Managing for Ecosystem Services and Livestock Production: Are There Tradeoffs?

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Introduction

Most all grazing lands have traditionally been managed to provide food and fiber through management practices to achieve sustainable forage and livestock production (Dunn et al. 2010). Yet, society is desiring that these lands also be managed for multiple ecosystem services (defined as provisioning, regulating, cultural and supporting services, Millennium Ecosystem Assessment 2003; Havstad et al. 2007; Toombs et al. 2010), although valuation remains problematic (Farber et al. 2002; Swinton et al. 2007; review by Gomez-Baggethun et al. 2010). Determining tradeoffs associated with changing management from principally a forage and livestock production-centric basis to blending of production and conservation outcomes remains an open frontier (Figure 1). Compounding the uncertainty with determination of tradeoffs is the reality that provision of multiple ecosystem services from grazing lands involves applying management practices on often complex landscapes (Boyd and Svejcar 2009).

Achieving both livestock production and provision of ecosystem services is difficult to balance (Figure 2) when equal weight is given to all possible ecosystem services as there is a need to increase livestock production to feed an ever-expanding world population along with societal desires to provide a diverse suite of ecosystem services (wildlife habitat, greenhouse gas mitigation, lifestyle, water quality and quantity, soil health, carbon sequestration and storage, Havstad et al. 2007). Fundamental to this discussion is the stark reality that livestock production is driven by a developed economic market system whereas markets have yet to emerge for ecosystem services, and therefore the benefits of providing these services have yet to be monetized. Moreover, livestock managers realize that there are possible current economic costs to them by using livestock as ecosystem engineers (Derner et al. 2009) to provide ecosystem services through potential lower livestock weight gains (Figure 3), but that these costs may be lessened or even overcome through the valuation of ecosystem services (Figure 4). Without incentives that compensate for this lost income, or developed markets for ecosystem services on which decisions could be made to modify management to emphasize additional outcomes that have economic rewards, this issue will remain problematic for land managers.

Here, I will address managing grazing lands for multiple ecosystem services within the context of livestock production goals. I will discuss the tradeoffs associated between beef production and 1) provision of habitat for wildlife (e.g., grassland birds and black-tailed prairie dogs (*Cynomys ludovicianus*)), and 2) greenhouse gas mitigation.

Tradeoffs between livestock production and provision of habitat for wildlife

Restoring historic disturbance regimes to enhance habitat for grassland birds and other declining wildlife (Thompson et al. 2008; Augustine 2011) may conflict with livestock production goals. Unlike the widespread use of fire to manage mesic grazing lands (Fuhlendorf and Engle 2004; Govender et al. 2006), fire use is controversial in semiarid grazing lands. For example, prescribed fires can create suitable habitat for the grassland bird Mountain Plover (*Charadrius montanus*), a species of concern in the western Great Plains (Augustine 2011; Augustine and Derner 2012); yet a tradeoff may exist for livestock production if prescribed burning results in lowered livestock gains in these semiarid grazing lands. Recent studies in shortgrass steppe have demonstrated that prescribed burns can be used to manage wildlife habitat without negatively affecting forage availability to cattle (Augustine and Milchunas 2009; Augustine et al. 2010) or livestock weight gains (Derner and Augustine, unpublished data). Implementation of these prescribed burns, however, should occur following average or above-average precipitation years when sufficient fuel loads are present and fire can effectively reduce vegetation structure to desired low levels. In addition, prescribed fires should only be conducted on < 50% of a pasture as an insurance policy to provide residual forage the following spring in case dry conditions reduce forage growth (Augustine and Derner 2012). An important tradeoff for producers and land managers regarding prescribed fire is the cost of implementing burns. Programs to transfer fire management knowledge and capacity from mesic to semiarid grazing lands could assist in reducing such costs.

Like fire, burrowing rodents were historic components of most semiarid grazing lands worldwide, but have experienced population declines or eradication due to conflicts with livestock production. Sustaining the role of black-tailed prairie dogs in grazing lands of the Great Plains may be central to conserving habitat for associated wildlife species because their effects are more stable in space and time than are the effects of fires. There is only scant scientific information, however, pertaining to a question of primary concern to livestock producers: to what extent are livestock weight gains affected by the presence and abundance of prairie dogs? The lack of such information has fundamental economic consequences for land managers with grazing lands containing prairie dogs. Prairie dogs may potentially reduce carrying capacity of livestock by (1) consuming forage, (2) clipping plants to increase visibility and enhance predator detection, (3) building soil mounds around their burrow entrances, and (4) changing plant species composition (Detling 2006).

