Differences in active and slow fractions of soil carbon under annual and perennial biofuel crops

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Introduction

- Perennial cellulosic cropping systems have been promoted as sustainable alternatives to grain-based biofuel crops due to their ability to produce large amounts of biomass with reduced inputs.
- The ability to sequester carbon could be a major benefit of cellulosic biofuel systems.
- Soil C is very dynamic and can accumulate in different pools (active, slow, and passive), all of which have different turnover rates.
- Studies typically measure total soil C, which is important for determining system level differences, but it does not indicate where soil C is accumulating.
- Determining the pools in which soil C is accumulating can provide insights into changes in site fertility and long-term carbon sequestration potentials.
- We measured active and slow soil carbon pools via a long-term incubation experiment across ten different biofuel cropping systems in two contrasting soils.

Objectives and Hypotheses

Objective: To measure the influence of soil type and biofuel cropping system on changes in active and slow pools of soil carbon.

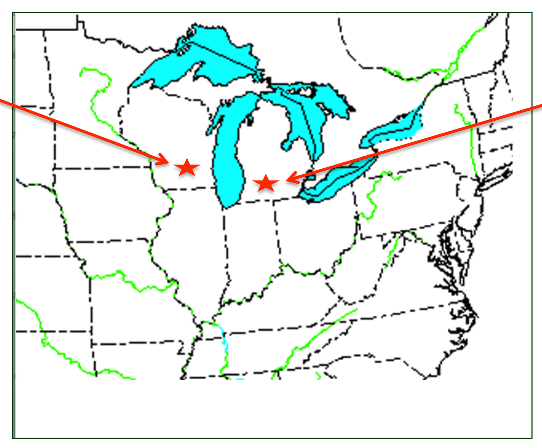
Hypotheses:

1. For any given system, active C pools will accumulate faster at ARL than KBS, because of higher ANPP at ARL. Slow C pools will also build more quickly at ARL than KBS because of ANPP differences as well as higher clay content in Mollisols versus Alfisols.
2. Perennials will have greater active C pools compared to annual systems due to more persistent roots, which contribute large amounts of C belowground. Additionally, greater root quantity, persistence, and more lignified roots in perennials versus annuals will lead to larger slow C pools under perennials.

Study Location

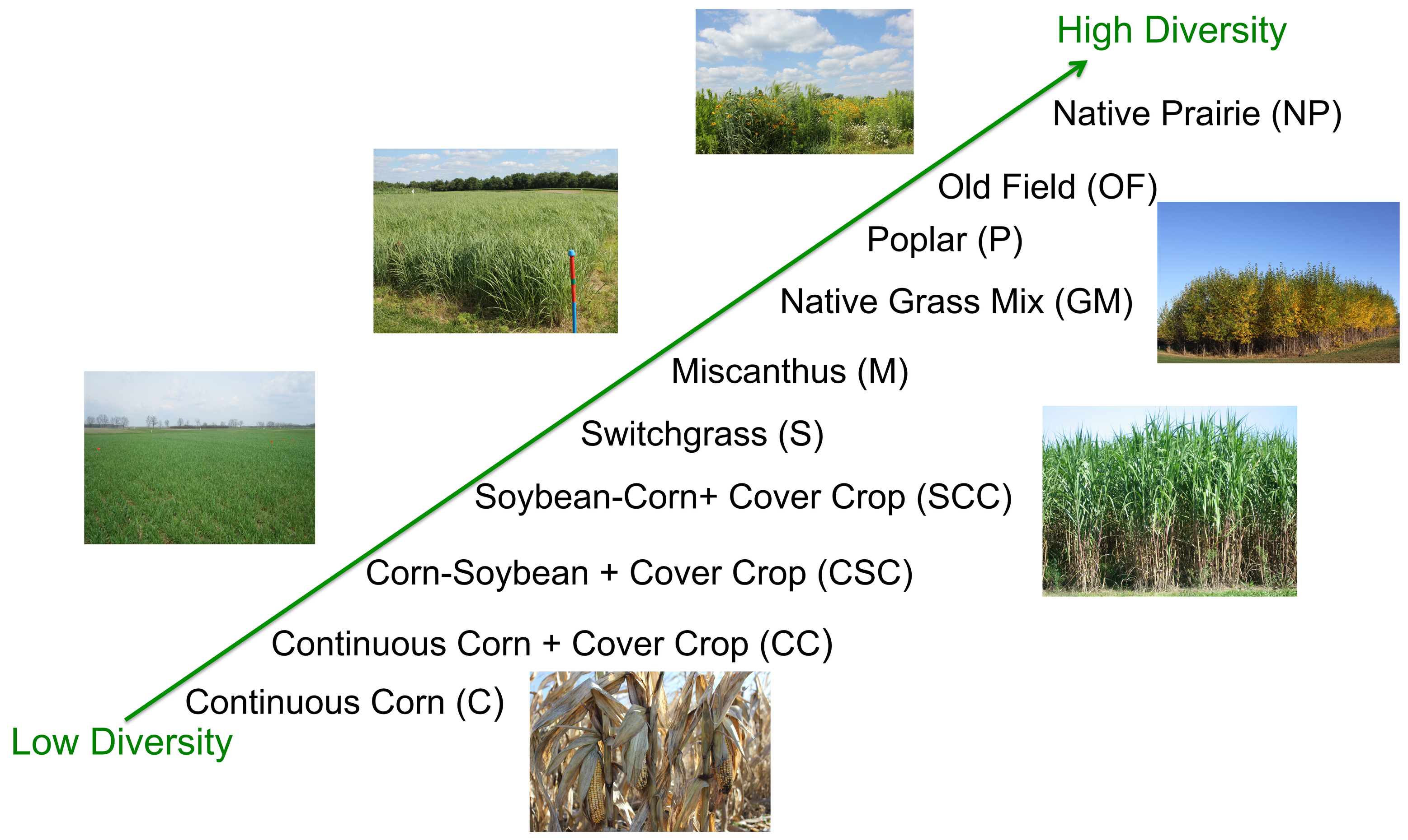
Arlington Field Station (ARL)

