PATCH BURNING AS A HETEROGENEITY APPROACH TO RANGELAND MANAGEMENT

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ABSTRACT

Patch burning is a novel approach to rangeland management that has potential to enhance biological diversity while maintaining livestock production on rangelands. Its foundation is based upon a long history of herbivory by large ungulates and the fire–grazing interaction on native rangelands. Traditional rangeland management generally attempts to minimize inherent rangeland heterogeneity. Patch burning, which uses the fire–grazing interaction to increase spatial heterogeneity of rangelands, allows free selection by large ungulates among burned and unburned patches within a landscape unrestricted by fencing. Because ungulates prefer to graze forage plants within recently burned patches, intense grazing moves across the landscape in the pattern created by burning patches. The result is a shifting mosaic of patches at different stages of recovery from burning and grazing disturbance. We suggest that emphasis on a heterogeneity-based approach to managing grasslands is a viable framework for conservation and a potentially useful tool in wildland fire management.

keywords: fire–grazing interaction, fuel management, heterogeneity, rangeland management.

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INTRODUCTION

Before European settlement of North America, fire and grazing by native ungulates interacted to create a dynamic and heterogeneous landscape. As individual disturbances, fire and grazing have different effects on ecosystems, but when considered as a dynamic, landscape-level interaction, their influences become more pronounced and synergistic. Grazing by bison (*Bison bison*) and other herbivores across the pre–European settlement landscape influenced the structure and function of many grasslands (Knapp et al. 1999), but the recent view is that the distribution of spatially unrestricted large ungulates within the landscape was not uniform and interacted with patterns of heterogeneity created by fire (Kay 1998; Fuhlendorf and Engle 2001, 2004). This becomes all the more evident when considering habitat requirements of habitat specialists such as grassland birds that evolved with bison grazing (Figure 1; Knopf 1996).

Managing grazing animals typically focuses on stocking rate and grazing systems with emphasis on uniform distribution of grazing disturbance (Holechek et al. 1998). As a result, most rangeland management practices (i.e., brush and weed control, fencing, etc.) have been implemented to promote livestock production by increasing dominance of a key forage species and maintaining uniform grazing patterns (Fuhlendorf and Engle 2001). Spatially variable management practices have been recommended only for attracting livestock to lightly used or unused areas with the objective of reducing spatial heterogeneity and increasing harvest efficiency (Hooper et al. 1969, Samuel et al. 1980, Vallentine 1989, Holechek et al. 1998). Fire management has followed a similar template, with fire application usually applied to reduce forage heterogeneity and to encourage uniform distribution of livestock grazing. Without patch grazing, frequent burning as practiced on ranches in the tallgrass prairie region reduces plant diversity and increases homogeneity of tallgrass prairie (Collins 1992). A paucity of research has evaluated the interactive effects of fire and grazing on heterogeneity. Here, we present an overview of an approach to managing rangelands that promotes heterogeneity by coupling fire and grazing in a spatially dynamic fashion that, together with implications for livestock production and wildlife habitat, might be of value in grassland ecosystem management.

PATCH BURNING AS AN ALTERNATIVE MANAGEMENT APPROACH

Patch burning is an alternative management approach that uses a fire–grazing interaction to produce a shifting mosaic landscape. Grassland patches that have been not burned in several years have an increased probability of fire and a decreased probability of grazing (Figure 2; Fuhlendorf and Engle 2004). Conversely, grassland patches that have burned recently have an increased probability of grazing because forage quality is high and a decreased probability of burning again until sufficient fuel accumulates. When a patch long excluded from fire is burned, patch preference by large herbivores shifts to the most recent

