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Abstract

Conservation of wildlife in managed landscapes can be facilitated by partnering with livestock producers to introduce grazing disturbances. The effects of grazing in grassland systems, however, are often a function of other disturbances that may occur simultaneously. The goal of this study was to determine how grazing and flooding disturbances interacted to affect butterfly communities on wetland reserve program easements. We sampled butterflies from 2008-2011 in two large grassland habitats, one exposed to low density cow-calf grazing and one maintained as a control. Both grassland habitats were severely flooded in 2008. Repeated-measures ANOVA suggested that time since flooding and the interaction between flooding and grazing were important predictors of butterfly richness at these sites. Grazing may have delayed the post-flood recolonization by butterflies, but by 2011, the grazed system contained a slightly higher species richness of butterflies than the ungrazed system. The grazed and ungrazed grasslands converged in butterfly species composition over the course of four years. Our results suggest that grazing may be a useful tool for managing wetland reserve program easement habitats and that both flooding and grazing did not appear to have lasting negative impacts on butterfly communities at our sites.

The restoration of tallgrass prairie systems often benefits when unique partnerships can be developed to accomplish management goals (Rowe 2010). To that end, the use of low-density, controlled grazing as a tool during grassland restoration is an appealing way to engage cattle producers in the process of ecosystem management in working landscapes (Vallentine 2001). Grazing management has had rather equivocal outcomes when it is used to achieve restoration goals (Kruess and Tscharntke 2002). Grazing has been shown to influence plant density, thatch cover, floral heterogeneity, and, in some cases, animal communities, but not necessarily towards a particular goal (e.g., Pöyry et al. 2005, Öckinger et al. 2006, Reiner and Craig 2011). Specific outcomes resulting from the use of cattle as a restoration tool seem to depend on soil structure, composition of the seed bank, stocking density, duration of grazing, and other management tools being used simultaneously (see Collins and Steinauer 1998, Nelson et al. 2011). Effects of stocking density and variation among grazing strategies (e.g., flash grazing, mob grazing, or rotational grazing) are fairly well understood – grazing for too long or at too high a density shifts grassland composition toward annuals and can facilitate colonization by invasive species (Vermeire et al. 2008). The outcome of controlled grazing, however, seems to vary unpredictably when land managers fail to account for other disturbance

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regimes (Collins 1987). This may be especially true when precipitation varies toward either extreme and forage quality is diminished through drought or vegetation is degraded by prolonged inundation.

For land managers working to achieve restoration outcomes within agricultural landscapes, developing partnerships that use cattle as a management tool still has several appealing results (Rowe 2010). For instance, use of cattle to control invasive species or create habitat heterogeneity is a low cost, and preferable, alternative to herbicide application (Shindler et al. 2011). Herbicide application often carries significant risk of nontarget effects and is costly to apply over large areas (Russel and Schultz 2010). In addition, use of cattle to manage grassland systems in the Midwestern USA is not associated with the same level of negative perception as use of fire, which may inadvertently harm insects and nesting birds (Vogel et al. 2007). Furthermore, including neighboring livestock producers in the process of restoration is a powerful form of community engagement that builds support for regional conservation goals (Shindler et al. 2011). In states such as Iowa, however, grazing has received limited attention as a management tool because most publically available grassland systems occur in riparian corridors enrolled in the Wetland Reserve Program (WRP) or the Conservation Reserve Program. In the case of land enrolled in the WRP, grazing could only be considered as a potential management tool if clear linkages can be made to wildlife conservation (NRCS 2011). Success of grazing on WRP easements may be particularly difficult to measure given potential interactions with flood disturbances in riparian systems. Indeed, flood frequencies in the Midwestern United States appear to increasing in response to continued changes in land cover and global climate change (see Villarini et al. 2011), so measuring wildlife responses to both grazing and flooding will be critical when assessing wildlife conservation on WRP easements.

The goal of this study was to determine whether the use of cattle as a management tool to restore grassland on WRP easements had a positive effect on the butterfly community. Butterflies were selected as a focal species for study because they are relatively species rich in grassland systems, are easy to identify on wing, and respond to subtle changes in vegetation (because caterpillars are dependent on particular species of host plants). In addition, the Natural Resource Conservation Service considers butterflies to be a focal species group for conservation (M. Monk, *personal communication*). We hypothesized that cattle grazing would gradually reduce butterfly species richness within the grassland system as their foraging slowed the trajectory of secondary succession. Secondly, we predicted that the species assemblage found in the grazed grassland would diverge in composition compared to a control habitat. Here, we report the results of the first four years of what is intended to be a decade long-term research endeavor.

