FIELD HANDOUT

MANAGING RANGELANDS FOR ECOSYSTEM SERVICES WORKSHOP AND FIELD DAY

UC SIERRA FOOTHILL RESEARCH AND EXTENSION CENTER, BROWNS VALLEY CA

OCTOBER 18, 2011

Grazing Trial: Ecosystem Service Responses to Cattle Grazing Intensity and Season

Background

Key goals to enhance ecosystem services on California annual grasslands include creation of a diverse vegetation structure to support grassland bird habitat needs, control of invasive plant species (e.g., medusahead), uniform distribution of cattle fecal loading to improve nutrient/pollutant distribution and retention, and efficient harvest of forage to maintain livestock performance and the ranching enterprise. Current management recommendations place heavy emphasis on attaining target residual dry matter (RDM) levels to sustain forage and livestock production. However, managing for RDM targets may adversely impact other ecosystem services, such as providing heterogeneous habitat to support diverse grassland bird communities, or suppressing invasive weeds that adversely impact both production and conservation goals.

Objective

The objective of this study is to examine the effects of cattle grazing intensity and season of grazing on agricultural productivity (forage harvested, animal unit days supported, cattle performance), diversity and resistance to weed invasion (herbaceous plant diversity, medusahead cover), grassland bird habitat (herbaceous vegetation structure, bare ground), and nutrient/pollutant retention and nitrogen cycling (fecal load distribution patterns relative to spatial and temporal leaching patterns, herbaceous seedling thinning and nitrogen availability).

Some Expected Outcomes and Known Relationships

Grazing Intensity – Forage Standing Crop – Grassland Bird Habitat

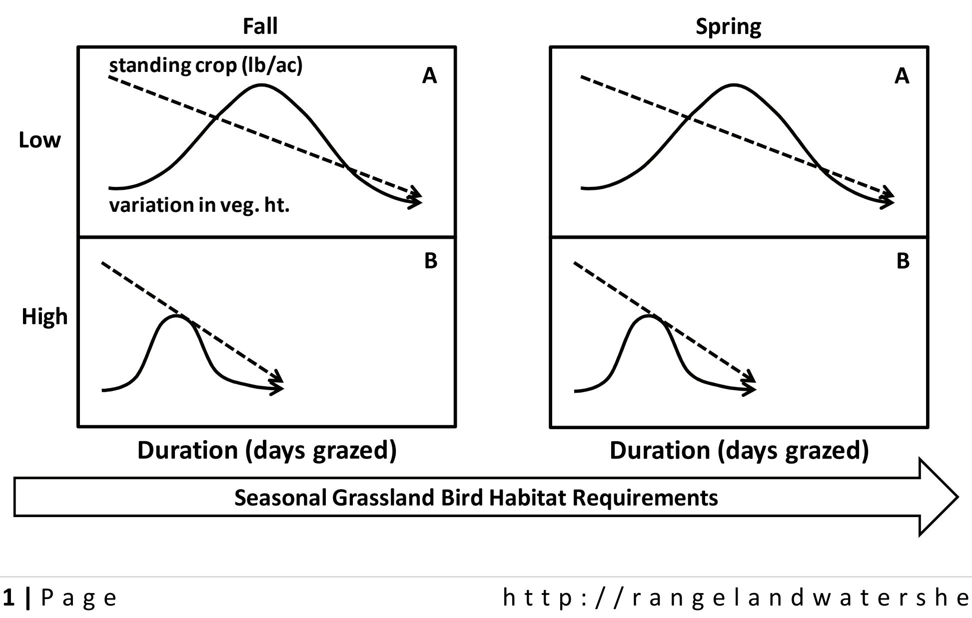

Figure 1. Potential changes in forage standing crop, or residual dry matter, and variation in herbaceous vegetation height with increased grazing duration in pastures with low (A) and high (B) stocking intensity (hd/ac). *It is important to examine* the vegetation patterns created by grazing management relative to seasonal bird species habitat requirements.