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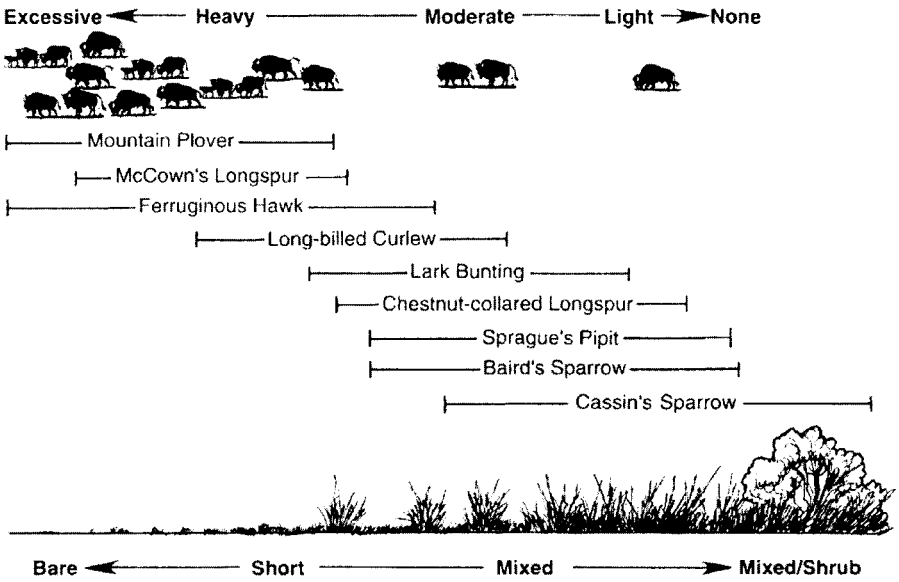

Fig. 1. The response of a shortgrass bird community to change in bison grazing intensity and vegetation structure. Different species have different habitat requirements so grazing can have a positive effect, negative effect, or no effect on different species of birds. From *Prairie Conservation* by Fred B. Samson and Fritz L. Knopf, eds. Copyright © 1996 by Island Press. Reproduced by permission of Island Press, Washington, D.C.

burn patch, and previously burned and grazed patches begin to recover. The result is a shifting mosaic landscape with diverse patches in various stages of recovery from burning and grazing, and the location of various patch types changes annually. Thus, spatiotemporal variability among patches is high, but, from a landscape perspective, stability is high because the landscape always includes a diversity of patches differing in disturbance history.

A Case Study

In 1989, The Nature Conservancy purchased the 11,800-ha Barnard Ranch in north-central Osage County, Oklahoma, and renamed it the Tallgrass Prairie Preserve. Since then, additional land acquisitions and leases have increased the preserve area to 15,600 ha. A spatially and seasonally variable prescribed burning program was initiated in March 1993, and 300

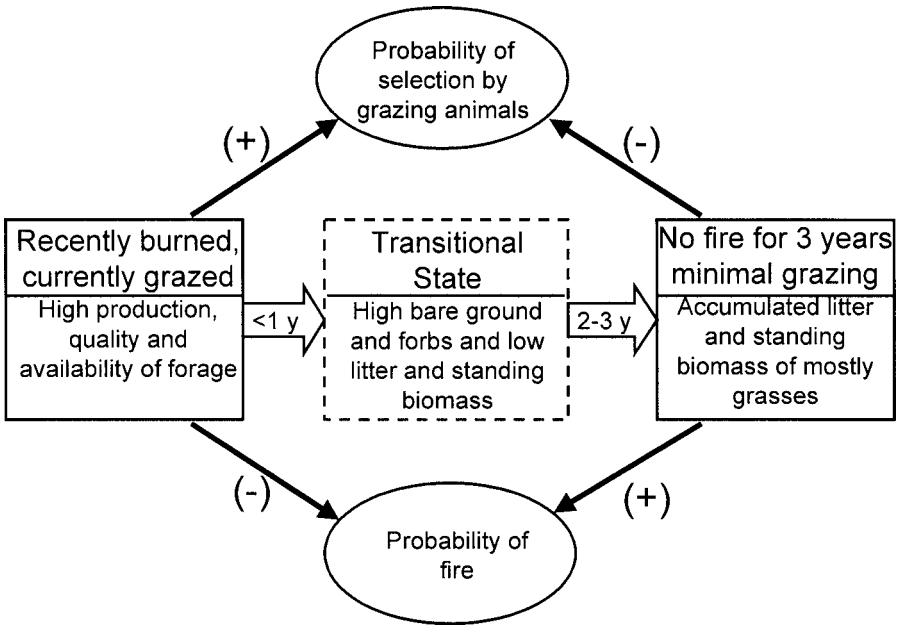

Fig. 2. A conceptual model demonstrating the dynamics of a patch within a shifting mosaic landscape where each patch is experiencing similar but out-of-phase dynamics. Ovals represent the primary drivers (fire and grazing), and squares represent the ecosystem states within a single patch as a function of time since focal disturbance. Solid arrows indicate positive (+) and negative (−) feedbacks in which plant community structure is influencing the probability of fire and grazing (Fuhlendorf and Engle 2004). Copyright © 2004 British Ecological Society. From *Journal of Applied Ecology,* by S.D. Fuhlendorf and D.M. Engle, ''Application of the fire–grazing interaction to restore a shifting mosaic on tallgrass prairie.'' Reprinted by permission of Blackwell Publishing Ltd.

