# Soil Biotic Indicators for Improving Native Plant Establishment in Disturbed Southwestern Grasslands

Martha Gebhardt[1] (marthag@email.arizona.edu), Jeff Fehmi[1], Craig Rasmussen[2], and Rachel Gallery[1]
[1]School of Natural Resources and the Environment, [2]Soil, Water, and Environmental Science
University of Arizona

## 1. Introduction

- In the arid Southwest U.S., land use change, non-native plant invasions, and changes in woody plant cover are widespread and increasing, typically resulting in losses of native plant and soil microbe diversity and shifts in hydrological and biogeochemical cycling (Skole et al., 1997).
- Soil microorganisms, including bacteria, archaea, and fungi, play important roles in these cycles, influencing water and nutrient uptake in plants as well as soil stability.
- Some evidence suggests that soil microbes could tip the competitive balance among plant species by exerting strong control over the establishment of seedlings in a community (Vogelsang & Bever 2009).
- Understanding the differences in the abundance, identities, and activities of soil microbes associated with woody and grass species could inform management strategies to improve native grass establishment.

## 2. Hypotheses

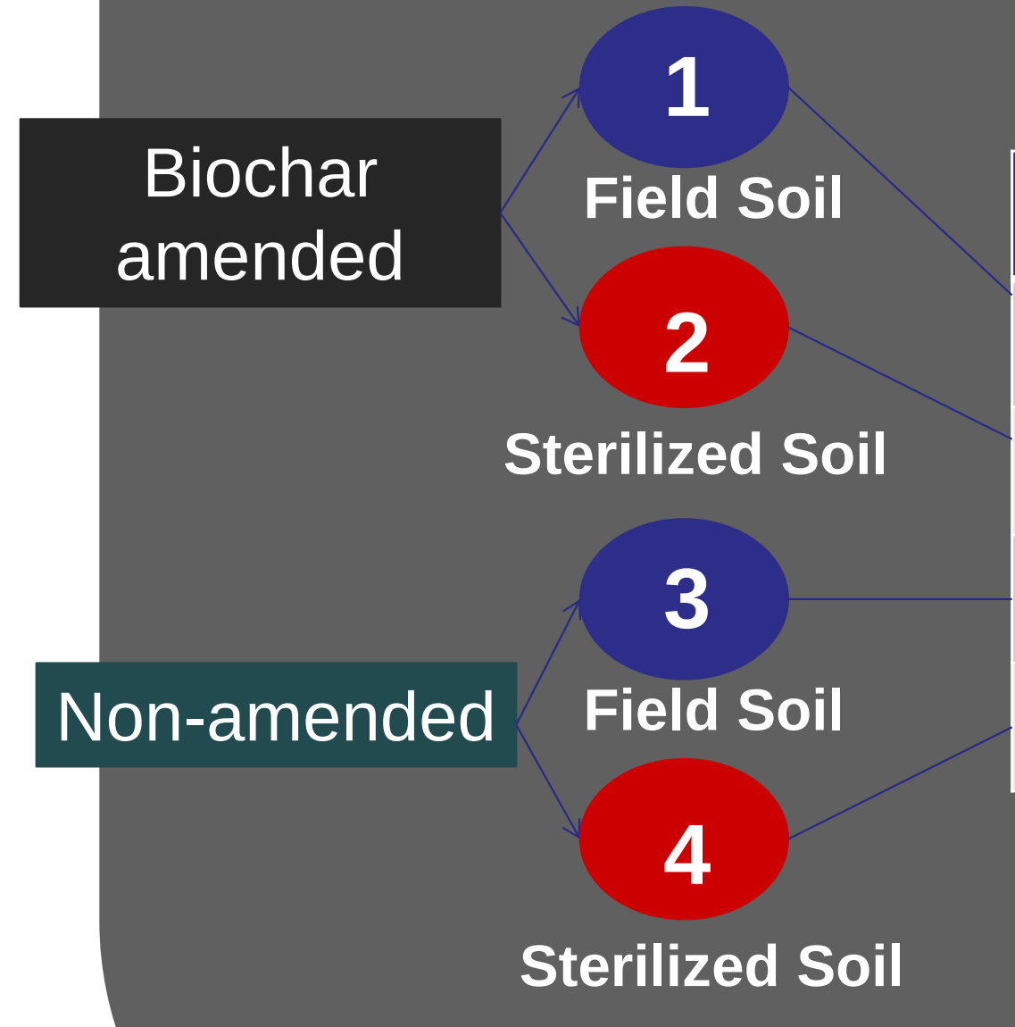
**Soil Amendment-** Biochar amendments to field soil will change the carbon and nitrogen availability to plants. Sterile soils with biochar could cause stressful conditions for plants by reducing water availability, resulting in lower plant growth than in field soils.