Cattle gained less weight in pastures of semiarid grazing lands with prairie dogs, but the reduction in weight gains was proportionately less than the increase in area colonized by prairie dogs (Derner et al. 2006). For example, relative to pastures without prairie dogs, livestock weight gains decreased by 6% with 20% of the pasture colonized by prairie dogs, and by 14% with 60% of the pasture impacted by prairie dogs (Derner et al. 2006). The 20% level of colonization by prairie dogs reduced the estimated value of livestock weight gain by $15/steer, whereas the 60% colonization level of prairie dogs reduced the value of livestock weight gain by $38/steer (Derner et al. 2006). Greater impacts of prairie dogs on livestock weight gains are expected in more productive grazing lands compared to semiarid grazing lands, as prairie dogs graze vegetation to approximately the same height in semiarid and more mesic grazing lands (Guenther and Detling 2003). The development of economic incentives or markets to

compensate for livestock production losses associated with prairie dogs may be one means to advance mountain plover habitat conservation on privately owned grazing lands.

Where grazing lands are predominantly managed for livestock production, there is often an economic incentive to use livestock grazing, rather than historic disturbances such as prescribed fire or black tailed prairie dogs, to manage for ecosystem services such as wildlife habitat. For example, livestock could potentially be used as ecosystem engineers (Derner et al. 2009) rather than prescribed fires to create suitable habitat for Mountain Plover, but what are the tradeoffs associated with livestock weight gain? Heavy cattle grazing at twice the recommended stocking rate during spring (March–May) or summer (May–October) for six years did not substitute for prescribed fire or prairie dog grazing in terms of effects on vegetation structure and Mountain Plover habitat (Augustine and Derner 2012). Livestock weight gains with the very heavy cattle grazing were substantially lower on a per head basis compared to those with the traditional grazing practice of moderate stocking (Derner and Augustine, unpublished data). Livestock gains, when expressed on a per acre basis, however, were higher, except in drought years (Derner and Augustine, unpublished data). Thus, both prescribed burning and black-tailed prairie dog grazing appear to be important and complementary means to manage for Mountain Plover breeding habitat in semiarid grazing lands, whereas grazing by livestock alone does not create suitable habitat (Augustine and Derner 2012).

Tradeoffs between livestock production and greenhouse gas mitigation

Grazing lands are increasingly looked upon to serve as cost-effective sinks for mitigating climate variability given their contribution to sequester atmospheric carbon dioxide (CO_2) as soil organic carbon with low to moderate stocking rates (Derner and Schuman 2007). Carbon sequestration also contributes to changes in soil physical, chemical, and biological properties that affect key soil functions, such as nutrient cycling (Janzen 2005).

Though data are limited, inclusive greenhouse gas inventories of grazing management systems provide useful insights regarding potential tradeoffs between mitigation benefits and livestock production. Liebig et al. (2010) evaluated two grazing management systems on grazing lands for their effect on factors contributing to net global warming potential in central North Dakota. The management systems, differing by stocking rate, possessed similar net global warming potential based on assessments of soil organic carbon change, soil-atmosphere methane (CH_4) and nitrous oxide (N_2O) flux, and ruminant CH_4 emissions. However, because of greater beef production on an area basis within the heavily grazed system, greenhouse gas mitigation benefits per unit of livestock weight gain were reduced by over five times compared to a moderately grazed management system. Such results suggest greenhouse gas mitigation by grazing lands will be more effective at lower stocking rates, but at a cost of lower beef production per unit land area.

Conclusions

Grazing lands have traditionally been managed for sustainable forage and livestock production. Tradeoffs exist with managing grazing lands for additional ecosystem services such as wildlife habitat (e.g., grassland birds and black-tailed prairie dogs) and greenhouse gases in the Great Plains of North America (Figure 3). Progress toward reducing economic tradeoffs between livestock production and provision of ecosystem services in grazing lands will require

1) society to acknowledge that there are added costs of managing for multiple ecosystem goods and services, and there is limited capacity of ranching enterprises to financially support these public goals, which are chiefly non-revenue generating, and 2) development of markets for ecosystem services. The latter is needed to assist in the transition from a primary focus of forage and livestock production to a larger portfolio of blended conservation and production goals for ranching enterprises to accomplish "win-win" outcomes (Figure 4).