Materials and Methods

Our study was conducted in at Chichaqua Bottoms Greenbelt, Iowa (hereafter, CBG). Chichaqua Bottoms Greenbelt is a 3,000 ha grassland and wetland nature preserve located in south-central part of the state near the Wisconsinan glacial terminus, or the Des Moines Lobe physiographic region (41°46’22N 93°23’06W). Prior to settlement, the vegetation of CBG was primarily a mosaic of grassland and swamp white oak savanna, with wet mesic prairie and sedge meadows in glacial kettles and lowlands and more xeric prairie communities on sandy aeolian deposits. Draining of wetlands and mesic grassland habitats for row crop agriculture resulted in a loss of 98% of the original vegetation within CBG after settlement. Most prairie habitats currently present at the site reflect active restoration efforts to decrease cover of cool season grasses such as *Bromus inermis* Leyss. and *Phalaris arundinacea* L. and increase the prevalence of conservative tallgrass prairie grasses, sedges, and forbs (Rosburg 2001).

We performed our study within two tall grass prairie restoration sites within CBG (41°46'14"N, 93°23'47"W). Both prairies are enrolled in the Wetland Reserve Program, and both are < 2 km from the Skunk River. One of the prairie restorations (Bolton-Hay prairie) was fenced and used for cattle grazing (see Fig 1a) while the other (Miller prairie) was used as a control. We were unable to secure permission from the National Resource Conservation Service to allow grazing at more than one wetland reserve program easement over the lifecycle of this project. Our butterfly sampling transects, however, were each ≈300 m apart and we treated each as independent (e.g., see Summerville and Crist 2001). Both prairies were roughly equal in area (ca. 375 ha) and contained similar vegetation when the study was initiated in 2008. Big bluestem (*Andropogon gerardii* Vitman), switch grass (*Panicum virgatum* L.), and reed canary grass (*P. arundinacea*) were dominant graminoids in both sites and represented ≥ 80% cover prior to the onset of cattle grazing. Both sites were seeded in 1994-1997 using a mixture of native prairie seeds comprised of 5-6 grasses and 18 forbs. By 2000, the sites had converged in composition to a nearly complete bi-culture of big bluestem and indian grass (*Sorgastrum nutans* L.). Polk County Conservation Board made several efforts over the period 2000-2004 to hay each prairie to reduce graminoid biomass. After each cutting of hay, forbs were introduced by interseeding or direct planting of germinated stock. Haying appeared to reduce the cover of Indian grass but switch grass quickly replaced it as the co-dominant component of the vegetation at each site. The difficulty in creating floristic heterogeneity within these systems contributed heavily to the decision to try light grazing as a management tool. Neither site had been burned for at least six years and neither had a prior history of mowing management for four years prior to the onset of this experiment.

Each prairie was significantly impacted by major flooding in May and June 2008 (Fig. 1b for an image from the grazed prairie), resulting in 6 weeks of inundation and loss of upwards of 90% of the standing biomass (Lown, *unpublished data*). In mid-August 2008, 100 cattle (cow-calf pairs) were introduced to the Bolton-Hay system to test the hypothesis that grazing would have a negative impact on butterfly species within the wetland reserve program easement. Weekly sampling of the butterfly fauna in both the grazed and control prairies was initiated simultaneously. To assess butterfly diversity, we used standard Pollard transect sampling techniques (Pollard and Yates 1993). Eight transects were positioned randomly throughout both the grazed and ungrazed tall grass prairie restorations (Fig. 1a). Transects were walked each week on days when ambient air temperature exceeded 19°C and there was no precipitation and low wind speed. Species observed in flight, basking, or nectaring within the sampling transect were visually identified and recorded; species requiring detailed examination were vouchered and identified in the lab. We considered all species within 5 meters of the observer in all directions as "within a transect" (after Pollard and Yates 1993). We took deliberate effort to pair the timing of cattle introduction to Bolton-Hay prairie with the performance of butterfly sampling each year from 2009-11. Annually, 100 cow-calf pairs were introduced to the prairie in mid-May and removed in mid-September and transect walks occurred weekly over the grazing season. Transects in the control prairie were walked within one-two days of the grazed site. We present the results from four years of grazing data (2008-2011). Species nomenclature follows Schlicht et al. (2007).