Kellogg Biological Station (KBS)



Study Location: Two Biofuel Cropping System Experiments are located in Arlington, Wisconsin and Hickory Corners, MI (KBS).

Methods



Experimental Design. The BCSE is a randomized complete block design with ten biofuel cropping systems (consisting of annual row crops, monoculture perennials, and perennial mixed grass systems) with five replicate blocks. The same design is installed at KBS (southwest Michigan) and ARL (south central Wisconsin)

Field and Laboratory Analysis. Soil cores to 1 meter were taken with a Geoprobe in the fall of 2013. Cores were separated into four depths, 0-10cm, 10-25cm, 25-50cm, and 50-100cm and sieved to 4mm. Soils were adjusted to 55% water filled pore space and incubated in a growth chamber at 25°C for 322 days.

C Mineralization Measurements. Samples were measured for CO_2 production periodically with a LI-820 Infrared Gas Analyzer. At each sampling, four measurements were taken over the course of 160 minutes.

Results

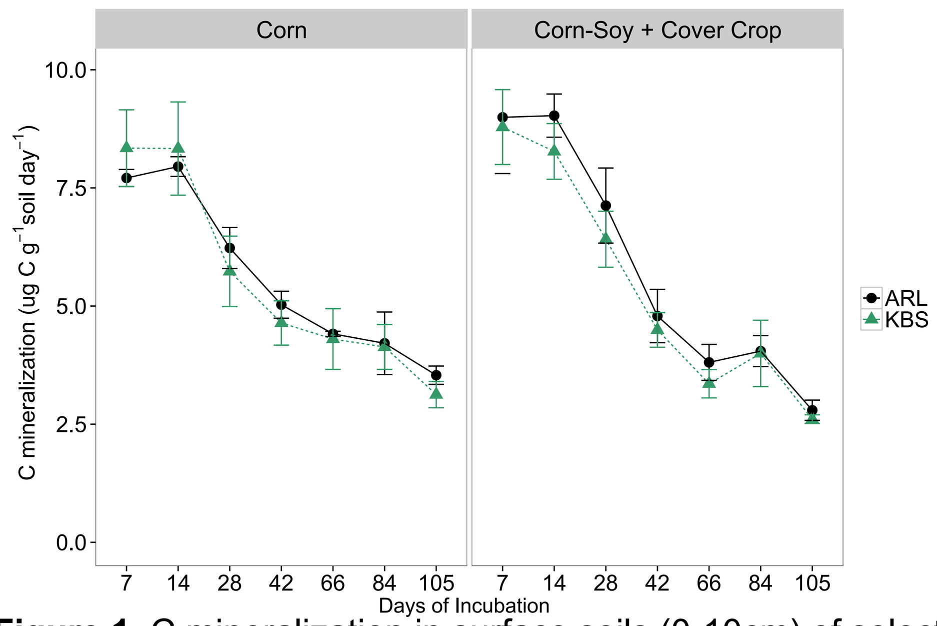


Figure 1. C mineralization in surface soils (0-10cm) of select annual systems. There were no significant differences between the two sites. All four annual systems followed this trend.

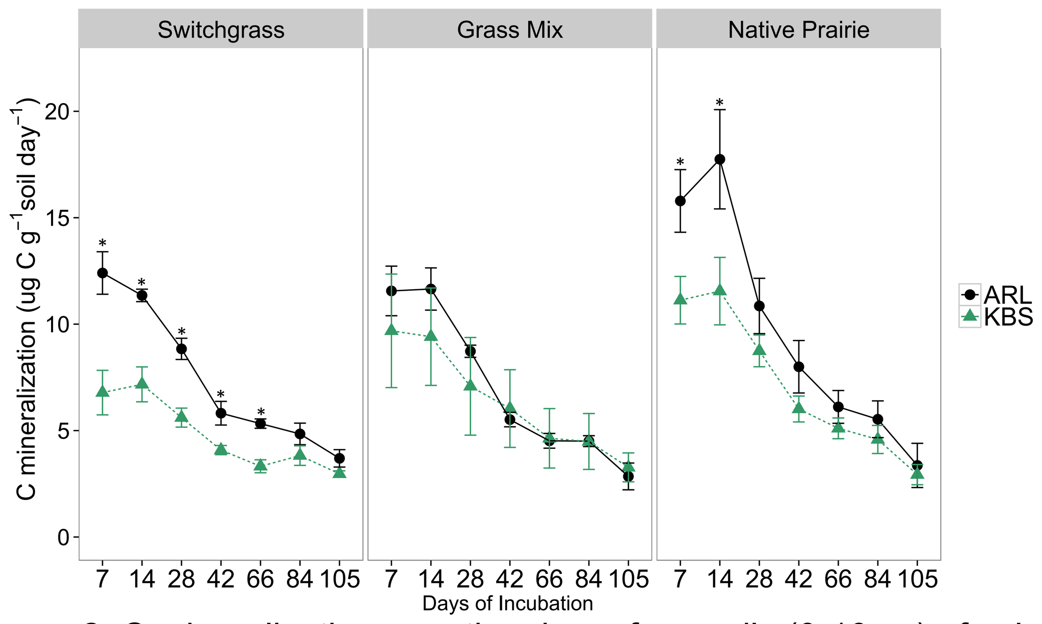


Figure 2. C mineralization over time in surface soils (0-10cm) of select perennial systems. Significant differences across site were evident in the switchgrass and native prairie systems (P<0.05). The remaining perennial systems followed trends similar to the grass mix system.

