UNIVERSITY OF CALIFORNIA
AGRICULTURE & NATURAL RESOURCES

SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Beef & Range Field Day

APRIL 21, 2005

Browns Valley, California

UNIVERSITY OF CALIFORNIA
AGRICULTURE & NATURAL RESOURCES

SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Presents:

Annual Beef & Range Field Day

APRIL 21, 2005

Cosponsored By:
Ecosystem Sciences & College of Natural Resources, UC Berkeley
University of California Cooperative Extension
Dept. of Plant Sciences, UC Davis
Land, Air & Water Resources, UC Davis
School of Veterinary Medicine, UC Davis

UC BEEF & RANGE FIELD DAY
Sierra Foothill Research & Extension Center

APRIL 21, 2005

AGENDA

Morning Master of Ceremonies – Roger Ingram Livestock/Farm Advisor, UCCE Placer/Nevada Counties

9:30am	Welcome – Bill Frost, Natural Resources Program Manager & County Director, UCCE El Dorado County
9:40am	**Sudden Oak Death** – David Rizzo, Assoc. Professor, Plant Pathology, UC Davis
10:05am	**Impacts of grazing on foothill wetlands** - Barbara Allen-Diaz, Professor & Executive Associate Dean, College of Natural Resources, UC Berkeley
10:30am	**Ecological site descriptions** – Mel George, Rangeland Management Specialist, Agronomy & Range Science, UC Davis
10:55am	**Animal Health Update** – John Maas, Extension Veterinarian, School of Vet. Med., UC Davis
11:20am	Walk to irrigated pasture
11:30am	**Agricultural Waste Discharge Requirement for Irrigated Lands:** Update – Dennis Heiman and/or Bill Croyle, State Water Resources Control Board
12:00pm	Tri-tip BBQ Lunch – Served by the Yuba-Sutter Cowbelles & SFREC Staff
12:45 pm	California Cattlemen's Association Officers: Industry Update

Afternoon Master of Ceremonies – Glenn Nader Livestock/Farm Advisor, UCCE Yuba/Sutter/Butte Counties

1:30pm	Travel to Sc-13 N.
1:45pm	**Irrigated pasture trial results** – Ken Tate, CE Rangeland Watershed Specialist, Agronomy & Range Science, UC Davis **Using Created Wetlands for filtering irrigation water** – Kate Knox, Graduate Student, Land, Air & Water Resources, UC Davis
2:15pm	<u>Fire Effects on</u>: **Water quality** – Ken Tate **Oaks** – Doug McCreary, Natural Resource Specialist, Integrated Hardwood Range Management Program, UC Berkeley **Soil** – Toby O'Geen, CE Specialist, Soil Resource, LAWR, UC Davis
2:45pm	**Residual Dry Matter Guidelines** – James Bartolome, Professor, Ecosystem Sciences, UC Berkeley **Pathogen Movement** – Ken Tate
3:30pm	Return to H.Q. and Adjourn

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Sudden Oak Death

David Rizzo, Plant Pathology, UC Davis

Background

Sudden Oak Death (SOD) is a new disease affecting tanoak *(Lithocarpus densiflora*) and oaks *(Quercus* spp) in California and Oregon, caused by the recently described pathogen *Phytophthora ramorum*. It has reached epidemic proportions in several counties in central California, leading to the death of tens of thousands of trees. In addition to oaks and tanoak, *P. ramorum* has been found in nearly all woody plant species in mixed evergreen and redwood forests from central California to southern Oregon. Plant species that are not killed appear to serve as a reservoir for the pathogen. The high susceptibility of tanoak to infection and death suggests that *P. ramorum* is an exotic pathogen, but its origins, and most details of its biology and ecology, remain unknown. Our limited knowledge only compounds our concern over the long-term implications of this epidemic for the ecology of coastal forests.

Susceptible Species

Confirmed cases of Sudden Oak Death have been reported in the coastal counties of central and northern California, from Mendocino in the south to Humboldt in the north. It has also been confirmed near Brookings in southern Oregon. All confirmed counties in California are required to follow state and federal regulations when handling or transporting host material. Your local County Agricultural Commissioner can provide you with up-to-date regulations. For a current list of regulated counties, as well as a complete list of regulated host plants, go to the web site of the California Oak Mortality Task Force: www.suddenoakdeath.org.

Sudden Oak Death infections are often fatal on tanoak, coast live oak, California black oak, canyon live oak, and Shreve oak. *P. ramorum* primarily attacks the tree's vascular system just below the bark, girdling the tree. The vascular system is the "plumbing" that transports nutrients and water throughout the tree. A tree infected with the pathogen is weakened and may also be attacked by other tree pests, such as bark beetles and decay fungi.

Symptoms

An early symptom on oaks may be the "bleeding" of a thick sap that appears on the bark surface. However, many other diseases and injuries may also cause similar symptoms. Underneath the bleeding bark there is a canker with dark patches of infected tissue surrounded by healthy tissue. Cankers and bleeding usually occur on the trunk within ten feet from the ground.

Other than the oaks, plants infected with *P. raramorum* most often show symptoms of leaf spots and twig dieback, and are considered foliar hosts. Pathogen spores can build up rapidly on the leaves of these hosts. California bay laurel *(Umbellularia californica*) is a foliar host that appears to play a significant role in the distribution of *P. raramorum* spores. Laboratory culture of *P. ramorum* is needed to confirm the diagnosis of Sudden Oak Death since many other agents cause similar symptoms. For diagnostic assistance, please contact your local

County Agricultural Commissioner or University of California Cooperative Extension (UCCE).

