2012

Butterfly Community Dynamics in a Restored Prairie Used for Biofuel Production

Nicholas E. TeBockhorst
University of Northern Iowa

Jarrett D. Pfrimmer
University of Northern Iowa

See next page for additional authors

Authors
Nicholas E. TeBockhorst, Jarrett D. Pfrimmer, and Mark C. Myers

BUTTERFLY COMMUNITY DYNAMICS IN A RESTORED PRAIRIE USED FOR BIOFUEL PRODUCTION

Nicholas E. TeBockhorst with Jarrett D. Pfrimmer and Dr. Mark C. Myers




Spring 2008 Site is prepared and seeded

Summer 2008 Flood washes seed away

Summer 2008 Site treated with glyphosate and planted with soybeans

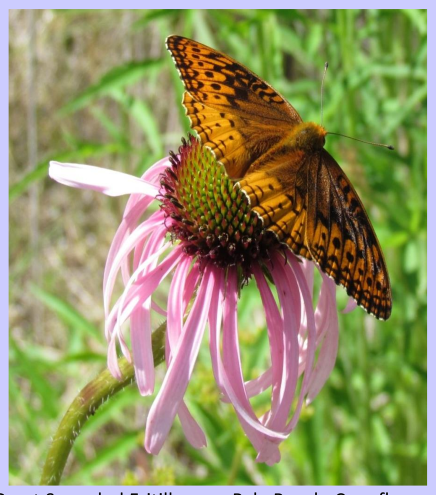
Spring 2009 Site is re-seeded

Summer 2009 Entire site is mowed to reduce weed competition

Summer 2010 First forbs and grasses emerge. First butterfly surveys

Spring 2011 Entire site is burned to stimulate plant growth

Spring 2012 Site is hayed for biomass harvest; Yields approx. 160 tons of biomass



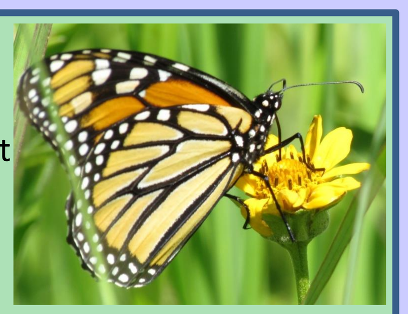
Great Spangled Fritillary on Pale Purple Coneflower

Abstract

The conversion of native Midwestern tallgrass prairie to monoculture production of corn (*Zea mays*) and soybeans (*Glycene max*) for food and fuel has resulted in a significant decrease in habitat for insect pollinators, including butterflies. Compared to conventional biofuels such as corn ethanol, prairie biomass produces greater energy yields while providing high quality wildlife habitat and protecting soil and water resources. My research took place at Cedar River Natural Resource Area in Black Hawk County Iowa, USA. In spring 2009, the University of Northern Iowa's Tallgrass Prairie Center seeded 48 research plots in conventional fields to one of four experimental treatments of native vegetation: 1) switchgrass monoculture, 2) warm-season grass mix (5 species), 3) biomass mix (8 forb and 8 grass species), or 4) prairie mix (20 forb, 3 sedge, and 9 grass species). During the summers of 2010, 2011, and 2012, our team conducted visual surveys of butterflies (class Lepidoptera), a group widely recognized as bioindicators of ecosystem health. I used these data to compare butterfly abundance, species richness, and composition among treatments over the three year study. I hypothesized that butterfly abundance and richness would increase over the three year period and that more diverse plantings would support a greater abundance and diversity of butterflies. Our results indicate that butterfly abundance and richness fluctuated depending on site management. This year, butterfly abundance started out high and remained high in biomass and prairie plots but decreased in grass plots, whereas richness started out high and decreased over the three survey periods. The conversion of marginal agricultural lands to areas of natural vegetation cultivated for biofuel production would be beneficial to increase abundance of butterflies through creation of habitat and providing host plant and nectar resources.

