Tillers 2003, **4**, 15-19

The Effects of Burning and Mowing on Soil Moisture, Soil pH, and Percent of Carbon and Nitrogen in Soil and *Andropogon gerardii*

JULIE EDWARDS, MICHELLE GILES, and CLAIRE TINDAL
Biology Department, Grinnell College, Grinnell, IA 50112

Abstract

As restoration of prairies has become popular, scientists have begun studying the natural occurrences, such as fire and grazing, on prairies and developing management plans that include these natural processes. However, some debate remains over which management techniques are the most productive. In order to understand the consequences of different management techniques for prairies, we examined the effects of spring burning and midsummer mowing on soil moisture, soil pH, and the percent of carbon and nitrogen in soil and in the roots and rhizomes of Andropogon gerardii *(Big Bluestem) on experimental reconstructed prairie. While our results were not significant, past studies have shown these treatments to have significant effects on prairie ecosystems.*

Introduction

Fire has historically been a component of the prairie ecosystem. Recurrent fire reduces the amount of litter, allowing more light to reach the plants earlier in the year, and thus increases photosynthetic activity. Furthermore, periodic fire prevents the invasion of woody species (Briggs and Knapp 1995). Therefore, fire is a main factor in determining the vegetation of the prairie. Fire also affects prairie soil. By removing litter, fire allows more sunlight to reach the soil, increasing its temperature, and allowing more air to circulate near the ground and evaporate soil moisture (Reichman 1987; Briggs and Knapp 1995). In addition, soil pH is affected by burning. The ash produced by the fire is basic, which would increase the pH (Tester 1989). Burning also affects the amount of nutrients in the soil and plants by increasing the rate of nutrient cycling. The decomposition of detritus that would take several years by microbes is accomplished by fire in seconds (Reichman 1987).

Grazing has also been found to have important effects on the prairie. Grazing mammals create heterogeneity in the ecosystem, which allows for increased biodiversity. Since large herbivores are selective eaters, they create vegetative patches. Grazers prefer to eat dominant grasses, which encourages the growth of subdominant species, such as forbs (Vinton et al 1993; Knapp et al 1999). Soil is also affected by grazing mammals. The decomposition of dead grazers as well as their excrement adds nutrients, such as carbon and nitrogen, to the soil (Knapp et al. 1999). The urea of grazers may also affect the soil by decreasing the pH (Kelting1954). Also, grazing influences the amount of nutrients in the belowground tissue of grasses because they overcompensate for the loss of tissue by translocating nutrients from the roots to aid in increased growth (Reichman 1987).

Due to the importance of these processes, prescribed burning, the introduction of grazers, or a combination of these practices have been utilized by various conservationists (Howe 1994). In some cases, grazing is not a viable practice and thus simulations such as mowing are implemented. While the effects of mowing are similar to grazing they differ in some important ways. Mowing increases the moisture in soil because the resulting debris decreases the amount of sunlight able to reach the soil and the amount of air circulation. Unlike grazing, mowing has no effect on pH because mowing does not involve the excrements of grazing mammals. Mowing has no effect on soil nutrients because, again, this process lacks the benefits of mammal excrements and corpse decomposition. However, mowing, like grazing, affects the amount of nutrients in the root and rhizomes of grasses because, after mowing, the plants translocate nutrients to aboveground tissue (Reichman 1987).

Although much is known about the effects of mowing, grazing and burning on the prairie, scientists are still debating which technique, or combination of techniques, results in the most productive prairie. To address this issue, we decided to study several factors that effect prairie net primary productivity. We tested soil moisture, soil pH, and the percent of carbon and total nitrogen in soil and in the roots and rhizomes of *Andropogon geradii* (Big Bluestem) in burned, mowed, burned and mowed, and