Management
The best defense against Sudden Oak Death is to use good management and sanitary practices including the following:

- Clean and disinfect all pruning, cutting, and chipping tools with a household disinfectant (such as Lysol, ethanol, or diluted bleach) after pruning host plants.

- Monitor oaks for bleeding symptoms year round. If bleeding symptoms are detected, seek confirmation that the cause is *Phytophthora ramorum* by contacting your County Agricultural Commissioner or UCCE.

- If you are in an infested county, do not move host material to uninfested areas. If host material must be removed from your property, it should be disposed of at a local landfill or transported to an approved collection facility.

The Future
We do not yet know where SOD will spread. In the wild, it is so far restricted to locations relatively near the Coast. However, many susceptible plant species grow in the Sierra Nevada so we are closely monitoring symptomatic plants to determine if the range of this disease spreads. We are hopeful that the hotter and drier conditions further inland will limit the ability of the disease to move eastward, but only time will tell.

RESEARCH ARTICLE

Long-term grazing study in spring-fed wetlands reveals management tradeoffs

Barbara Allen-Diaz
Randall D. Jackson
James W. Bartolome
Kenneth W. Tate
Lawrence G. Oates

Spring-fed wetlands perform many important functions within oak-woodland landscapes, and livestock grazing modifies these functions. We used 10-year (long-term) and 3-year (paired-plot) experiments to better understand grazing management effects. We studied spring ecosystem responses in plant composition, diversity and cover; channel morphology; water quality; aquatic insects; and greenhouse gases. Lightly and moderately grazed wetlands exhibited lower insect family richness than ungrazed springs. Plant cover was maintained for the first 7 years of grazing, and plant diversity was not significantly affected. At the same time, removal of grazing decreased emissions of the greenhouse gas methane, and increased nitrate levels in spring waters. The results reveal important management tradeoffs relative to key response variables. In general, light cattle grazing at springs appears to be desirable from an ecosystem function perspective.

Oak-woodland springs provide green habitat and water throughout California's Mediterranean-style dry season, making them highly desirable ecosystems, islands of biodiversity and high productivity.

Wetland ecosystems are highly productive and valued for numerous reasons including wildlife habitat, biodiversity, water quantity and quality, and human uses. They are also relatively small ecosystems, occupying less than 1% of the state. Because livestock are thought to damage the physical, chemical and biological integrity of these systems, they are subject to government regulations, ranging from seasonal use requirements to complete livestock removal (Allen-Diaz and Jackson 2002). Livestock grazing can affect the functioning of spring-fed wetlands by acting as a nutrient filter and altering plant community composition (Jackson 2002).

These systems are also highly variable, making it difficult to predict responses to management (Allen-Diaz et al. 2001). For example, first-order (headwater) and fourth-order streams (such as the Yuba River) may have similar vegetation, but their responses to grazing may differ because of substrate (the bedrock, gravels and soils on which plants grow), slope or other environmental differences.

Spring-fed wetlands of the oak woodlands fall into two broad categories — rocky and marshy (Allen-Diaz and Jackson 2000). Where spring water emerges in and around rocky substrates, little soil development occurs. Water quickly forms channels, and overstory trees and shrubs are frequently present. The rocky wetlands typically maintain two distinct zones, an area immediately surrounding the emergent water source (referred to as springs) and the resulting channelized creek (fig. 1A).

On more shallow slopes, the flow of emergent water is slower and more diffuse, allowing the development of dense, herbaceous vegetation, which further reduces flow. These marshy sites typically do not support trees or shrubs, probably because of anaerobic soil.

Grazing and soil-water research

Rangelands occupy about 57 million acres in California. About 42% of these acres are privately owned and provide most of the forage for California's cattle industry. Approximately 9,000 miles of streams and 125,000 acres of wetlands occur on California rangelands. Many consider livestock grazing on rangeland a potential nonpoint source of pollution and thus, a serious threat to the health of California waters. Our research carefully examines these concerns.

In a long-term study, Experiment A, we tracked species composition and cover for more than a decade, primarily on rocky-type wetlands, under three levels of grazing intensity at the UC Sierra Foothill Research and Extension Center (SFREC) east of Marysville, Calif. (Allen-Diaz and Jackson 2000). Species composition was recorded in early June

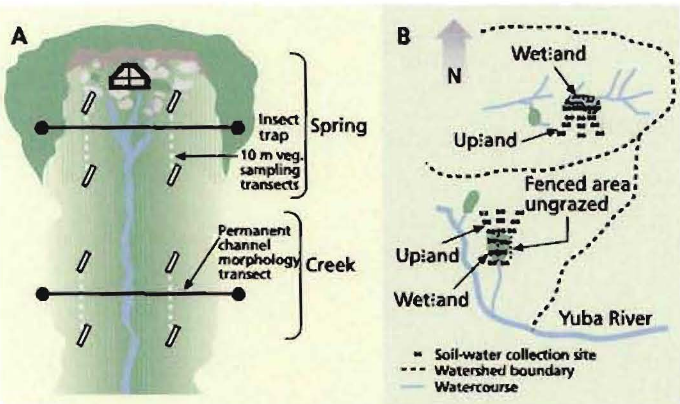


Fig. 1. Typical morphology of rocky spring-fed wetlands; Experiment (A) and (B) study layouts.

