Utilizing Patch Burning to Enhance Vegetation Management in the Southern Great Plains

Morgan L. Russell[1]
Charles A. Taylor, Jr.[2]
Cody B. Scott[3*]
Ethan R. Frierson[4]

[1]*Assistant Professor, Department of Ecosystem Science and Management, Texas A&M AgriLife Research and Extension Center, San Angelo, Texas 76901*
[2] *Professor, Texas A&M AgriLife Research and Extension Center, Sonora, Texas 76950*
[3]*Professor, Department of Agriculture, Angelo State University, San Angelo, Texas 76909*
[4]*Former Graduate Student, Angelo State University, San Angelo, Texas 76909*

ABSTRACT

Prescribed burning and livestock grazing can increase plant diversity by reducing the competitive ability of some invasive plants. The research objectives of this study were: 1) to quantify vegetation response to patch burning and livestock grazing, 2) to determine cattle grazing distribution patterns following patch burning, and 3) to quantify body weight performance of grazing heifers following patch burning. Ten percent of 3 pastures (roughly twelve ha) was patch-burned in March of 2015. The remaining 3 pastures were not patch burned. All pastures were exposed to cattle grazing at a moderate stocking rate. Vegetation response (cover, density, and herbaceous production) and livestock response (weight gained) were monitored. In addition, we monitored cattle grazing patterns using GPS collars. Prickly pear (*Optuntia* sp.) cover decreased ($P < 0.04$), and prickly pear density tended to decrease ($P = 0.06$). Patch burning also increased ($P < 0.04$) mesquite (*Prosopis glandulosa*) mortality. Bitterweed (*Hymenoxys odorata*) densities were similar between burned and non-burned patches, while annual broomweed (*Gutierrezia dracunculoides*) densities were reduced ($P < 0.01$) by fire. Forage production on the burned patches were similar ($P = 0.07$) to non-burned controls. Heifer weights were greater ($P < 0.03$), but only during certain times post-fire. Heifers grazing in pastures where patch burning was applied spent more time grazing in burned patches especially early in the grazing season. These results suggest that patch burning can be used to alter livestock distribution while reducing the cover and density of some invasive plants.

Key Words: patch-burn; grazing; prescribed burning; prickly pear; brush encroachment

INTRODUCTION

Various restoration techniques have been utilized on rangelands for over 60-years to reduce invasive plant encroachment and reverse downward trends in herbaceous plant productivity and species diversity (Scholes and Archer 1997; Van Langevelde et al. 2003; Ansley et al. 2004). Restoration efforts involving mechanical and chemical plant control treatments, although effective, are often cost prohibitive (Teague et al. 2001). Prescribed burning can be effective in controlling some invasive species and promotes increased plant

*Corresponding author: Cody.Scott@angelo.edu

diversity by reducing the competitive ability of unpalatable grasses and forbs.

Livestock grazing influences ecosystems by altering plant communities, influencing woody plant encroachment, and affecting above ground herbaceous production (Allred et al. 2012). Prudent livestock grazing, especially using grazing systems that provide for deferment, typically increases plant diversity (Frost and Launchbaugh 2003). Unfortunately, poor grazing distribution often limits the beneficial effects of rotational grazing, even in intensive grazing systems. Livestock develop preferences for plants (Provenza 1995) and patches of vegetation, resulting in poor grazing distribution within a pasture (Bailey et al. 1996). Preferences for patches of vegetation are often the result of differences in forage quality and the presence of chemically-defended plants.

Others (Weir et al. 2013) have suggested that combining a mixture of prescribed burning and livestock grazing may further improve plant diversity while providing some control of invasive woody plants and succulents. Patch burning has been used to attract cattle to burned patches in the central Great Plains. Results from these efforts have suggested that combining patch burning and livestock grazing can promote greater plant diversity (Fuhlendorf and Engle 2004). Unfortunately, little information is available on (1) how rangelands and (2) how livestock respond to patch burning in the semi-arid southern Great Plains. We hypothesized that cattle would focus on patch burns, further enhancing the vegetation response. In addition, we hypothesized that patch burning would alter livestock grazing distribution because livestock tend to focus grazing efforts on recently burned patches (Cummings et al. 2007).

