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## **Livestock Grazing to Enhance Landscape Heterogeneity**

### Overview

Grazing is the act of herbivorous foraging on vegetation. The Bureau of Land Management, part of the Department of the Interior, regulates domestic livestock grazing on American public lands. Their overall objective is to ensure the long-term health and productivity of these public lands and to create multiple environments that result from healthy watersheds. Livestock grazing now competes with other land-use objectives in the western United States, such as conventional and renewable energy resources, in addition to outdoor recreation and rural residential development. Other issues which public land managers must face are climate change, wildfires, invasive plant species, and rural residential population increases. Since 1940, there has been a continued gradual decrease in the amount of grazing use authorized by the federal government.

The ecology of natural grazing ecosystems is highly complex, but can be understood in several elemental ways. S.J. McNaughton measured productivity and plant biomass to determine the effects of grazing in the Serengeti. It was found that grazing stimulated net primary productivity in most study locations. Grazing also appeared to maintain the vegetation in an immature, rapidly growing state similar to the beginning of the rainy season. In this way, grazing enhances forage quality and rate of production. There is some degree of grazing succession in the Serengeti – for example, zebra following wildebeest graze on vegetation that wildebeest ignore, thus allowing the wildebeest's target plant species to re-grow. The trophic web of this ecosystem suggests that the acceleration of energy and nutrient flow rates is based on intense grazing pressure. The evolution of digestive, morphological, and behavioral traits in animals in response to those traits in plants suggest a co-evolution of plants and animals in the Serengeti ecosystem [McNaughton 1985].

Grazing by domesticated animals, on the other hand, inevitably modifies the vegetation from an otherwise pristine state, and thus any grazing removes plants that would otherwise be undisturbed [Preston et al 2003]. Therefore, any type of grazing could possibly be interpreted as overgrazing. Overgrazing is very difficult to quantify, and vegetation changes resulting from grazing are complex. Preston et al point out that few studies quantify the influence of grazing on erosion and the loss of productivity [Preston et al 2003]. Other concerns raised by grazing include those of trampling by the hooves of livestock. 'Hoof action' is derived from keeping a concentrated number of animals in a small pasture, which allegedly helps break up compacted ground crust, aid water infiltration, and incorporate manure, litter, and seeds into the soil to help new

seedlings become established – all of which has little to no evidence to support it. It was found by the authors that trampling density affected seedling emergence – heavy trampling may increase seedling density in moderately wet conditions. Heavily trampled soils also take up more water immediately after they are trampled [Hart et al 1993].

Scale of patchiness in the landscape mosaic is important for predicting movement and selectivity of grazing herbivores. Wallis-DeVries et al performed field experiments in which patches of different qualities of grass were created, with animals showing high selectivity for patches of higher quality. They did not adjust their movement patterns to reflect patchiness. It was determined that selectivity is impaired in fine-grained environments and highly effective in coarse-grained environments. Large herbivores seem to perceive large patches as one continuous resource, rather than a collection of smaller ones. Overall results found that with regard to variability in scale of patchiness, large grazing animals will avoid small patches and concentrate on large patches when foraging costs are low, which has important implications for optimal-foraging theory [Wallis-DeVries et al 1999]. Optimal foraging theory was also examined in Senft et al [1987], in which it is shown that many herbivores exhibit resource matching both on a regional scale and on a landscape scale. Over-matching is prominent when herbivores are selecting plants from within a community, in order to maximize nutrient intake [Senft et al 1987].

The effects of grazing pressure on forage quality were discussed in Milchunas et al [1994]. In areas where grazing selects for short, prostrate species with high leaf to stem ratios, long-term grazing improved forage quality. In areas where selective grazing consumed palatable species, long-term grazing selected for less palatable, less nutritious species, leading to an overall decrease in forage quality. Long-term grazing in a place such as Colorado short-grass steppe may be expected to have relatively minor effects on forage quality, as grazing does not significantly alter community physiognomy or competition in these areas. Conclusions about defoliation were not particularly strong; there are many factors contributing to different responses. Overall results indicate that the quantity of forage produced in response to defoliation is not indicative of quality of forage produced. Water resource appears to have very little effect on year-to-year yields [Milchunas et al 1994]. In areas of Australia which have been cleared for farming and then subsequently grazed, plant species richness and diversity were greatly reduced. Grazed areas had relatively lower numbers of native species and higher numbers of non-native, invasive species, which in some cases can be attributed to site disturbance [Pettit et al 1995].