Giant Swallowtail on Wild Bergamot

Background



Monarch on False Sunflower

Over 99% of native tallgrass prairie in the Midwestern USA has been converted to high input monoculture systems which do little to provide habitat for native wildlife, including insects. In recent years, the push for renewable energy has led to the development of lignocellulosic biomass energy sources which capture sunlight to form carbon compounds which can later be burned as fuel for electrical generation. These systems can produce greater energy yields compared to monoculture crops and may reduce conventional fossil fuel consumption and emissions (Hill 2009; Tilman *et. al.* 2006). When co-fired with coal, burning 5% biomass for one year at a single power plant could reduce CO_2 emissions by 177,000 tons (CVBP 2002).

The cultivation of biomass feedstocks through conventional agriculture does little to support biodiversity and has contributed to the decline of butterfly populations in the Midwest (Swengel *et al.* 2010; Schlicht *et al.* 2009). Alternative lignocellulosic biomass crops including a mix of forbs, grasses, and legumes may support a greater abundance and diversity of butterflies while still allowing biomass production and harvest.

We studied butterfly community characteristics at an experimental research site where four prairie plant assemblages are being grown for biomass production. We chose to study butterflies as an indicator of the benefits this system may have to ecosystems. Butterflies respond rapidly to environmental change, are diverse and relatively easy to identify, and respond to plant diversity due to requirements for larval host plants and nectar sources (Myers *et. al.* 2011; Shepard and Debinski 2005). They are also important pollinators of prairie plants. Our objectives were to compare butterfly abundance, richness, and community composition in the four vegetation treatments across three soil types. We also compared data from 2012 to previous years to determine how butterfly communities change over time based on how the site is managed for biomass production.

Methods

We conducted our research at the Cedar River Natural Resource Area, owned by the Black Hawk County Conservation Board, Iowa, USA. The site was seeded in 2009 by the University of Northern Iowa's Tallgrass Prairie Center. There are four vegetation treatments on three soil types. Treatments include: switchgrass monoculture, warm season grass mix (5 grass species), biomass mix (8 forb, 8 grass species), and prairie mix (20 forb, 3 sedge, and 9 grass species). There are a total of 48 research plots in addition to 12 non-plot areas which were seeded with the prairie mix at double the forb seeding rate. Research plots were managed identically within each year. Management practices included mowing (2009), no management (2010), burning (2011), and haying (2012; see timeline above).

We walked 50 m transects in each of the 48 research plots plus the 12 non-plot areas at a pace of 10 m/min during three survey periods from June to July. Any butterfly within a 3 m radius of the surveyor was visually identified or caught with a net and identified.

Within each survey period, we calculated the average number of butterflies observed per survey as an indicator of butterfly abundance. For species richness, we used the total number of species observed in two surveys per period. The total number of individuals of each species over three survey sessions were pooled for the community composition analysis. We conducted two-way repeated measures ANOVA to compare butterfly abundance and richness among treatments and soil types over time. For community composition, we square root transformed the data and generated a Bray- Curtis dissimilarity matrix. We used PERMANOVA to test for significant differences in community composition by treatment, soil type, or year and non-metric multidimensional scaling to visualize differences in species composition among plots.