We used a two-step analysis process to determine how the use of cattle grazing affected the butterfly communities at our sites. First, we used repeated measures analysis of variance to determine if butterfly species richness differed between the grazed prairie and the ungrazed prairie (df = 1), sampling year (df = 3), and the interaction between year and grazing (df = 3) (after Von Ende 2001). To determine species richness of butterflies, we pooled the butterfly data from each transect within each prairie (control vs. grazed). We did not weight species richness using measures of abundance because we cannot rule out double-counting of individuals within

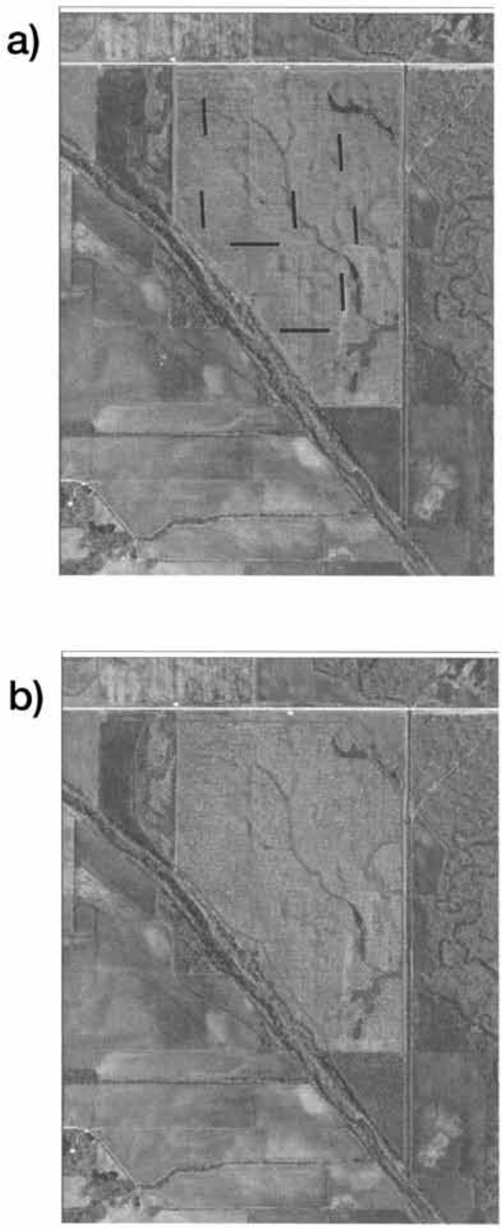

Figure 1. (a) Map of Bolton-Hay Prairie (41°46'14"N, 93°23'47"W), a 375 ha tall grass prairie reconstruction in which cattle were used to create early seral grassland habitats. Location of butterfly transects is shown (—). The control site (not shown) is just north. (b) Zone of inundation from a flood in 2008. Nearly all of Bolton-Hay prairie was submerged under 1-2 meters of water for 6 weeks.

Table 1. List of butterfly species sampled from grazed and ungrazed tallgrass prairie reconstructions within Chichaqua Bottoms Greenbelt, Iowa. Sampling occurred weekly from May – August 2008-2011.

Family	**Species**	**Present in grazed?**	**Present in ungrazed?**
Hesperiidae			
	Epargyreus clarus (Cramer)		X
	Pholisora catullus (F.)		X
	Ancyloxypha numitor (F.)	X	X
	Hylephila phyleus (Drury)	X	X
	Atalopedes campestris (Boisduval)		X
	Polites peckius (Kirby)	X	X
	Polites themistocles (Latreille)		X
	Euphyes dion (Edwards)		
Papilionidae			
	Papilio glaucus (L.)		X
	Papilio cresphontes (Cramer)		X
	Papilio polyxenes (F.)	X	X
Pieridae			
	Pieris rapae (L.)	X	X
	Pontia protodice (Boisduval & LeConte)		X
	Colias eurytheme Boisduval	X	X
	Colias philodice Godart	X	X
	Eurema lisa (Boisduval & LeConte)	X	X
Lycaenidae			
	Lycaena hyllus (Cramer)	X	X
	Lycaena dione (Scudder)	X	
	Everes comyntas (Godart)	X	X
	Strymon melinus (Hubner)		X
Nymphalidae			
	Danaus plexippus (L.)	X	X
	Euptoieta claudia (Cramer)		X
	Speyeria cybele (F.)	X	X
	Speyeria idalia (Drury)		X
	Boloria bellona (F.)	X	X
	Chlosyne gorgone (Hubner)		X
	Chlosyne nycteis (Doubleday & Hewitson)	X	
	Phyciodes tharos (Drury)	X	X
	Junonia coenia (Hubner)	X	X
	Polygonia interrogationis (F.)	X	
	Nymphalis antiopa (L.)	X	
	Vanessa atalanta (L.)	X	X
	Vanessa cardui (L.)	X	X
	Limenitis archippus (Cramer)	X	X