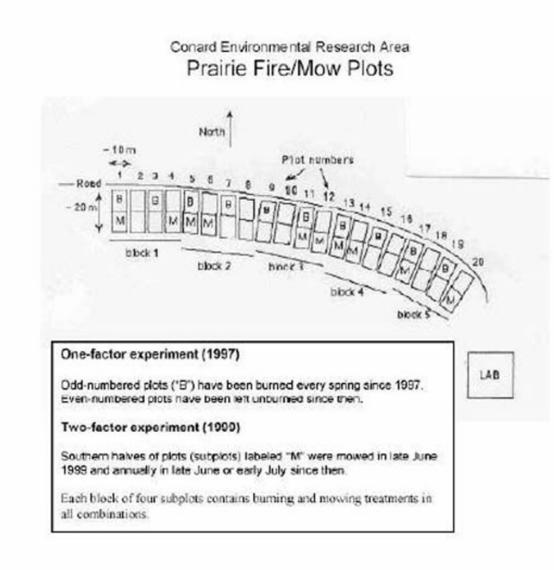

Figure 1 –Experimental Design

untreated plots at a restored prairie. We decided to sample *A. gerardii* because it is a dominant grass that defines the tallgrass prairie (Reichman 1987). Soil moisture is a limiting factor in productivity because it is necessary for photosynthesis (Turner et al. 1997). Soil pH is limiting as it affects the solubility of many nutrients that are important to the plants. Also, if pH is not in an optimal range, toxic compounds can be released from the soil (Raven and Berg 2001). Carbon and nitrogen in soil and in plant roots and rhizomes are important to plant growth since they are essential components of many organic compounds used to build new tissue.

Methods

We conducted our experiment from October 8th, 2003 to November 24th, 2003. We used the 20 two-factor (burning and mowing) 10 m by 10 m experimental plots at Conard Environmental Research Area (CERA). Every other was burned each spring since 1997 and 10 randomly designated plots were mowed annually in late June since 1999. Plots were arranged in blocks, so that each block had one plot of each treatment (Figure 1).

In each plot, we determined a random point and took a 10 cm sample of soil using a soil corer. Then we found the specimen of *Andropogon gerardii* that was closest to the random point and unearthed a sample of the roots and rhizomes of the plant.

After collection, the soil samples were weighed, dried, and weighed again to determine the soil moisture. Five grams of the dried soil was ground up, mixed and dissolved in 5 mL of distilled water to determine the soil pH for each plot. Soil carbon and nitrogen was determined from a ~20 mg finely ground sample using a ThermoFinnegan C/N Analyzer. Identical procedures were used to find percent carbon and nitrogen for ~5 milligram samples of the roots and rhizomes of *Andropogon gerardii*.

We used an analysis of variance (ANOVA) test to determine if there are any significant effects of block burning, mowing or their interaction on the amount of soil moisture, on soil pH, and the percent of carbon and nitrogen in soil and in the roots and rhizomes of *A. gerardii*.

Results

We did not find any significant effects for any of the treatments (Tables 1-2, Figures 2-9). However, the burn effect was marginally nonsignificant for root carbon content (p= .055, Table 1), with unburned plots displaying higher content (Figure 4). There were no significant block effects (F-values not shown).

Discussion

While we did not find burning or mowing to have any significant effects, many studies in the past have found significant effects for these treatments. Our lack of significance could be the result of many factors. One general explanation is our small sample size; we only had 5

Table 1 - ANOVA Results: Roots of Andropogon gerardii

Variable	*Treatment*	*F*	*P-value*
% Carbon - Roots	burned	4.27	0.055
	mowed	0.16	0.699
	burned x mowed	0.89	0.36
% Nitrogen - Roots	burned	2.08	0.168
	mowed	1.99	0.178
	burned x mowed	0.89	0.36
Ratio of C/N	burned	0.76	0.395
	mowed	1.43	0.249
	burned x mowed	0.04	0.839

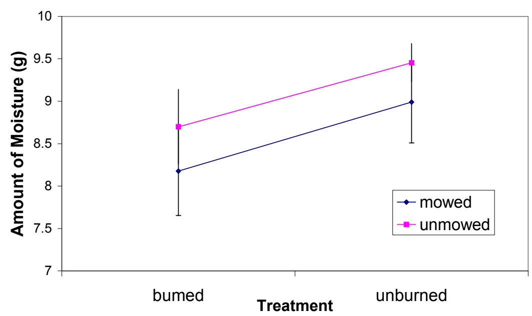

Figure 2 - Mean Soil Moisture Two-Factor Experimental Plots at CERA (+/- 1 SE). There were no significant effects.