Figure 1. Average butterfly abundance by year A) 2012, B) 2011, C) 2010

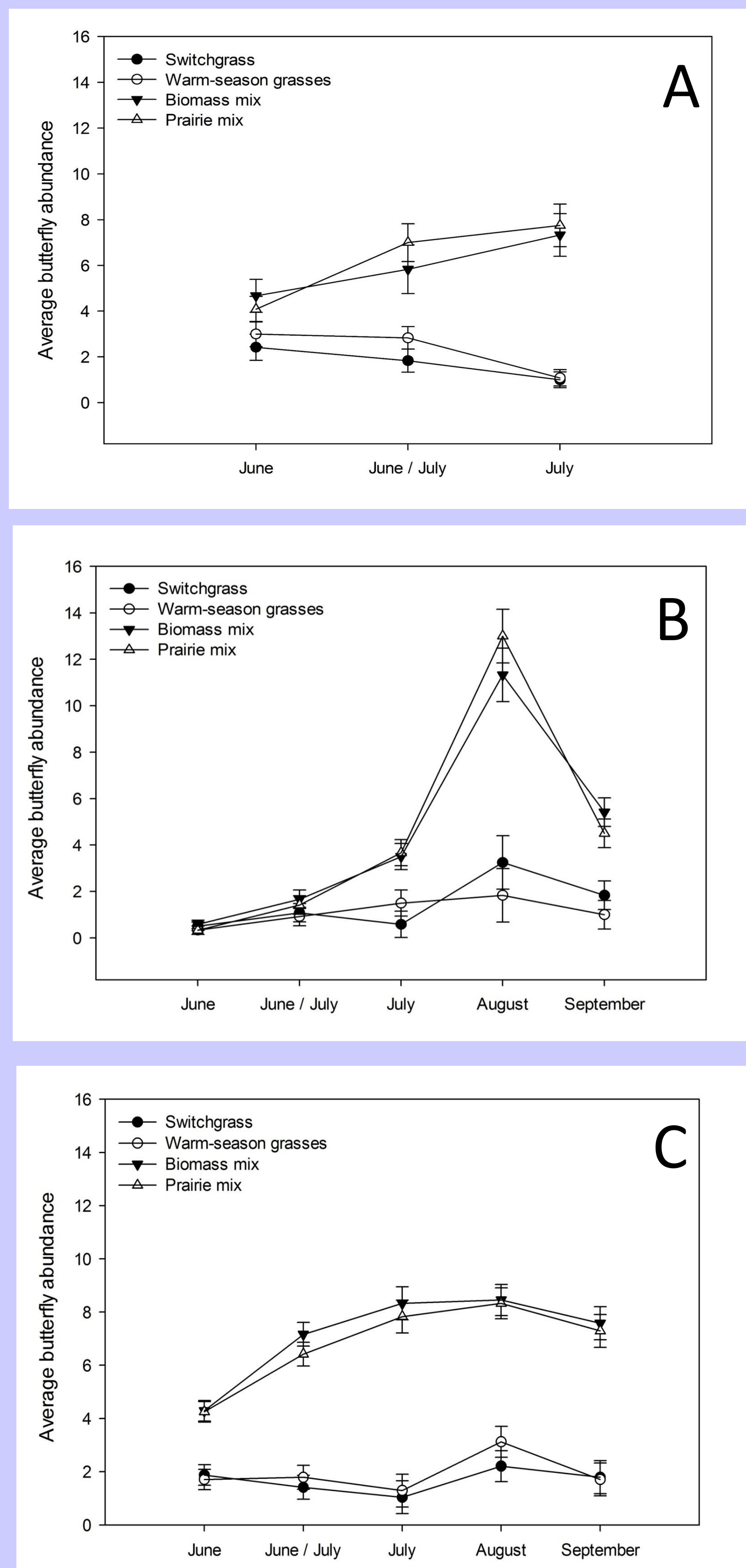


Figure 2. Total butterfly richness by year A) 2012, B) 2011, C) 2010