Table 2. Results of repeated measures analysis of variance model to test for year and treatment effects on butterfly species richness at Chichaqua Bottoms Greenbelt.

Response Variable	Source	df	MS	*F*	*P*
Butterfly species richness	Treatment (grazed vs. control)	1	5.06	2.33	0.15
	Error a[1]	14	2.17		
	Year	3	280.85	122.08	0.001
	Year×Treatment	3	29.43	12.80	0.001
	Error b[2]	42	2.30		

[1] Between-subject error from repeated measures ANOVA used to test main treatment effects (von Ende 2001).
[2] Within-subject error from repeated measures ANOVA used to test time effects (von Ende 2001).

each prairie on each sampling date (Vogel et al. 2007). Pooling of data among transects within each prairie is justified because transects were unlikely to be independent replicates of "prairie habitat" (e.g., see Piegorsch and Bailer 1997). Second, we used non-metric multidimensional scaling ordination to assess how species composition of butterflies changed within the two prairies over time. We used the Jaccard index of similarity as our ordination metric because it is based only on species presence or absence rather than proportional abundance (McCune and Grace 2002). Importantly, we were unable to replicate multiple prairies with comparable pre-grazing vegetation and comparable levels of flooding in 2008. In addition, as noted above, we were unable to secure permission to allow grazing at more than one site. We are careful; therefore, to limit the scope of our inferences to the single study system that is the concern of this research paper.

Results

A total of 34 butterfly species was observed over the 2008-11 sampling period (Table 1). Total species richness observed within the grazed prairie over the duration of this study was 22, whereas 29 total species were observed from the ungrazed prairie (Table 1). Regal fritillary (*Speyeria idalia* Drury), a prairie-specialist nymphalid listed as special concern in Iowa, was only observed within the ungrazed habitat. Additionally, the dion skipper (*Euphyes dion* Edwards), another relatively specialized, sedge-feeding species, was also found only from the ungrazed prairie in 2010 and 2011. Other species sampled only from the ungrazed habitat were represented by a single individual (e.g., *Papilio cresphontes* Cramer and *Pholisora catullus* F.). We did not detect any species of conservation concern from the grazed prairie, but this habitat supported large populations of late season butterflies which tend to colonize disturbed habitats, such as the little sulfur (*Eurema lisa* Boisduval and LeConte) and the buckeye (*Junonia coenia* Hubner) in 2009 and 2010.

Species richness of butterflies was significantly different among sampling years and between grazed and ungrazed prairies in some years but not others (Table 2). In the immediate aftermath of the early 2008 flooding, butterfly species richness was very low in both grazed and ungrazed prairies. Species richness of butterflies rebounded over the interval 2009-2011, with increases in observed species richness occurring relatively quickly in the ungrazed prairie (Fig. 2). In 2008, a total of 4 species were observed across all sampling transects in the ungrazed prairie. In 2009, the number of species observed had grown to an average of seven *per transect* (for a total of 15 from the entire ungrazed habitat). Grazing was correlated with what appeared to be a slower post-flood recovery of the butterfly fauna in 2009 (Fig. 2). Specifically, ungrazed prairie transects contained, on average, twice as many species as transects in grazed prairie. By 2010, differences among the two prairies had disappeared, and by 2011 the highest species richness observed per transect was within the grazed prairie habitat (Fig. 2). Importantly, the average species richness of butterflies within the grazed habitats was progressively and significantly higher over the four-year sampling interval ($F = 122.08$, df = 3, $P < 0.001$).

