Implications for Carbon Sequestration: Management Effects on Annual and Perennial Root Production

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Introduction

- Roots are the primary carbon input to soils and play an important role in regulating the terrestrial carbon cycle.
- However, accurately assessing root carbon inputs remains a challenging task, especially deciphering the effects of management practices on root carbon quantity.
- Recent breeding efforts have developed perennial crops that produce edible grains without the need to replant or till every year.
- It is projected that these crops will provide more ecosystem services than annual crops, largely due to their root systems.
- Research regarding ecosystem services in these intensively managed perennial crops is scarce and belowground C dynamics are unknown.
- In the perennial wheat ecosystem services trial we compared annual winter wheat and perennial intermediate wheatgrass root biomass under conventional and organic management practices.

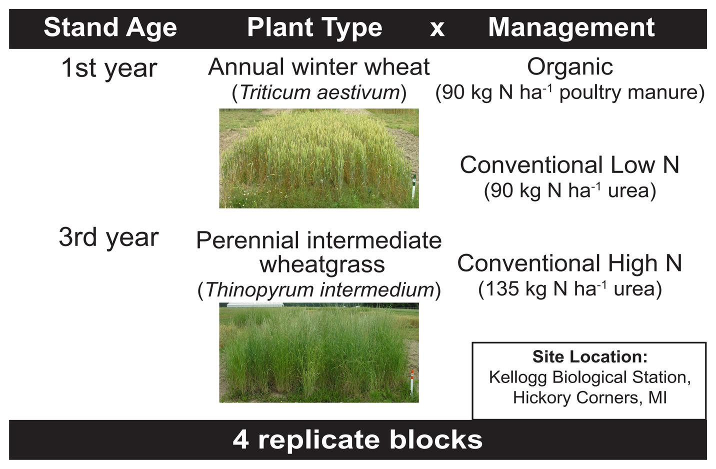
Objectives

1) Determine the quantity of root biomass for annual winter wheat and perennial intermediate wheatgrass.

2) Investigate the effects of management on root biomass for both species.

3) Quantify soil C dynamics in surface soils.

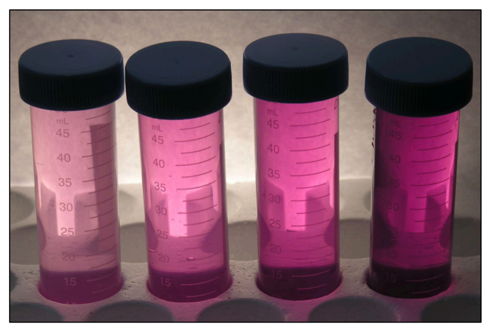
Methods



Experimental Design: Perennial Wheat Ecosystem Services Trial. Split-plot randomized complete block design.

Field Sampling: A geoprobe was used to extract soil cores to a depth of 1 m.

Root Preparation: Dry sieving for coarse root determination (left) and wet sieving for fine root determination (right).



Permanganate Oxidizable Carbon (POXC): Protocol based on Wile et al. (2003) and is an indicator of the labile C pool. The amount of carbon oxidized is a function of the quantity of permanganate reduced. The higher the POXC values the lower the intensity of the color of the solution. Photo: Courtesy of Mark Freeman

Statistical Analysis: Data was analyzed using Proc Mixed in SAS ($p \leq 0.05$)