Grazing Intensity – Soil Hydrologic Function

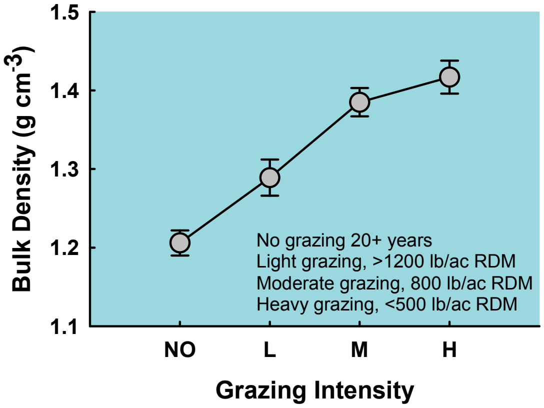

Figure 2. It is well known that increased grazing intensity can impact soil bulk density and hydrology on annual rangelands. Generally, there is reduced infiltration with increased stocking intensity, *which has ramifications for* stream flow generation processes, pollutant transport potential, soil water holding capacity, rooting depth, and nutrient retention.

Tate, K.W., D.D. Dudley, N.K. McDougald, and M.R. George. 2004. Effects of Canopy and Grazing on Soil Bulk Density on Annual Rangeland. *J. Range Management*. 57:411-417.

Grazing Intensity – Stream Water Quality

Grazing Intensity	TSS (mg/L)	NO_3-N (mg/L)	DOC (mg/L)	*E. coli* (cfu/100mL)
Not grazed	1.5	0.1	4.5	310
Moderate	6.5	0.4	3.2	425
Heavy	24.0	0.8	3.5	1250

Table 1. Concentration of total suspended sediments (TSS), nitrate-N (NO_3-N), dissolved organic C (DOC), and *E. coli* from 3 annual rangeland watersheds with different cattle grazing intensity treatments. Concentrations reported are means of ~125 samples collected from each watershed 2007-08 winter growing season. Grazed watersheds (moderate=0.8 aum/ac, heavy=1.9 aum/ac) were grazed Nov-May, and non-grazed watershed had not been grazed for 10 years.

Microbial Pollutant Filtration by Annual Grasslands

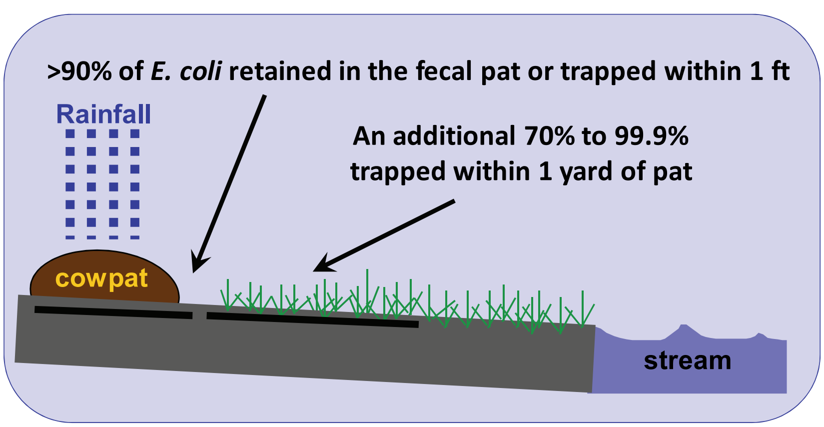

Figure 3. Annual grasslands are extremely effective at attenuating microbial pollutants in surface runoff. Research has repeatedly shown that over 90% of microbial pollutants are trapped within cattle fecal pats, and over 70% of microbial pollutants released from pats during rainfall-runoff events are trapped for each yard of runoff distance. Thus, spatial pattern of cattle fecal pats has *major ramifications* for water quality.

Tate, K.W., E.R. Atwill, N.K. McDougald, M.R. George. 2003. Spatial and Temporal Patterns of Cattle Feces Deposition on Rangeland. *J. Range Management*. 56:432-438.

Atwill, E.R., K.W. Tate, M. Das Gracas C. Pereira, J.W. Bartolome, G.A. Nader. 2005. Efficacy of Natural Grass Buffers for Removal of *Cryptosporidium parvum* in Rangeland Runoff. *J. Food Protection*. 69:177-184.

Tate, K.W., E.R. Atwill, J.W. Bartolome, G.A. Nader. 2006. Significant *E. coli* Attenuation by Vegetative Buffers on Annual Grasslands. *J. Environmental Quality*. 35:795-805.