The non-metric multidimensional scaling ordination required two ordination axes to significantly reduce the stress (i.e., variance) in the data. The first ordination axes reduced the stress in the data to an average of 27.4 ($P < 0.01$), and the second reduced stress by a smaller amount, 5.6 ($P \leq 0.03$). Combined, these axes reduced the stress in the data by 89.6%. The ordination suggested that butterfly assemblages converged to a similar species composition two years after the flooding of 2008 (Fig. 3). Butterfly assemblages were fairly different in 2008 and 2009, but there did not appear to be a major effect of grazing on butterfly species composition. Rather, butterflies appeared to opportunistically colonize prairies post-flooding. For example, immediately after flooding, the only species of butterflies present in either habitat were cabbage white (*Pieris rapae* L.), the clouded sulfur (*Colias philodice* Godart), the orange sulfur (*Colias eurytheme* Boisduval), the least skipper (*Ancyloxpha numitor* F.), and the monarch (*Danaus plexippus* L.). These species share a combination of traits; they are regionally abundant, feed upon ruderal host plants, and have a large capacity for dispersal.

Discussion

Flooding clearly had a significant, negative effect on butterflies in both the grazed and the ungrazed prairie WRP easements. Importantly, the vegetation in what would become the grazed prairie did not really "recover" from flooding until mid-2009, and at that point, plants had been exposed to 4 months of cattle grazing (two months at the end of 2008 and 2 months in early summer 2009). Given this set of circumstances, we would have expected to have seen significant impoverishment of butterfly richness in the grazed system for the duration of this experiment (Joy and Pullin 1999, Schtickzelle et al. 2007). Instead, we revealed a pattern of immediate species impoverishment post-flood, followed by gradual increases in richness within both grasslands. The differences in butterfly composition between the two prairies in 2008 and 2009 (Fig. 3) may thus be more attributable to quicker post-flood recolonization by species in the ungrazed prairie, which experienced a relatively quick re-vegetation in the absence of cattle. Therefore, cattle may have influenced the speed of post-flood plant recovery and butterfly recolonization, but grazing did not appear to create a different butterfly community *per se*.

We attribute the relatively weak effect of grazing on butterflies (and the rather speedy post-flood recovery in both grasslands) to be attributable to the large portion of undisturbed grassland in the surrounding landscape. Chichaqua Bottoms is ≈ 7500 ha in total area, and only 33% of the total preserve was flooded. No additional habitat within the preserve was grazed. Studies of the effects of grazing on butterflies in Europe suggest that cattle can increase butterfly diversity within a habitat provided that the landscape contains potential colonists (e.g., donor pools) (Kreuss and Tscharntke 2002). Grazing and flooding appear to have the most long-term community effects when habitats are isolated from neighboring patches (e.g., Schtickzelle et al. 2007). It will be illuminating to determine if the patterns in butterfly species richness and community composition reported here persist over additional sampling years. Because cattle appear to be browsing heavily on cottonwood seedlings (*Populus deltoids* Bartram ex. Marsh), willows (*Salix* spp.), big bluestem, and switch grass (Thomas Rosburg,

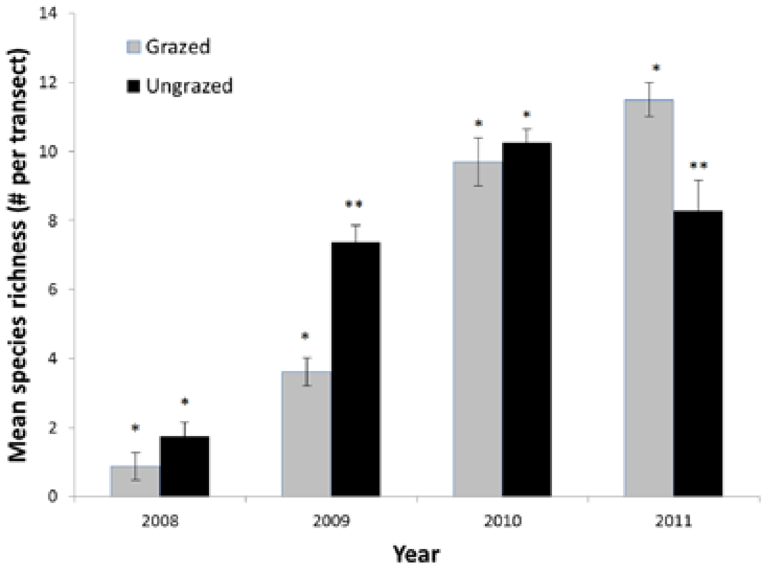

Figure 2. Annual variation in butterfly species richness (2008-2011). Butterflies were sampled from eight transects within two large tall grass prairie reconstructions. Species richness was higher in the ungrazed prairie one year after flooding, but was lower in the ungrazed prairie in 2011. Means within each sampling year that are flagged with differing (*) are significantly different ($P \leq 0.001$).

