The role of soil aggregates in sequestering carbon in restored temperate grasslands

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Abstract

Temperate grasslands act as carbon sinks, and thereby play an important role in the global carbon cycle. Carbon stabilization by water-stable soil aggregates (conglomerates of soil particles that maintain their form when subjected to water disturbance) is a proposed mechanism for long-term carbon storage. Soil disturbances and the cultivation of grasslands have been shown to change the abundance and stability of soil aggregates. This study investigates whether the restoration of formerly cultivated fields back to grasslands influences the soil's ability to store carbon. Specifically, we examine the impact of prolonged management of restored grasslands on carbon content in soil aggregates.

Introduction

- Soils function as a terrestrial sink in the global carbon cycle and contain in the order of 2300 Gt C (Jobbagy and Jackson). Most of this C is stored within soil aggregates (Six et al. 2000).
- Soil aggregates are conglomerates of mineral particles (sand, clay, and silt) that are held together by microbial polysaccharides, fungal hyphae, and plant debris (root fragments) into water-resistant structures (USDA 1996). Larger aggregates generally contain more C than smaller aggregates (Jastrow et al. 1998).
- Urban soils are increasingly being restored to grasslands. A key question is whether restoration practices can improve soil C sequestration over time.

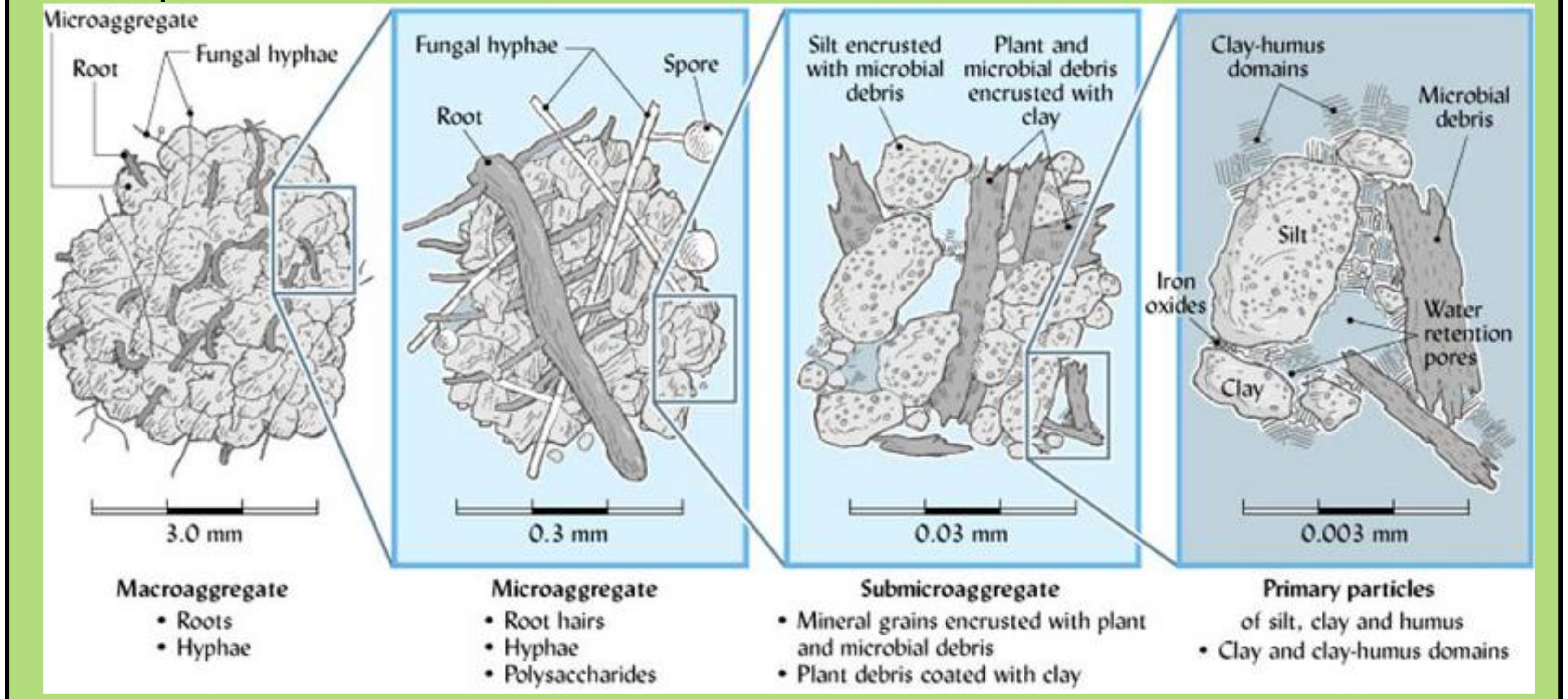

Figure 1: Four levels in this hierarchy of soil aggregates (Diagram Courtesy of R. Weil)*