Spatial Extent of Stream Flow Generation and Leaching Potential at SFREC

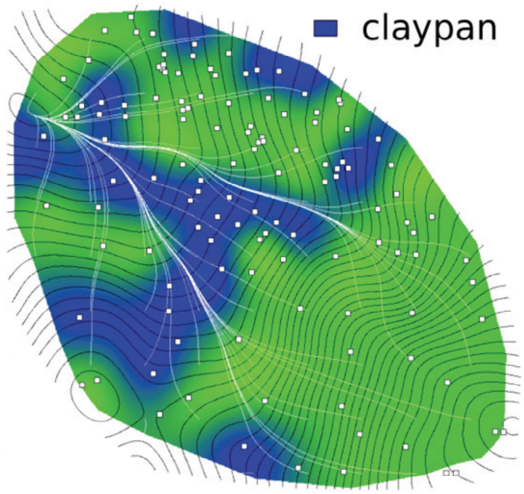

Figure 4. Annual grassland soils at SFREC do not uniformly contribute to runoff and pollutant transport. Near stream areas and areas with a shallow, low permeability claypan produce the majority of storm flow and thus drive pollutant transport. Thus, the spatial and temporal pattern of cattle fecal load relative to these stream flow generation zones has *major ramifications* for water quality.

Swarowsky, A., R.A. Dahlgren, K.W. Tate, J.W. Hopmans, A.T. O'Geen. 2011. Catchment Scale Soil Water Dynamics in Mediterranean Oak Woodland. *Vadose Zone Journal*. 10:800-815.

O'Geen, A.T., R A. Dahlgren, A. Swarowsky, K.W. Tate, D.J. Lewis, M.J. Singer. 2010. Connecting Soil Hydrology and Stream Water Chemistry in California Oak Woodlands. *California Agriculture*. 64:78-84.

Study Area

The study is being conducted on four pastures at the UC Sierra Foothill Research and Extension Center (Figure 5). Pasture sizes range from 93 to 122 acres, and are open grassland with <5% tree cover. Pasture slopes range from 5 to 35% with dominant west and east facing aspects represented in each pasture. In the late 1960s and early 1970s, these pastures were converted from dense oak woodland (>75% tree and shrub cover) to open grassland by repeated chemical, mechanical, and burning treatments. For the 10 years prior to this study (2000 – 2010) grazing occurred during the fall and winter, with a mean stocking rate of ~7 acres per animal unit year (AU is one 1,000 pound cow without calf). Mean herbaceous standing crop (RDM) at the initiation of this grazing study was approximately 2400 lb/ac, which was largely dominated by medusahead.

Grazing Treatments

This study includes four cattle stocking intensity treatments (~1.5, 3.0, and 5.0 acres per AU, and a non-grazed control) applied during the fall and spring grazing seasons. The fall grazing period will commence in early October with onset of the first germinating rainfall event. The start of the spring grazing period will be determined based on the phenological stages of the grassland plant species. To achieve medusahead management goals, each treatment group of cattle will be returned to the pastures once desirable forage species (e.g., wild oats, soft chess) have matured and prior to full maturation of medusahead plants. Fall and spring grazing periods will continue on each treatment until available forage conditions are inadequate to support cattle. This will be established via evaluation of current standing crop, cattle diet nutritional quality, and cattle nutrient demands. Protein and mineral supplements will be placed in each pasture. Grazing period durations will depend on the individual stocking intensity treatments (i.e., higher stocking intensity treatments will have shorter total durations), and are anticipated to range from several weeks to three months.

Study Pasture and Sample Site Layout

A grid of permanently marked sample sites has been established in each pasture (Figure 5). This allows characterization of services across the entire pasture area, and allows for spatial analyses of responses of ecosystem service metrics to grazing treatments.