Results

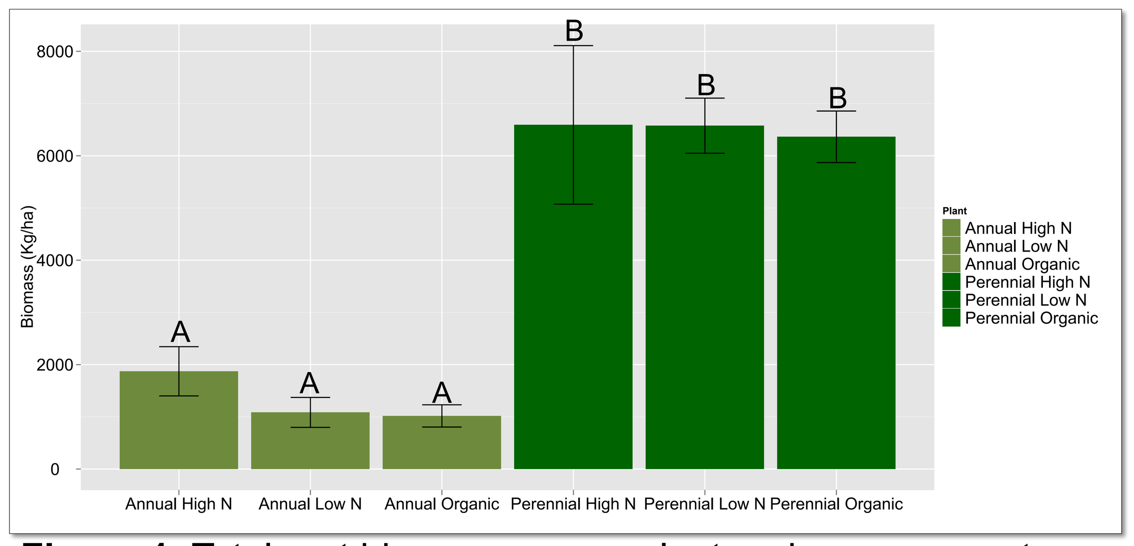


Figure 1. Total root biomass across plant and management. Perennial roots had approximately five times the amount of root biomass than their annual counterparts.

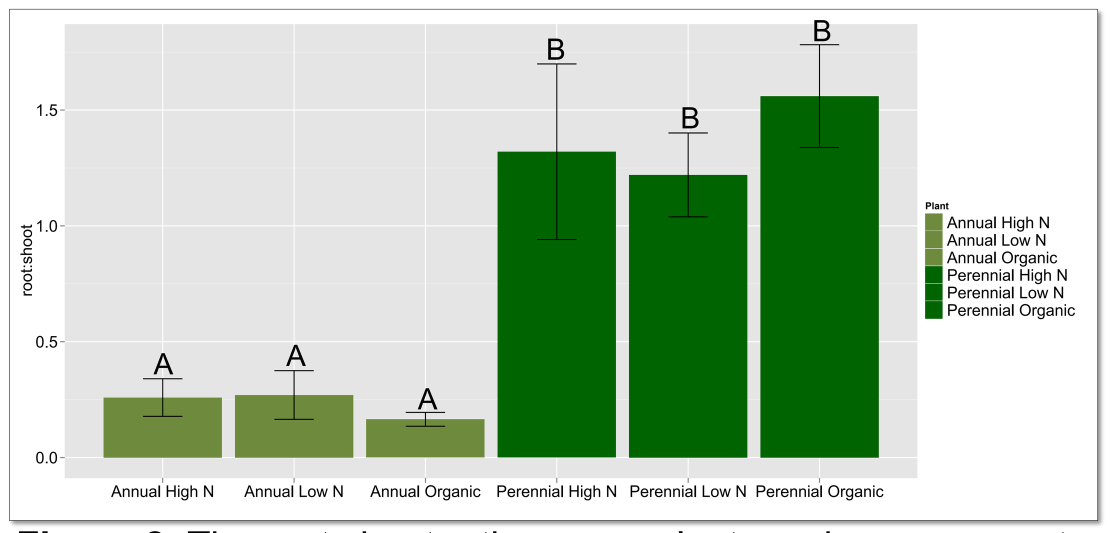


Figure 2. The root:shoot ratio across plants and management. Root biomass was greater than aboveground biomass in perennials.

