Fire and nutrient cycling in shortgrass steppe of the southern Great Plains, USA

P.L. Ford[1] and C.S. White[2]
[1]*USDA Forest Service, Rocky Mountain Research Station, Albuquerque, New Mexico, Email: plford@fs.fed.us,*
[2]*University of New Mexico, Albuquerque, New Mexico, USA*

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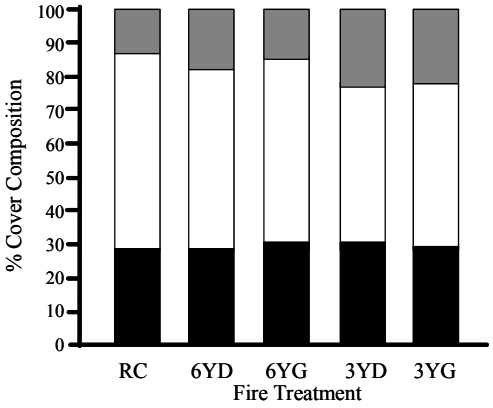
Introduction Fire in semi-arid grasslands releases nutrients bound up in organic matter and accelerates the rate of decomposition in the soil. This research experimentally tested effects of season and frequency of fire on nutrient cycling dynamics in shortgrass steppe. The objective was to identify if fire treatments have the ability to increase potential grassland productivity relative to untreated 'reference condition' grassland. Many such studies focus on short-term, direct effects of fire. However, this study is part of a long-term, 18-year study examining both direct, and indirect effects of fire in the growing *vs.* dormant season at return intervals of 3, 6 and 9 years.

Materials and methods The study is located in semi-arid shortgrass steppe in the southern Great Plains of northeastern New Mexico, USA (36º 31' 20" N, 103º 3' 30" W). The never-ploughed, ungrazed, 160-ha site has mostly native vegetation with the sod-forming *Buchloë dactyloides* and the bunchgrass *Bouteloua gracilis* being the dominant plant cover. The experimental design was completely randomised with 5 treatments and 5 replicate 2-ha plots per treatment. Treatments were 3–year dormant- (3D) and growing-season (3G) burn cycles (twice burned), 6-year dormant- (6D) and growing-season (6G) burn cycles (burned once), and unburned, reference condition (RC) plots. The first two rounds of treatments were applied in 1997 and 2000 with measurements taken during the drought year of 2003. Response variables included % bare ground, litter and live perennial grass cover, soil organic matter content, pH, sodium adsorption ration, field available nitrogen (N) as nitrate and ammonium, potentially mineralisable N (PMN), and other soil and plant nutrients.

Results The only suggested difference in cover variables among treatments ($p = 0.07$) was between the unburned (RC) plots with a mean of 60% litter cover and the 3-year dormant-season (3D) fire treatment with a mean of 46% litter cover (Figure 1, Table 1). There were significant differences in the levels of boron, calcium, and sodium in vegetation among treatments, but no generalities could be made regarding fire effects. Depending on the frequency, fire can either increase or deplete soil nutrients. The main differences among soil variables occurred between the 6D and 3D fire treatments (Table 1). When differences were suggested, the 6D treatment always had a significantly higher mean than 3D ($p = 0.06$), but did not significantly differ from the other treatments (Table 1 and Figure 1). In addition, ammonium was significantly higher in 6D than in RC.

Table 1 Tukey's Studentised Range Test means (values the same letter are not significantly different (alpha = 0.10))

Grouping		Mean (SD)	n	Treatment
Litter %	A	60 (1)	5	RC
	AB	54 (5)	5	6G
	AB	54 (8)	5	6D
	AB	49 (9)	5	3G
	B	46 (10)	5	3D
PMN:	A	41 (8)	5	6D
Nitrate	AB	36 (6)	5	RC
µg/kg	AB	35 (6)	5	6G
	AB	32 (4)	5	3G
	B	30 (2)	5	3D
PMN:	A	0.70 (.09)	5	6D
Ammonium	AB	0.52 (.13)	5	3G
µg/kg	AB	0.51 (.07)	5	6G
	B	0.49 (.19)	5	RC
	B	0.47 (.10)	5	3D



Live grass cover (black), Litter (white), Bare ground (grey)

Figure 1 Ground cover by treatment

Conclusions The current results of this long-term study suggest that in semi-arid grasslands a 3-year fire frequency (burned twice in 6 years), regardless of season, may be too short, and may cause a greater loss of litter and limiting N resources, than other frequencies. The 6-year dormant-season fire (i.e. burned once in 6 years), is the only fire treatment that shows the potential for increased site production relative to 'reference condition' unburned grassland.