MATERIALS AND METHODS

This study was conducted in 2015 at the Texas Range Station between Barnhart and Ozona, Texas (30°59.000' N 101°09.000' W). The study area consisted of 1300 ha of semi-arid rangeland with annual precipitation of 540 mm, characterized by infrequent rainfall and mild to hot temperatures where most forage growth occurs during the spring and summer months. Dominant shrub species consist of mesquite (*Prosopis glandulosa*), dominant succulents include prickly pear (*Opuntia polyacantha* and *Opuntia engelmannii*), and the dominant grass species include Tobosa (*Hilaria mutica*), curly mesquite (*Hilaria berlangeri*), and buffalo grass (*Buchloe dactyloides*). When cool season precipitation occurs, annual bitterweed (*Hymenoxys odorata*) and annual broomweed (*Gutierrezia dracunculoides*) are common. Both are considered poor quality forage for livestock.

Six pastures of approximately equal size (120-ha) were used. Three of the six pastures were randomly selected for patch-burning. Patch-burn treatments consisted of 12 ha or 10% of each pasture burned. The remaining three pastures were used as control treatments and were not burned. Patch burning occurred on 11 March 2015 and ignitions started at approximately 0900 hours. Environmental conditions at time of ignition consisted of: 79°F, 56% RH, and 8-12 mph SE winds. In addition to the patch-burn treatments, 72 heifers were used to graze the treatment and control pastures at a stocking rate of 12-ha per animal unit. Heifers were randomly assigned to treatments and pastures. Performance of the heifers was measured by their overall weight gain during the study. Heifer weights were taken in January prior to the study, 30 days post burn in April, and at the end of the study in July.

To assess vegetation response to our treatments we measured standing crop, mesquite mortality (no regrowth following top kill), bitterweed density, annual broomweed density, prickly pear canopy cover, and prickly pear density. Herbaceous vegetation sampling occurred prior to burning (February) and at peak biomass (mid-June) and at the end of the growing season (September). Mesquite mortality, prickly pear cover and density, and herbaceous cover were also sampled at the end of the growing season in September. Bitterweed density was estimated in June. Standing crop was estimated by clipping all vegetation to ground level in five, randomly placed 0.25-m^2 quadrats within each plot. Vegetation was sorted by species. Standing crop was the sum of current-year biomass and residual biomass from previous years' growth. Harvested vegetation was dried at 60°C for 48-hours and weighed to the nearest 0.01 g. Twelve transect lines measuring 61.6 meters were established in treatment site. Prickly pear canopy cover was assessed by recording the length of each prickly pear under the 61 m transect line.

Global Positioning System (GPS) collars were used to monitor grazing distribution of cattle (Augustine and Derner 2014). Two heifers were randomly selected from each pasture within each treatment and fitted with GPS collars attached for two-week intervals. After two weeks, collars were removed and placed on two different heifers in each pasture. Locations of grazing heifers were taken every ten minutes and recorded.

Data were analyzed using generalized least squares (MIXED procedure of SAS, Littell et al. 2006) to quantify plant community response. Our model included burning and grazing or grazing alone. We used standing crop, cattle weights, mesquite mortality, bitterweed density, broomweed density, prickly pear cover, and prickly pear density as response variables and our experimental unit was pasture. We set statistical significance at $P < 0.05$.

RESULTS

Growing conditions leading up to the start of the study were extremely dry (2011-2014 averaged 356 mm), however, 2015 experienced one of the wettest years on record averaging 717 mm of rainfall. Herbaceous forage production was similar between treatments both before and after burning. However, patch burning reduced forage production from 2,508 kg/ha before burning to 1907 kg/ha after burning (Treatment X Time Interaction; $P < 0.07$).

Prickly pear cover was reduced ($P < 0.04$) from 8.4 to 4.6% canopy cover with patch-burning compared to non-burned controls (Fig. 1). Prickly pear density decreased ($P = 0.06$) from 10,327 pads/ha to 7,795 pads/ha.

Patch-burning decreased ($P < 0.04$) the number of live mesquite stems emerging from the ground on burned patches (Fig. 2). Mesquite mortality rates were 9.7 and 0.9 % on burned and non-burned plots, respectively. Bitterweed densities were similar ($P < 0.27$) between burn and non-burned patches (data not shown). Conversely, broomweed densities were reduced ($P < 0.01$) by 63% with patch-burning (Fig. 3).