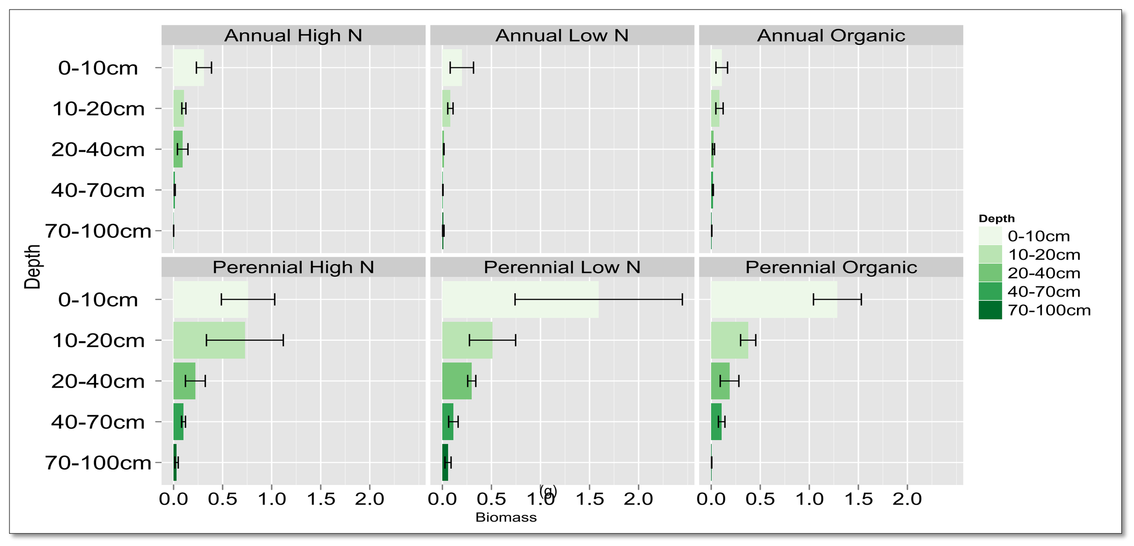


Figure 3. Coarse root biomass by depth across plants and management. The majority of root biomass was found at 0-40cm in both plant systems.

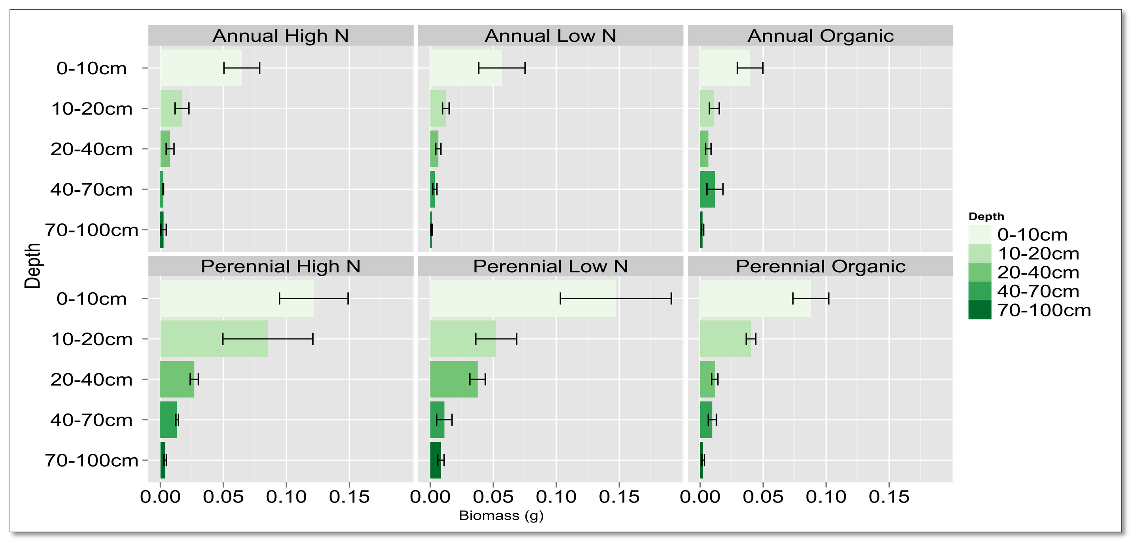


Figure 4. Fine root biomass by depth across plants and management. Annuals and perennials allocated fine roots differently throughout the soil profile.