**Soil Sterility-** Sterilized soils, which reduce microbial activity, will cause a pulse of labile carbon and nutrients that could result in initial rapid plant growth that will decline over time. Field soils should have more gradual but sustained plant growth.

**Plant functional groups-** Differences in plant tissue chemistry and carbon quality among the plant species and functional groups tested (Warm Season Perennial C3 Grass [WSPG], Cool Season Perennial C4 Grass [CSPG], and woody shrub) will change the abundance and activity of microbes in soils.

## 3.Study Site and Experimental Design

Using a fully factorial experiment, we examined the interactions and feedbacks among plant species, soil sterilization treatments, soil amendments, and soil microbial communities. Soils were collected from the Santa Rita Mountains, outside the SRER (31.822370, -110.734166). Soil treatments included autoclave sterilization and amendment with biochar resulting in four different soil treatments (Fig. 1a). Five native species, including warm season perennial grasses, a cool season perennial grass, and a woody shrub were studied in each of the four soil treatments (Fig. 3).



Biochar amended

1 Field Soil

2 Sterilized Soil

Non-amended

3 Field Soil

4 Sterilized Soil

Fig. 1a Four soil treatments studied in the experiment

| Soil Treatment | Water Holding Capacity (g) |
|---|---|
| Field Soil with Biochar | 5.6778 |
| Sterile Soil with Biochar | 6.2511 |
| Field Soil No Amend | 5.3711 |
| Sterile Soil, No Amend. | 5.0133 |

Fig. 1b Soil water holding capacity determined by the difference in pot mass 30 minutes after watering and before watering weights.

