Managing for Biodiversity and Livestock: Fire and Grazing

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Introduction
Biodiversity is an essential component to any healthy, functioning ecosystem. It can serve as a guide to the land manager that the water cycle, nutrient cycle, and energy flowing through the system are properly balanced. Grasslands, whether in the form of pastureland, rangeland or Conservation Reserve Program land, are important ecosystems that provide a variety of goods and services such as: 1) forage for livestock, 2) habitat for wildlife, 3) plant and animal diversity, 4) hydrologic function for ground water recharge, 5) carbon sequestration, and 6) open space for aesthetic value.

In the Great Plains, grasslands, which provide nearly 80% of the feed for beef cattle, are the backbone of the cow-calf industry. Mismanagement, introduction of exotic species, and fragmentation of native grasslands in the eastern portion of the Great Plains by row crop agriculture and urban sprawl have made them vulnerable to noxious weed and non-native species invasion, increased wildlife nest predation, and general loss of habitat.

During the last 50 years, scientific scrutiny of standard grazing practices designed to optimize livestock production on grasslands of the Great Plains has led to observations that other ecosystem services that grasslands provide are constrained. Strong profit motives are likely responsible for decisions to apply high stocking rates that often result in a landscape dominated by shorter, more grazing-resistant plant communities. It's easy to place blame on this practice because of the striking impacts overstocking has on wildlife, water quality, and plant diversity. Yet, some more sophisticated techniques of rotational grazing often result in a uniform vegetation structure across the landscape, albeit not as short as heavy continuous grazing.

Recent investigations suggest that age-old management tools (water developments, fencing, salt and mineral placement, herding) aimed at improving grazing distribution have resulted in a predictable habitat structure that may actually reduce plant and animal diversity across a managed landscape. Grassland bird diversity has become the focal illustration to prove this point. Proponents of a multiple-use concept, meaning grasslands could be managed for both ecosystem goods (livestock production) and services (habitat, carbon sequestration, diversity, etc.), argue for a change in how we manage livestock grazing.

Fire and Grazing
In the last 10 years, a new strategy called "patch-burn grazing" (Fig. 1) has been proposed as an alternative to conventional rotational grazing techniques. The concept behind patch-burn grazing is to reintroduce ecosystem processes that once dominated the Great Plains. Historical evidence suggests that fire and large ungulate grazing co-existed for a long time in the Great Plains such that these ecosystem processes created a shifting mosaic of vegetation structure across the landscape.

Figure 1. Patch-burn in eastern South Dakota tallgrass prairie, spring 2007. Photo by A.J. Smart, 2007.

This mosaic of vegetation structure created a tight evolutionary bond between plants and animals, and maximized regional diversity. Patch-burn grazing offers several intriguing benefits to the landscape and the land manager. First and most obvious, patch-burn grazing brings back fire as a management tool to the landscape. Fire has been suppressed in the Great Plains for the last 100+ years. There are unique places such as the Flint Hills of Kansas or the Osage Hills of Oklahoma where fire is still a consistent part of the land management process. However, for the most part, fire is quite rare, especially in the northern Great Plains states of South Dakota and North Dakota.

Secondly, no rest period is required after fire. Cattle can be placed in the pasture immediately after the burn or can even be in the pasture when the burn occurs. Thirdly, no fences or additional water developments are needed. The desired outcome of patch-burn grazing is to increase the structural heterogeneity across the landscape, hopefully resulting in increased plant and animal diversity; "if you build it, it will come." Several recent publications from the southern Great Plains have provided evidence that plant and animal diversity has increased through patch-burn grazing. Traditional grassland management has shown less forbs, insect species, and grassland birds compared to patch-burn grazing.

This patch burn-graze strategy has been tested in the tallgrass prairie ecoregion of Oklahoma and Kansas where the predominant native grass species are warm-season, and where late-spring burns are effective in controlling exotic cool-season species. In addition, these experiments have been carried out on large tracts (>4,000 acres) in a region where grassland fragmentation is less severe. In the northern tallgrass prairie region of the US, landscapes are highly fragmented, tract sizes are smaller, and dominant plant species are quite different, which makes them vulnerable to invasive species and reduces environmental quality.

Preliminary results of patch-burn grazing studies conducted in the northern tallgrass prairie of eastern South Dakota indicate similar ecosystem processes of burning and grazing have resulted in increased spatial structural heterogeneity across the landscape. We used a multivariate technique called principal component analysis to compare continuous seasonal grazing to patch-burn grazing in vegetation structural components across the landscape. As shown in Figure 2, the first axis, which accounts for 52% of the variation, separates the sites based on the amount of grass, litter, and visual obstruction. The second axis, which accounts for 23% of the variation, separates the sites based on native versus introduced species.