In our study, we tested the hypotheses that:

1. As the duration of land management increases, greater %C will be stored in aggregates;
2. Remnant (pristine) grasslands will have aggregates with a higher %C content than aggregates from restorations; and,
3. Larger aggregates will contain higher %C than smaller aggregates.

Statistics

Differences in the abundance and %C of aggregates between sites were tested using two-way analysis of variance (management *x* site) with the null hypothesis that there was no difference in aggregate abundance or aggregate %C among management category or sites within each category. When the null hypothesis was rejected, post-hoc Tukey tests were undertaken. All data were log transformed prior to analysis to ensure normality.

Methods and Materials

Sites: We collected soil from three sites in each of the following categories:

- R0 → unmanaged old field (0 years of restoration)
- R1 → early stage restoration (<7.5 years of restoration)
- R2 → intermediate stage restoration (>7.5 years of restoration)
- R3 → model restoration (>7.5 years of restoration, high quality)
- P3 → model remnant (pristine)

Methods: We determined aggregate size distribution by wet sieving and separation of the aggregates into four size classes:

- 8mm – 4mm → Classed as macroaggregates
- 4mm – 2mm → Classed as macroaggregates
- 2mm – 0.25mm → Classed as macroaggregates
- 0.25mm – 0.053mm → Classed as microaggregates

Dried samples were ground to a fine powder, tested for carbonate content, and then analyzed for C content using a LECO TruSpec CN elemental analyzer.