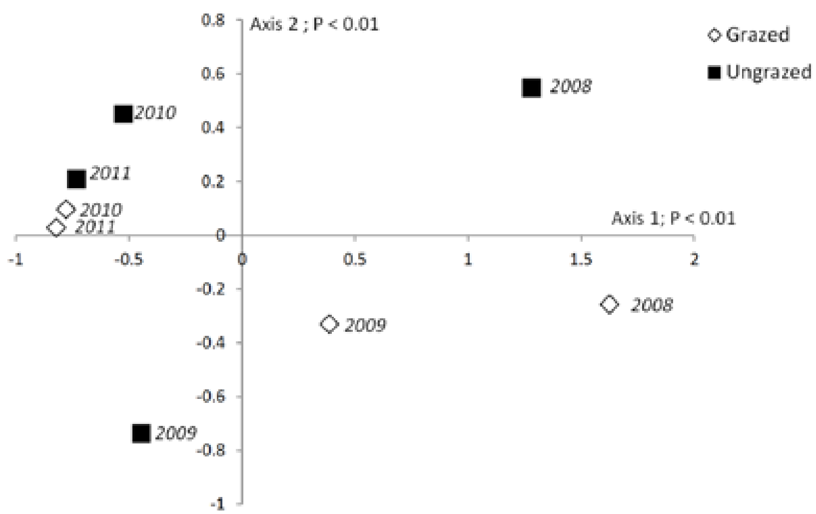

Figure 3. Results of non-metric multidimensional scaling analysis of butterfly communities sampled from two large tall grass prairie reconstructions in 2008-2011. Two ordination axes were determined to be significant ($P \leq 0.05$). Although species composition was very different post-flooding (2008), butterfly assemblages converged in species representation in grazed and ungrazed prairies.

unpublished data), it seems unlikely that continued low-intensity grazing would suddenly reduce butterfly diversity. Rather, as early seral plants colonize exposed soil surfaces where cattle have trampled vegetation or wallowed, we expect additional species to be recorded in the grazed area.

In contrast, butterfly diversity is expected to continue to decline as thatch cover increases in the ungrazed habitat. By 2011, the thatch cover attributable to reed canary grass and big bluestem was ≈ 95% of the standing biomass in the ungrazed prairie. This post-flood recovery to a near two-species system suggests that passive management in response to flooding disturbance may not be an option on WRP easements. Interestingly, other studies are emerging that suggest a similar theme: some active management to maintain habitats in an early seral state will be critical to achieving conservation goals (Konvicka et al. 2008). The potential for decreasing species richness over time in the ungrazed prairie (which is suggested by the pattern in Fig. 2) should be disturbing to land managers in the Midwest, where upwards of two-thirds of the wetland reserve program easements occur in the 100 year floodplain of rivers. Given that there is evidence that flood frequency is increasing in the Midwest (Villarini et al. 2011), the ability to achieve restoration outcomes in post-flooded grasslands may be difficult to achieve *without* using tools such as light grazing (Konvicka et al. 2008). Additional years of data, including an analysis of plant responses to cattle grazing, will help us create a series of recommendations for how land managers can set goals for the use of low-density grazing and how they can assess the effectiveness of cattle in creating habitat heterogeneity within otherwise homogeneous tall grass prairie restorations.

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Literature Cited

Collins, S. L. 1987. Interactions of disturbances in a tallgrass prairie. Ecology 68: 1243-1250.

Collins, S. L., and E. M. Steinauer. 1998. Disturbance, diversity, and species interactions in tall grass prairie, pp. 140-158. *In* A.K. Knapp, J.M. Briggs, D.C. Hartnett and S.L. Collins, S.L. (eds.). Grassland Dynamics. Oxford University Press, London, UK.

