The Effects of Prescribed Fire Regimes on Soil Physical Properties in Minnesota Tallgrass Prairie

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Introduction

- **Tallgrass prairie** habitat is greatly diminished to less than 1% of original area. Managing these few remaining ecosystems correctly can maximize biodiversity and carbon sequestration outcomes.
- Conserved prairies fall under two **site histories**:
  - ❖ ***Remnant prairie*** soil has never been tilled or disturbed
  - ❖ ***Restored prairie*** soil has been tilled but has remained untouched for some time.
- **Prescribed fire** is a management strategy used to reduce thatch, woody plants, and improve biodiversity. It is typically done in the spring every 3-5 years.
- Prescribed fires can also positively alter soil physical and chemical properties through stimulation plant growth, mineralization, and nutrient homogeneity.
- The effects of fire may vary with soil type, fire frequency, and site history (remnant or restored).
- While the number of studies examining prescribed fires and their effects on the forest soils, our understanding of prescribed burns on prairie soil health are limited.
- **Research Objective:** Therefore, this study was conducted to determine the effects of prescribed fire frequency on soil physical health indicators in remnant and restored prairies

Materials and Methods

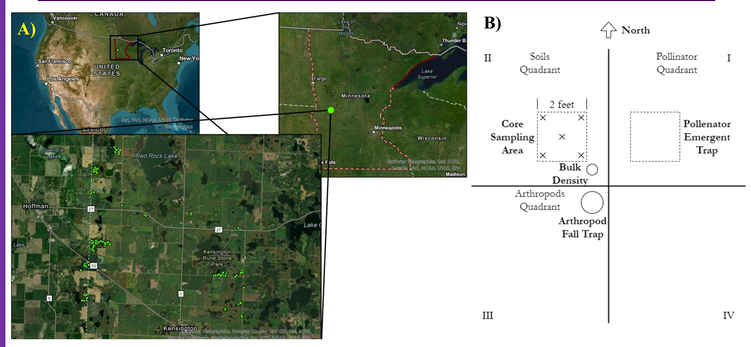

Figure 1. (A) Sampling sites (B) Diagram of sampling point

- **Soil sampling:** 28 prairie sites in Douglas County, MN on July 24-26, 2023. A total of 263 samples were collected
- Bulk density (BD; 0-3cm) samples were weighed and dried
- Core samples (0-10cm) were separated into two fractions:
  - ❖ ***2-5 mm:*** Aggregate stability was measured using dried aggregates
  - ❖ ***< 2 mm:*** Maximum water holding capacity (MWHC) and gravimetric water content (GWC)
- **Years postfire:** the amount of time in years since last prescribed burn
- **Statistical Analysis** (e.g., descriptive statistics and ANOVA) was done using R-studio (4.3.3v)

Results

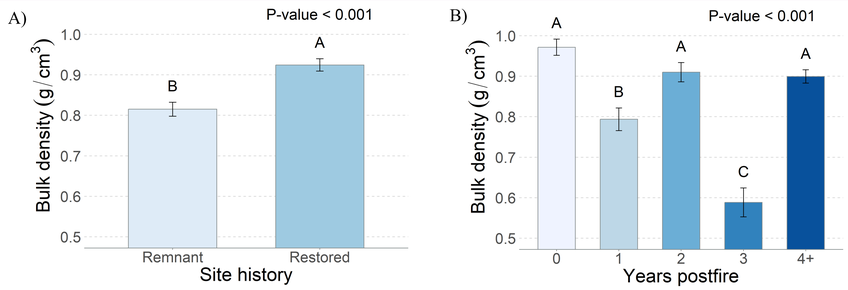

Figure 2. Mean (± SE) bulk density (g cm^{-3}) by site history (A) and years postfire (B). Different letters indicate significance by Tukey HSD (P < 0.05).