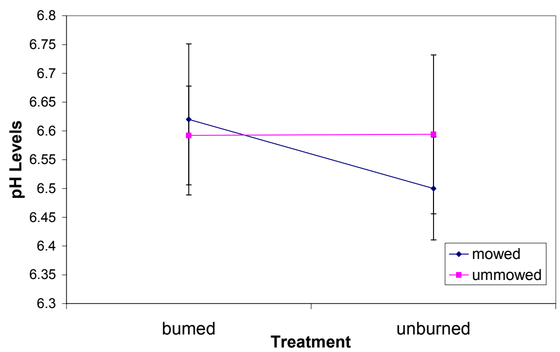

Figure 3 - Mean Soil pH for two-factor experimental plots at CERA (+/- 1 SE). There were no sigificant effects.

Table 2 - ANOVA Results: Soil

Variable	*Treatment*	*F*	*P-Value*
% Carbon - Roots*	burned	0.76	0.397
	mowed	0.07	0.8
	burned x mowed	0.04	0.845
% Nitrogen - Roots*	burned	0.86	0.367
	mowed	0.19	0.666
	burned x mowed	0.06	0.814
Ratio of C/N	burned	0.49	0.496
	mowed	0.01	0.944
	burned x mowed	0.12	0.73
Soil Moisture	burned	2.03	0.174
	mowed	0.8	0.384
	burned x mowed	0	0.958
Soil pH	burned	0.27	0.61
	mowed	0.08	0.775
	burned x mowed	0.29	0.598

replicates for each treatment. Each specific characteristic studied was also influenced by various other factors.

We did not find any significant differences in soil moisture. However, Briggs and Knapp (1995) found burning to reduce soil moisture and Kelting (1954) found grazing to have no effect on soil moisture. Thus, we expected to find lower moisture on the burned plots for both mowed and unmowed. However, since our plots were burned in the spring when drying is reduced due to snow melts and rain showers, the differences in the amount of soil moisture between the burned and unburned plots were reduced (Reichman 1987). Another factor that may have influenced our data was the rain shower preceding our data collection.

Our results indicate only minuscule differences in pH for any of the treatments. While we did not find any significant differences in pH, past studies indicate that pH should have been affected by our treatments. Tester (1989) found that fire increases soil pH because of the basic ash, and Kelting (1954) found that grazing decreases pH. Thus, we expected to find the highest pH on burned, unmowed plots and the lowest on the unburned, mowed plots. Our results may be due to the fact that our plots were mowed and not grazed. Mowing lacks the presence of animals associated with grazing, and it is these animals' excrements that alter the pH.

We found no significant differences in the percent of carbon and nitrogen in soil or in the roots and rhizomes of *A. gerardii*. We expected burning to increase the amount of nutrients in the soil because it causes increased rates of nutrient cycling, but decrease the amount of nutrients in the roots and rhizomes, because the plant would translocate nutrients from the roots to the aboveground tissue after burning. A possible reason for why we did not find significant effects for our burn treatments is because of the frequency of burning at CERA. Since the plots are burned less than two years apart, the amount of nutrients consumed by the fire is greater than the amount released by the increased rates of nutrient cycling (Reichman, 1987). Also, since we did our sampling in the fall, *A.gerardii* was translocating nutrients back to its roots to prepare for winter, which would decrease the original displacement of nutrients due to burning.

We expected mowing to have no effect on the amount of nutrients in the soil which our results support. However, if we had tested grazing instead of mowing we would have

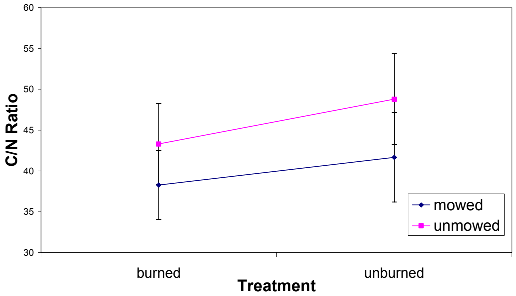

Figure 4 - Mean ratio of percent carbon to percent nitrogen in roots and rhizomes in Andropogon gerardii (+/- 1 SE). There were no significant effects.