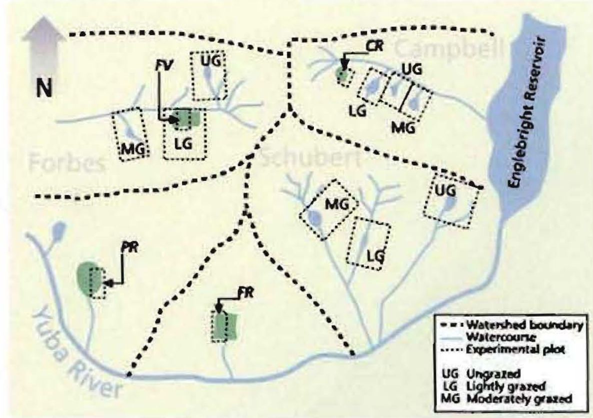


Fig. 2. Location of experimental plots at the UC Sierra Foothill Research and Extension Center. The 10-year (Experiment A) sites were in Forbes, Campbell and Schubert watersheds; the 3-year study (Experiment B) sites were Forbes Valley (FV), Pole-line Ridge (PR), Campbell Roadside (CR) and Fireline Ridge (FR).

each year from permanent 16.25- or 32.5-foot (5- or 10-meter) line-point transects, which were randomly located on either side of the channel within the wetland zone. Changes in stream-channel shape (morphology)(Allen-Diaz et al. 1998) and water quality (Campbell and Allen-Diaz 1997) were also examined for approximately 5-year periods on the same sites (fig. 2). Channel morphology changes were recorded along two randomly placed 32.5-foot (10-meter) line-point transects located perpendicular to the flow of the spring or creek. We collected water samples at the spring-head, or spring source, and in the creek and analyzed them in the field using a HACH DREL2000 Water Testing Kit.

In a paired-plot study at the SFREC, Experiment B, we examined marshy springs to closely evaluate soil-water nitrate levels and greenhouse-gas emissions for 3 years. We collected soil water from preinstalled, porous, soil-water cup samplers (Model 1900, SoilMoisture Equipment, Santa Barbara). When possible, samples of upland soil water and wetland surface water were collected monthly (fig. 1B). Within the wetland, surface-water samples were collected in 100-milliliter (mL) specimen cups to assess nitrate output and compare with upland soil-nitrate levels. The UC Division of Agriculture and Natural Resources Analytical Laboratory analyzed water samples by a diffusion-conductivity analyzer. Carbon (CO_2), nitrogen (N_2O) and methane (CH_4) gas emissions were collected monthly from March to September 2002 (with the exception of May) in vented static flow chambers. Gas samples were analyzed by gas chromatography (SRI Instruments, Torrance, Calif.).

All sites had historically similar fall-winter-spring grazing histories that left approximately 600 to 750 pounds per acre residual dry matter (RDM), or aboveground biomass, in the uplands. In 1993, sites within watersheds were randomly assigned to the following treatments in a randomized block design:

- Grazing removal (ungrazed, UG, approximately 1,200 to 1,500 pounds per acre upland RDM).
- Light grazing (LG, approximately 800 to 1,000 pounds per acre upland RDM).
- Moderate grazing (MG, approximately 600 to 700 pounds per acre upland RDM).

Experiment B took place on the marshy sites, to take advantage of their greater area. Marshy springs were sampled in 1999 and 2000. Then, these sites were divided so that grazing treatment comparisons could be made within sites (Jackson 2002). This meant that only two treatment levels could be compared — moderate grazing and grazing removal. Posttreatment samples were collected in 2001 (fig. 2).

Grazing effects on wetlands

Plant species composition. Changes in species composition provided evidence of fundamentally different vegetation dynamics in these systems. One way to examine these changes is with a CCA (Canonical Correspondence Analysis) site score, an index variable that collapses species composition into one measure. This statistical technique is useful for interpreting plant community structure that is related to environmental variables (McCune and Grace 2002). For example, in this case we used it to compare changes in species composition related to grazing levels in Experiment A. The CCA site scores were much more variable from year to year for springs than for creeks on the rocky-type wetlands (fig. 3). Implications for management are that species composition can be manipulated by altering the grazing intensity along creeks. In springs, how-

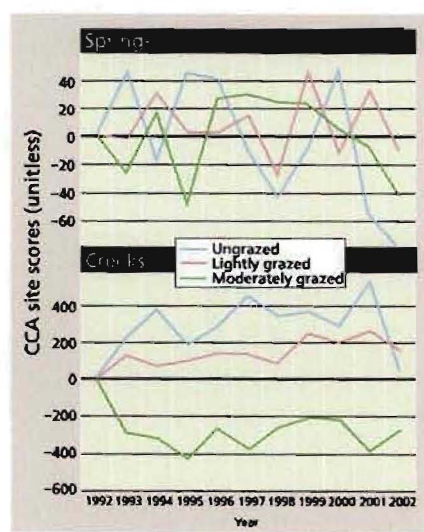


Fig. 3.* Species composition over time as affected by grazing intensity in Experiment A.