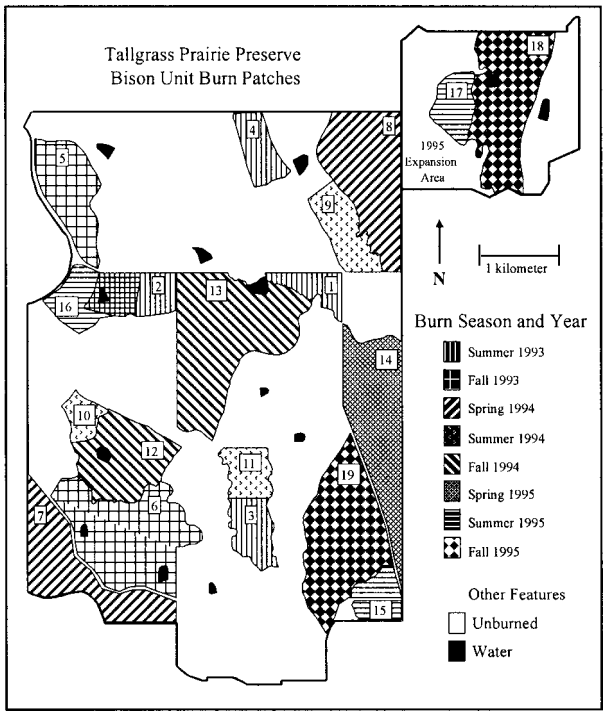

Fig. 3. Prescribed fires on the Tallgrass Prairie Preserve, Oklahoma, during 1993–1995. Numbers refer to the order in which burns were conducted. Bison within this area were allowed unrestricted selection of the landscape and primarily selected the most recently burned patches, which resulted in a shifting mosaic of patch types that were dependent upon time since fire (Coppedge and Shaw 1998). Copyright © 1998 Society for Range Management. From *Rangeland Ecology and Management,* by B.R. Coppedge and J.H. Shaw. Reprinted by permission of the authors and Alliance Communications Group, a division of Allen Press, Inc.

bison were introduced to a 1,973-ha portion of the preserve, the fire–bison unit, in October 1993. The fire–bison unit has systematically expanded with bison herd growth and now supports 2,400 bison on 8,500 ha. The fire regime within the fire–bison unit consists of 80% dormant-season (40% fall and 40% late spring) and 20% growing-season prescribed fires conducted in a random pattern intended to mimic pre–European settlement burn frequency and season. Prescribed burns are conducted on variably sized patches under a range of fuel and weather conditions with a 3-y return interval (Hamilton 1996).

The randomly located burn patches within the bison unit at the Tallgrass Prairie Preserve (Figure 3; Coppedge and Shaw 1998) have created a mosaic of patches grazed at different intensities by the bison herd. Even though stocking rate for the entire bison enclosure is moderate (6–7 ha/animal unit) (Coppedge et al. 1998*a*), bison use recently burned patches heavily and use unburned patches lightly (Coppedge and Shaw 1998). The result is differential succession among patches, just as other studies have predicted (Coppedge and Shaw 1998, Coppedge et al. 1998*a*). The effect of patch fire history on bison selectivity increases the landscape structural diversity. Forbs, the primary contributors to plant diversity in tallgrass prairie (Howe 1994, Collins and Glenn 1995), increase within recently burned patches because bison are strongly graminivorous (Coppedge et al. 1998*b*).