Patch-burning improved weight gain during the middle of the study ($P < 0.03$), but by the end of the study animal performance was similar between patch-burn and non-burned sites (Fig. 4). Overall, weight gain during the study was similar regardless of the presence of fire ($P < 0.11$). Global Positioning System collars revealed that grazing heifers spent significantly ($P < 0.02$) more time on recently burned areas of the patch-burn sites. During the first two-week period following the March patch-burns, heifers spent on average 59% of grazing time in patch-burned sites. During the second grazing period, heifers spent approximately 95% of their time in recently burned areas. However, during the third grazing period, heifers spent only 36% of their time in the patch-burned portions of the pastures.

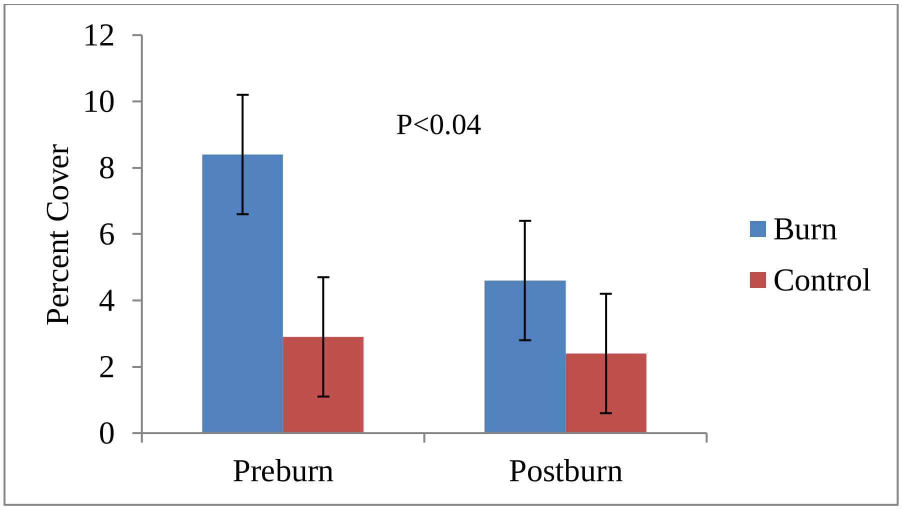

Figure 1. Prickly pear cover (%) pre-burn and post-burn comparisons relative to non-burned controls during a patch-burn grazing study in West Texas.

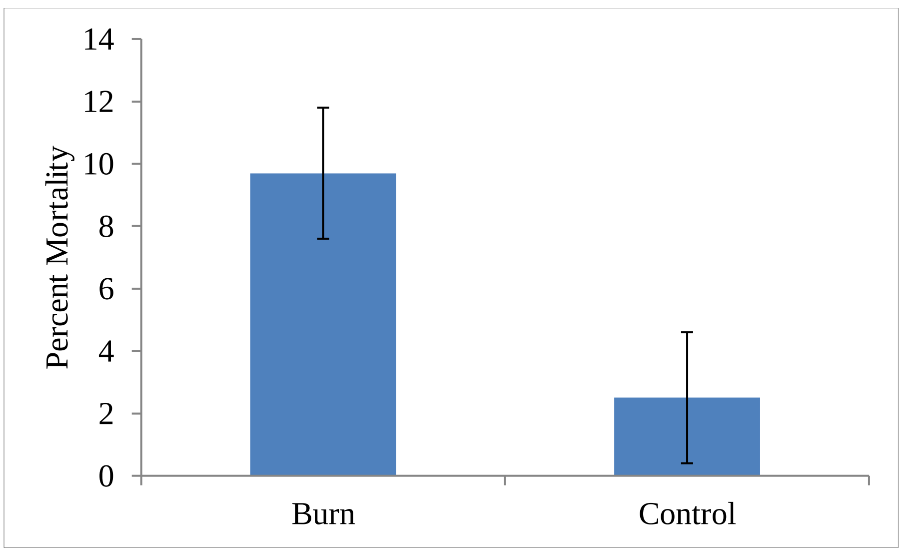

Figure 2. Percent (%) mesquite mortality comparisons between patch-burned areas and non-burned controls following patch-burn grazing treatments.