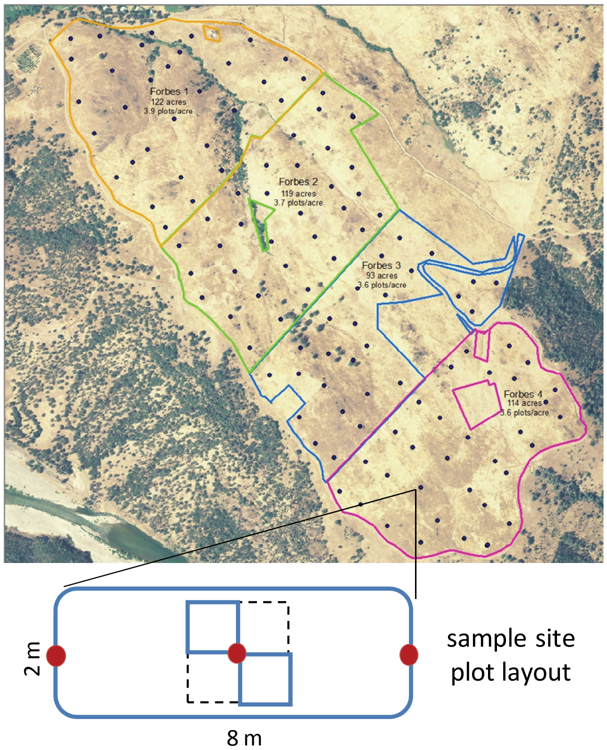

Figure 5. Map of the four study pastures with dots representing the location of permanently marked sample sites. At each sample site, plant, habitat, and fecal loading metrics will be measured.

Metric	Purpose for Measurement	Timing of Measurement
plant species composition	medusahead cover, forage species cover, diversity	before fall & spring, after spring
bare ground	grassland bird habitat, water quality	before & after fall & spring, every 3 to 6 days during grazing periods, weekly between grazing periods (winter)
vegetation height	grassland bird habitat	
cattle fecal loading	nutrient distribution, water quality	
forage standing crop	forage harvest, water quality	
cattle diet quality	animal performance	before and after fall & spring, every 6 days during grazing periods
cattle weight & body score	animal performance	before & after fall & spring

Table 2. Ecosystem service metrics examined in this study.

Measurements

Each sample site is comprised of a center point, two 0.10 m^2 plots at that center, and a 2 m by 8 m belt transect (Figure 5). Plant species composition by cover, percent bare ground, and standing crop (forage mass by comparative yield) are measured on the two 0.10 m^2 plots (Table 2). Grazing impacts will be recorded at each 0.10 m^2 plot, including observation of vegetation trampling, grazing, and/or fouling by dung. Vegetation height (vertical visual obstruction) will be measured via a Robel pole at the center point of each sample site, viewed from each end of the belt transect. Fecal loading (pats/m^2) will be measured in the belt transect. Changes in cattle weights and body condition (score) will be measured before and after grazing periods. Cattle diet quality will be determined using near infrared reflectance spectroscopy (NIRS) on randomly selected field fecal samples (Table 2).

Herbaceous Seedling Thinning and N Availability

One advantage of conducting management scale grazing studies is the opportunity to embed mechanistic work examining how grazing might affect key ecosystem functions, such nitrogen (N) supply and its impacts on forage production and quality. Decades of research in California rangelands have made it clear that there are large gaps in our fundamental understanding of controls over forage productivity—the conventional variables of climate, soil, species composition, and residual dry matter (RDM) do not account for the large spatial and temporal variability in plant productivity. Similarly, nitrogen budgets in this system are not balanced—with plants taking up 60% more nitrogen each year than is accounted for in the soil available pool (through soil organic matter and litter mineralization, N deposition, and N fixation). Our recent work has demonstrated that the missing supply of N in the annual N budgets in California grasslands is due to seedling thinning. In these annual grasslands, at the end of the growing season, most plant N is in the seeds rather than the litter. Over 90% of annual grass seeds germinate each year, and 50-90% of germinated seedlings die through self-thinning, providing pulses of labile N. This N is supplied at peak plant demand – making seedling thinning the ideal self-timed fertilizer. We have demonstrated that seedling thinning inputs not only account for the missing N in annual budgets, but also explain a majority of the variability in seasonal timing of soil nutrient supply, as well as 30-70% of site to site variability in N, P, and S supply. Furthermore, our experiments have shown that typical site-to-site and year-to-year variability in seed production (which can vary 4- to 100-fold) causes up to 2-fold variation in plant primary production and N content.