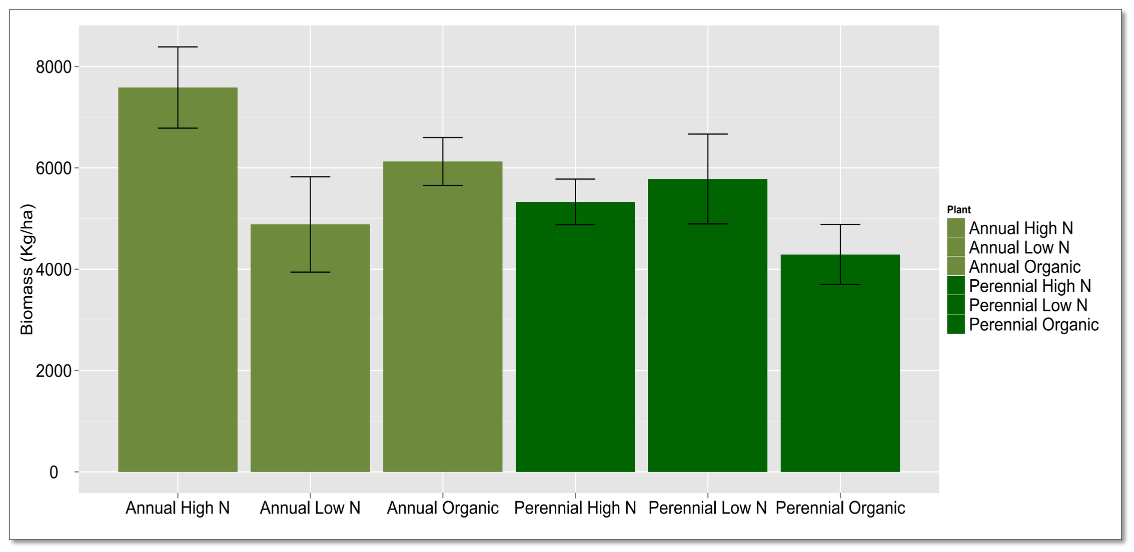


Figure 5. Total aboveground biomass across a plant and management gradient. Annuals tended to have greater biomass under High N and Organic management, while perennials had slightly greater biomass under Low N management.

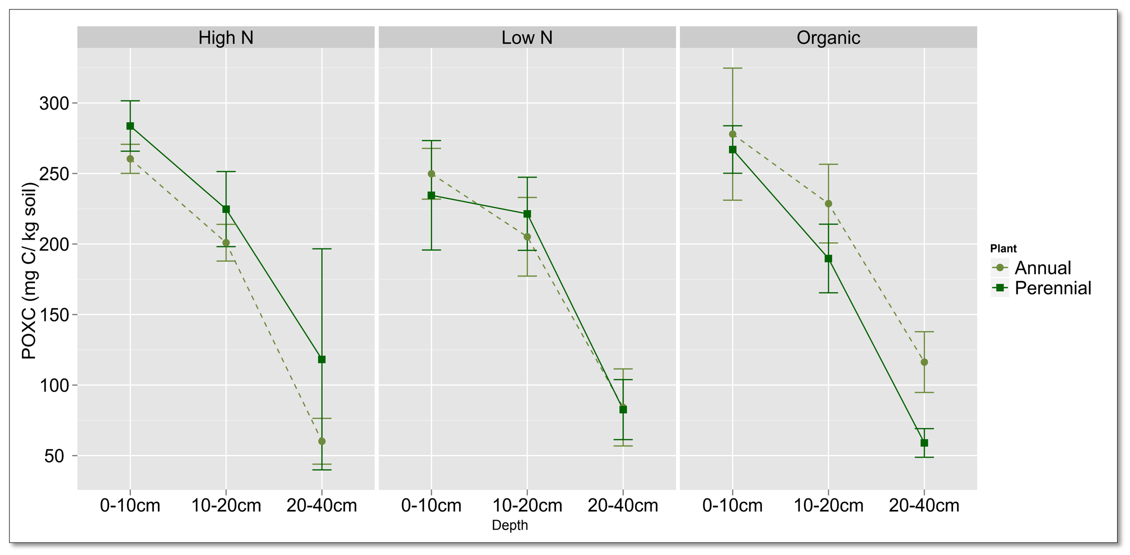


Figure 6. Annual and Perennial POXC values across Management. High variability in the labile C pool was evident across the three management practices for both species. POXC values were lower at 20-40 cm compared to top soil depths.

Conclusions

- For the second consecutive year, perennial intermediate wheatgrass had five times the amount of root biomass than annual winter wheat.
- Belowground root biomass was greater than total aboveground biomass in the perennial system across all three managements.
- Management did not have a significant affect on above or belowground biomass.
- Greater root biomass at the surface may largely contribute to the labile C pool.
- Perennial grains have the potential to increase soil organic carbon over time.

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