

Sierra Nevada Grasslands: Interactions Between Livestock Grazing and Ecosystem Structure and Function¹

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Livestock grazing plays an integral role in the grass-dominated ecosystems of the Sierra Nevada. Grazing has been asserted to influence such key ecological characteristics as water quality, net primary productivity, nutrient cycling, plant and animal diversity, wildlife habitat availability, and oak regeneration (Belsky and others 1999, Kauffmann and Krueger 1984). Although there are many reports of these effects, an important task is determining which assertion constitutes reliable knowledge. In other words, how well do we know the cause of change? In fact, there is precious little conclusive experimental evidence (Allen-Diaz and others 1999). We do know that managers have varying control over essential elements of grazing, such as kind of grazing animal, number of grazing animals, and the season of grazing animal use. Many reports on grazing affects either fail to establish adequate experimental controls or are inadequately documented as to the details of grazing (Allen-Diaz and others 1999, Tate and others 1999). The result is uncertainty about the true effects of grazing. We do know that managers can use grazing animals to achieve conservation objectives as well as limit potential adverse impacts (Allen-Diaz and Jackson [in press]).

Case Study

Spring-fed wetlands in the Sierra Nevada oak woodlands are a good example of an ecosystem where grazing animals are expected to have a large, potentially negative impact on plant community dynamics and biogeochemical cycling (Fleischner 1994). Although wetlands in the Sierra Nevada represent a small fraction of the total land cover, they are particularly important areas and affect ecosystem processes at rates disproportionate to their size. Wetlands are very productive, support high biodiversity, provide wildlife habitat, and have significant effects on water quality (Mitsch and Gosselink 1993). In the case of the spring-fed wetlands nestled within the oak woodland/annual grass community of the Sierra Nevada foothills, they exist within a context of historical grazing. If we are to learn the best way to protect these rare and important systems, we must garner a better understanding of how grazing affects them and in what manner they can best be managed.

Long-term (4 to 14 years of continuous data collection, depending on variables) research has been focusing on the effects of various controlled cattle-grazing treatments on spring-fed wetlands of the Sierra Nevada foothills at the University of California's Sierra Foothill Research and Extension Center near Brown's Valley, California. Treatment plots range from 0.75 to 1.2 hectares and are enclosed with a 2-strand electric fence. Each plot contains a spring and ephemeral creek in addition to the annual grassland and oak woodland matrix. Cattle numbers and days of use are recorded during three to four grazing periods per year in order to achieve grazing treatment levels of 800–1,000 kg/ha (light grazing) or 500–600

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kg/ha (moderate grazing) residual dry matter (RDM) in the uplands. The third grazing treatment removes domestic grazing animals from the plots. Using annual grass RDM as the quantified treatment level follows existing management practices for grazing California annual grassland (Bartolome and others 2002). Researchers have tracked species composition, cover, channel morphology, water quality, and aquatic insects (Allen-Diaz and Jackson 2000, Allen-Diaz and others 1998a, Campbell and Allen-Diaz 1996) and examined carbon, nitrogen, and methane dynamics (Jackson and Allen-Diaz 2002, Oates and others 2004).

Research findings show that, in some cases, plant composition can be manipulated with grazing and that lightly grazed sites maintain a greater diversity and evenness of species. Total plant cover (*fig. 1*) did not differ among the sites after 7 years, but after 10, moderately grazed sites showed significant decreases in cover (indicating the importance of long-term monitoring). The effect on water quality varied. Spring-fed wetlands did not show any response to grazing treatments (*table 1*) during the first 5 years of the study, (Campbell and Allen-Diaz 1996), but further studies showed that removing grazing from spring-fed wetlands resulted in increased nitrate concentrations in spring waters (Allen-Diaz and others [in press], Jackson 2002) (*fig. 2*). On the other hand, removal of grazing also resulted in lesser emissions of methane, a potent greenhouse gas (Oates and others 2004). Channel morphology did not vary with treatment (Allen-Diaz and others 1998), but the species richness of aquatic insects tended to decrease with moderate grazing (Allen-Diaz and others 1998b).