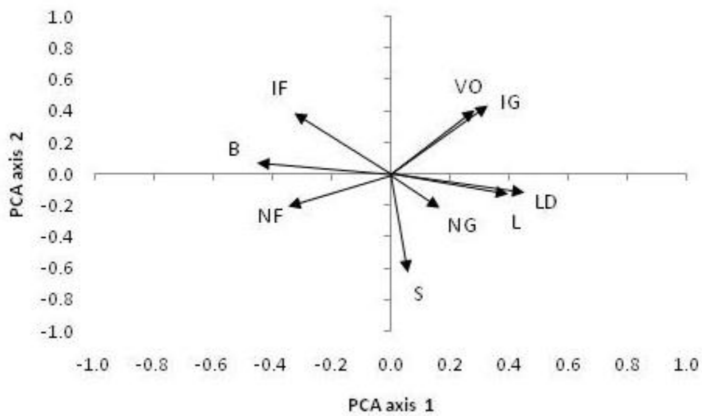

Figure 2. Eigenvector loadings on principal component axes for vegetation components measured in August 2008 from continuous grazing and patch-burn grazing in an eastern South Dakota native prairie. First principal component (PCA axis 1) and second principal component (PCA axis 2) account for 52% and 23% of the variation, respectively. VO= visual obstruction, IG=introduced grass cover, LD=litter depth, L=litter cover, NG=native grass cover, S=shrub cover, NF=native forb cover, B=bareground cover, and IF=introduced forb cover.

Sampling locations within treatments were separated based on principal component scores for axis 1 and axis 2 (Fig. 3). Continuous grazing resulted in sampling locations being more similar and representative of higher visual obstruction, introduced grass, and litter. Patch-burn grazing sampling locations were spread farther apart based on principal component scores. The two sampling locations on the left side of the graph were burned in 2007 and 2008 and the two sampling locations on the right side of the graph have not been burned. Notice the two unburned sampling locations within the patch-burn grazing treatment are more similar to the continuous grazing treatment. These data provide evidence that structural heterogeneity is increased through patch-burn grazing compared to traditional continuous grazing in native northern tallgrass prairie.

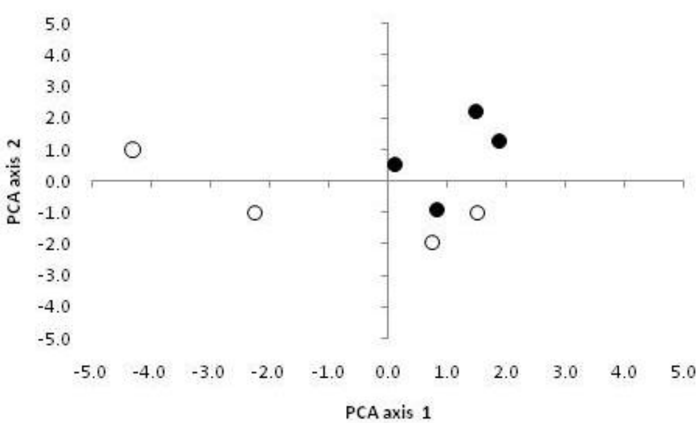

Figure 3. Principal component scores of vegetation measurements conducted in August 2008 from sampling locations within continuous grazing (closed circles) and patch-burn grazing (open circles) in an eastern South Dakota native prairie measured.

We have not yet collected other ecosystem service measurements, such as invertebrate or grassland bird diversity. Further research is needed to confirm the response to patch-burn grazing by other ecosystem structural components. However, we believe that the northern tallgrass prairie will respond in a similar manner as the southern tallgrass prairie.

Advocates of multiple-use management for grasslands in the Great Plains have suggested that incorporating ecosystem processes of fire and grazing is beneficial at restoring a shifting mosaic of vegetation structure across the landscape. Supporters of patch-burn grazing use landscape heterogeneity in vegetation, insects, and grassland birds as evidence to support their claims. Alternatively, one needs to consider that fire is a tool just as grazing is a useful tool. Grazing also can be manipulated by stocking density, timing, intensity, and recovery period. The next section will discuss grazing systems that can be implemented to create biodiversity while maintaining livestock production.

Grazing without fire

Rotational grazing gives the manager the tools to accomplish a variety of objectives. As mentioned in the introduction, native grasslands in the eastern portion of the northern Great Plains are particularly vulnerable to introduced cool-season grasses and weedy forbs (native and introduced). Grazing strategies that incorporate strategic timing of grazing to put pressure on introduced species can release the native species from competition (moisture, nutrients, and sunlight). Many of the commonly used grazing systems can accomplish this goal, while at the same time create structural heterogeneity across the landscape that benefits plant and animal diversity. The following section will discuss these systems in more detail.