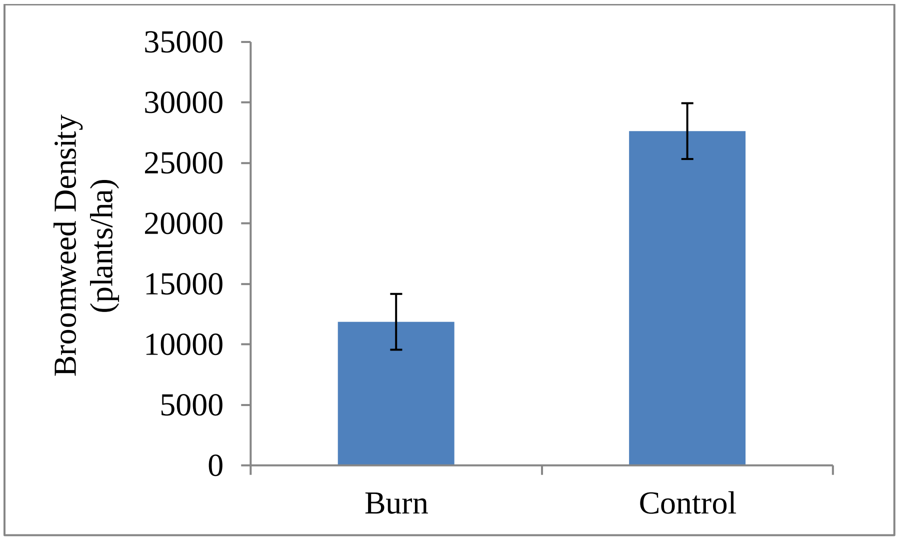

Figure 3. Comparison of patch-burned grazing to non-burned controls on broomweed density (plants/ha) in West Texas.

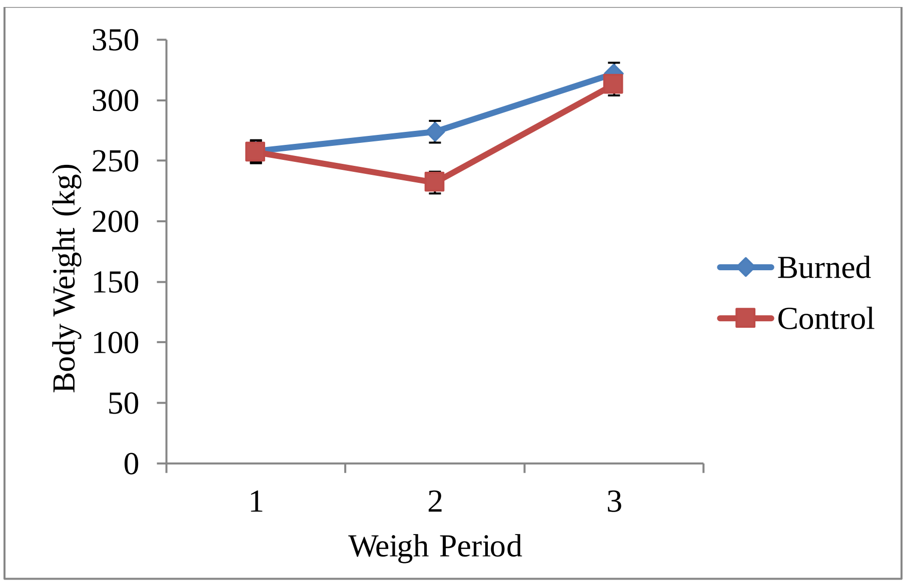

Figure 4. Heifer grazing weights (kg) on semi-arid rangeland every two weeks following patch-burning in West Texas.

CONCLUSION AND DISCUSSION

Based on the results of this study, patch burning can be an effective method to improve woody and prickly pear management, without compromising forage production or loss of grazing. Reductions in mesquite density and prickly pear cover occurred after patch burning. Conversely, total standing crop was similar between burned and non-burned controls. Typically, a dormant season burn will produce a short-term forage loss during the first growing season and protective cover following fire. Spring and autumn fire effects on productivity have been variable, with losses for 1 to 3 yr., no change, or modest increases (Whisenant and Uresk 1989, Redmann et al. 1993; Shay et al. 2001). Scheintaub et al. (2009) reviewed research of fire effects throughout the western Great Plains and determined more than half reported reduced productivity and only 15% reported greater productivity following fire. Although plant response is undoubtedly affected by post-fire precipitation, the lack of change in total standing crop indicates mixed-prairie productivity is resistant to fire in the semi-arid southern Great Plains.