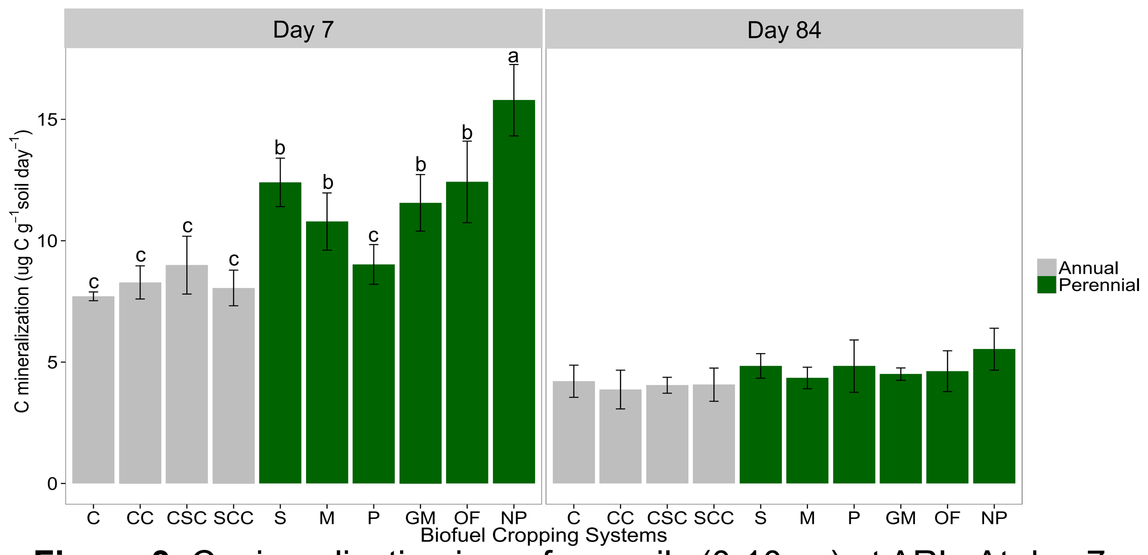


Figure 3. C mineralization in surface soils (0-10cm) at ARL. At day 7 perennial systems had significantly greater C mineralization rates (active C) compared to annuals (P<0.05) . No significant differences were evident at day 84 (slow C).

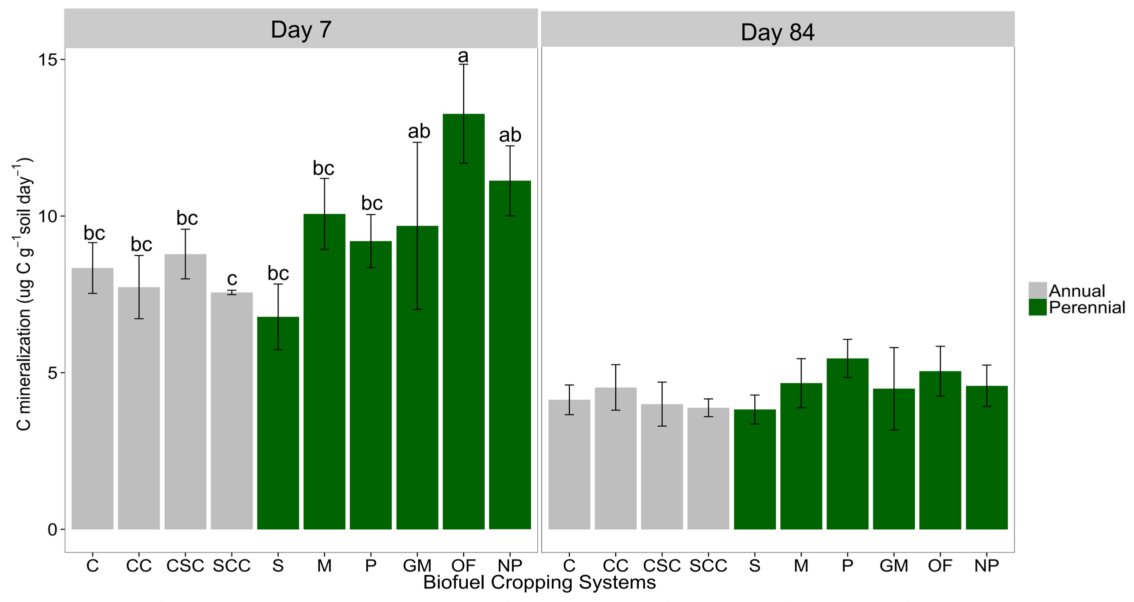


Figure 4. C mineralization in surface soils (0-10cm) at KBS. At day 7 the diverse perennial systems had significantly greater C mineralization (active C) compared to annuals. No significant differences were evident at day 84 (slow C).

Summary

- Active C was significantly greater at ARL compared to KBS in the switchgrass and native prairie systems.
- Due in large part to greater root biomas (data not shown), perennial systems had significantly greater active C compared to annual systems at both KBS and ARL, although differences were less consistent at KBS.
- The difference difference between annual and perennial systems dissipates late in the incubation, suggesting no significant differences among systems in the in the slow C pool.
- Future steps will include calculating decay rates to determine pool size and mean residence times.

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