APPLYING THE PATCH-BURNING APPROACH TO RANGELAND MANAGEMENT

A fundamental idea behind patch burning is that prescribed fire can be conducted without sacrificing stocking rate of herbivores in a management unit. Conventional wisdom for planning prescribed fires on rangelands often suggests that grazing be deferred or stocking rate reduced to allow fine fuel accumulation that will produce desired fire prescriptions (Vallentine 1989). Patch burning in conjunction with moderate stocking rate allows fuel accumulation without the economic burden of reduced stocking. Focal grazing in recently burned patches greatly reduces herbivory in adjacent patches, which allows homogeneous fuel accumulation throughout unburned patches.

Fuels and Fire Management

Patch burning might mitigate wildfire risk across the landscape by modifying grassland fuel load and by moderating fire behavior. Prescribed burning to reduce fuels is most cost-effective when subsequent fuel accumulation is limited (Fernandes and Botelho 2003). In a fire–grazing interaction, grazing pressure is focused in recently burned patches, preventing fine fuel accumulation in those patches for at least a year following burning while simultaneously allowing fuel accumulation in adjacent unburned patches. Patches recently burned and intensively grazed contain sparse fuel and function as effective firebreaks. When compared to traditional management, litter cover is less in patch-burned landscapes in all patches except those unburned the longest (Figure 4).

Strategic placement and orientation of patches within a landscape context could further enhance the effectiveness of patch burning as a fuel management tool (Finney 2001). Orienting recently burned and grazed patches that act as firebreaks perpendicular to the direction of most probable wildfire spread could reduce fire intensity and rate of spread by interrupting headfires and forcing fire to spread less intensely as backfires and flankfires (Figure 5).

Biodiversity and Biological Conservation

Birds are considered ecological indicators of ecosystem health because of their diverse habitat requirements (Bradford et al. 1998, Canterbury et al. 2000). Indeed, North American grassland birds exhibit large variability in habitat selection, ranging from preference for highly disturbed areas with minimal vegetation cover to preference for undisturbed areas with abundant vegetation litter (Wiens 1974). It is not surprising, then, that North American grassland birds are declining rapidly (Knopf 1994) on rangelands where ‘‘good’’ management implies moderate disturbance distributed

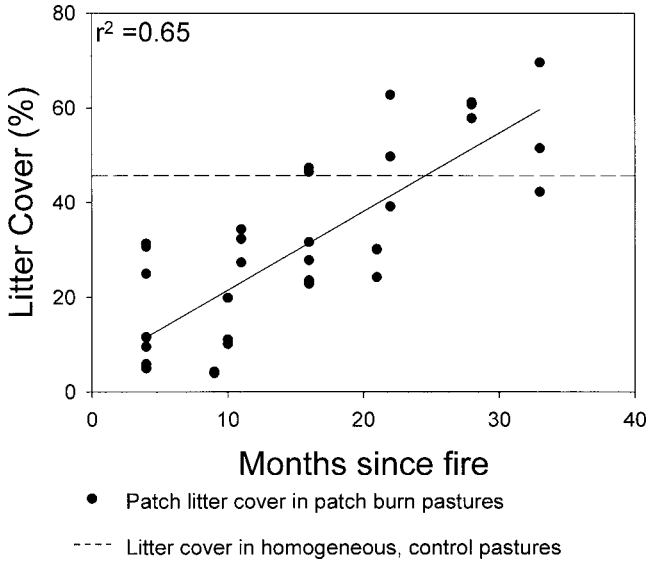

Fig. 4. Litter accumulation in pastures managed traditionally for homogeneity and in pastures managed for heterogeneity with patch burning. Litter cover is minimal in recently burned patches and recovers slowly in recently burned patches that attract intensive grazing.