*Note: Figures 3 and 5 in this on-line PDF are corrected from the printed version.

Cattle grazing causes visual changes in oak-woodland spring structure. However, spring composition is stable over time, and hoof-caused hummocks do not result in detrimental changes to composition, productivity or water quality.

ever, species composition is controlled by the vagaries of climate, not by grazing intensities at the levels we studied.

Herbaceous diversity. No significant differences in the total number of species (relative to pretreatment 1992 values) were observed at any of the wetland sites. Common species are listed in table 1. In both experiments, there were no changes in the relative amounts of native and nonnative species over time under any grazing treatment. Lightly grazed wetlands maintained greater species evenness (maximum when all species have the same number of individuals) and diversity (Shannon-Weaver and Simpson indices) relative to 1992 pretreatment values than either ungrazed or moderately grazed plots (Jackson 2002). At creeks, moderately grazed plots maintained greater relative total species, evenness and diversity than lightly grazed and ungrazed plots, which were not significantly different from each other.

On marshy springs (Experiment B), we observed decreased diversity with grazing removal for 1 year. Our results indicate that light grazing on spring-fed wetlands and moderate grazing on resultant down-slope creeks maintain current plant diversity.

Herbaceous cover. Because plant cover conserves soil, improves water quality and is correlated with plant productivity, it is an important measure of ecosystem health. After 7 years, we found no significant differences in herbaceous cover among grazing intensity treatments. However, by 2002, moderate grazing resulted in a significant decrease in plant cover. Sustained grazing at moderate or higher intensities on these systems is not desirable from an ecosystem conservation perspective, to prevent significant erosion and prevent undesirable changes in species composition. However, our short-term study showed that occasional moderate grazing does not significantly affect plant cover.

Channel morphology. Five years of data from permanent cross-section transects of the springs and resultant creeks in Experiment A showed no changes in channel morphology due to grazing treatment (Allen-Diaz et al. 1998). Ungrazed springs and creeks exhibited more year-to-year variability than grazed springs and creeks, although these differences were not statistically significant. Channel widening and flattening of waterways can have important effects on fish populations, especially in second and lower-order streams.

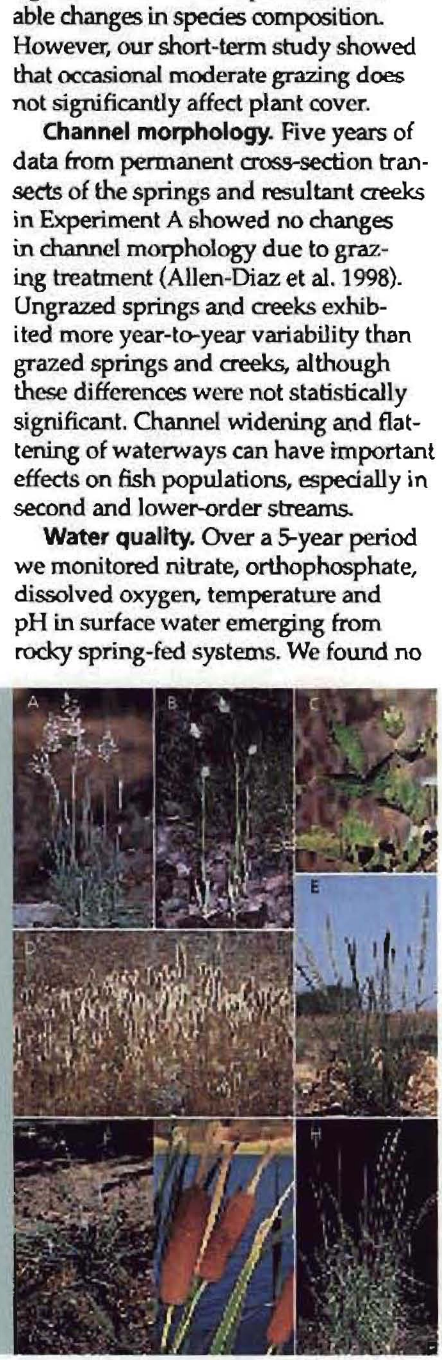
Water quality. Over a 5-year period we monitored nitrate, orthophosphate, dissolved oxygen, temperature and pH in surface water emerging from rocky spring-fed systems. We found no

TABLE 1. Dominant herbaceous-layer plant species in springs and creeks at Sierra Foothill Research and Extension Center, Experiments A and B

Common name	Species	Family	Native/ Introduced*
Blue wild-rye (H)	*Elymus glaucus*	Poaceae	N
California blackberry (C)	*Rubus ursinus*	Rosaceae	N
California grape	*Vitis californica*	Vitaceae	N
Common spike-rush	*Eleocharis macrostachya*	Cyperaceae	N
Dallis grass (F)	*Paspalum dilatatum*	Poaceae	I
Dogtail (B)	*Cynosurus echinatus*	Poaceae	I
False brome	*Brachypodium distachyon*	Poaceae	I
Flat sedge	*Cyperus odoratus*	Cyperaceae	N
Hedge nettle	*Stachys albens*	Lamiaceae	N
Italian ryegrass (E)	*Lolium multiflorum*	Poaceae	I
Italian thistle	*Carduus pycnocephalus*	Asteraceae	I
Narrow-leaved cattail (G)	*Typha angustifolia*	Typhaceae	N
Rabbitfoot grass (D)	*Polypogon monspeliensis*	Poaceae	I
Rattlesnake grass	*Briza minor*	Poaceae	I
Ripgut brome	*Bromus diandrus*	Poaceae	I
Seashore vervain	*Verbena litoralis*	Verbenaceae	I
Soft chess	*Bromus hordeaceus*	Poaceae	I
Velvet grass (A)	*Holcus lanatus*	Poaceae	I
Water cress	*Rorippa nasturtium-aquaticum*	Brassicaceae	N

* N = native, I = introduced (Hickman 1993).