The effect of grazing on spring-fed wetlands is complex, but in a broad sense, these studies indicate that some level of grazing is probably desirable, particularly from the standpoint of species diversity and productivity. In addition, removal of grazing can have a negative impact on water quality by increasing the concentration of nitrates that are released into spring waters. However, the results also suggest that high levels of grazing can damage these systems and grazing in general may increase methane greenhouse gas emissions. Therefore, appropriate management, including adjustments to the timing and intensity of grazing, should be used to maximize the health of these wetlands and their benefit to the larger landscape.

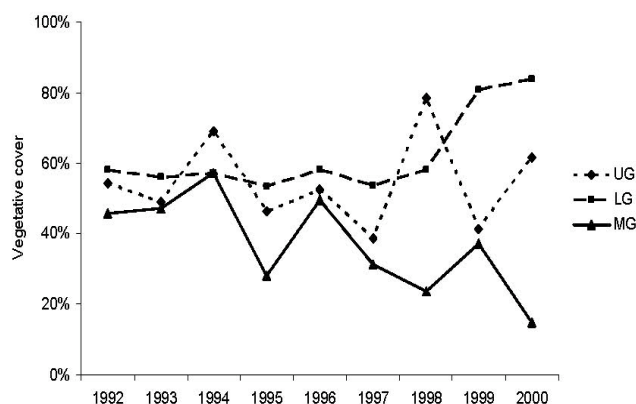


Figure 1— Changes in total mean vegetation cover on ungrazed (UG), lightly grazed (LG), and moderately grazed (MG) springs at Sierra Foothill Research and Extension Center. Adapted from Allen-Diaz and Jackson (2000).

Table 1— *Spring-fed wetlands did not show any response to grazing treatments after 5 years on Sierra Foothill Research and Extension Center springs.*

Water Quality Measures	Moderately Grazed	Lightly Grazed	Ungrazed
Nitrate (mg/l)	1.17 (1.02)	1.78 (1.15)	1.92 (1.08)
Orthophosphate (mg/l)	0.10 (0.05)	0.13 (0.08)	0.15 (0.09)
Dissolved O ₂ (mg/l)	4.85 (1.62)	7.02 (10.96)	5.32 (1.90)
Temperature (degrees C)	17.42 (4.29)	17.62 (3.75)	17.77 (3.43)
pH	6.85 (0.64)	6.81 (0.57)	6.79 (0.56)

Adapted from Campbell and Allen-Diaz (1996).

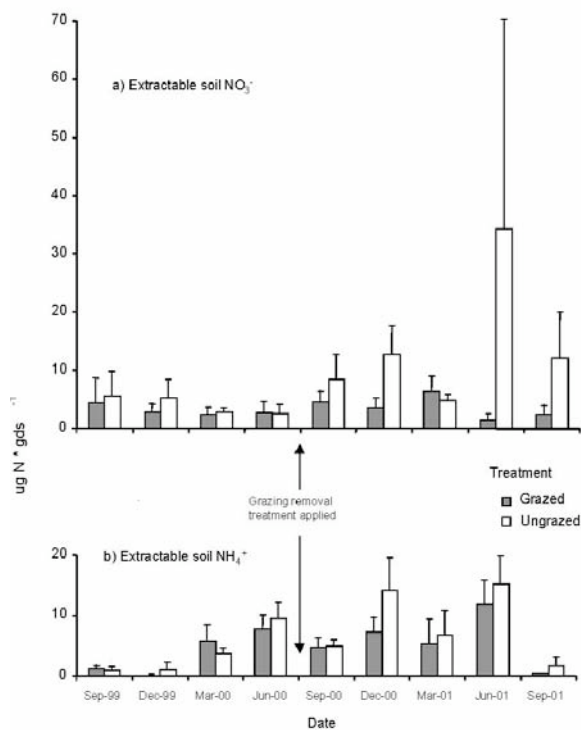


Figure 2— Mean ($\pm$ SE) 2M-extractable soil (a) NO₃⁻ and (b) NH₄⁺ pools from spring-fed wetland sites. Figure indicates increased nitrate concentrations in spring waters with removal of grazing.

