The contribution of soil aggregates to carbon sequestration in restored urban grasslands

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Introduction

As urban development continues to replace or transform native grasslands, restoration has become increasingly critical for maintaining soil organic matter (SOM) accrual.

A key question is whether SOM accrual can be reinvigorated when disturbed soils are restored to grasslands. The beneficial effects of grassland restoration on C accrual in agricultural fields is well established [1,2,3].

Few studies have examined the effects of grassland restoration on degraded urban sites as a means for C sequestration. Here, we evaluate the potential for soil C accrual in urban grassland restorations, and compare these data with soil C in remnant grasslands.

We focus on the role of soil aggregates where SOM is stabilization by physical occlusion within aggregates, chemical interactions with clay minerals, and biochemical recalcitrance.

Microaggregates (53- 250 µm diam.) form a pool of physically protected C with much-reduced turnover rates relative to macroaggregates (> 250 µm). Conversely, macroaggregates contain more C than microaggregates but are more susceptible to decomposition with disturbance.

Study Sites

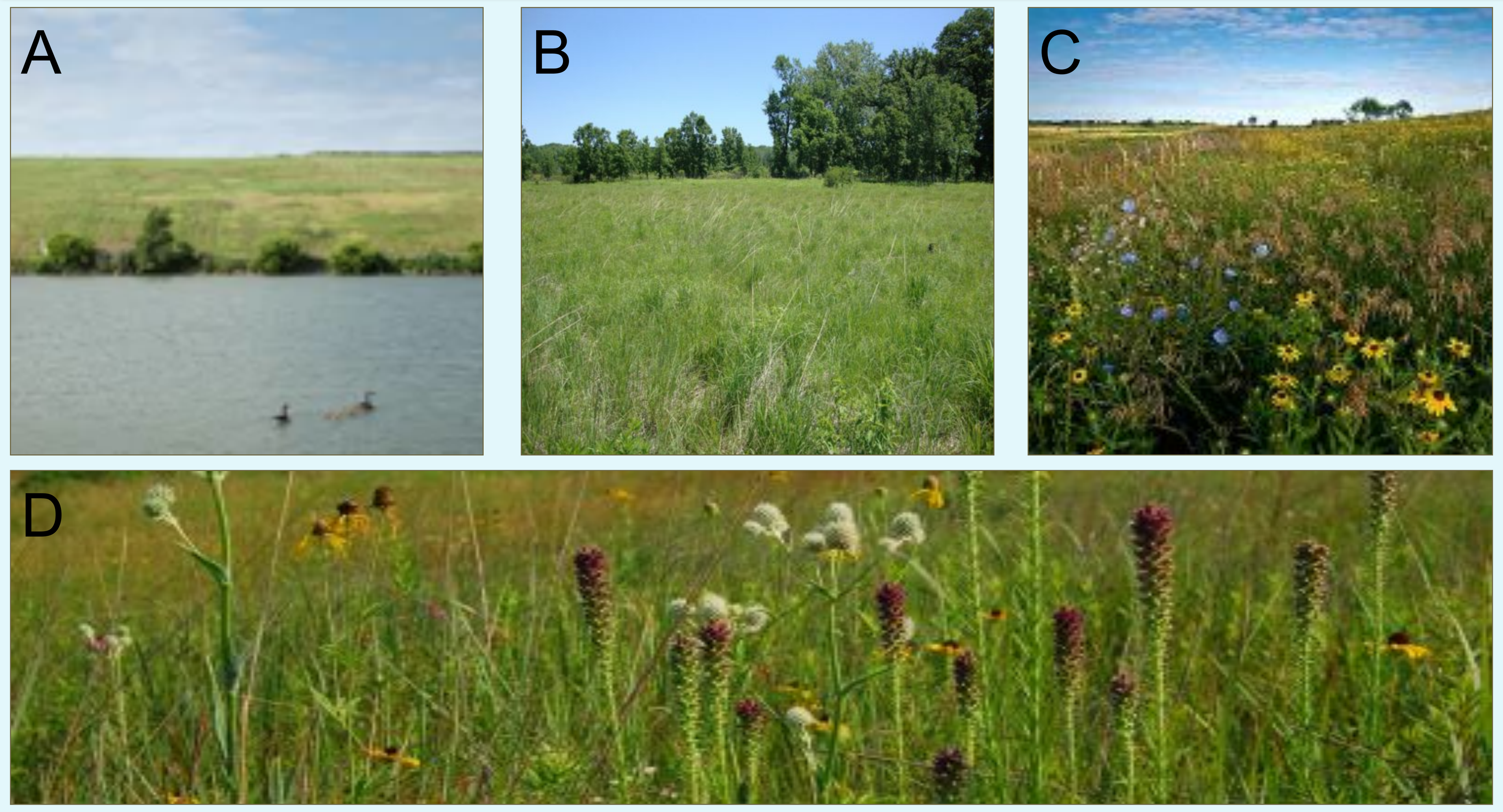

Figure 1. Study sites: A. Unrestored; B. Early-restoration; C. Model restoration; D. Remnant grassland.

Our study was undertaken in the Chicago region (population 9 million) in a network of restored and remnant grasslands created as part of the '100 Sites for 100 Years' project by Chicago Wilderness. We collected soil cores from three sites in each of the following management categories:

→ Unmanaged old fields (no restoration)
→ Early-stage restoration (1-5 years of restoration)
→ Late-stage restoration (>10 years of restoration)
→ Model restoration, i.e., resemble remnants (>10 years of restoration)
→ Model remnant (pristine)

Methods

Aggregate size distribution: aggregates were isolated using wet sieving, sorted into micro- and macroaggregate size classes, dried, and weighed.

Carbon content: aggregate fractions were analyzed for bulk C content by combustion, and for the natural abundance ^{13}C by IRMS. Isotope composition was expressed in standard notation ($\delta^{13}C$) in parts per thousand (‰) relative to Vienna-Pee Dee Belemnite (VPDB).

Biomarkers: samples were analyzed for lignin by TMAH thermochemolysis GC-MS.