Rest and deferred rotation

Historically and still to this day, rest-rotation and deferred rotation grazing strategies have been effective tools to provide contrasting vegetation structures that have benefited wildlife and plant vigor. Essentially, one pasture or paddock is left ungrazed for an entire year (rest-rotation) or until the key forage species has headed out (deferred rotation).

In the eastern Great Plains, deferred rotation can be just as effective as resting the entire year. This is partly due to the fact that the Great Plains receives most of its precipitation during the growing season. During this time plants not grazed during the growing season are able to develop a full canopy and a healthy root system, and store reserves in stem bases and rhizomes. In the inter-mountain west, most precipitation falls as rain and snow from October through April. In this type of climate, pasture receiving an entire year rest is benefitted the most because the majority of the precipitation is outside the summer growing season. A deferment during the hot dry summer does little to help the vigor of plants because root growth and carbohydrate storage occurs during the wet and cool months of spring and fall.

Deferred and rest-rotation systems can be fenced with inexpensive temporary electric fencing or with different levels of permanent fences (single, double, triple high-tensile electric, or barbed wire). Water also needs to be provided to each paddock or pasture. This can be accomplished by temporary means (if specifically used in summer) or provided by permanent sources (if purpose is to use in winter).

Since a ranch is typically split into many pastures, the deferred or rested pastures will produce vegetation unimpeded by grazing livestock that results in excellent nesting cover for a variety of game and non-game birds. In addition, previously grazed pastures would display a varied vegetation structure depending on how much was defoliated and how much regrowth occurred in the previous year. This type of system should produce a mosaic of vegetation structure types across the landscape, benefiting a wide variety of plant and animal diversity.

Intensive early stocking

Intensive early stocking is a modification of season-long continuous grazing in that the pasture is double stocked but only grazed half the year. This type of system was developed in the central tallgrass prairie ecoregion of Kansas and Oklahoma. Historically it also was incorporated with annual burning, but it doesn't necessarily have to be burned to work effectively. The reasoning behind this strategy was to avoid the typical reduction in animal performance that comes in late summer. In addition, livestock prices tend to be higher in mid-summer compared to early fall due to historic patterns in supply and demand.

In the eastern northern Great Plains, intensive early stocking is quite useful in putting pressure on exotic cool-season grasses such as Kentucky bluegrass and smooth bromegrass, while releasing the native tall warm-season grasses. We have conducted a couple years of intensive early stocking in eastern South Dakota and have not seen the typical response in animal performance (Table 1), but have noticed an increase in native warm-season grass composition and higher residual forage at the end of the growing season compared with season-long continuous grazing (Fig. 4).

Table 1. Early- and late-season average daily gain (ADG), overall average daily gains, gain per hectare (ha), and standard errors for intensive early stocking (IES) and season-long continuous (SL) stocking systems in eastern South Dakota (Schell 2011).

Treatment	**0-60 day ADG**	**60-120 day ADG**	**Overall ADG**	**Gain/ha**
	- - - - - - - - - - - - kg/d		- - - - - - - - - - - -	- kg/ha -
IES	0.56(±0.09)[a]	NA	0.56(±0.07)[a]	70.98(±4.32)[a]
SL	0.61(±0.09)[a]	0.67	0.64(±0.07)[a]	78.76(±4.32)[a]

[a] Means followed by different letters within the same column are significantly different ($P < 0.05$)

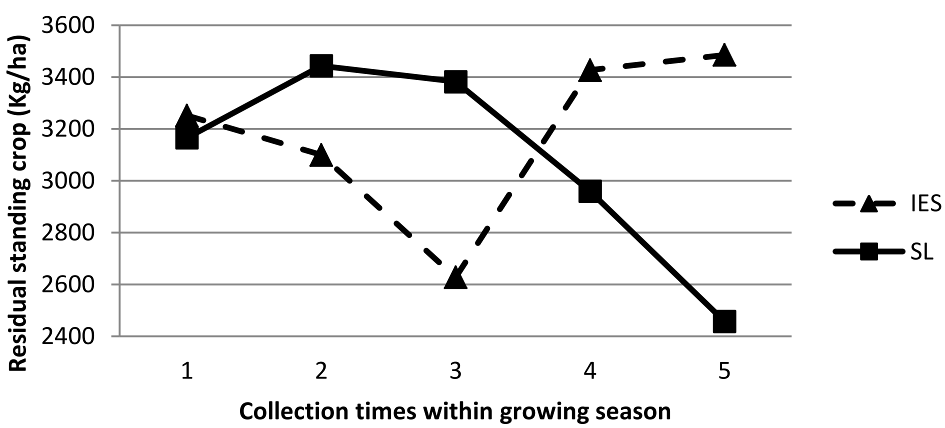

Figure 4. Residual standing herbage for intensive-early stocking (IES) and season-long continuous (SL) stocking systems in eastern South Dakota (Schell 2011). Collection times refer to the beginning of the grazing in late May (1), 30 days later (2), the end of the IES grazing (3) ,30 days after the end of IES (4), and at the end of the season-long grazing treatment (5).