Photo credits: Joseph M. DiTomaso (A–E), Jack Kelly Clark (F), ANR Communication Services (G), Suzanne Paisley (H).



Removal of livestock grazing resulted in increased levels of nitrate in wetland waters and thus higher levels of nitrate pollution compared to grazed springs.

significant differences among grazing intensity treatments in Experiment A (Campbell and Allen-Diaz 1997).

In Experiment B, marshy spring-fed wetlands appeared to intercept and retain nitrate as it moved along its hydrologic path from upland soils to emergent spring waters (Jackson and Allen-Diaz 2002). Furthermore, the removal of livestock grazing from these wetlands impaired the ability of the springs to retain nitrate. Grazing removal allowed dead plant material to accumulate (fig. 4), thereby inhibiting plant production (hence, plant nitrogen demand), resulting in stream-water nitrate concentrations that far exceeded the U.S. Environmental Protection Agency's surface-water maximum standard of 714 μmol[5] (micromoles[5] or 10 parts per million [ppm])(fig. 5).

Aquatic insects. Aquatic insects are frequently used to evaluate the ecological integrity of streams. Reduced community numbers may indicate organic pollution or habitat degradation. Insects were identified to the family level from a 1-year sample (collected quarterly) in Experiment A. Analysis was limited to families with aquatic genera; wholly terrestrial families were excluded. Lightly grazed and moderately grazed wetlands exhibited lower family richness than ungrazed springs at each sampling date. The lowest cumulative family-richness values (sum of all families for the year) were found for moderately grazed springs followed by lightly grazed springs.

Greenhouse gases. Methane (CH_4) is a greenhouse gas that is important to global climate change. It is "radiatively active," warming the lower atmosphere by absorbing thermal radiation. Methane contributes approximately 20% of terrestrial trace gases into the atmosphere (Bouwman 1990; Cicerone and Oremland 1988). The atmospheric concentration of methane has increased from 0.7 to 1.7 ppmv (parts per million by volume) in the last 200 years (Tyler 1991). When compared to carbon dioxide (CO_2), the relative contribution of methane to the Earth's energy balance exceeds its relative concentration in the biosphere. This is because methane generally absorbs reflected radiation 25 times more effectively than carbon dioxide (Bartlett and Harriss 1993).

Wetland systems are generally considered sources of methane because biomass rots in anaerobic conditions (Schlesinger 1997). We assessed the effects of grazing on methane fluxes (the amount released into the air) in spring-fed wetlands in Experiment B (Oates 2002). Air temperature had the strongest influence on methane flux, followed by soil water content and grazing presence or absence. The mean methane flux was 9.29 ± 4.37 mg CH_4–C/m^{-2}/hr^{-1} (mean ± S.E.) with a range of –0.19 to 147.88 mg CH_4–C/m^{-2}/hr^{-1} (methane flux measured as carbon in the form methane in milligrams per square meter per hour). Water content at these sites was 39.66% ± 2.29%, with a range of 14.51% to 60.64%. Grazing removal significantly decreased methane emissions; grazed was 16.01 ± 8.48 mg CH_4–C/m^{-2}/hr^{-1}, and ungrazed was 2.57 ± 1.15 mg CH_4–C/m^{-2}/hr^{-1}.

Guidelines and research gaps

Spring-fed wetlands are small, patchy ecosystems nestled within a matrix of oaks and annual species; they are important in overall landscape structure and function in a way that is disproportionate to their size. Much of the water exiting California oak-woodland watersheds passes through these highly productive spring-riparian zones, which are located at the interface of the terrestrial-aquatic ecosystem. Our data indicates that wetland vegetation in these zones, typically cattails *(Typha angustifolia)*, sedges, rushes and perennial grasses, act as nutrient filters for waters emerging at the soil surface.

High herbaceous plant production is one of the key factors for maintaining ecosystem services, by promoting carbon sequestration and nutrient conservation from the terrestrial landscape. A factor such as grazing, which influences ecosystem productivity, is an important control on ecosystem services.

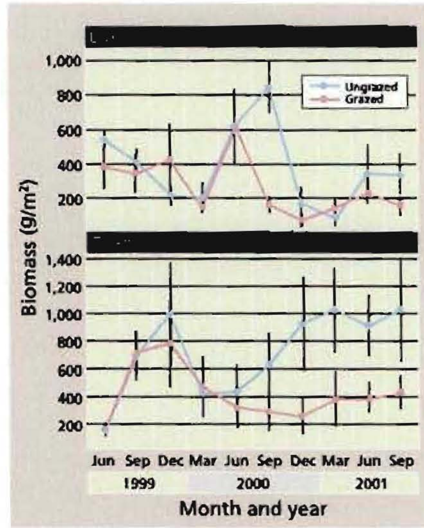


Fig. 4. Live and dead plant biomass from grazed and ungrazed plots in Experiment B.

