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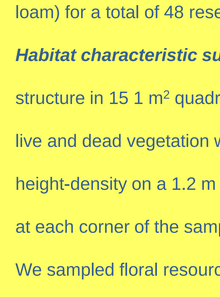
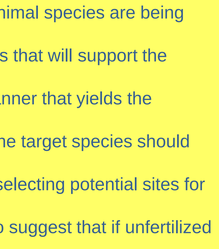


ABSTRACT

We studied interrelationships between prairie plant establishment, habitat heterogeneity, and bird and butterfly biodiversity in an experimental prairie reconstruction in Iowa, USA. We seeded 48 research plots on three soil types with one of four treatments containing one, five, 16, or 32 species. During early establishment, neither bird nor butterfly abundance, species richness, or community diversity varied among the three soil types; however, there were significant treatment × soil type interactions when comparing bird and butterfly community composition among plots. Our results demonstrate that plots established with identical seed mixes and management practices developed variable habitat characteristics due to variation in edaphic conditions and that animal communities were structured in response to this heterogeneity. We discuss the conservation implications of our findings in the context of the utilization of native prairie species as an agroenergy feedstock.



BACKGROUND

In the Midwestern USA, the conversion of the native tallgrass prairie ecosystem to row crop agriculture over the past 150 years has resulted in the loss of habitat extent and heterogeneity (Sampson and Knopf 1994), with consequent declines in biodiversity, including grassland birds (Askins et al. 2007) and butterflies (Swengel et al. 2011). Habitat heterogeneity may arise in prairie reconstructions when local disturbance regimes are identical if spatial variation in topo-edaphic characteristics causes differential plant establishment and/or growth over time (Benton et al. 2003; Fuhlendorf et al. 2006).

We sought to address the following research questions:

1) In plots established with identical management practices on different soil types, how does variation in soil characteristics affect vegetation structure and plant community composition, particularly as such characteristics relate to bird and butterfly habitat needs?

2) Do birds and butterflies respond to soil-induced habitat heterogeneity during the early establishment phase of a prairie reconstruction?

METHODS

Study design. Research was conducted at the Cedar River Natural Resource Area in Black Hawk County, Iowa. The site had a 20-yr history of row crop production until 2009, when our research plots were seeded with one of four perennial biofuel crop treatments: 1) switchgrass monoculture, 2) warm-season grass mix (5 species), biomass mix (16 species), or prairie mix (32 species). Each of the four treatments were replicated four times on three soil types (Flagler sandy loam, Saude loam, and Spillville/Coland clay loam) for a total of 48 research plots.

Habitat characteristic surveys. From May to June 2010, we sampled vegetation composition and structure in 15 1 m^2 quadrats along 50 m transects. Percent bare ground, litter and canopy coverage of live and dead vegetation were estimated using Daubenmire cover classes. We measured vegetation height-density on a 1.2 m Robel pole placed in the center of the quadrat and measured litter depth (mm) at each corner of the sampling frame.

We sampled floral resources in each plot five times from June through September 2010 along the same transects. The number of forb species in bloom and number of inflorescences of each species were recorded in 20 1 m^2 quadrats.

Bird and butterfly surveys. From 1 May to 30 July 2010 we visually surveyed birds by walking transects bisecting each plot parallel to its longest dimension. Each plot was sampled 9 times during the season between 30 minutes after sunrise and 1100 h. From June to September, we visually surveyed butterflies at a pace of 10 m/min along 50×6 m strip transects.

Data analysis. We tested for differences in bird and butterfly community composition by treatment and soil type a using multivariate PERMANOVA. We then employed non-metric multidimensional scaling to visualize patterns of variation in bird and butterfly community composition by treatment and soil type using the full data set .To further explore significant treatment × soil type interactions, we then generated NMDS plots using subsets consisting of only the grass plots for birds and only the forb-rich plots for butterflies

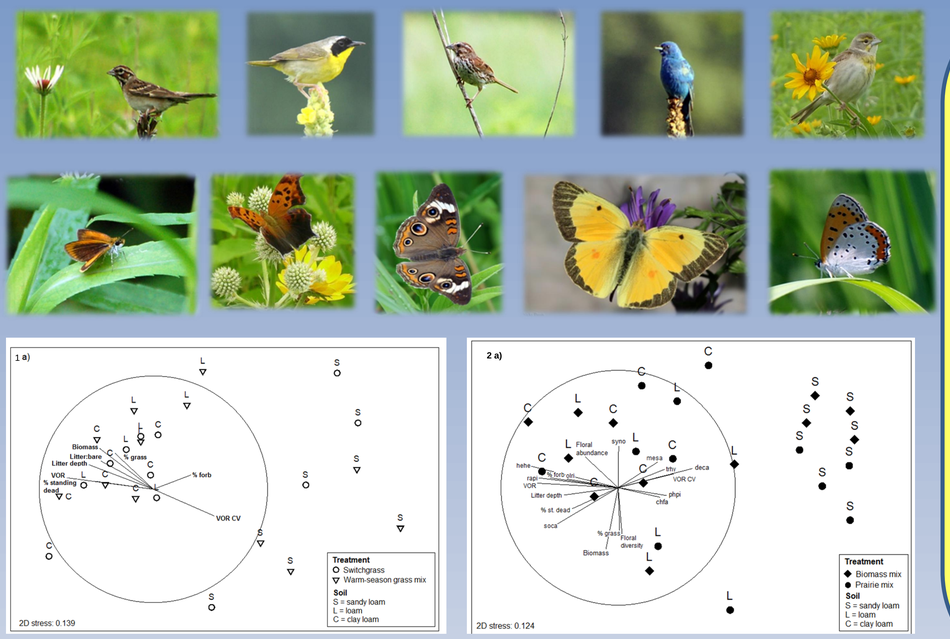
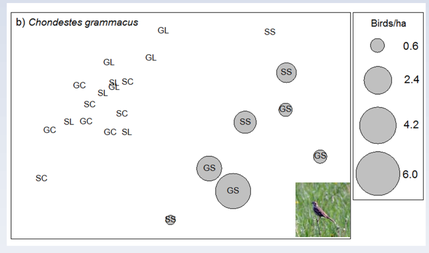
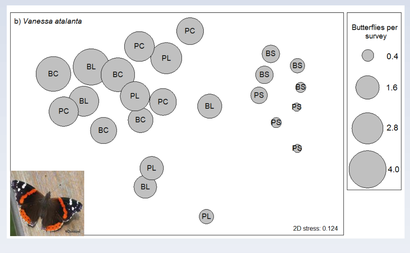
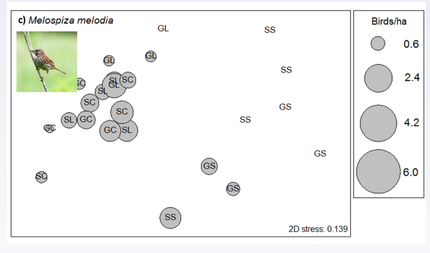