Patch-burning increased mesquite mortality on burned patches compared to non-burned patches of the pasture. Mesquite is considered a fire-resistant woody species because of dormant buds belowground that initiate resprouting after topkill from fire. Fire was apparently an integral part of pre-settlement grassland and savanna ecosystems in the southern Great Plains (Frost 1998); fire likely suppressed but did not entirely eliminate the expansion of woody plants. Nevertheless, prescribed fire applied at the key time periods is considered a useful tool in managing woody species like mesquite. For example, winter prescribed burn killed 77% of mesquite seedlings in Vernon, Texas (Ansley et al. 2015). Even though patch burning may reduce mesquite densities, some basal resprouting is expected. Even with an intense prescribed fire, typically 15-30% of seedlings survive, further emphasizing the importance of follow-up treatments (Ansley et al. 2015). Mesquite tree size varied across burn plots. Most of the reduction in density of mesquite trees was trees under 2 m tall.

Prickly pear cover was reduced by more than 50% with patch-burning compared to non-burned controls; however, prickly pear density was not reduced. Research in northern mixed-grass prairie reported that fire reduced prickly pear cover by 42%, but similar to our study, their results also demonstrated limited prickly pear mortality (Vermeire and Roth 2011).

Although patch-burning was unsuccessful at significantly reducing bitterweed densities, broomweed densities were reduced by 63%. Fire has been an effective tool at reducing broomweed densities in Texas, where winter fires in the panhandle reduced broomweed cover to < 6% compared to non-burned controls (Heirman and Wright 1973). Germination of annual broomweed typically occurs in late fall on this site. Patch burning after germination in this study apparently killed most of the broomweed seedlings. Our results agree with those of Heirman and Wright (1973), who indicated in a west Texas study that early-spring fires reduced common broomweed production. Neuenschwander et al. (1978) found that, in a year when broomweed populations were low in unburned mesquite/tobosagrass communities, winter fire had no effect on broomweed populations the first year post fire. Results from these two Texas studies and ours disagree with those of Towne and Owensby (1983), who found that in northeastern Kansas winter (January) fire increased common broomweed density. Fall fires (October and November) in their study also increased broomweed density, but spring (April) fires had no effect compared to the control. Towne and Owensby (1983) indicated that common broomweed in their region did not germinate until after April, and attributed the increased density from fall and winter fires to the clearing of litter, which produced favorable conditions for broomweed establishment. Thus, the timing of emergence of common broomweed seedlings may have a profound effect on how seasonal fires affect post-fire populations.

Grazing distribution and animal performance were enhanced with patch-burn grazing. Grazing heifers that were allowed access to patch-burned areas had increased weight gains during the middle time period of the study and spent a significant amount of their time in the burned portion. Fire apparently improved the quality of post-fire regrowth by removing old, standing dead plant material that was coarse and low in forage quality. Unfortunately, forage quality was not measured in this study.

Following dormant-season burning, plant regrowth is young, green, and considerably higher in quality when soil moisture is adequate. Grazing animals are attracted to regrowth and will preferentially graze such areas. In tallgrass prairie, cattle spend 75% of the time grazing on the most recently burned patches in a patch-burn grazing scenario. Apparently, increases in forage quality on the patch-burned areas directly improved animal performance and attracted heifers to the recently burned area improving overall grazing distribution of the pasture during the middle of this study. In situations where grazing distribution is poor, patch burning could be implemented to alter pasture distribution and utilization.

Integrating prescribed burning with grazing presents a potentially sustainable, ecological, and economical practice when compared to the conventional mechanical and chemical methods of woody plant and prickly pear management. Development of patch-burn grazing recommendations on semi-arid landscapes may enable land managers and agency personnel to utilize fire in combination with livestock to alter grazing distribution and possibly improve livestock gains.

ACKNOWLEDGEMENTS

Research reported herein was supported by United States Department of Agriculture – Forest Service, Southern Research Station for Forestry Research.

REFERENCES

Ansley RJ, Teague WR, Pinchak WE, Kramp BA, and Jones DL. 2004. Long-term grass yields following chemical control of honey mesquite. J Range Manag. 57:49-57.

Ansley RJ, Kramp BA, and Jones DL. 2015. Honey mesquite (*Prosopis glandulosa*) seedling responses to seasonal timing of fire and fireline intensity. Rangeland Ecol and Manag. 68:194-203.

Allred BW, Fuhlendorf SD, Smeins FE, and Taylor CA. 2012. Herbivore species and grazing intensity regulated community composition and an encroaching woody plant in semi-arid rangeland. Basic and Appl Ecol. 13:149-158.