Results

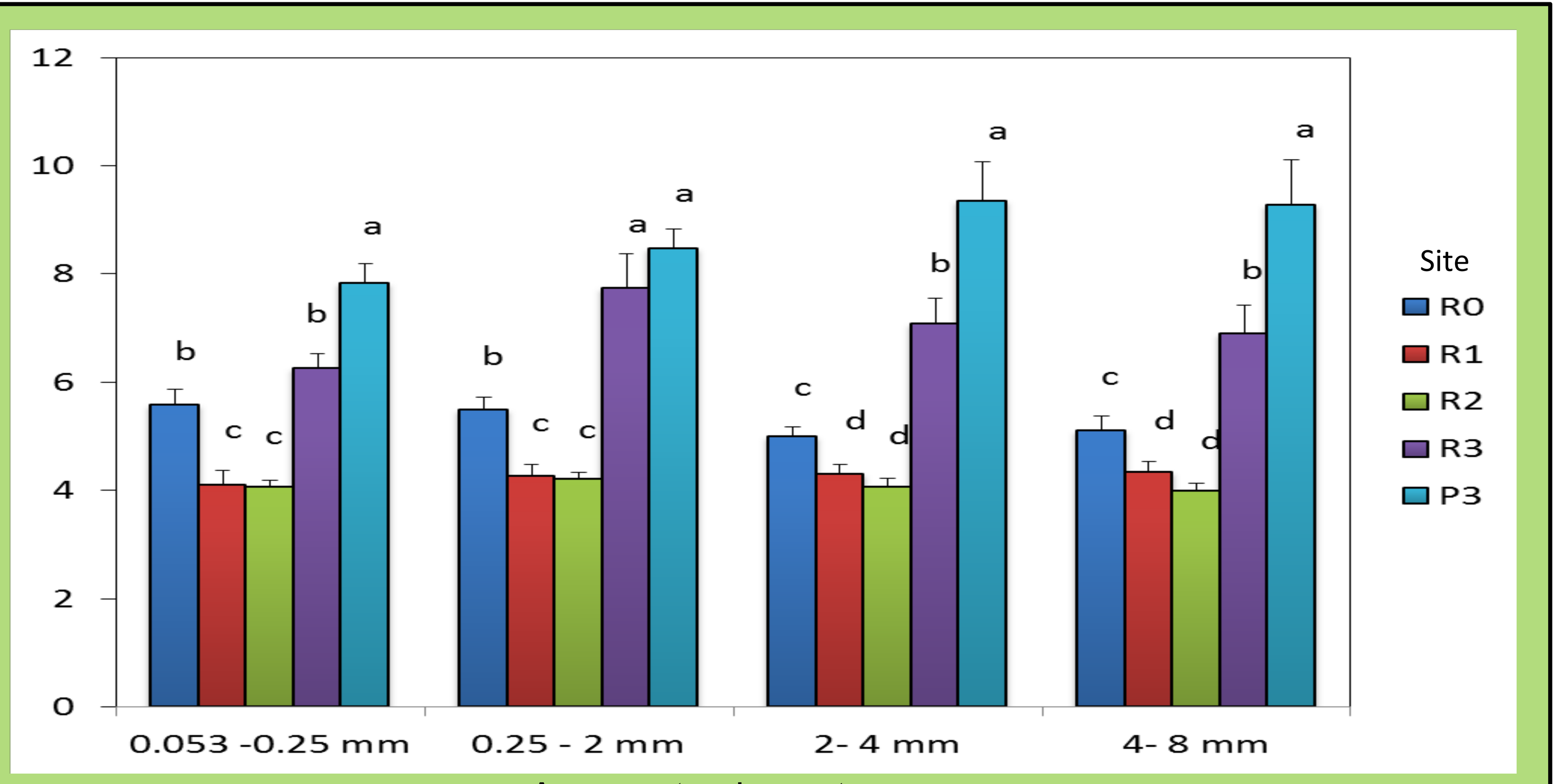

Figure 2: %C by aggregate size classes for restored and remnant (pristine) grasslands. Site abbreviations correspond to those listed in the Methods. Vertical bars indicate the standard error of the mean. Within each aggregate size class, columns with the same letter do not differ significantly.