While our current work clearly demonstrates that seed production and seedling thinning are important controllers over nutrient supply and plant production, we have no idea how the intensity and timing of grazing impacts seed production or seedling thinning dynamics. We will utilize this grazing trial to investigate how grazing regime impacts: 1) seed production; 2) seedling germination and thinning; and 3) timing and amount of soil N supply.

Some Known Relationships

Annual Nitrogen Supply on Annual Grasslands

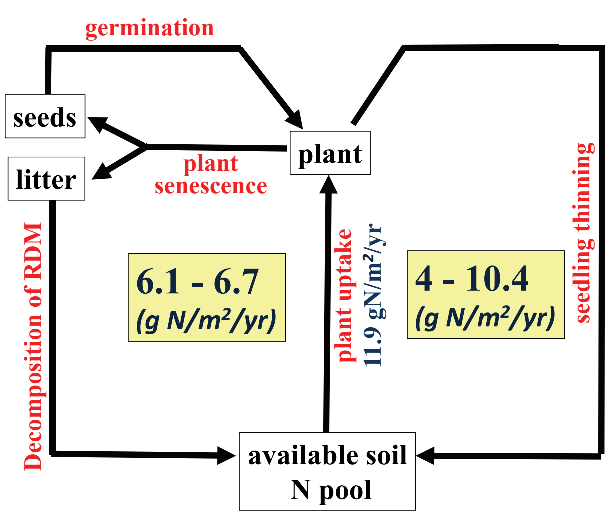

Figure 6. Annual N supply through the decomposition of Residual Dry Matter (RDM) pathway, vs. through the seedling thinning pathway.

Seed Density – Plant Productivity – Plant N Content

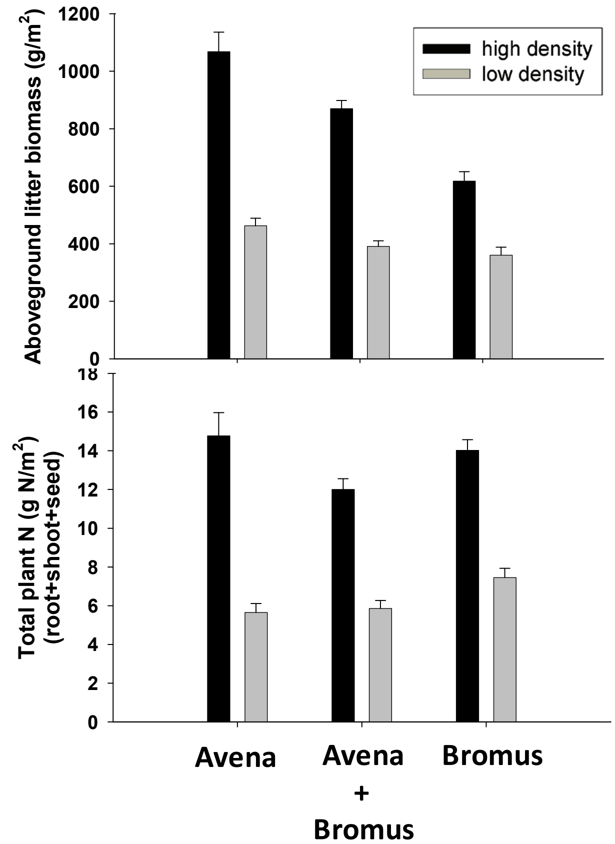

Figure 7. Impacts of seed density on end-of-season plant production (top panel) and plant N content (bottom panel). Seeds were planted at typical germination densities (80,000 seeds/m^2, high density) and at typical end-of-season densities (10,000 seeds/m^2, low density) as monocultures of *Avena barbata, Bromus hordeaceus,* or a mix of the two. High densities doubled plant production and N content.

Please find associated information, track results from this grazing project, and monitor the development of the larger adaptive rangeland management project at:

California Rangeland Watershed Laboratory
http://rangelandwatersheds.ucdavis.edu/

Center for Environmental Policy and Behavior
http://environmentalpolicy.ucdavis.edu/

Eviner Laboratory
http://www.plantsciences.ucdavis.edu/plantsciences_faculty/eviner/

USDA-ARS Rangeland Resources Research Unit
http://www.ars.usda.gov/main/site_main.htm?modecode=54-09-00-00