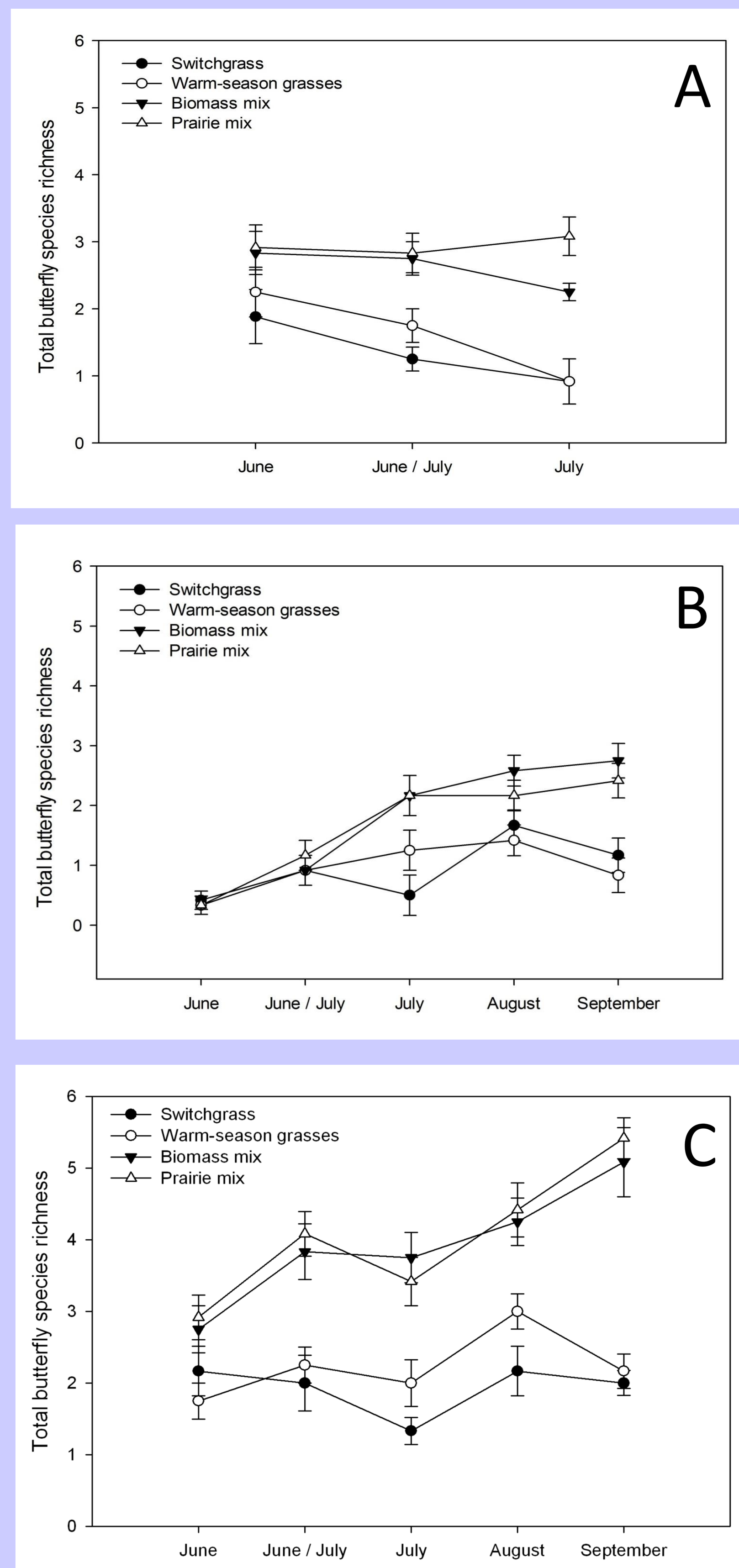


Figure 3. Non-Metric Multidimensional Scaling of 2012 butterfly community composition by treatment