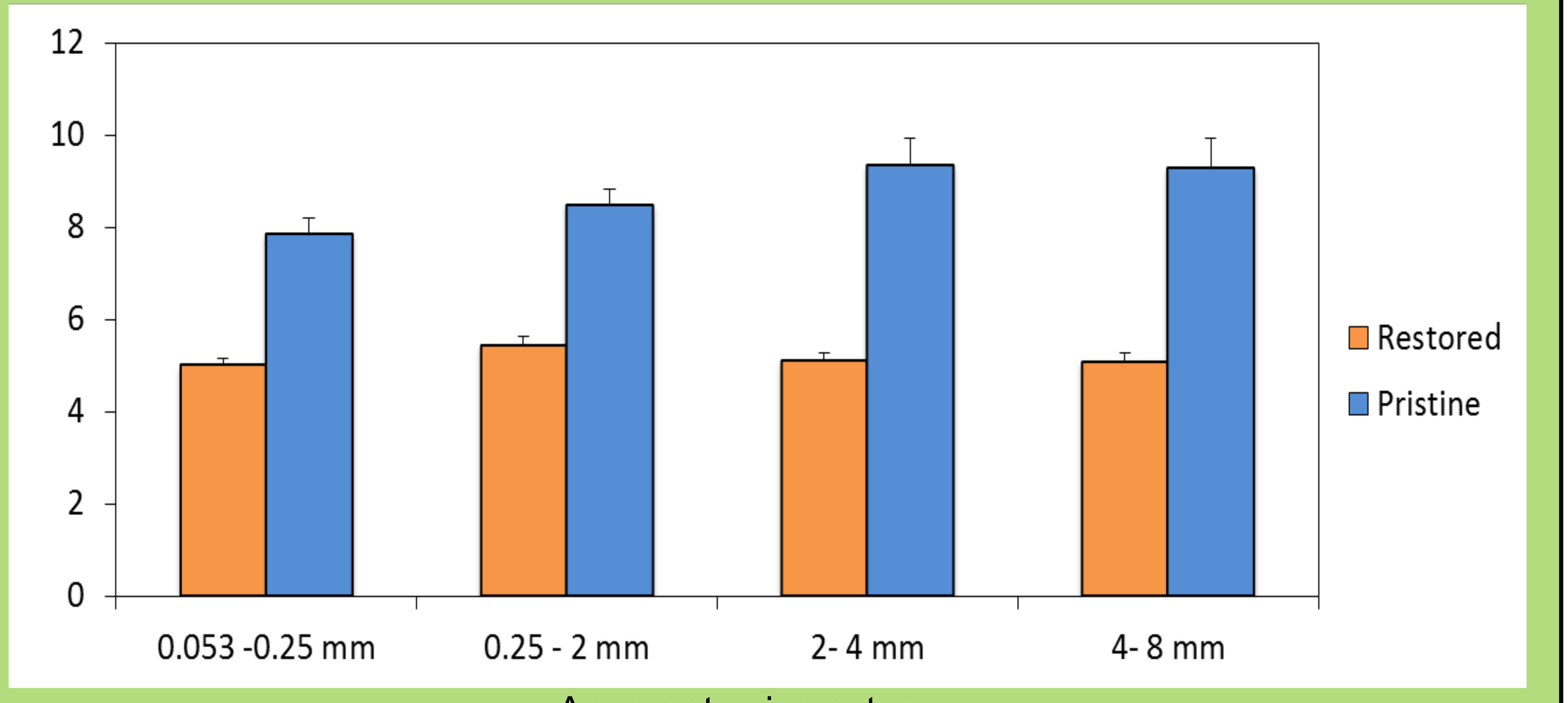

Figure 3: Mean %C by aggregate size classes averaged over all restored sites and compared with levels in remnant (pristine) grasslands. Vertical bars indicate the standard error of the mean.

Results Continued

Table 1: Probability values for aggregate %C across management histories and sites

Aggregate Size Category	Management history (R/P)	Site	Management x Site
0.053 - 0.25 mm	<.0001	0.867	0.969
0.25 - 2 mm	<.0001	0.852	0.988
2- 4 mm	<.0001	0.966	0.999
4 - 8 mm	<.0001	0.973	0.966
	Significant	Not significant	Not significant

Discussion

- Remnants (P3) and model restorations (R3) showed significantly higher %C than other management categories (Fig. 2). Management history was also an important determinant in aggregate %C content (Table 1). These findings provide some support for hypothesis 1.
- Aggregates from remnant grasslands (P3) had significantly higher %C levels than those from restored grasslands (Fig. 3). This result supports hypothesis 2.
- In remnants (P3), %C increased with increasing aggregate size, which supports hypothesis 3. In contrast, %C in aggregates from restored sites, particularly the early stage management and non-model restorations (R0, R1, R2), was similar across all size categories (Fig. 2, 3).
- Together, these results demonstrate the value of protecting remnant grasslands. They also suggest that long-term restoration may be needed to enhance the C sequestration potential in urban grasslands.
- **Future Studies** will include stable isotope analyses (^{13}C) to determine the sources of C inputs into aggregates.

References

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