2015

Above- and belowground biomass and soil respiration in a low-input perennial biofuel production system

Jordan Young

Jessica Abernathy

Kenneth Elgersma

Above- and belowground biomass and soil respiration in a low-input perennial biofuel production system

Jordan Young*, Jessica Abernathy, and Kenneth Elgersma

Department of Biology, University of Northern Iowa, Cedar Falls IA

*Email: youngjar@uni.edu

Background

- Global climate change largely depends on the atmospheric carbon balance, of which soil respiration is a significant component.
- Native perennial prairie vegetation is being tested as an alternative to corn for renewable biofuel production.
- Mixtures of this vegetation are considered 'carbon negative' because net CO_2 sequestration exceeds atmospheric release[1].
- Studies have shown that aboveground biomass and the rate of carbon sequestration are both increased by planting a diverse mixture of species versus a monoculture[1].

Research Question:

How does the diversity of biofuel vegetation mixtures affect soil respiration, aboveground biomass and belowground biomass?

Methods

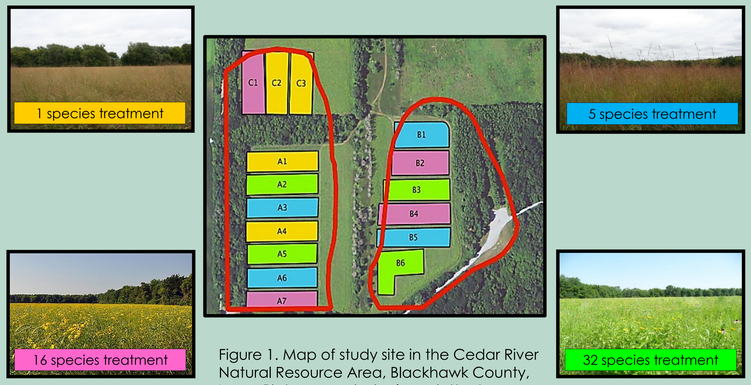

Figure 1. Map of study site in the Cedar River Natural Resource Area, Blackhawk County, Iowa. Plots are coded using a letter to denote field and a number to denote plot within that field.

- Experimental Design: 4 replicate plots of 4 diversity treatments

  Treatments:
  - 1 species – switchgrass monoculture
  - 5 species – warm season C4 grasses
  - 16 species – grasses, forbs, and legumes
  - 32 species – grasses, forbs, legumes, and sedges
- Soil respiration was measured 5 times throughout the summer of 2015 using a Li-COR LI-8100A Automated Soil CO_2 Flux System and averaged for each plot
- 1 soil core (7.5 cm W X 15 cm D) was taken from each plot and roots were washed, dried and weighed to find belowground biomass
- Aboveground biomass was collected annually from 2010-2013 and averaged for each plot

Results

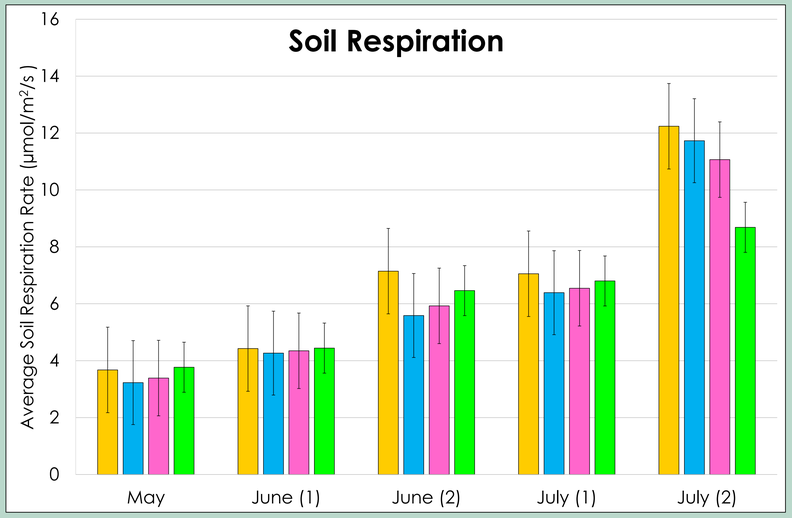

Figure 2. Average soil respiration rates (µmol/m²/s) for each treatment separated by sampling round. Sampling round had a significant effect on respiration (p<0.0001, below) and there was a marginally significant difference among diversity treatments (p = 0.091).