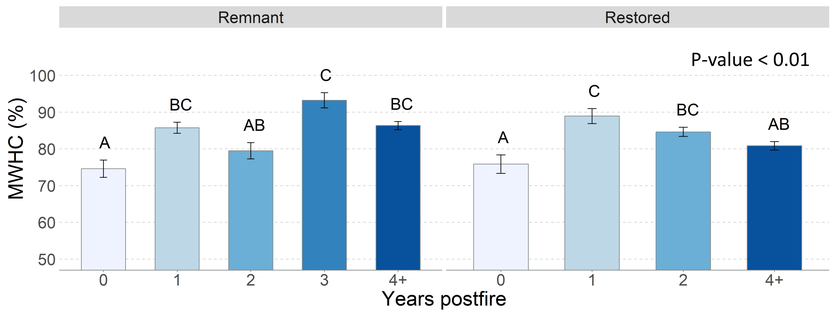

Figure 3. Mean (± SE) maximum water holding capacity (%) by site history and years postfire. Different letters indicate significance by Tukey HSD (P < 0.05).

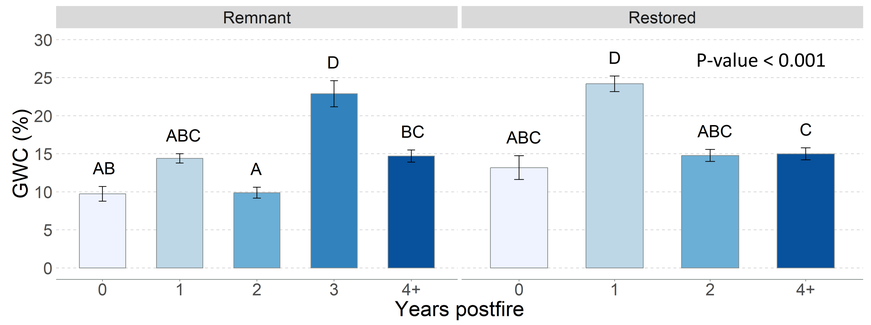

Figure 4. Mean (± SE) gravimetric water content (%) by site history and years postfire. Different letters indicate significance by Tukey HSD (P < 0.05).

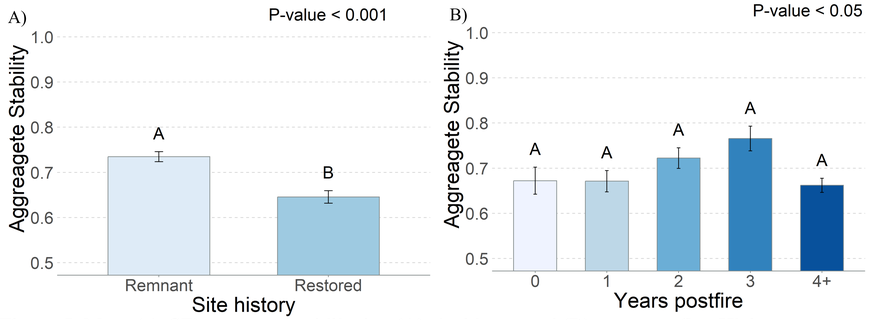

Figure 5. Mean (± SE) aggregate stability by (A) site history and (B) years postfire. Higher aggregate stability (Slake) value is indicative of healthy soils.

Table 1. ANOVA factors for site history (S; remnant or restored), years postfire (Y), and the resulting two-way ANOVA (S * Y). Significance is indicated in bold with a P-value < 0.05 .

AVOVA Factor		BD		MWHC		GWC		Aggregate Stability	
	df	F-value	P -value	F-value	P -value	F-value	P -value	F-value	P -value
Site History (S)	1	22.3	**< 0.001**	6.15	**< 0.05**	2.74	NS	22.2	**< 0.001**
Years Postfire (Y)	4	24.1	**< 0.001**	15.6	**< 0.001**	16.2	**< 0.001**	2.57	**< 0.05**
S * Y	3	1.88	NS	3.94	**< 0.01**	7.47	**< 0.001**	0.296	NS

Conclusions

- A significantly lower BD and a higher aggregate stability indicates that remnant prairies may have better soil processes (e.g., infiltration rates, root penetration, soil aeration, and reducing surface runoff and erosion) than restored prairie.
- Many soil properties improve when a fire happened three years prior (BD, MWHC, and GWC [for remnants]).
- The MWHC in remnant prairie sites increased with years postfire. This trend is true regardless of site history but is more pronounced is remnant prairie.
- Initially, soil properties do not improve from a fire the occurred that year, but generally improve over time.
- 4+ years postfire sites range from sites that have had fire in the last decade to sites that have had fire suppression for more than 70 years. Because of this, soil properties are not receiving the benefits of prescribed fire.
- Future studies must be conducted to determine the amount of time postfire when soil properties start to degrade.

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