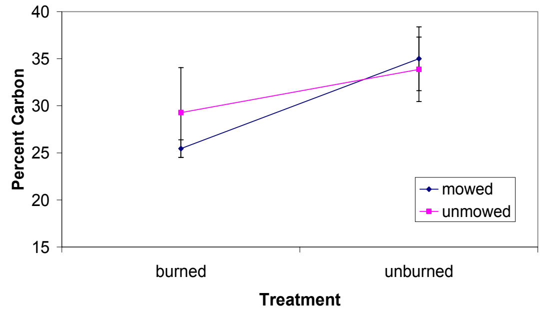

Figure 5 - Percent Carbon in roots and rhizomes of Andropogon gerardii (+/- 1 SE). There were no significant

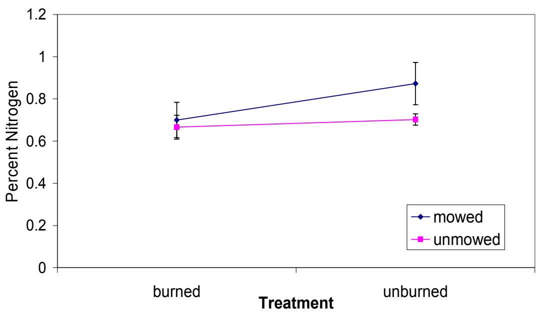

Figure 6 - Percent Nitrogen in roots and rhizomes of Andropogon gerardii (+/- 1 SE). There were no significant effects.

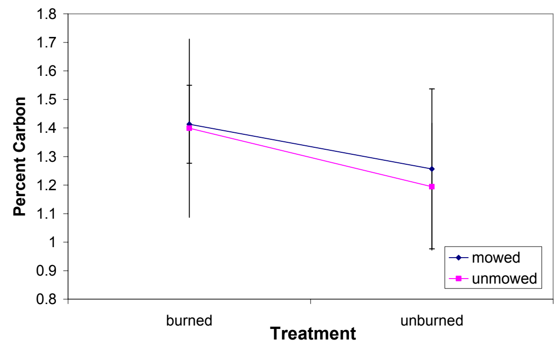

Figure 7 - Percent Carbon in Soil (+/- 1 SE). There were no significant

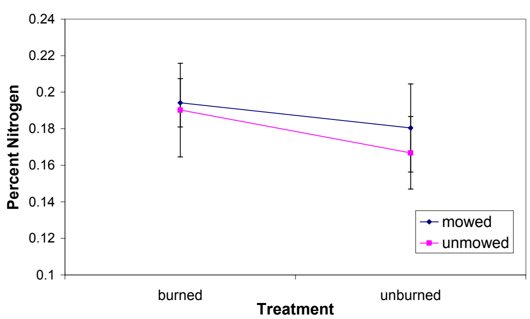

Figure 8 - Percent Nitrogen in Soil (+/- 1 SE). There were no significant effects.

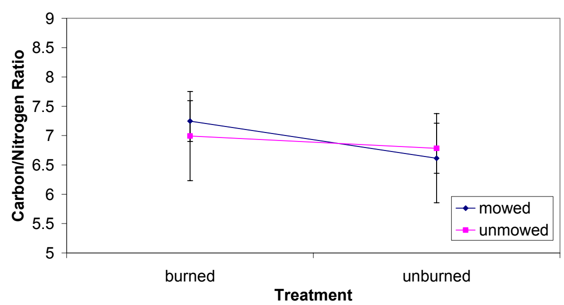

Figure 9 - Mean Ration of Carbon to Nitrogen in Soi at CERA (+/- 1 SE). There were no significant effects.

expected grazing to increase the amount of nutrients in the soil largely due to the presence of grazing mammals and the added nutrients from their excrements and decomposing carcasses (Risser 1982; Knapp et al. 1999). Mowing should have decreased the amount of nutrients in the below ground plant tissue due to the plants translocation of these nutrients from the roots in response to mowing, but our results did not support this. This may be due, again, to the translocation of nutrients to the roots and rhizomes that was occurring at the time of our sampling.