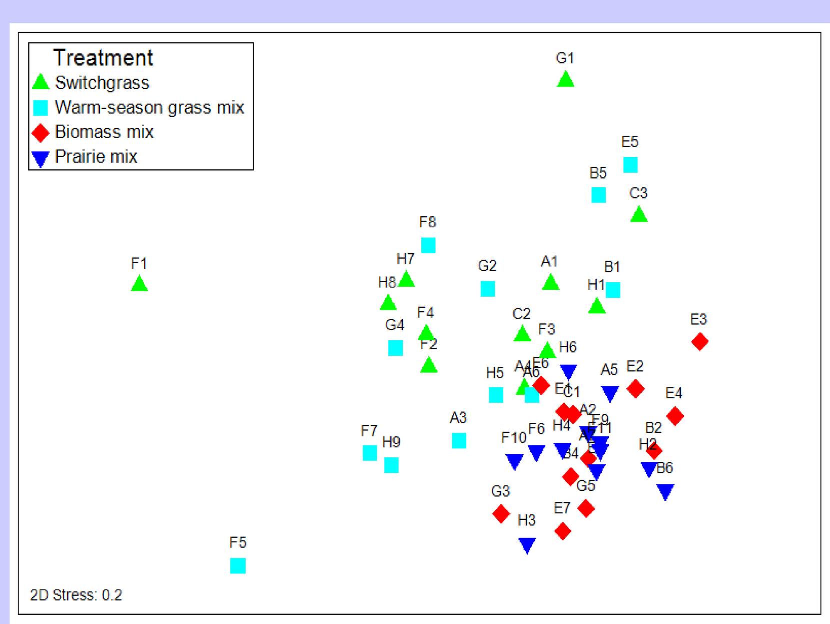
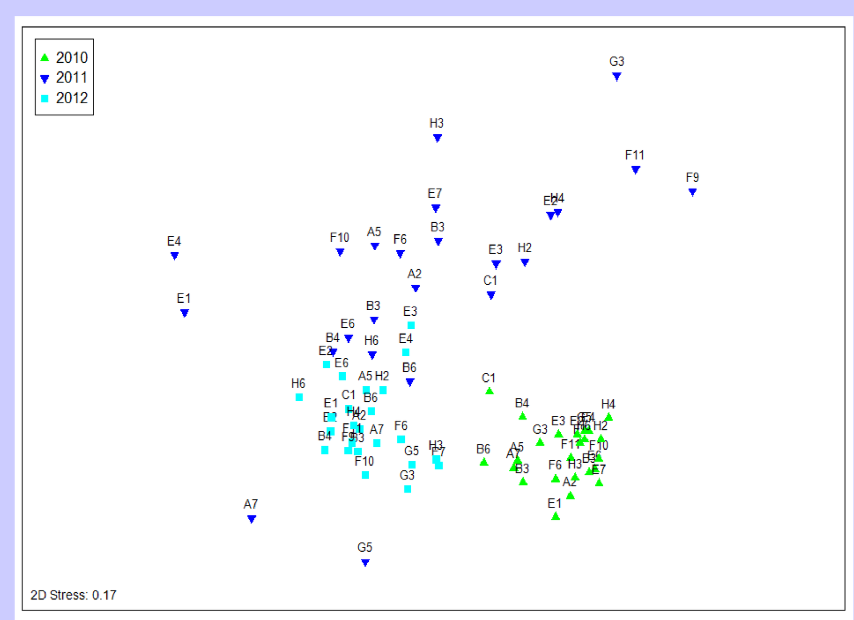


Figure 4. Non-Metric Multidimensional Scaling of 2010-2012 butterfly community composition in biomass and prairie mix plots



Results

2012 Butterfly community characteristics

We observed a total of 799 butterflies representing 24 species: 586 individuals from 21 species in the research plots and 213 individuals from 18 species in the unburned non-plot areas. Butterfly abundance was significantly greater in the biomass and prairie mix plots than in the warm-season grass and switchgrass plots during all three sampling periods (Fig. 1a). There was a significant time × treatment interaction (ANOVA, $F_{6,84} = 5.82$, $p < 0.001$); butterfly abundance in biomass and prairie mix increased over time while abundance in switchgrass and warm-season grass plots declined over time (Fig 1a). Butterfly species richness was significantly greater in the biomass and prairie mix plots than in the warm-season grass and switchgrass plots during all three sampling periods (Fig. 2a; ANOVA, $F_{3,42} = 18.89$, $p < 0.001$). Butterfly species richness was significantly lower in July than during the June sampling period (ANOVA, $F_{2,82} = 4.71$, $p = 0.011$). Butterfly abundance (ANOVA, $F_{8,110} = 5.09$, $p = < 0.001$) in the unburned non-plot areas was significantly greater than in the biomass and prairie mix in June, but significantly lower during the June/July and July sampling periods. Soil type did not significantly affect butterfly abundance or species richness in 2012.

Butterfly community composition varied significantly between the prairie and biomass mix plots and the warms-season grass and switchgrass plots (Fig. 3; PERMANOVA, $F_{3,36} = 4.53$, $p = 0.0001$). Butterfly assemblages in biomass and prairie plots were more diverse, less variable, and with greater proportional representation from great spangled fritillaries (*Speyeria cybele*), painted ladies (*Vanessa cardui*), and eastern tailed-blues (*Everes comyntas*) compared to the grass plots, which had greater relative abundance of hackberry emperors (*Asterocampa celtis*).