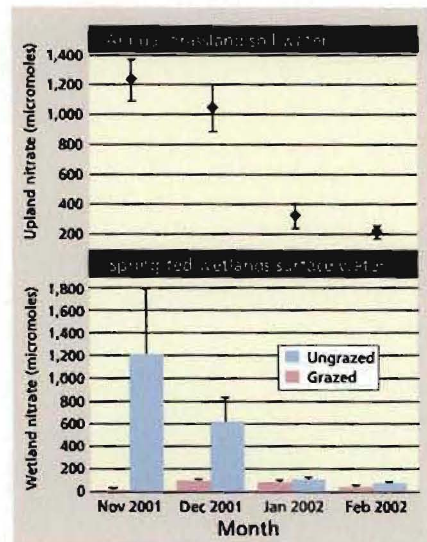


Fig. 5.* Soil and surface-water nitrate concentrations from Experiment B during winter 2001-2002.

Livestock grazing also shapes plant communities in these systems. Our studies show that nutrients (nitrogen) from the surrounding environment flow into the spring systems, supporting great productivity in concert with water and energy surpluses. Removal of livestock grazing resulted in increased levels of nitrate in wetland waters and thus higher levels of nitrate pollution compared to grazed springs. When grazing was removed, these

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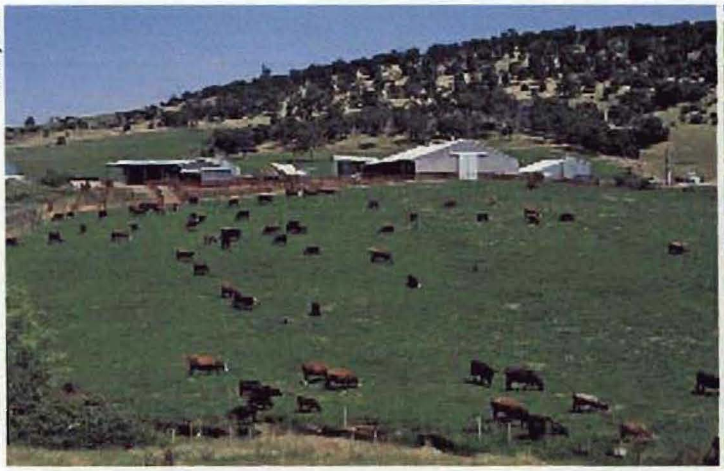
Jack Kelly Clark



Research on the ecological impacts of cattle grazing was conducted over a 10-year period at the UC Sierra Foothill Research and Extension Center in Browns Valley (near Marysville).

Spring-wetland ecosystems evolved with grazing wildlife, and later domestic animals. Light livestock grazing fosters plant diversity and helps to maintain nitrate levels in spring waters.

systems underwent greater changes in plant composition resulting in decreased plant diversity. Some degree of herbivory appears desirable from an ecosystem function perspective, although consistently high grazing intensities will reduce herbaceous cover to undesirable levels.

Future work should examine ecosystem interactions with the atmosphere as greenhouse-gas concentrations continue to rise. The removal of livestock grazing from these systems, especially during the early summer when the combination of temperature and soil water is at an optimal level for methane production, may reduce methane emissions. However, nitrate levels in spring waters increase with grazing removal, and preliminary data shows that grazing removal also increases the production of the greenhouse gas nitrous oxide (N_2O).

In addition to introduced cattle, spring-wetland systems are grazed by wildlife of all kinds. Grazing is an integral part of these systems; it evolved with them, and the plants and wildlife grazers (and later domestic grazers) are adapted and continue to adapt to each other. These studies demonstrate the importance of and need for long-term research, and show that tradeoffs exist for different management scenarios and different measured environmental factors.

B. Allen-Diaz is Professor, J.W. Bartolome is Professor, and L.G. Oates is Graduate Student, Department of Environmental Science, Policy and Management (ESPM) – Ecosystem Sciences, UC Berkeley; R.D. Jackson is Assistant Professor, University of Wisconsin, Madison (formerly ESPM Post-Doctoral Student); and K.W. Tate is UC Cooperative Extension Specialist, Department of Agronomy and Range Science, UC Davis.
Thanks to students Katie Phillips, Shelly Evans, Jeff Fehmi, Chris Campbell, Mark Spencer, Aimee Betts, Eric Hammerling and Clay Taylor. Special thanks to Mike Connor, Dave Labadie and the SFREC staff for years of help and support, and to the UC Integrated Hardwood Range Management Program for funding.

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ECOLOGICAL SITE DESCRIPTIONS

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Introduction

Several years ago USDA Natural Resources Conservation Service decided to replace their traditional range site descriptions that focused primarily on forage production in favor of ecological site descriptions that include vegetation dynamics and broader resource uses and values as well as forage production. Soils with like properties that produce and support a characteristic plant community and respond similarly to management are grouped into the same ecological site. Ecological sites are differentiated one from another based on 1) significant differences in species or species groups, 2) significant differences in species composition, and 3) differences in productivity, and 4) soil factors that influence species composition or productivity (NRCS 2003).