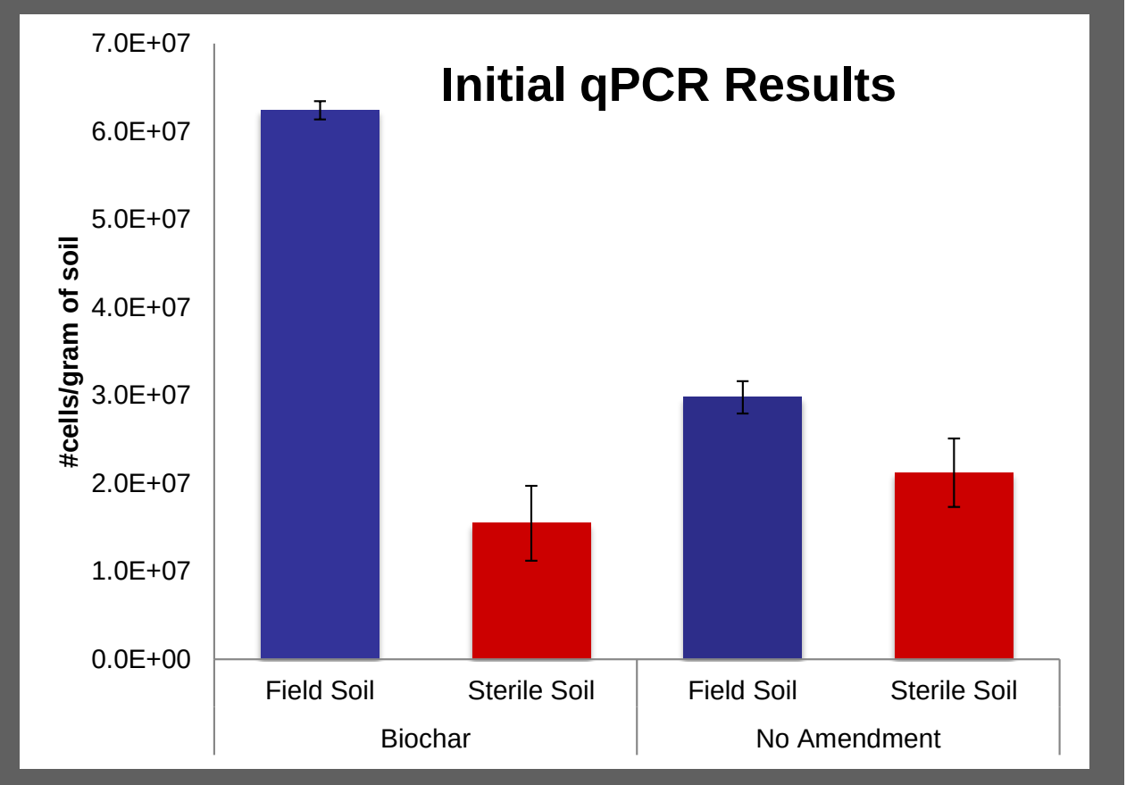


Fig. 2 Relative abundance of archea and bacteria were measured via qPCR for each of the soil treatments before planting. Soil sterilization reduced microbial abundance compared to field soils.

## 4. Experimental Plant Species

*Bouteloua gracilis* WSPG
Growing in sterile soil amended with biochar

*Hilaria belangeri* WSPG
Growing in sterile soil amended with biochar

*Leptochloa dubia* WSPG
Growing in sterile soil amended with biochar

*Elymus elymoides* CSPG
Growing in sterile soil with no amendment

*Calliandra eriophylla* Woody
Growing in non-sterile soil amended with biochar

Fig. 3 Images of the plant species studied in the experiment. Genus and species as well as soil treatment are described below each image