References

- Allen-Diaz, B.; Barrett, R.; Frost, W.; Huntsinger, L.; Tate, K. 1999. **Sierra Nevada ecosystems in the presence of livestock: A report to the Pacific Southwest Station and Region.** Albany, CA: USDA Forest Service; March 22. 144 p.
- Allen-Diaz, B.; Jackson, R.D. 2000. **Grazing effects on spring ecosystem vegetation of California's hardwood rangelands.** *Journal of Range Management* 53: 215-220.
- Allen-Diaz, B.; Jackson, R.D. In press. **Herbaceous responses to livestock grazing in Californian oak woodlands: A review for habitat improvement and conservation potential.** In: Planning for biodiversity: Bringing research and management together. A symposium for the California Southcoast ecoregion; 2000. February 29-March 2; Pomona, California.
- Allen-Diaz, B.; Jackson, R.D.; Bartolome, J.W.; Tate, K.W.; Oates, L.G. 2004. **Long-term grazing study in spring-fed wetlands reveals management tradeoffs.** *California Agriculture* 58(3): 144-148.
- Allen-Diaz, B.H., Jackson, R.D.; Fehmi, J.S. 1998a. **Detecting channel morphology change in California's hardwood rangeland spring ecosystems.** *Journal of Range Management* 51: 514-518.
- Allen-Diaz, B.H., Jackson, R.D.; Spencer, M. 1998. **Grazing effects on California's oak woodland springs and creeks.** Abstract. Annual meeting of the Society of Range Management; 1998 Feb. 8-12; Guadalajara, Mexico.
- Bartolome, J.W.; Frost, W.E.; McDougald, N.K.; Connor, M. 2002. **California guidelines for residual dry matter (RDM) management on coastal and foothill annual rangelands.** Univ. of California Division of Agricultural Natural Resources, Rangeland Monitoring Series, Publication 8092. 8 p.
- Belsky, A.J.; Matzke, A.; Uselman, S. 1999. **Survey of livestock influences on stream and riparian ecosystems in the western United States.** *Journal of Soil and Water Conservation* 54: 419-431.
- Campbell, Christopher G.; Allen-Diaz, Barbara. 1997. **Livestock grazing and riparian habitat water quality: An examination of oak woodland springs in the Sierra foothills of California.** In: Pillsbury, Norman H.; Verner, Jared; Tietje, William D. Proceedings of a symposium on oak woodlands: ecology, management, and urban interface issues; 1996 March 19-22; San Luis Obispo, CA. Gen. Tech. Rep. PSW-GTR-160. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 339-346.
- Fleischner, T.L. 1994. **Ecological costs of livestock grazing in western North America.** *Conservation Biology* 8: 629-644.
- Jackson, R.D. 2002. **Structure and function of spring-fed wetlands in an oak savanna.** Berkeley: University of California; 101 p. Ph.D. dissertation.
- Kauffman, J.B.; Krueger, W.C. 1984. **Livestock impacts on riparian ecosystems and streamside management implications: A review.** *Journal of Range Management* 37: 430-438.
- Mitsch, W.J.; Gosselink, J.G. 1993. **Wetlands.** 2nd edition. New York: Van Nostrand Reinhold; 721 p.
- Oates, L.G.; Jackson, R.D.; Allen-Diaz, B. 2004. **The effects of grazing on methane emissions from spring-fed wetlands in a California oak savanna.** Poster, 57th annual meeting of the Society of Range Management; 2004 Jul. 24-29; Salt Lake City, Utah.
- Tate, K.W.; Dahlgren, R.A.; Singer, M.J.; Allen-Diaz, B.; Atwill, E.R. 1999. **Monitoring water quality on California rangeland watershed: Timing is everything.** *California Agriculture* 53: 44-48.