Differences in Biomass Distribution and Production Budgets between Cropland and Prairie Grassland

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We study the mechanisms of ecosystem C uptake and retention at two sites with common soil types and climate but differing in management practices. Carbon uptake is measured by the eddy covariance technique. Aboveground and belowground plant biomass, soil microbial biomass, and soil organic carbon (SOC) dynamics are measured via nearby chronosequence on the same soils.

At our study sites (a corn/soybean rotation and a 25-year-old restored prairie near the agricultural site) gross primary production is very similar, averaging about 2500 g C m-2 y-1. Nevertheless, net ecosystem production (NEP) differs greatly due to the different management practices. The prairie site is a strong and stable carbon sink with an average NEP of -307 g C m-2 y-1 over 9 years. This NEP sustains net increases in biomass and production of belowground ecosystem components, including SOC stocks and the standing crop of roots and microbial biomass. For the prairie, we have established that, on a yearly basis, about 10-14% of NEP is allocated to SOC accrual, 7% of NEP supports net root production, and 2% of NEP supports net growth increments of microbial biomass. Thus, 23% of the year's NEP sustains net gains of root and microbial biomass as well as SOC accrual rates averaging 43 g C m-2 y-1. The remaining 77% of NEP is allocated to production of aboveground litter (which is burned as a management practice to maintain the prairie ecosystem and does not contribute significantly to SOC accrual rates).

The cultivated site is rotated annually between corn and soybean, which is a common regional practice. During years when the land is cultivated with corn, NEP averages -270 g C m-2 y-1. Thus, a proportion of NEP might potentially sustain accrual of SOC and soil microbial production. However, when the field is cultivated with soybean, the land becomes a source of CO_2 (average NEP is 181 g C m-2 y-1), mostly because the short period of C uptake associated with soybean phenology results in large ecosystem carbon losses. Overall, the positive effects to the production budget that could occur under corn are cancelled by large losses during soybean years, resulting in a lack of energy to sustain SOC accrual under corn/soybean rotations in this area.

Overall, we found that phenological effects on the period of C uptake can be a key factor contributing to sustained ecosystem carbon gains as well as SOC accrual.