Grazing by livestock affects native wildlife, mainly by removing protective cover species. However, other species may benefit from this stripping of cover. Johnston et al examined the impact of grazing on small mammals in Oregon's Monument National Park. Species associated with cover or shrubs were affected negatively by grazing, whereas grazing had no effect on species associated with minimal vegetative cover. The authors also researched riparian areas, since riparian areas attract cattle, finding that

the small mammals associated with riparian areas are negatively affected by grazing. Research findings implicated that grazing pressure removes herbaceous and shrub cover, thus decreasing small mammal biomass. The authors suggest reducing grazing pressure in the national park in order to create small mammal cover habitat, as well as identifying thresholds at which sensitive species begin to decline [Johnson et al 2008]. Soderstrom et al discussed semi-natural pastures in Europe which have developed after centuries of livestock grazing, some of which tolerate or even require grazing pressure, focusing specifically on between-year farmland bird communities. Somewhat counter-intuitively, they found that there is no significant effect of grazing upon ground-nesting birds. Other bird species, particularly insectivorous birds, depend upon grazing. The authors suggest maintaining semi-natural pastures through different grazing intensity schedules in order to maximize farmland bird conservation [Soderstrom et al 2001]. Aspen grazing by elk was briefly implicated in a research study involving aspen declines [Romme et al 1995], but the authors concluded that a complex interaction between elk abundance, climatic variation, fire, and mammalian predators controls aspen regeneration dynamics.

The most drastic example of landscape degradation due to grazing pressure was the example of reindeer grazing in Norway. Jorg Loffler found that large-scale ecosystem-wide changes occur as a result of reindeer grazing. Reindeer have been herded for hundreds of years, primarily by the Saami population. Reindeer grazing places alarming pressure on the environment, yet it is the only practical way to produce food above the tree line. The current stress of reindeer grazing definitely exceeds the landscape carrying capacity, resulting in degradation – however, grazing does not compete with other interests in northern Norway. The author found, most notably, that the changes in the ecosystem result in a depression of the alpine latitudinal belts. The author concludes that the mountain landscape will be ‘desert-like’ in the future [Loffler 2000].

Overall, changes to vegetation caused by grazing are complex and could involve removal of plants, species introduction, and accelerated growth. In the Tarija Altiplano, grazing livestock is an important component of a rural lifestyle. Livestock provides a certain level of security – local people regard them as a sort of insurance against adversity. The authors conclude that grazing today doesn’t affect the quality of vegetation any more than it did during the past 1000 years, and grazing ultimately provides a form of security to local people. This paper successfully incorporates the human element, particularly in pastoral areas. The authors demonstrated that grazing can be managed sustainably and responsibly [Preston et al 2003]. This was one of my favorite papers to read, because I felt that it successfully incorporated a human element within livestock grazing, as well as proving that grazing can be managed sustainably.

## Annotated Bibliography

**Hart, R., J. Bissio, M. Samuel, and J. Waggoner Jr. 1993. Grazing systems, pasture size, and cattle grazing behavior, distribution, and gains. *Journal of Range Management* 46: 81-87.**

This paper looks at intensive, time-controlled, rotational grazing systems. Some benefits of rotational grazing include hoof action, which supposedly breaks up surface crusts, aids water infiltration, incorporates litter and manure into the soil, speeds nutrient cycling, and buries seeds to help new plants grow, although this cannot be supported by research. The authors' experimental design was aimed at separating the effects of time-controlled rotation from those of pasture size and distance to water; hypothesizing that cattle grazing activity would be similar on both rotated and continuously grazed pastures, and grazing would be less uniform and cattle would travel farther and gain less in larger continuously grazed pastures than in smaller continuously grazed pastures. The authors found that trampling densities affect seedling establishment, most notably in wet years. Heavily trampled soils do take up water faster than lightly trampled soils. Other conclusions reached include properly stocked and distributed livestock are important for sound range management. Although the main conclusions in this paper are more useful for range management and cattle stocking, the inclusion of trampling with respect to seedling establishment and trampling on the landscape.