## 5. Results

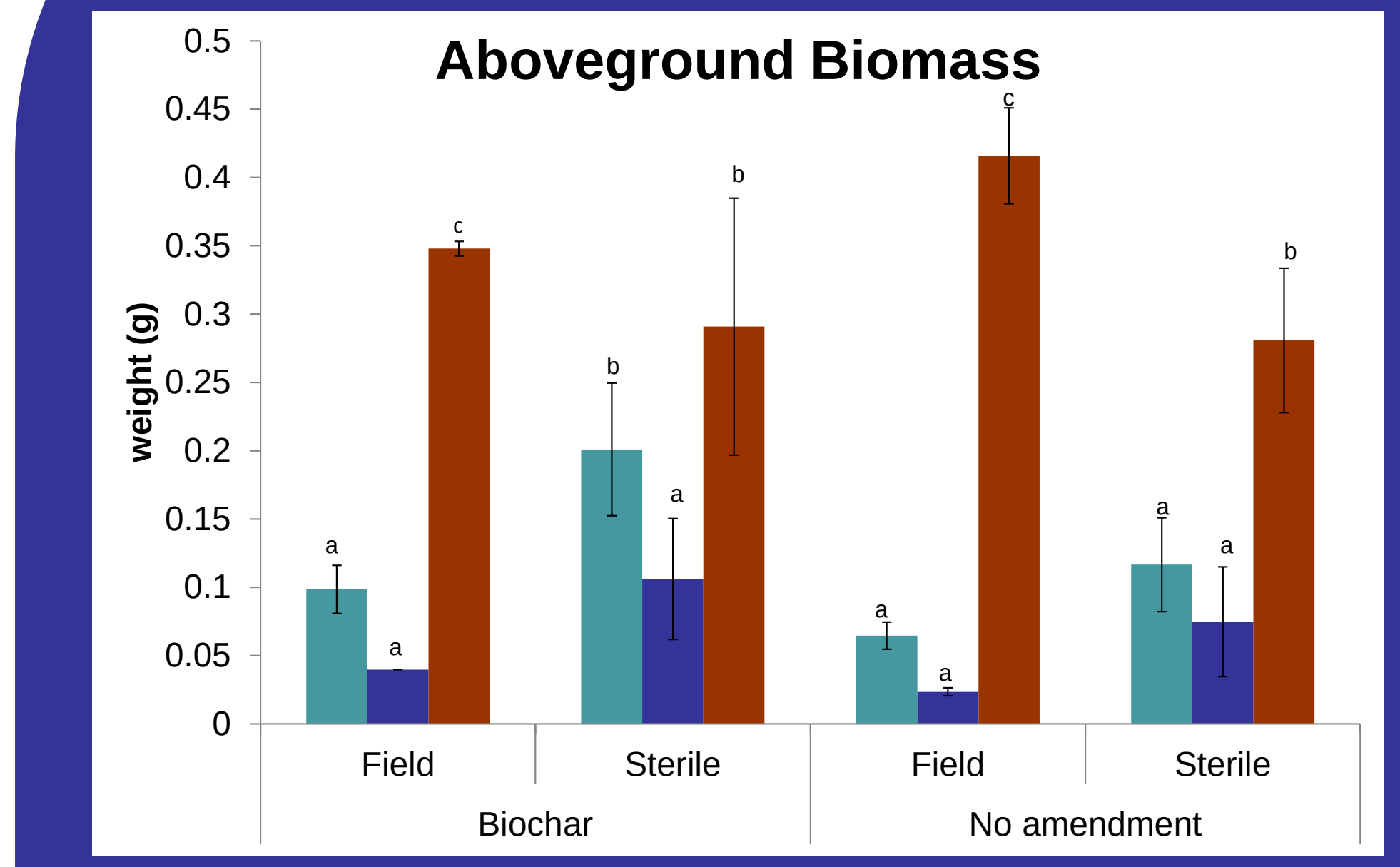


Fig. 4a Average dry weight (g) aboveground biomass in the four soil treatments for the three plant types

•Aboveground biomass of woody shrubs was significantly greater than grass biomass in field soils with and without biochar amendment (Fig. 4a, $F_{1,\ 56}$ = 4.24, p = 0.044).

•Soil sterilization significantly reduced the difference in aboveground biomass between grasses and woody shrubs (Fig. 4a, Tukey Kramer comparisons are denoted by a, b, c).

