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# Biochar and Managed Perennial Ecosystems: Testing for Synergy in Ecosystem Function and Biodiversity

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**Abstract**
Biochar is a carbon-rich material that is similar to charcoal. It is produced when biomass is burned in the absence of oxygen, a process otherwise known as pyrolysis. Pyrolysis and the production of biochar are currently being promoted as a means to both produce domestic fuel (biooil) and concurrently producing a co-product that increases crop yield and sequesters carbon in the soil (biochar). While there may be many potential benefits in the application of biochar to agricultural soils, such as enhanced soil fertility and improved soil water status, there are no studies of higher-order ecological and ecosystem effects of biochar and its potential synergistic interactions (either positive or negative) on complex perennial systems. The goal of this field experiment is to determine how biochar and manure addition directly affect ecosystem structure and function in perennial systems, specifically soil nutrients, water, plants, and soil organisms.

**Keywords**
Ecology Evolution and Organismal Biology

**Disciplines**
Agricultural Science | Agriculture | Ecology and Evolutionary Biology

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## Introduction

Biochar is a carbon-rich material that is similar to charcoal. It is produced when biomass is burned in the absence of oxygen, a process otherwise known as pyrolysis. Pyrolysis and the production of biochar are currently being promoted as a means to both produce domestic fuel (biooil) and concurrently producing a co-product that increases crop yield and sequesters carbon in the soil (biochar). While there may be many potential benefits in the application of biochar to agricultural soils, such as enhanced soil fertility and improved soil water status, there are no studies of higher-order ecological and ecosystem effects of biochar and its potential synergistic interactions (either positive or negative) on complex perennial systems. The goal of this field experiment is to determine how biochar and manure addition directly affect ecosystem structure and function in perennial systems, specifically soil nutrients, water, plants, and soil organisms.

## Materials and Methods

In April 2011, we established five experimental blocks each containing six 4-$m^2$ plots (30 total plots). Within each replicate block, we randomly assigned plots to one of six treatments: factorial combinations of two nutrient addition levels (0 and 4.5 kg manure $m^{-2}$) and three biochar levels [0, 1% and 3% of soil volume]. A diverse seed mixture of 30 tall grass prairie species was planted following plot set up. In March 2012, the plots were burned to remove excess vegetation litter that may have hindered new growth (Figure 1).

## Results and Discussion

This was the second year of this study, and in many plots the weedy annuals were less prominent. Foxtail still dominated, but planted species, such as smooth ox-eye, yellow coneflower, little bluestem, and side oats grama, were more evident. We anticipate that the planted perennials will be dominant in the coming year.

As in the first year, we found that there was no difference in total plant biomass (weeds and planted species) among the biochar and manure treatments (Table 1). The biomass of the planted species only, however, was greater in the 3 percent biochar treatment regardless of manure addition. The number of plant species (richness) was not affected by manure, but was more in the 3 percent biochar additions. There was no effect of biochar on root biomass or mycorrhizal colonization of roots.

Soil pH and gravimetric water content were not affected by the treatments. Biochar improved soil carbon concentration (Figure 2). This suggests that this type of biochar contributes to carbon sequestration. We will continue to monitor both above- and below-ground community development and nutrient levels over the next year to determine how biochar may affect non-agricultural communities.

## Acknowledgements

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**Table 1. Mean (± standard error) plant community and soil parameters with biochar and manure treatments, year 2.**

| | Control | | | Manure (4.5 kg $m^{-2}$) | | |
|---|---|---|---|---|---|---|
| | **0** | **1%** | **3%** | **0** | **1%** | **3%** |
| Total biomass (g $m^{-2}$) | 631.24 ± 170 | 744.4 ± 188 | 497.8 ± 79 | 663.2 ± 97 | 548.7 ± 71 | 585.61 ± 60 |
| Planted biomass (g $m^{-2}$) | 59.9 ± 14 | 42.1 ± 18 | 119.2 ± 50 | 23.5 ± 11 | 64.2 ± 23 | 111.6 ± 38 |
| Species richness | 8.0 ± 1.6 | 8.0 ± 1.8 | 11.6 ± 1.0 | 9.6 ± 2.7 | 8.6 ± 1.5 | 13.4 ± 1.4 |
| pH | 8.0 ± 0.03 | 7.9 ± 0.07 | 8.1 ± 0.06 | 7.9 ± 0.05 | 7.9 ± 0.07 | 8.0 ± 0.05 |

**Figure 1. Experimental biochar plots, after prescribed burn March 28 (a) and prairie vegetation in September (b) 2012, at the ISU Western Research Farm.**

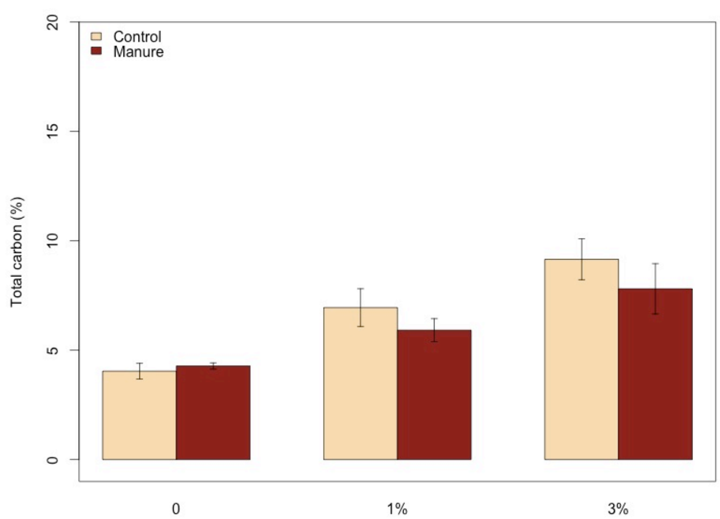


**Figure 2. Change in soil carbon (%) with biochar and manure application.**