Soil Respiration	Wilks' λ	psuedo-F	Df_{num}	Df_{den}	p	
Between Time						
(Intercept)	**0.03443**	**1009.5**	**1**	**36**	**<0.0001**	***
Soil	0.98847	0.21	2	36	0.8115	
Diversity	**0.83771**	**2.32**	**3**	**36**	**0.0912**	.
Soil:Diversity	0.82436	1.28	6	36	0.2917	
Within Time						
Time	**0.07567**	**100.77**	**4**	**33**	**< 0.0001**	***
Soil:Time	**0.49886**	**3.43**	**8**	**66**	**0.0023**	**
Diversity:Time	0.65359	1.27	12	87.601	0.2490	
Soil:Diversity:Time	0.57212	0.84	24 1	16.333	0.6780	

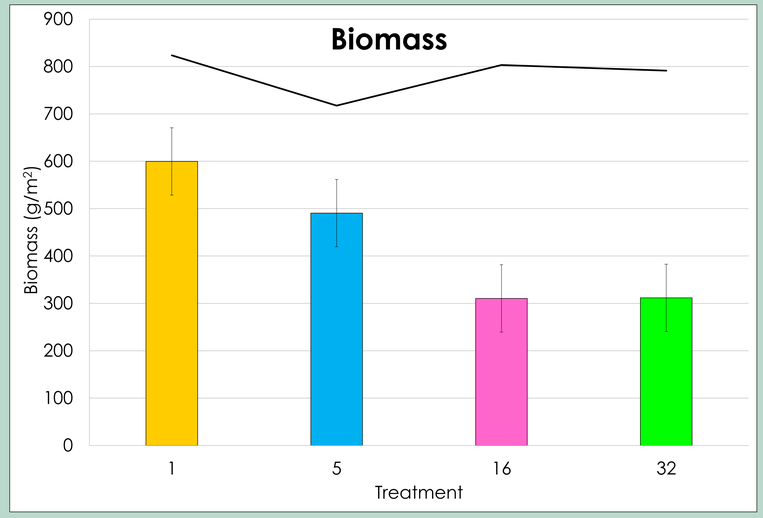

Figure 3. Bars represent average belowground biomass (g/m²) and black line represents average aboveground biomass (g/m²), which varied significantly (p<0.05, below) across treatments.

Aboveground biomass	Wilks' λ	psuedo-F	Df_{num}	Df_{den}	p	
Between Time						
(Intercept)	**0.01075**	**3311.3**	**1**	**36**	**<0.0001**	***
Soil	**0.48114**	**19.4**	**2**	**36**	**<0.0001**	***
Diversity	**0.80603**	**2.9**	**3**	**36**	**0.0488**	*
Soil:Diversity	**0.66266**	**3.1**	**6**	**36**	**0.0161**	*
Within Time						
Time	**0.17926**	**37.8**	**4**	**33**	**<0.0001**	***
Soil:Time	**0.28517**	**7.2**	**8**	**66**	**<0.0001**	***
Diversity:Time	**0.53741**	**1.9**	**12**	**87.6**	**0.0411**	*
Soil:Diversity:Time	0.63096	0.7	24	116.3	0.8584	

Conclusions

- Soil respiration rates increased with time throughout the growing season across diversity treatments.
- In this preliminary study, diversity did not have a significant effect on soil respiration; however, studies have revealed significant effects of diversity as well as other factors including leaf N, soil temperature and soil moisture[2,3]
- Aboveground biomass was significantly different between diversity treatments while belowground biomass was not, which is likely due to differences in sampling intensity.

Ongoing Work

- Analyzing effects of soil type, nutrient availability, temperature and moisture on soil respiration rates
- Measuring root density and growth rates using minirhizotrons
- Investigating the role of litter decomposition on carbon sequestration in the context of biofuel production

Acknowledgements

I would like to thank Sarah Huebner for all of her assistance out in the field and in the lab, and my committee members, Dr. Mark Sherrard and Dr. Mark Myers. Thank you to the UNI Biology department, the NSF, and Iowa EPSCOR for their support of this research. This material is based upon work supported in part by the National Science Foundation Grant # EPSC-1101284. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Literature Cited

1. Tilman, D., J. Hill, and C. Lehman. 2006. Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass. *Science* **314**:1598-1600.
2. Dias, A.T.C., J. Ruijven, and F. Berendse. 2010. Plant species richness regulates soil respiration through changes in productivity. *Oecologia* **163**:805-813.
3. Metcalfe, D.B., R.A. Fisher, and D.A. Wardle. 2011. Plant communities as drivers of soil respiration: pathways, mechanisms, and significance for global change. *Biogeoscience* **8**:2047-2061.