Augustine DJ, and Derner JD. 2014. Controls over the strength and timing of fire-grazer interactions in a semi-arid rangeland. J Appl Ecol. 51:242-250.

Bailey DW, Gross JE, Laca EA, Rittenhouse LR, Coughenour MB, Swift DM, and Sims R L. 1996. Mechanisms that result in large herbivore grazing distribution patterns. J of Range Manag. 49:386-400.

Cummings DC, Fuhlendorf SD, and Engle DM. 2007. Is altering grazing selectivity of invasive forage species with patch burning more effective than herbicide treatment? Rangeland Ecol and Manag. 60:253-260.

Frost CC. 1998. Presettlement fire frequency regimes of the United States: a first approximation. In: Prudin, T.L., Brennan, L.A. (Eds.), Proceedings: Fire in Ecosystem Management, 7–10 May 1996; Boise, ID, USA. Tall Timbers Fire Ecology Conference Proceedings No. 20. Tallahassee, FL, USA, pp. 70–81.

Frost RA and Launchbaugh KL. 2003. Prescription grazing for rangeland weed management. Rangelands. 25:43-47.

Fuhlendorf SD and Engle DM. 2004. Application of the fire-grazing interaction to restore a shifting mosaic on tallgrass prairie. J Appl Ecol. 41:604-614.

Heirman AL and Wright HA. 1973. Fire in medium fuels of west Texas. J Range Manag. 26:331-335.

Littell RC, Milliken GA, Stroup WW, and Wolfinger RD. 2006. SAS system for mixed models. Cary, NC, USA: SAS Institute. 633 p Neuenschwander, L. F., H. A. Wright, and S. C. Bunting. 1978. The effect of fire on a tobosagrass-mesquite community in the Rolling Plains of Texas. The Southwest Nat. 23:315-337.

Neuenschwander LF, Wright HA, and Bunting SC. 1978. The effect of fire on a tobosagrass-mesquite community in the rolling plains of Texas. The Southwest Nat. 23:315-338.

Provenza FD. 1995. Postingestive feedback as an elementary determination of food preference and intake in ruminants. J Range Manag. 48:2-17.

Redmann RE, Romo JT, and Pylypec B. 1993. Impacts of burning on primary productivity of Festuca and Stipa-Agropyron grasslands in central Saskatchewan. Am Midl Nat. 130:262273.

Scheintaub MR, Derner JD, Kelly EF, and Knapp AK. 2009. Response of the shortgrass steppe plant community to fire. J Arid Environ. 73:1136-1143.

Scholes RJ and Archer SR. 1997. Tree-grass interactions in savannas. Annu Rev Ecol Syst. 28:517-544.

Shay J, Kunec D, and Dyck B. 2001. Short-term effects of fire frequency on vegetation composition and biomass in mixed prairie in south-western Manitoba. Plant Ecol. 155:157-167.

Teague WR, Ansley RJ, Kreuter UP, Pinchak WE, and McGrann JM. 2001. Economics of managing mesquite in north Texas: a sensitivity analysis. J Range Manag. 54:553-560.

Towne G, and Owensby C. 1983. Annual broomweed [*Gutierrezia drancunculoides* (DC.) Blake] response to burning and mulch addition. J Range Manag. 36:711-712.

Van Langevelde F, Van De Vijiver C A.D.M., Kumar L, Van De Koppel J, De Ridder N, VanAndel J, Skidmore AK, Hearne JW, Stroosnyder L, Bond WJ, Prins H.H.T, and Rietkerk M. 2003. Effects of fire and herbivory on the stability of savanna ecosystems. Ecol. 84:337-350.

Vermeire LT and Roth AD. 2011. Plains prickly pear response to fire: Effects of fuel load, heat, fire weather, and donor site soil. Rangeland Ecol and Manag. 64:404-413.

Weir JR, Fuhlendorf SD, Engle DM, Bidwell TG, Cummings DC, Elmore D, Limb RF, Scasta JD, and Winter SL. 2013. Patch burning: integrating fire and grazing to promote heterogeneity. Publication E-998, Oklahoma Cooperative Extension Service. 26 pp.

Whisenant SG and Uresk DW. 1989. Burning upland mixed prairie in Badlands National Park. Prairie Nat. 21:221-2