**Johnston, A., and R. Anthony. 2008. Small-mammal microhabitat associations and response to grazing in Oregon. *Journal of Wildlife Management* 72: 1736-1746.**

This paper evaluates the effect of grazing on small mammals. The authors' hypothesis stated that grazing does not influence small mammals, after accounting for microhabitat associations. The examination of microhabitat proved to be the most interesting for me. This was the only study I could find which evaluated the effect of grazing on small mammals, and I found its conclusions to be well thought-out and practical. The authors suggest reducing grazing pressure in the national park in order to create small mammal cover habitat, as well as identifying thresholds at which sensitive species begin to decline. The most useful management implication is retiring several grazing allotments in the national park in question. The authors only specifically addressed Monument National Park, but of course there are broader applications.

**Loffler, J. 2000. High mountain ecosystems and landscape degradation in northern Norway. *Mountain Research and Development* 20: 356-363.**

The author of this paper presents the large-scale ecosystem-wide changes which occur as a result of reindeer grazing. The current stress of reindeer grazing definitely exceeds the landscape carrying capacity, resulting in degradation – however, grazing does not compete with other interests in northern Norway. The author concludes that the mountain landscape will be 'desert-like' in the future, including animal population declines, and the traditional society of the Saami will suffer. The author raises the point that reindeer grazing denudes the landscape and is highly detrimental to the ecosystem,

yet it is the only feasible means of producing food in high mountain ecosystems. Furthermore, there is no other competing land use interest, with the exception of nature conservation. No management implications are stated, although it is made clear that any significant changes are likely to be made.

**McNaughton, S. 1985. Ecology of a grazing ecosystem: the Serengeti. *Ecological Monographs* 55: 260-294.**

Primary productivity and herbivory in the Serengeti National Park were the main focus of this case study. Controlled, protected areas were compared to grazed areas to determine grazing pressure and patterns. Among other things, the author found that grazing animals tend to become concentrated in highly productive areas, and that fire does not have a terribly large impact upon grazing. Similar to Romme et al, the author found that trophic interactions are highly complex and hard to disentangle, with many unique variables. This paper took a very exhaustive look at an ecosystem which revolves around grazing animals in a savannah habitat. Ultimately, the ecosystem is based on additive fluxes, which result in energy and nutrient movement across the landscape. These types of facilitated relations lead the author to introduce his theory of co-evolution which gives the ecosystem coherence and continuity. Overall, this paper takes an insightful, comprehensive approach to an ecosystem which revolves around grazing animals.

**Milchunas, D., A. Varnamkhasti, W. Lauenroth, and H. Goetz. 1994. Forage quality in relation to long-term grazing history, current-year defoliation, and water resource. *Oecologia* 101: 366-374.**

Resource quality of short-grass steppe was examined in areas which had experienced varying degrees of grazing pressure. Field studies with clipped and water sections of treated study areas, when compared with grazed areas, showed different responses to long-term grazing. In areas in which grazing selects for short, prostrate species with high leaf to stem ratios, long-term grazing improved forage quality. In areas where selective grazing consumed palatable species, long-term grazing selected for less palatable, less nutritious species, leading to an overall decrease in forage quality. Long-term grazing in a place such as the short-grass steppe may be expected to have relatively minor effects on forage quality, as grazing does not significantly alter community physiognomy or competition in these areas. Negative effects of grazing are most evident in wet conditions. The authors found that annual net primary productivity may not be a good indicator of the quality of yields. Conclusions about defoliation were not strong; there are many factors contributing to different responses. They did find that past grazing history interacts with current grazing treatment in determining nitrogen and energy availability to consumers. Positive feedback of increased forage quality with defoliation was diminished by long-term heavy grazing. Overall results were that the quantity of forage produced in response to defoliation is not indicative of quality of forage produced. Water resource appears to have very little effect on year-to-year yields.

**Pettit, N., R. Froend, and P. Ladd. 1995. Grazing in remnant woodland vegetation: changes in species composition and life form groups. *Journal of Vegetation Science* 6: 121-130.**

This paper focused on removal of plant species from remnant vegetation patches by grazing animals in previously forested areas of Australia which have been cleared for farming. The authors found that plant species richness and diversity were greatly reduced after grazing. They also found that grazed areas had relatively lower numbers of native species and higher numbers of non-native, invasive species, which in some cases can be attributed to site disturbance. The authors found that native perennial shrubs and herbs suffer the greatest loss of species in the woodland remnants, which are often consumed in late summer after other annual pasture species have been eaten. Native perennial grasses are not strongly affected by grazing, and take advantage of the habitat provided by forest clearing. The conclusions drawn are clear, concise, and soundly backed by data and experimental design, although the only management suggestion the authors make is to fence remnant woodlands in order to allow native perennial species to regenerate.