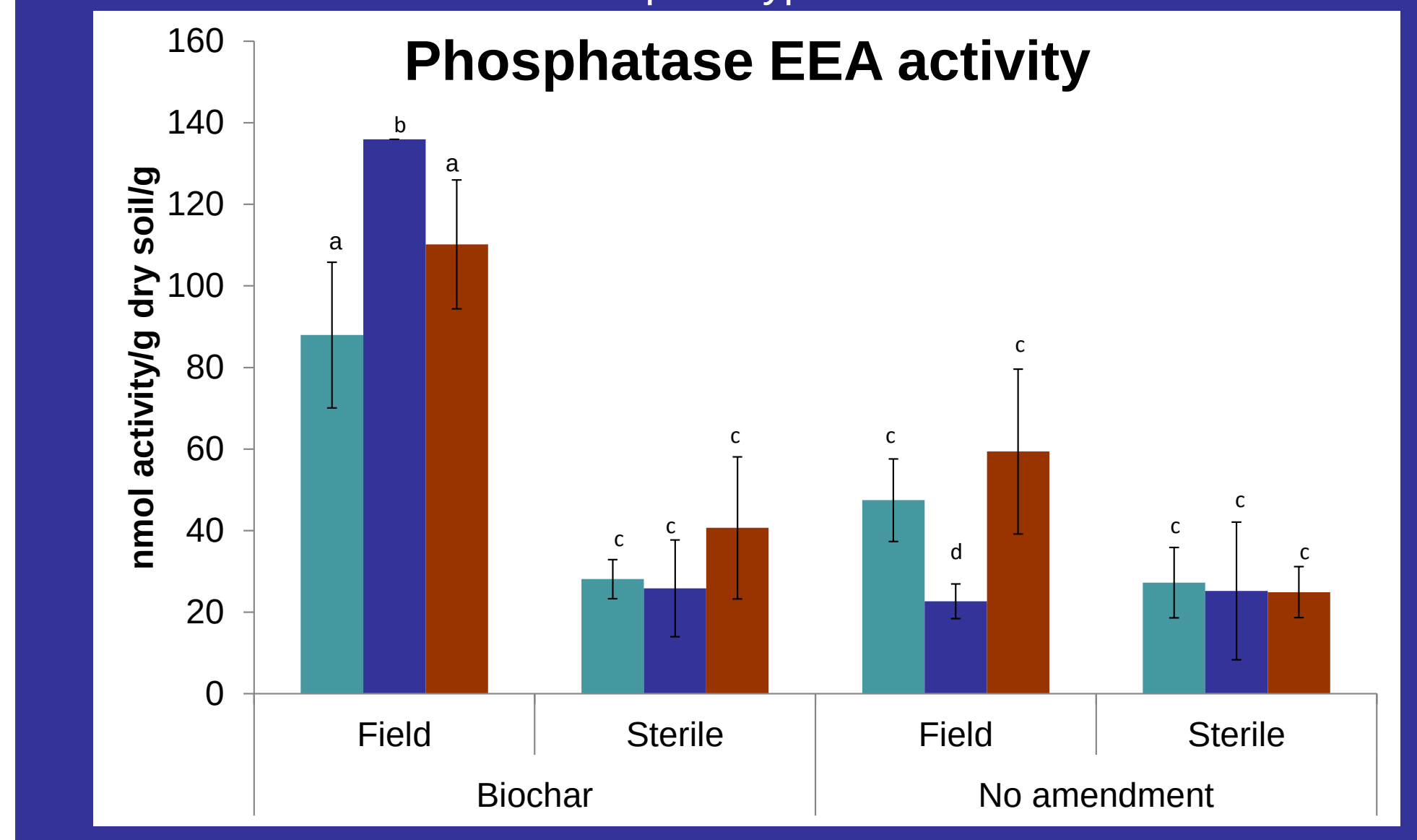


Figure 4b Average potential extracellular phosphatase activity determined by fluorometric enzyme assays

• Across all plant functional groups, the strongest positive effect on potential phosphatase activity was found in field soils amended with biochar (Fig. 4b, $F_{3,68}$= 3.774, p=0.0144)

• Soil sterilization reduced overall potential phosphatase activity and this was significant in WSPG and woody shrub species (Fig. 4b, Tukey Kramer comparisons are denoted by a, b, c).