In October 2003 USDA NRCS and the California Rangeland Research and Information Center began a joint project to develop ecological site descriptions for the oak woodlands in Major Land Resource Areas 15 (Coast Range) and 18 (Sierra Nevada Foothills) (Figure 1). Within MLRA 15 there are approximately 122 soil series supporting oaks or associated shrub and grassland vegetation. MLRA 18 has about 50 different soil series. There are three objectives in this project:

1. Survey vegetation (understory, shrubs and trees) to determine species composition and productivity of selected soil series in MLRA 15 and 18.
2. Delineate ecological sites using vegetation survey and existing information.
3. Write ecological site descriptions that include state and transition models.

Vegetation Survey Methods

Oak woodland vegetation is being surveyed along a 100 m transect. Tree and shrub canopy cover, tree and shrub density, understory productivity and understory species composition are determined along this transect at 5 m intervals. A baseline for rangeland health is also being determined for the site represented by the transect. The interagency rangeland health assessment procedure has been adapted for use on California's annual rangelands. To the extent possible history of grazing and vegetation management is being recorded for each site.

Preliminary Results

During the spring and summer of 2004 more than 20 Livestock, Range and Natural Resource Farm Advisors and several USDA NRCS Conservationists surveyed more than 300 transects from Shasta County to Kern and Ventura Counties (Figure 2). Using canopy cover, tree and shrub density and understory productivity transects were clustered into 16 groups in MLRA 15 and 13 groups in MLRA 18. In MLRA 18, which includes UC SFREC, the groups are based on density of foothill pine, interior live oak, blue oak, ceanothus, poison oak and understory productivity. In MLRA 15 the groups are based on the density of coast live oak, blue oak, valley oak, black oak, poison oak, manzanita and understory productivity.

Management Implications

Replacing range site descriptions, ecological site descriptions will become the basis for establishing carrying capacities for grazing during development of farm and ranch plans by USDA NRCS. These descriptions are also used by various state, local and private groups to determine grazing capacity of lands under their management. Additionally, the state and transition models will synthesize what is known about vegetation change over time due to fire, grazing, drought and protection. Managers and natural resource planners will be able to use this information to estimate vegetation changes that can be expected due to proposed management practices.

Acknowledgements

Surveying 300 transects in a few months and processing the data was a major undertaking and was completed because of the efforts of more than 20 UC Livestock and Range Management Farm Advisors, UC SFREC and HREC staff, UC Davis staff and several NRCS Conservationists.

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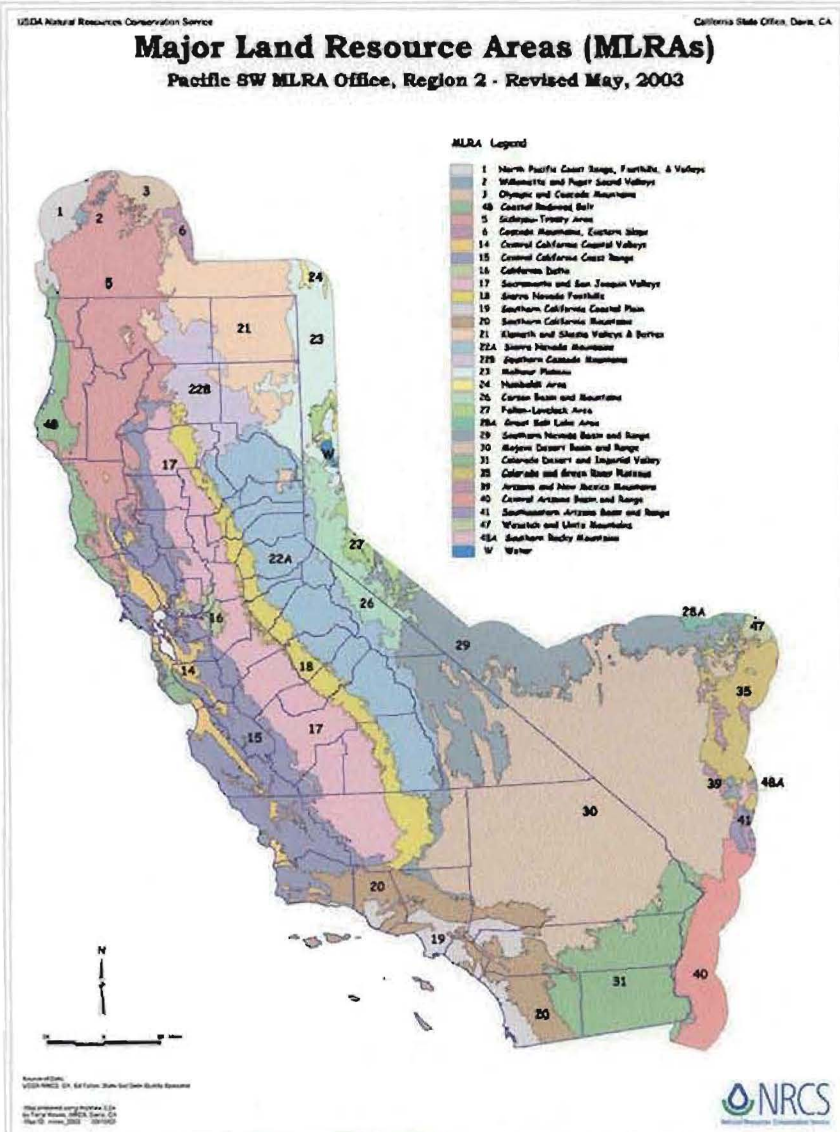

Figure 1. Major land resource areas for California.