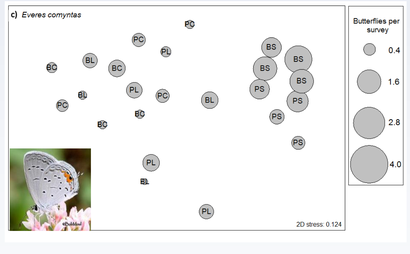
Figure 1) Non-metric multidimensional scaling (NMDS) of bird community composition in the 24 grass plots in. Vector overlays (a) depict Spearman correlations of individual habitat variables with the NMDS axes. Bubble plots illustrate differences in b) *Chondestes grammacus*, c) *Melospiza melodia*, d) *Cistothorus platensis*, and abundance by soil type. The first letter of the two-letter label refers to vegetation treatment: Sw = switchgrass, G = warm-season grass mix; the second soil type: S = sandy loam, L = loam, and C = clay loam.

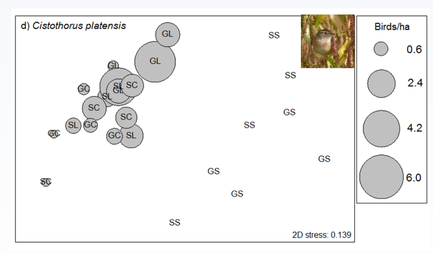
Figure 2) NMDS of butterfly community composition in the 24 forb-rich plots. Vector overlays (a) depict Spearman correlations of individual habitat variables with the NMDS axes. Four-letter codes indicate floral abundance of individual species: chfa = *Chamaechrista fasciculata*; deca = *Desmodium canadense*; hehe = *Heliopsis helianthoides*; olri = *Oligoneuron rigidum*; phpi = *Phlox pilosa*; rapi = *Ratibida pinnata*; soca = *Solidago canadense*; syno = *Symphyotrichum novae-angliae*; thry = *Trifolium hybridum*. Bubble plots illustrate differences in b)*Vanessa atalanta*, c) *Everes comyntas,* and d) *Desmodium canadense* abundance by soil type.

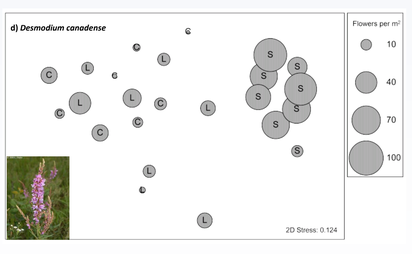












RESULTS

For both birds and butterflies, abundance and species richness was significantly greater in forb rich than grass plots, and there was no effect of soil. Soil affected the community composition of both groups of organisms in a significant treatment x soil interaction. (Figures 1 and 2)

Birds. We recorded 1,036 bird observations representing 22 species. Bird assemblages on sandy loam were dominated by species preferring open ground and sparse vegetation, whereas assemblages on loam and clay loam were dominated by birds preferring taller, more dense vegetation with abundant litter. (Figure 1)

Butterflies. We recorded sightings of 2,110 butterflies representing 31 species, and identified 54 forb species (17 treatment 37 non–treatment) in bloom during the 2010 growing season. In forb-rich plots, vegetation structure and individual plant expression varied greatly among soil types, and this variation affected butterfly community composition. (Figure 2)

CONCLUSIONS

Our study demonstrates that variation in edaphic characteristics generates habitat heterogeneity during grassland establishment in the absence of disturbance events. If particular animal species are being targeted for conservation, identifying soil types that will support the establishment and/or growth of plants in a manner that yields the particular habitat characteristics required by the target species should be a primary consideration in assessing and selecting potential sites for restoration and management. Our results also suggest that if unfertilized native prairie vegetation were cultivated as an agroenergy feedstock over large areas, underlying variation in topo-edaphic characteristics would generate habitat heterogeneity detectable by birds, butterflies, and other wildlife species, even if uniform management actions were applied at large spatial scales.

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