**Preston, D., J. Fairbairn, N. Paniagua, G. Maas, M. Yevara, and S. Beck. 2003. Grazing and environmental change on the Tarija Altiplano, Bolivia. *Mountain Research and Development* 23: 141-148.**

This paper looks at both the physical environment of the Tarija Altiplano and the importance of grazing in very rural livelihoods. The authors examined the use of the Tarija Altiplano's natural resources, as well as whether the use of this resource is sustainable. The authors introduce the idea that any grazing removes plants that would otherwise be undisturbed, and this constitutes overgrazing – hence any grazing could be described as overgrazing. This paper successfully incorporates the human element, particularly in pastoral areas. The authors demonstrated that grazing can be managed sustainably, and contradicts the notion of 'overgrazing'.

**Romme, W., M. Turner, L. Wallace, and J. Walker. 1995. Aspen, elk, and fire in northern Yellowstone Park. *Ecology* 76: 2097-2106.**

This paper drew few conclusions and ultimately emphasized how complex ecosystems can be. Aspen tree stands in Yellowstone appear to be deteriorating, due to thinning stems; while old stems are not being replaced by new stems. The authors developed two hypotheses: extensive fires would stimulate the production of so many aspen sprouts that elk would not be able to eat them all; and elk would be more attracted to burned areas, thus causing regeneration to take place in unburned areas far from the burned areas. Ultimately, neither of these theories proved workable. The authors concluded that a complex interaction between elk abundance, climatic variation, fire, and mammalian predators controls aspen regeneration dynamics. The paper is inconclusive, citing that more research is needed to more clearly identify critical factors in aspen regeneration. The authors did not draw any definitive conclusions. However, they demonstrated the complexity of an ecosystem in which a large number of grazing herbivores are not exclusively implicated in a problem such as reduced aspen

regeneration. Their hypotheses were simplistic, and may have been better served by a holistic approach.

**Senft, R., M. Coughenour, D. Bailey, L. Rittenhouse, O. Sala, and D. Swift. 1987. Large herbivore foraging and ecological hierarchies. *Bioscience* 37: 789-799.**

This paper further contends optimal foraging theory as it applies to large herbivores. Large-scale foraging patterns are broken down into matching, over-matching, and under-matching. Matching occurs when an animal adjusts its foraging behavior to adapt to changing dietary rewards. Over-matching is a disproportionately large response to a change in reward, and under-matching is a disproportionately smaller response. Over-matching is most prominent when herbivores are selecting plants from within a community, in order to maximize nutrient intake. Many herbivores exhibit matching, both on a regional scale and on a landscape scale. The authors propose that ecological hierarchies can be applied to foraging behavior, and do so thoroughly with regard to both mechanisms and behavior. Their hypotheses are explained and reasoned well, and created many more research questions in the process.

**Soderstrom, B., T. Part, and E. Linnarsson. 2001. Grazing effects on between-year variation of farmland bird communities. *Ecological Applications* 11: 1141-1150.**

The authors examined the ecological effects of grazing on between-year farmland bird communities. Their primary measure of grazing pressure was grass height, which appears to be the only major habitat modification between years which may influence farmland bird abundance. The authors suggest maintaining semi-natural pastures through different grazing intensity schedules in order to maximize farmland bird conservation. Further research may be warranted to discover which other habitat modifications, if any, influence species richness and diversity in pasturelands.

**Wallis-DeVries, M., E. Laca, and M. Demment. 1999. The importance of scale of patchiness for selectivity in grazing herbivores. *Oecologia* 121: 355-363.**

The authors of this paper predicted the importance of scale of patchiness on movements and selectivity of a large grazing herbivore in a controlled field experiment. Selectivity is impaired in fine-grained environments and highly effective in coarse-grained environments. Spatial scale affects selectivity when patchiness is fine-grained, and the authors conclude that there is an increased cost in selection which the animals are not willing to make. They also found that large herbivores do not simply follow a random pattern while foraging, and instead follow a linear path while foraging at a scale of 1-15 m, and at larger scales movement is more random. Overall results found that with regard to variability in scale of patchiness, large grazing animals will avoid small patches and concentrate on large patches when foraging costs are low, which has important implications for optimal-foraging theory.