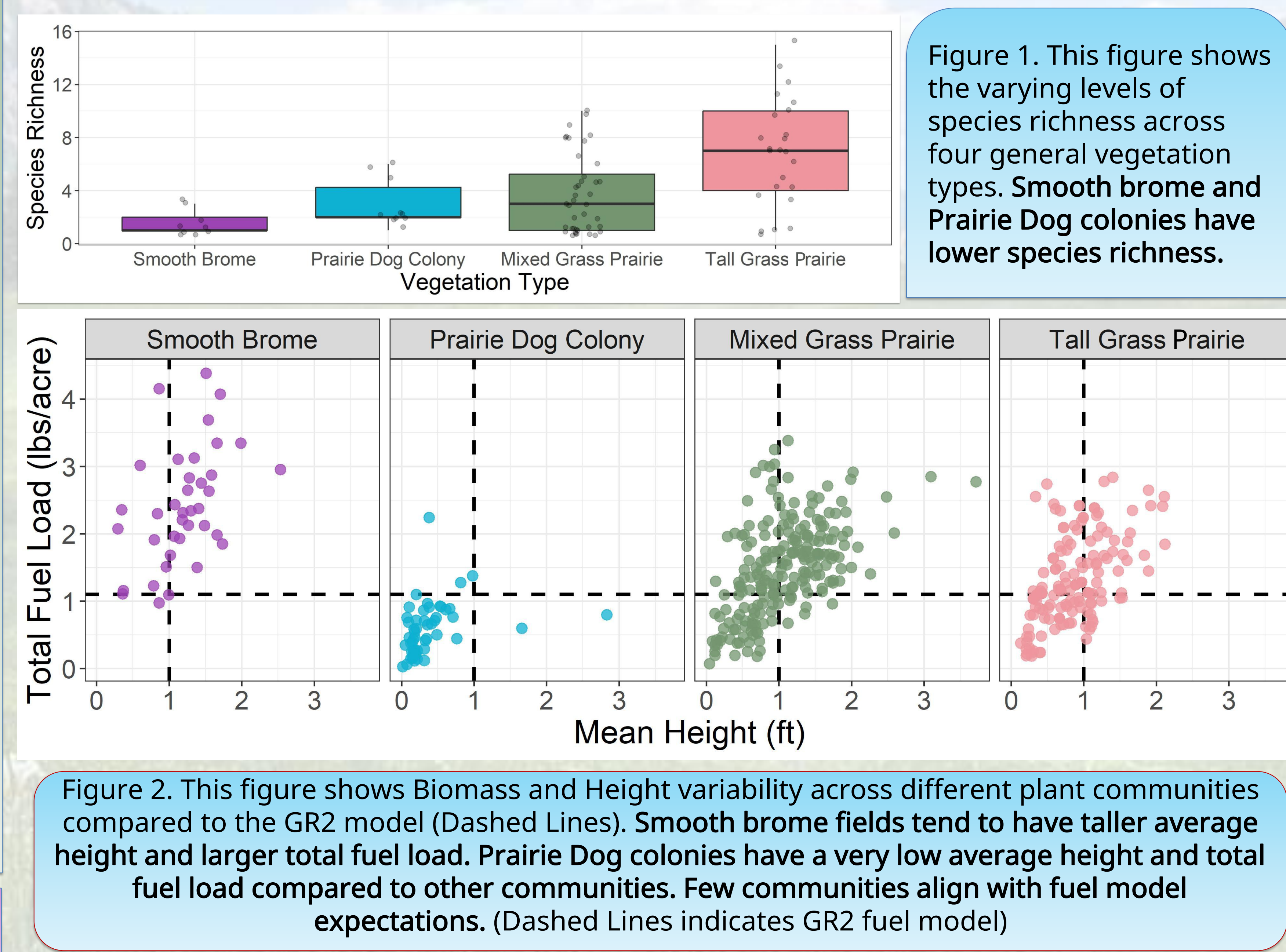


Figure 3. Variation in the Rate of Spread (Panel 1) and the Heat Per Area (Panel 2) aspects of fire behavior across vegetation types compared to the GR2 model (Dashed Line). Letters in each panels indicate differences in fire behavior between vegetation types. **Smooth brome communities consistently have higher fire intensity and rate of spread compared to other vegetation types.**

## Key Findings

- There is **huge variation within grassland areas** that are not represented by commonly used fuel modeling software.
- Areas with a predominantly **smooth brome (*Bromus inermis*) vegetation type exhibit high fire intensity** and low species richness.
- In smooth brome both fire spread rates and heat per area are significantly higher than those of other vegetation types.
- **Prairie dog colonies exhibited reduced fire intensity** and low species richness likely due to their behaviors; clipping tall vegetation, burrowing, and grazing, which together lower fuel loads.
- **Tall and Mixed grass prairies exhibited significantly lower heat per area released** due to reduced fuel loads compared to smooth brome communities. These areas also have higher species richness.

Smooth Brome

## Limitations

- Litter biomass possibly under-estimated due to mixing with soil.
- Prairie dogs clip standing vegetation mixing it with last year's litter.
- Three-week sampling period allowed for landscape variation.
- BEHAVE software's 40 mph wind limit underrepresents extreme fire events, like the Marshall fire. Rate per Spread is limited by this factor.

## Recommendations

- Develop land management practices to **disrupt smooth brome invasion**: it can be managed using integrated methods like mechanical removal, herbicides, and prescribed burns.
- We need to do more work to understand **how prescribed fire affects grassland species richness** which then reduces extreme wildfire behavior.
- Work to develop and **hone fire behavior models to incorporate the variation** in grassland ecosystems.

## Acknowledgements