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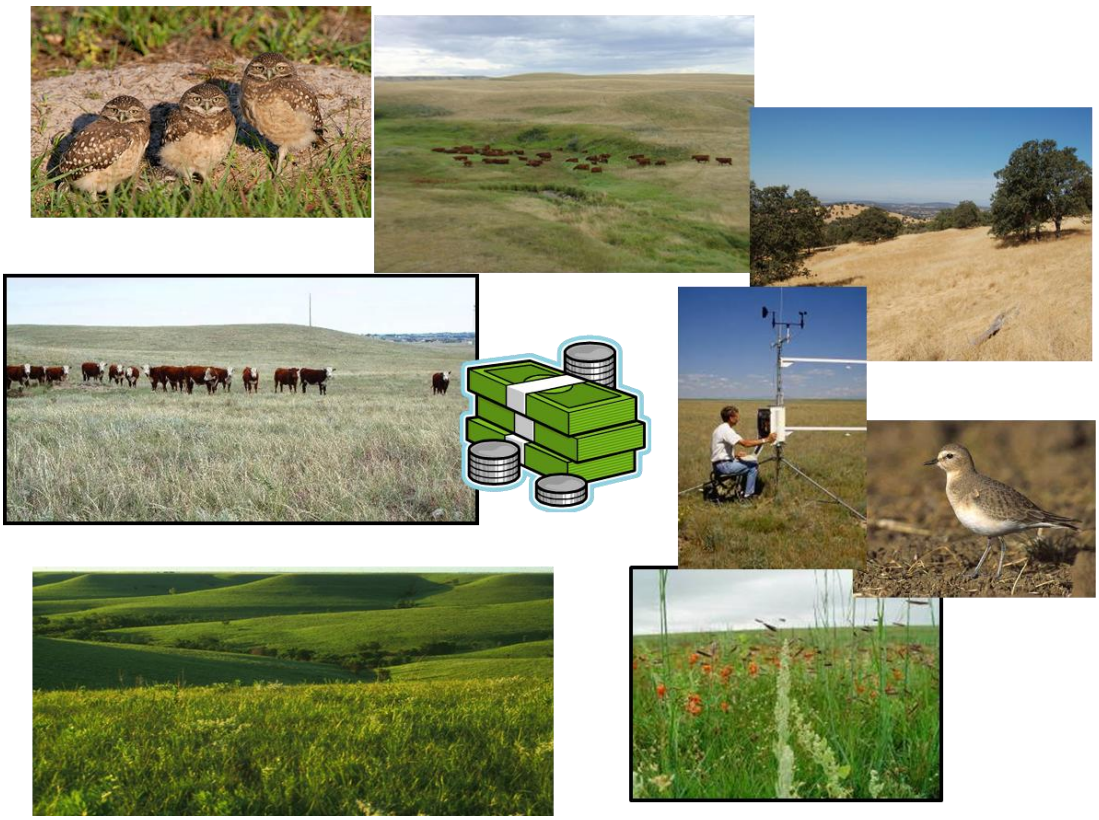

Figure 1. Blending of production and conservation outcomes on grazing lands (from Derner et al. *in review*)

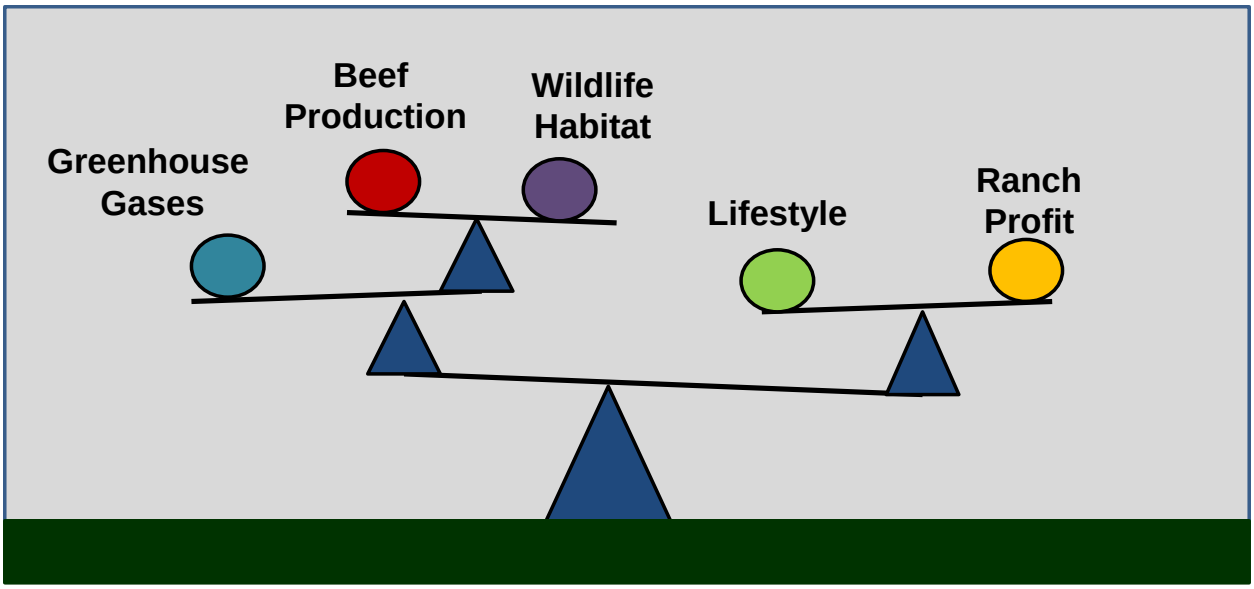

Figure 2. Balancing of ecosystem services and production goals when each is given equal weighting (from Derner et al. *in prep*)