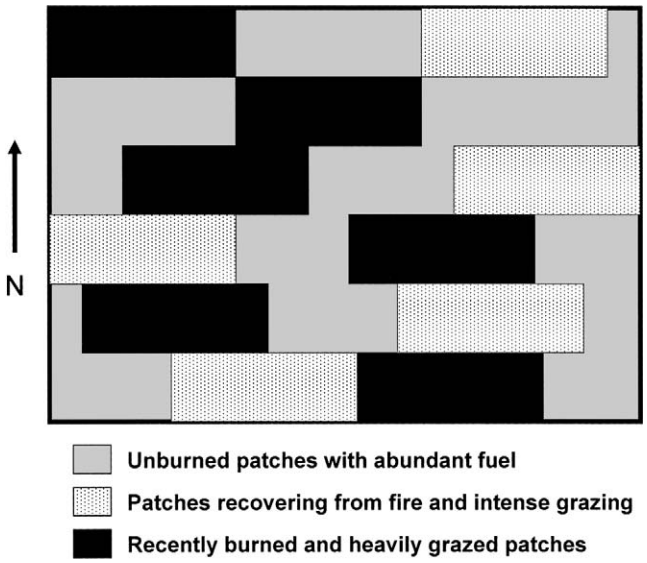

Fig. 5. Conceptual diagram of a landscape managed with patch burning to reduce wildfire potential by interrupting fire spread across a grassland landscape in which fuel beds are characteristically composed of continuous, fine fuel.

evenly across the landscape, precluding both heavily disturbed areas and undisturbed areas. Similar to the Tallgrass Prairie Preserve, implementation of a fire–grazing interaction on rangelands with cattle as surrogates for bison creates a shifting mosaic of vegetation types that provide diverse habitats (Fuhlendorf and Engle 2004, Townsend 2004, Fuhlendorf et al. 2006). Patch-burned landscapes provide suitable habitat for bird habitat specialists that require abundant litter and tall vegetation structure in patches not recently burned and for habitat specialists that require bare ground and open vegetation structure (Harrell 2004).

Patch burning followed by intense forage use by either bison or cattle for 1 y has not resulted in resource degradation but, rather, produces brief pulses of early seral vegetation across the landscape coinciding with recently burned patches (Fuhlendorf and Engle 2004). Following intense forage use of the burned patches, ruderal plant species increase in these patches, but within 3 y tallgrass species return to pre-disturbance dominance (Coppedge et al. 1998*a*, Fuhlendorf and Engle 2004). This differs from patch degradation associated with intense, recurrent grazing by livestock of preferred areas under continuous grazing systems (Fuls 1992). In patch burning, burned and intensely grazed patches are spatially dynamic, not static, so that patches that experience focal fire and grazing disturbance are rotated across the landscape over years.

Herbivore Productivity

Domestic cattle respond to patch burning management by grazing in recently burned patches 75% of the time, and cattle productivity has not declined compared to traditional range management (Fuhlendorf and Engle 2004). Similar to cattle, managing for heterogeneity through patch burning followed by heavy grazing has not negatively influenced bison production on the Tallgrass Prairie Preserve. In fact, bison have maintained high reproductive rates without nutritional supplementation (R. Hamilton, The Nature Conservancy, personal communication), a contrast to reduced cattle performance in the absence of nutritional supplementation under traditional rangeland management (Hughes et al. 1978, McCollum and Horn 1990). By increasing patch and vegetation diversity across the landscape, greater amounts of cool-season plants were available to bison during the winter nutritional stress period (Coppedge et al. 1998*b*).

Invasive Species

Central U.S. grasslands are currently under threat by two highly invasive plant species. Eastern redcedar (*Juniperus virginiana*), a native tree, is fire intolerant but has spread at an exponential rate through many grasslands that have not been burned in a decade or more (Snook 1985). Sericea lespedeza (*Lespedeza cuneata*), an exotic perennial legume, is aggressively invading many North American grasslands (Brandon et al. 2004). Our early observations suggest both these invasive species can be more effectively managed with patch burning than with traditional grazing management and prescribed fire systems. Eastern redcedar might be more vulnerable to prescribed fire in a patch-burn system because of the greater fuel accumulation in unburned patches and subsequently greater fire intensity. While neither fire nor grazing alone have detrimental effects on sericea lespedeza, frequent, intense grazing that immediately follows fire in a patch-burn system appears to reduce invasion into native grasslands (Fuhlendorf and Engle 2004).

SUMMARY

Patch burning is an alternative rangeland management option that facilitates landscape heterogeneity, whereas traditional rangeland management practices promote homogeneity. We propose that a patch-burning approach will approximate the historic range of variability on grasslands like the tallgrass prairie by reinstating a fire–grazing interaction. This approach has potential to maintain greater biodiversity by increasing heterogeneity and reducing invasive species while providing rangeland managers with greater flexibility for managing patterns of grazing and fire.

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