In South Dakota, wildlife agencies such as SD Game, Fish and Parks Department and US Fish and Wildlife Service routinely practice a modification of intensive early stocking on their managed game and waterfowl production land. In their cases, the grazing is typically on a rotation cycle of 1 out of 3 years or 1 out of 5 years. This frequency maintains an acceptable species composition of warm-season grasses. Recently, SD Game, Fish and Parks Department has been trying to restore native prairie tracts using repeated intensive early stocking for many years (>5) in a row. They have seen positive results in the recovery of over-rested Kentucky bluegrass-dominated native prairie (Fig. 5).

Figure 5. Native prairie response to repeated early season high intensity grazing for >5 years on SD Game, Fish and Parks' game production area located near Clear Lake, SD. The tallgrass in the foreground (left picture) is big bluestem. Prior to the initiation of this prescribed grazing treatment, this area was predominantly Kentucky bluegrass and smooth bromegrass (right picture). Photo by A.J. Smart, 2011.

High intensity low frequency

High intensity low frequency grazing involves a moderate to high stocking rate to accomplish a uniform grazing with low residual plant height followed by a long recovery period (normally one to two years). The idea behind this strategy is to favor grazing tolerance mechanisms of some species (decreasers) and hurt the species with grazing avoidance mechanisms (increasers and invaders). Caution needs to be exercised using this grazing strategy because animal performance can suffer if daily forage intake is limited and/or forage quality is poor as livestock graze lower into the plant canopy. Few producers practice this grazing system because of this limitation. However, it can provide a shifting mosaic of very short structured vegetation and tall structured vegetation across the landscape.

The Forty Bar Ranch near Iona, South Dakota practices a modification of high intensity low frequency grazing by incorporating different levels of intensities (light, moderate, heavy, and intense). The recovery period is typically 15-18 months or five seasons. For example, if a pasture is grazed in the fall (2010), it won't be grazed until the spring of 2012 (Fig. 6). Since this ranch has all four grazing intensities happening on the ranch at once, there is a shifting mosaic of vegetation structure on an annual basis. In addition, livestock performance is good because they are moved often enough and not assigned to a particular grazing intensity the entire grazing season. This gives the manager the flexibility to tackle certain vegetation objectives for each pasture.

Figure 6. An example of High Intensity Low Frequency grazing at the Forty Bar Ranch near Iona, SD. This pasture was grazed intensively in the fall of 2010 (photo on the left) and was not grazed until spring of 2012. The photo on the right was taken exactly one year later on 9-24-2011. Dominant grasses of this ecological site consist of western wheatgrass, green needlegrass, little bluestem, sideoats grama, and big bluestem.

Ultra high stock density
Ultra high stock density or "mob grazing" is a relatively new concept. The main focus of this grazing strategy is to trample standing forage to build soil organic matter and ecosystem health. In order to maintain animal performance, it is recommended to graze off the top 20% of the plant during each grazing cycle. Some of the trampled stems will break off and become litter and some will remain intact to produce regrowth. If the goal is to graze the pasture more than once, then you need to be careful not to trample too much herbage until the last grazing cycle. The number of grazing cycles will be dependent upon how much rainfall is received and how much residual leaf area is present. If you wait until the forage is mature, you may desire to graze more of the plant (40-50%) and trample the rest of the herbage.

Under the management scenario described above, it is also possible to combine rest-rotation or deferred rotation with ultra high stocking density. Thus, there should be some portions of the farm/ranch with mature standing forage from the previous year, current ungrazed forage from this year, newly trampled forage and various residual heights from grazed areas. Ultra high stocking density can be used to graze and trample brush, help trample in legume and grass seed, and increase soil health.

Conclusion
In summary, eastern grasslands of the Great Plains are vulnerable to invasion of exotic species, land fragmentation, and habitat loss. The combination of fire and grazing, or grazing alone applied strategically, is an effective way to increase biodiversity while maintaining livestock production on grasslands. Managers should consider their current objectives, infrastructure, labor, and knowledge and skill level before deciding which grazing/fire strategy they should adopt.