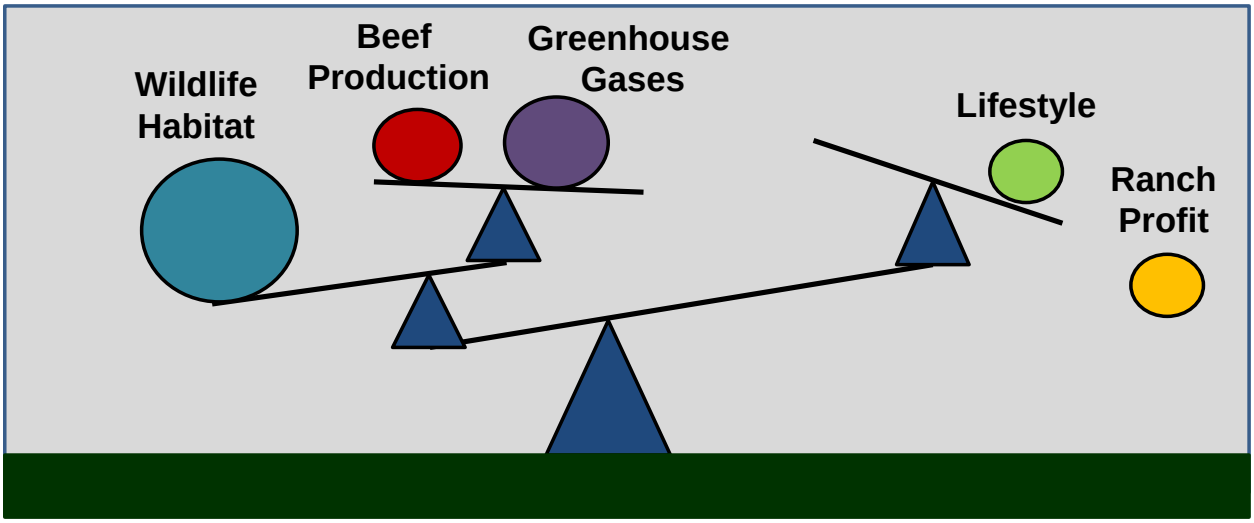

Figure 3. Benefits to one ecosystem service may result in tradeoffs of other ecosystem services and production goals (from Derner et al. *in prep*)

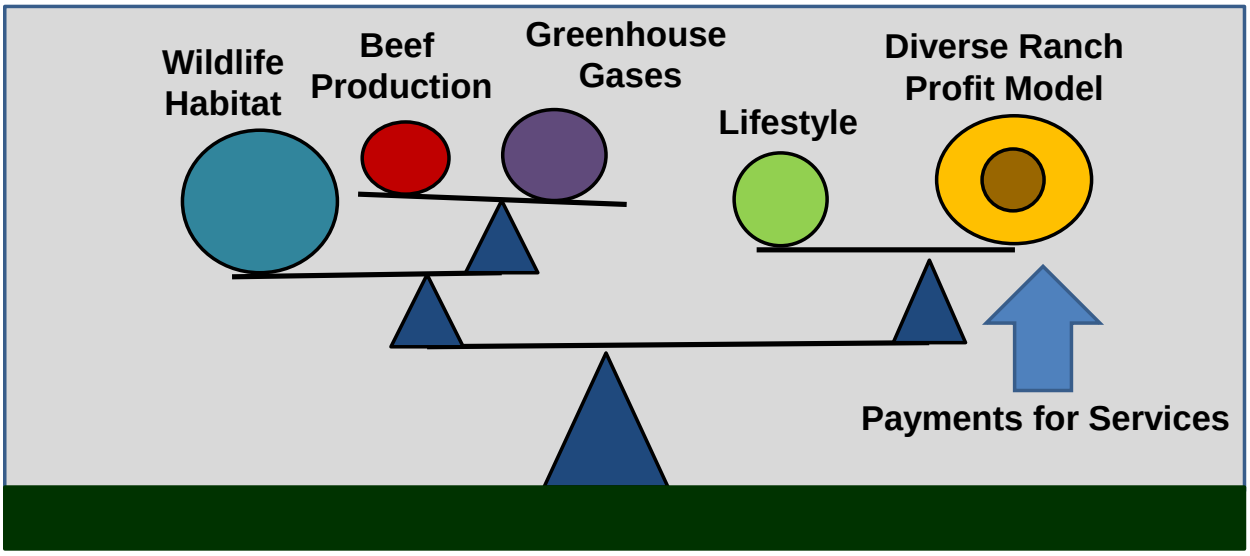

Figure 4. Payments for ecosystem services may balance the tradeoffs associated with reduced beef production (from Derner et al. *in prep*)