Joy, J., and A. S. Pullin. 1999. Field studies on flooding and survival of overwintering large heath butterfly *Coenomympha tullia* larvae on Fenn's and Whixall mosses in Shropshire and Wrexham, UK. Ecological Entomology 24: 426-431.

Konvicka, M., J. Benes, O. Cizek, F. Kopecek, O. Konvicka, and L. Vitaz. 2008. How too much care kills species: grassland preserves, agri-environmental schemes, and extinction of *Colias myrmidone* (Lepidoptera: Pieridae) from its former stronghold. Journal of Insect Conservation 12: 519-525.

Kruess, A., and T. Tscharntke. 2002. Grazing intensity and the diversity of grasshoppers, butterflies, and trap-nesting bees and wasps. Conservation Biology 16: 1570-1580.

McCune, B., and J. B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach, OR.

(NRCS) Natural Resource Conservation Service. 2011. The Wetland Reserve Program: statues and guidelines. United States Department of Agriculture, Washington, DC.

Nelson, K. S., E. M. Gray, and J. R. Evans. 2011. Finding solutions for bird restoration and livestock management: comparing grazing exclusion levels. Ecological Applications 21: 547-554.

Ö**ckinger, E., A. K. Eriksson, and H. G. Smith. 2006.** Effects of grassland abandonment, restoration, and management on butterflies and vascular plants. Biological Conservation 133: 291-300.

Piegorsch, W. W., and A. J. Bailer. 1997. Statistics for environmental biology and toxicology. Chapman and Hall Press, London, UK.

Pollard, E., and T. J. Yates. 1993. Monitoring butterflies for ecology and conservation. Chapman and Hall Press, London, UK.

Pöyry, J., S. Lindgren, J. Salminen, and M. Kuussaari. 2005. Response of butterfly and moth species to restored cattle grazing in semi-natural grasslands. Biological Conservation 122: 465-478.

Reiner, R., and A. Craig. 2011. Conservation easements in California blue oak woodlands: testing the assumption that livestock grazing as a compatible use. Natural Areas Journal 31: 408-413.

Rosburg, T. R. 2001. Iowa's prairie heritage: from the past, through the present, and into the future. Proceedings of the 17th annual North American Prairie Conference 17:1-14.

Rowe, H. I. 2010. Tricks of the trade: techniques and opinions from 38 experts in tallgrass prairie restoration. Restoration Ecology 18: 253-262.

Russell, C., and C. B. Schultz. 2010. Effects of grass-based herbicides on butterflies: an experimental investigation to advance conservation efforts. Journal of Insect Conservation 14: 53-63.

Schlict, D. W., J. C. Downey, and J. C. Nekola. 2007. Butterflies of Iowa. University of Iowa Press, Iowa City, IA.

Schtickzelle, N., C. Turlure, and M. Baguette. 2007. Grazing management impacts on the viability of the threatened bog fritillary butterfly *Proclossiana eunomia*. Biological Conservation 136: 651-660.

Shindler, B., R. Gordon, M. W. Brunson, and C.Olsen. 2011. Public perceptions on sagebrush ecosystem management in the great basin. Rangeland Ecology Management 64: 335-343.

Summerville, K. S., and T. O. Crist. 2001. The effects of habitat fragmentation on patch use by butterflies and skippers (Lepidoptera). Ecology 82: 1360-1370.

Vallentine, J. F. 2001. Grazing management. Academic Press, Inc., New York. 673 p.

Vermeire, L. T., R. K. Heitschmidt, and M. R. Haferkamp. 2008. Vegetation responses to seven grazing treatments in the Northern Great Plains. Agriculture Ecosystems and Environment 125: 111-119.

Villarini, G., J. A. Smith, M. L. Baeck, and W. F. Krajewski. 2011. Examining flood frequency distributions in the Midwest USA. Journal of the American Water Research Association 47: 447-463.

Vogel, J, A., D. M. Debinski, R. R. Koford, and J. R. Miller. 2007. Butterfly responses to prairie restoration through fire and grazing. Biological Conservation 136: 732-740.

Von Ende, C. N. 2001. Repeated-measures analysis: growth and other time-dependent measures, pp. 134-157. *In* S.M. Scheiner and J. Gurevitch (eds.). Design and Analysis of Ecological Experiments, 2nd edition. Oxford University Press, London, UK.