Results

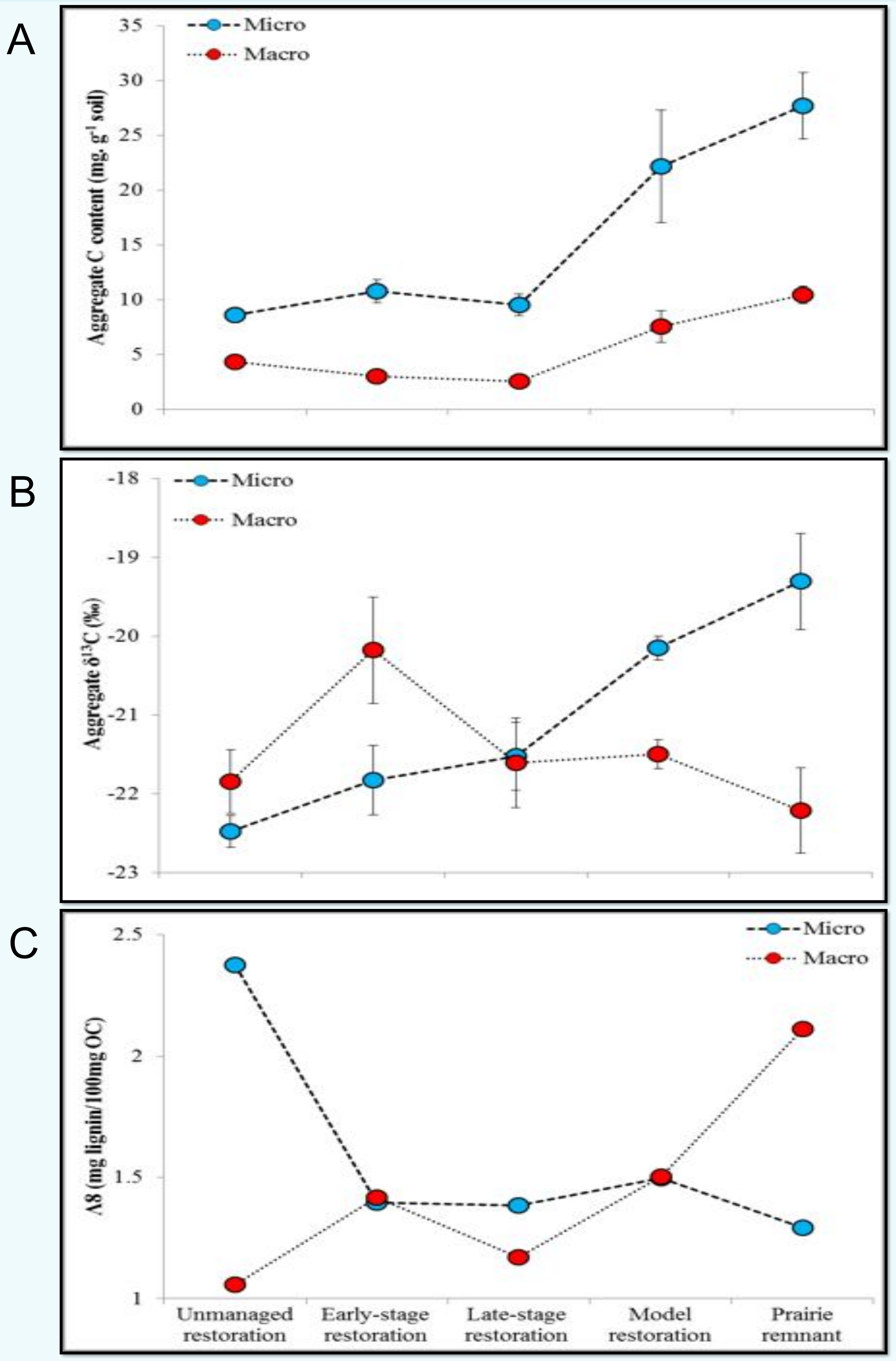

Figure 2. Results of soil analyses:
A. Aggregate C content (corrected for sand content)
B. Aggregate $\delta^{13}C$ signatures
C.Total lignin content (Λ 8)
Vertical bars indicate the standard error of the means.

Comparisons

Unmanaged Restoration | Early Stage Restoration | Model Restoration | Model Remnant

Macroaggregates

%C:	Low levels of C	Slight increase in C
$\delta^{13}C$:	C_3 forbs + some C_4 inputs	Primarily C_3 forbs
Λ8:	Low total lignin	High total lignin

Microaggregates

%C:	Low levels of C	High levels of C
$\delta^{13}C$:	C_3 forbs	C_3/ C_4 forbs
Λ8:	High total lignin	Low total lignin

Discussion

Soil aggregate C content was higher in micro- than macroaggregate fractions (Figure 2A).
→ *Carbon accrual occurs in microaggregates but macroaggregates are unstable.*

Aggregate C content only increased between early and model restorations, i.e., those resembling pristine prairies, and C levels in model restorations approached those in prairie remnants (Figure 2A).
→ *The markers of restoration success and the perception of a high quality (model) restoration are reflected in increases in aggregate C content.*

Stable isotope $\delta^{13}C$ signatures show that C_3 forbs were increasing contributors to macroaggregate C in grasslands whereas C_4 plants were increasing contributors to microaggregate C content (Figure 2B).
→ *Promoting C_4 grass establishment is critical to increasing soil C storage in urban systems.*

The amount of lignin (Λ 8) in microaggregates decreases with restoration practice but increases in macroaggregates (Figure 2C).
→ *Carbon quality is important in aggregate C storage as well as quantity.*

Acknowledgements

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