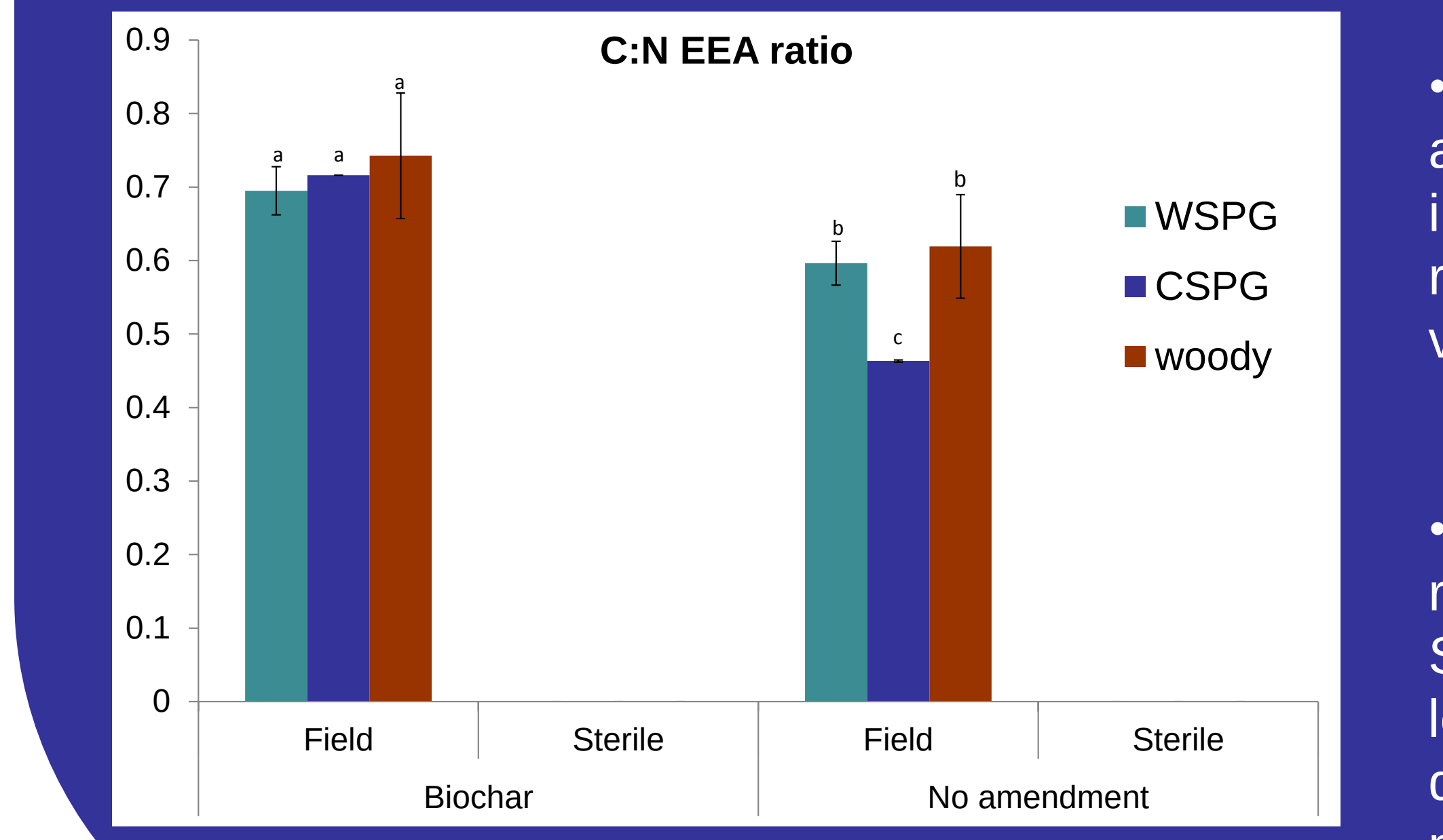


Fig 4c C:N activity in the soil determined by fluorometric enzyme assays using the equation: ln(β-Glucosidase) / ln(N-acetyl-β-Glucosaminidase+ leucine aminopeptidase)

• The stoichiometry of potential enzyme acquisition activities (C:N) provides insight into the relative allocation of resources towards the acquisition of C versus N (Sinsabaugh et al., 2008).

•C:N ratios in field soils were similar regardless of soil amendment. Sterilization resulted in C:N activity levels that were below the level of detection (Fig. 4c, $F_{1,70}$= 0.081, p=0.776).

## 6. Main Conclusions

•Soil sterilization, which significantly reduces the abundance and activity of the microbial community, could change the competitive dynamics of grasses and woody shrubs.

•In field soils, biochar amendment increased potential extracellular enzyme activity and aboveground plant growth compared to non-amended soils.

•Growth responses to soil sterilization and amendment addition were more sensitive in grass species than in the woody shrub *C. eriophylla*.

•Grass establishment in severely disturbed soils could be improved with biochar amendments that increase microbial activity, but more research is needed.

## 7. Ongoing Analyses

•Microbial biomass via chloroform fumigation and characterization of the relative abundance of bacterial, archea, and fungal communities via qPCR will be analyzed by plant functional group and soil amendments.

• Soil biogeochemical investigations will be performed to determine nutrient availability including KCl extraction, total organic carbon, and total organic nitrogen analyses.

## Acknowledgements

We thank Yusheng Qian and Elizabeth Freniere for laboratory assistance, Dr. Jean McLain (SWES) for help with qPCR analyses, and Shawn Stone for field assistance. Additionally, we would like to thank UA Institute of the Environment Faculty Seed Grant and Rosemont Mine Corporation for financial support.

References:

- Skole, D.L., et al. 1997. A land cover change monitoring program: Strategy for an international effort. Mitigation and Adaptation Strategies for Global Change 2.2-3: 157-175.
- Sinsabaugh, R.L., et al. 2008. Stoichiometry of soil enzyme activity at global scale. Ecology Letters 11:1252-1264.
- Vogelsang, K.M. and J.D. Bever. 2009. Mycorrhizal densities decline in association with nonnative plants and contribute to plant invasion. Ecology 90:399-407.