Double sampling a 55-year CRP chronosequence for soil carbon assessment

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SOC accumulation will slow with CRP grassland age
(according to C saturation theory)

INTRODUCTION

- The **Conservation Reserve Program (CRP)** was established in 1985 as a voluntary program to encourage farmers to convert degraded agricultural land into grassland.
- Questions remain on how effective CRP is in restoring the soil organic carbon (SOC) loss from intensive agriculture.
- **De et al. (2020)** sampled a chronosequence of 19 sites (241 soils total) and found…
  - ✓ Hillslope position had strong effects on soil health recovery
  - ✓ SOC did not fully recover even after 40 years of CRP (relative to a native grassland benchmark)
  - ✓ Labile C, measured as potentially mineralizable C, was the most improved and across all landscape positions.
  - ✓ The SOC in response of years in CRP in 2009.
- **This study** resampled a chronosequence in 2023 to evaluate the temporal changes in soil C from 2009.
  - We **hypothesize** that native grassland will remain static while CRP treatments will show muted responses over time according to the "C saturation hypothesis" (**Center Figure**). We also offer alternative hypotheses (**Fig. 1**).

METHODS

- Location: 12 sites were re-sampled in northern IA and southern MN (**Fig. 3**).
- Soil sampling: 0-15 & 15-30 cm depths with a 2 cm diameter soil probe at 5 hillslope positions (summit, backslope, footslope, and toeslope),
- Measurements: soil pH, bulk density, inorganic C, SOC, labile carbon (Fig. 4), $\delta^{13}C$ of C pools, and maximum water holding capacity.
- Statistics: we will compare soil measurements within the new sampling of the chronosequence to make normal inferences. But **the novelty of this experiment is that we will be able to compare sites between sampling years** to determine if chronosequence approach works in this scenario, and tests hypotheses (**Center Figure** and **Fig. 1**).

RESULTS & DISCUSSION

- The CRP are incrementally increasing labile C in soils, especially after 10 years (**Fig. 4**, *middle*).
- CRP increases the contribution of C3 grasses to labile C (**Fig. 4**, *bottom*).
- More analyses are currently underway.

CONCLUSION

- Chronosequences are often used to "*substitute space for time*". However, we don't know how well they reflect true changes with time.
- Resampling, or *double-sampling*, a chronosequence after 15 years will help us resolve this uncertainty.
- This study will also help to inform balancing the soil ecosystem services of CRP with stakeholders' interest in other new uses (like grazing). We want to be sure that these new uses do not compromise benefits like SOC sequestration and improved soil biological activity over longer-term timescales.

ACKNOWLEDGEMENTS

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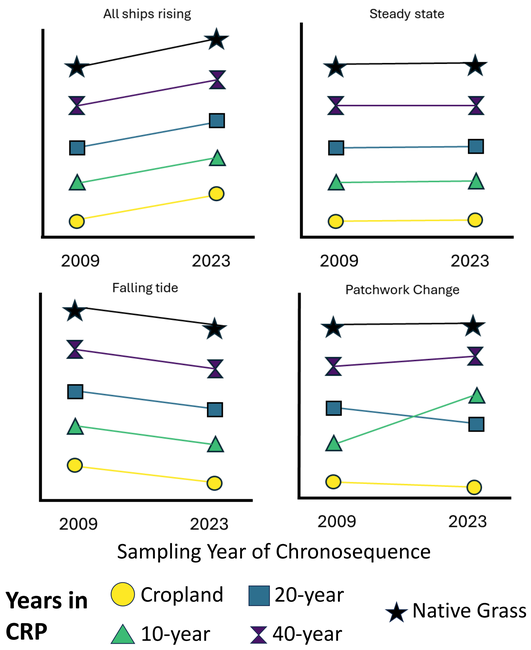

Figure 1. Alternative hypotheses to primary one (Middle Figure). All ships rising = all treatments will increase in SOC. Steady state = no change in all treatments. Falling tide = all treatments decreasing. Patchwork change = random, unpredictable changes in SOC.

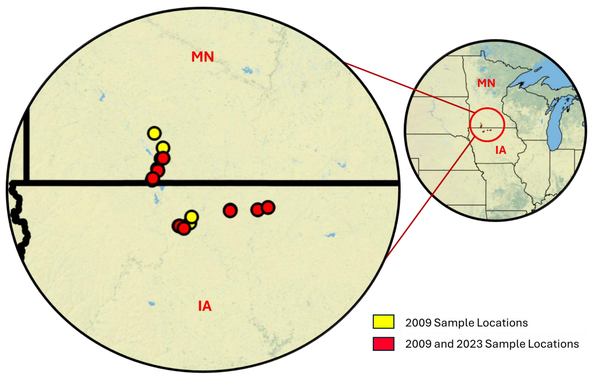

Figure 2. Sampling points for both 2009 and 2023 chronosequence sampling in northern IA and southern MN.

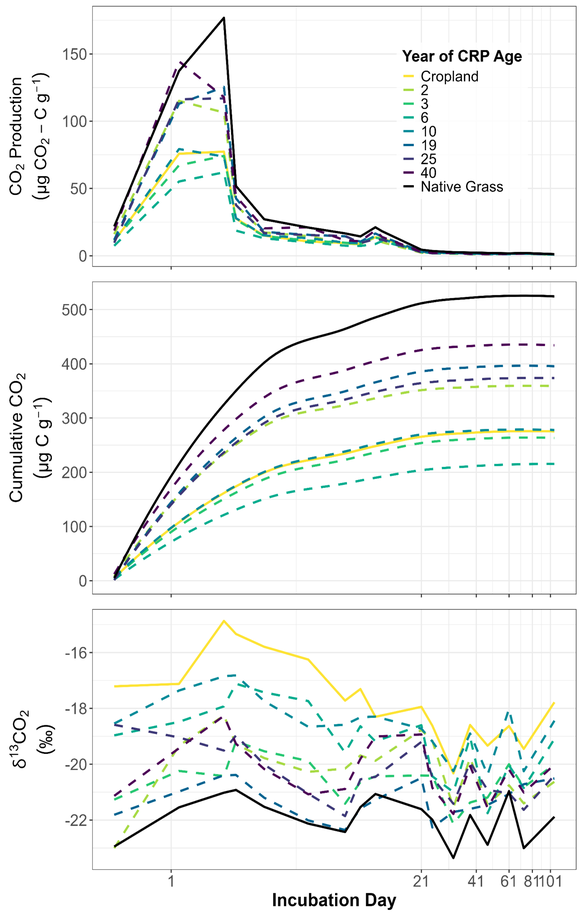

Figure 3. 101-day incubation of soils from 2009 chronosequence sampling to look at pool of labile carbon and the $\delta^{13}C$. *Top*: instantaneous CO_2 production. *Middle*: cumulative CO_2 production. *Bottom*: $\delta^{13}C$ of CO_2.

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