Community dynamics

Butterfly abundance (ANOVA, $F_{2,84} = 201.05$, $p = < 0.001$) and species richness (ANOVA, $F_{2,84} = 52.31$, $p = < 0.001$) varied significantly among each year of the study. Abundance (Fig. 1a-c) and richness (Fig. 2a-c) were highest in 2010, intermediate in 2012, and lowest in 2011. Butterfly community composition in the prairie and biomass mix plots varied significantly among years (Fig. 4; PERMANOVA, $F_{2,54} = 27.25$, $p = 0.0001$). Red admirals (*Vanessa atalanta*) were the second most abundant species (427 individuals) in 2010 but were found in low abundance (< 10 individuals) in 2011 and 2012. Butterfly numbers and diversity were low and community composition was more variable in 2011 compared to 2010 and 2012 (Fig 4). Great spangled fritillaries (*Speyeria cybele*) and eastern tailed-blues (*Everes comyntas*) were proportionally more abundant in 2012 than in previous years.

Discussion & Conclusion

We have shown that low input high diversity seed mixes for prairie biofuel production would have ecosystem benefits. In 2012, following a late spring biomass harvest, butterfly abundance was greater than during a year after burning (2011) but less than a year with no management (2010). Butterfly richness started out greater this year compared to 2011 but was similar to richness during a non-burned, non-harvested year (2010). The higher butterfly abundance at the beginning of this year was most likely due to the abundant flowering of pale purple coneflower (*Echinacea pallida*) in the non-treatment areas. These results coincide with Swengel (1996) who found that specialist butterfly populations generally decline after a fire and that declines persist for multiple years. The authors also found that specialist species are more likely to be present after haying than burning.

Pipevine Swallowtail

We found a large difference in butterfly abundance and richness this year between grass and forb mix plots. This leads to the conclusion that floral diversity in a biomass production field would lead to greater ecosystem health and would increase butterfly abundance and richness. I would predict that if it were not for a severe drought this year which caused stress among plants, that butterfly abundance and richness would continue to increase for the rest of the survey period. Weather and its effects on butterfly populations demand future study.

My research demonstrated that biomass production using native prairie vegetation supported high levels of butterfly abundance and richness and that butterfly species composition changed greatly over time. In the future, I plan to relate results from our butterfly surveys to data our team has collected on flower abundance and phenology in response to management.

Literature cited

Chariton Valley Biomass Project. 2002. Environmental Strategies Plan. Prepared for U.S. Department of Energy; contract #DE-FC36-96GO10148. Centerville, Iowa 52544-8922. 43 pgs.

Hill J (2009) Environmental costs and benefits of transportation biofuel production from food-and lignocellulose-based energy crops: a review. Sustainable Agriculture Part 1:125–139

Myers MC, Hoksch BJ, Mason JT (2011) Butterfly response to floral resources during early establishment at a heterogeneous prairie biomass production site in Iowa, USA. Journal of Insect Conservation 16:457–472

Schlicht D, Swengel A, Swengel S (2009) Meta-analysis of survey data to assess trends of prairie butterflies in Minnesota, USA during 1979–2005. Journal of Insect Conservation 13:429–447

Shepherd S, Debinski DM (2005) Evaluation of isolated and integrated prairie reconstructions as habitat for prairie butterflies. Biological Conservation 126:51–61

Swengel AB (1996) Effects of fire and hay management on abundance of prairie butterflies. Biological Conservation 76:73–85

Swengel SR, Schlicht D, Olsen F, Swengel AB (2010) Declines of prairie butterflies in the midwestern USA. Journal of Insect Conservation:1–13

Tilman D, Hill J, Lehman C (2006) Carbon-negative biofuels from low-input High-diversity grassland biomass. science 314:1598–1600

Special Thanks to:
Iowa Power Fund, UNI Biology Department, Tallgrass Prairie Center, Black Hawk County Conservation, Dave Williams , Daryl Smith, Greg Houseal, Jarrett Pfrimmer, Dr. Mark Myers, Benjamin Hoksch, & Drew Miller