C/N ratio is an important indicator of root tissue quality in plants. Past studies state a smaller ratio of carbon to nitrogen occurs on the most productive plots (Callaham 2002). Therefore, we expected to find the plot with the lowest C/N ratio in *A. gerardii* roots and rhizomes to indicate the most productive plot. However, since the differences in our data were nonsignificant, we cannot determine which treatment results in the most productive prairie.

The reasons why we did not find any significant differences in the C/N of *A. gerardii* roots and rhizomes are the same as the reasons why we found no significant differences in the amount of nutrients in the roots and rhizomes. Since we collected our data in the fall when prairie grasses are translocating nutrients belowground in preparation for the winter, the differences in the amount of nutrients due to our treatments is diminished. Also, nutrient content in roots and rhizomes depends on the amount of nutrients in the soil, which also did not differ among treatments.

In conclusion, we could not determine which management technique results in the most productive prairie. Additional studies should focus on the effects of treatment frequency, season of treatment, and season of data collection. Furthermore, studies that consider the effects of these treatments on biodiversity should also be conducted because productivity is only one aspect of prairie health. A prairie with high productivity may be a prairie dominated by only a few species. Likewise, a prairie with high biodiversity may not have substantially higher productivity than a prairie with moderate biodiversity (Freeman 2002). Thus, a successful prairie management strategy should include practices that result in a balance between productivity and biodiversity.

Acknowledgments

We would like to thank Sue Kolbe for her assistance and guidance in the lab and Peter Jacobson for aiding us with the C/N analyzer. Also, we would like to thank Professor Brown for helping develop and conduct our experiment.

Literature Cited

Briggs, J.M., and A.K. Knapp. 1995. Interannual variability in primary production in tallgrass prairie: climate, soil moisture, topographic position, and fire as determinants of aboveground biomass. *American Journal of Botany* 82(8): 1024-1030.

Callaham, M.A., M.R. Whiles, and J.M. Blair. 2002. Annual fire, mowing, and fertilization effects on two cicada species (Homoptera: Cicadidae) in tallgrass prairie. *American Midland Naturalist* 148(1):90-101.

Freeman, S. 2002. Biological science volume 2: evolution, diversity, and ecology. Prentice Hall. Upper Saddle River.

Howe, H.F. 1994. Managing species diversity in tallgrass prairie: assumptions and implications. *Conservation Biology* 8(2): 691-704.

Kelting, R.W. 1954. Effects of moderate grazing on the composition and plant production of a native tall-grass prairie in central Oklahoma. *Ecology* 35(2): 200-207.

Knapp, A.K., J.M. Blair, J.M. Briggs, S.L. Collins, D.C. Hartnett, L.C. Johnson, and E.G. Towne. 1999. The keystone role of bison in north American tallgrass prairie: bison increase habitat heterogeneity and alter a broad array of plant, community, and ecosystem processes. *BioScience* 49(1): 39-49.

Raven, P.H., and L.R. Berg. 2001. Environment, 3rd edition. Harcourt College Publishers, Fort Worth.

Reichman, O.J. 1987. Konza prairie: a tallgrass natural history. University Press of Kansas, Lawrence, KS.

Risser, P.G., and W.J. Parton. 1982. Ecosystem analysis of the tallgrass prairie nitrogen cycle. *Ecology* 63(5): 1342-1351.

Tester, J.R. 1989. Effects of fire frequency on oak savanna in east-central Minnesota. *Bulletin of the Torrey Botanical Club* 116(2): 134-144.

Turner, C.L., J.M. Blair, R.J. Schartz, and J.C. Neel. 1997. Soil N and plant responses to fire, topography, and supplemental N in tallgrass prairie. *Ecology* 78(6): 1832-1843.

Vinton, M.A., D.C. Hartnett, E.J. Finck, and J.M. Briggs. 1993. Interactive effects of fire, bison (*Bison bison*) grazing and plant community compostition in tallgrass prairie. *American Midland Naturalist* 129(1): 10-18.