Figure 2. Locations of 2004 oak-woodland vegetation surveys.

Cattle Identification and Cattle Health
Where are we going and who has been there before us?

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Originally, cattle identification provided a means to determine ownership of an individual animal. Because of the high value placed on cattle in human society, this ownership aspect of identification was very important throughout history and remains so today. The use of ear notches and waddles in U.S. pasture and range cattle was simply an extension of methods used by ancient civilizations. Additionally, individual animal identification is necessary for performance records for cattle. This is the case for dairy cattle in terms of milk production records and numerous health related parameters such as somatic cell counts and reproductive performance records. Beef cattle producers also use identification methods to track performance in terms of reproduction, growth, calf performance and a host of other measurements. Animal identification is also important in the case of disease outbreaks and for disease surveillance. When a disease outbreak occurs animal identification is essential for tracing animals, limiting the spread of disease, and minimizing losses. Recent evidence of this need includes the exotic Newcastle Disease outbreak in California and neighboring states, tuberculosis in cattle in several western states, and the recent Canadian cows with BSE--four in Canada and one in the U.S. in 2003. Finally, animal identification would be necessary for product source verification systems, where product (milk, cheese, meat, leather, etc) can be tracked back to the farm or ranch of origin or through the entire production chain.

In the United States we have been fortunate in terms of our need for identification systems. We have been relatively isolated geographically and have not experienced as many disease outbreaks as some other parts of the world in our cattle populations. In the western states we have relied on brands for ownership and disease trace back for parts of three centuries. With the advent of the Brucellosis control programs and the metal ear tags placed in female cattle for calf hood vaccination or blood testing, we have had an additional means of individual animal identification that proved useful for many years. In terms of disease investigations this tool was always less than perfect; however, the cost was low for implementation and producer acceptance was good.

Because of recent disease outbreaks and the increased pressure of worldwide trading partners the need for individual animal identification has been highlighted. However, many practical questions have surfaced as to how we are going to accomplish this task. Therefore, it is instructive to examine the methods and experiences of others with regard to cattle identification programs.

The first example we will discuss is the French cattle identification system. France is an important example because they have the largest cattle herd in continental Europe and they are the largest beef exporter in the European Union. France is about 1.3

times the size of California. France has a human population of 60 million and California has less than 36 million. France has about 20 million cattle and all the cows and calves in California would number less than 6 million. It is obvious that cattle production in France is a major agricultural concern. The average herd size is about 70 cows and the average farm is about 150 acres or slightly less. Many of the cows are dairy cows or dual purpose cattle (milk cows that are later slaughtered for beef). They also have large numbers of beef cattle such as Charolais, Simmental, Maine-Anjou, etc. The French started their animal identification program in 1978 with the introduction of permanent individual animal identification. They have refined and revised their program many times over the past 27 years, including the creation of a national data base for cattle identification data in 1999.

When a calf is born the owner registers the birth of the animal and submits a request for that animal's individual identification. This submission goes to Department authorities. A Department in France is equivalent to a county in the U.S. Each Department coordinates with the national identification system to process each registration and request. The owner can submit this information by mail, fax, or email. The owner then receives in the mail the animal's passport with all required information and two ear tags for application on the calf. This process is usually accomplished within 7 days. The passport is the animal's permanent documentation and must be retained at all times by the owner and must accompany the animal during any and all movements or changes in ownership. The two ear tags are applied to the calf as soon as practical and by law within 7 days of birth. Both ear tags are identical and contain the country code (FR), the department number (for example 71), an eight digit unique number with the last 4 digits being the animal's working number for day-to-day herd use. Additionally, there is a bar code on the tag that is unique for all this information. For example, the two tags might have FR (country code) 71 (the Department code) 1256 7891 (the last 4 digits being the working number), and the bar code for all this information. If one or both of the ear tags are lost, the owner must reapply for replacement tags and a passport document in a process similar to that when the calf was born.

On the front side of the passport will be the animal's unique identification number in addition to the following information: the 4 digit working number, sex, breed, date of birth, place of birth (premise information), cow's identification number, breed of cow, breed of bull, and the animal's health certificate document. The back side of the passport contains the animal's genetic certification data, the passport document number, and 6 places to record a change in location or ownership. Each of these change of location/ownership blanks contain the animal's identification number, a unique premise identification description and number, a date of arrival, a date of departure, and a signature line. Whenever an animal is sold or moved this information must be supplied on the passport and this must be accompanied by a valid signature. If an animal dies for any reason, a veterinarian must document that occurrence on the animal's passport and submit that information to the animal health authorities. In essence, each animal that dies has a death certificate issued via the completion of the passport and health certificate document.

In France, most of the 3 million-plus cattle that are slaughtered each year for beef are more than 24 months of age. These animals are tested for BSE and the animal identification documents are essential for this surveillance process to occur. When any animal is taken to the slaughter facility it must have both ear tags in place (the tags must be identical to each other) and the animal must be accompanied by its original passport. The passport and the ear tags must match and additional bar coded documents are prepared the day prior to slaughter. These bar coded documents are based on the passport/ear tag information and will accompany the various parts of the animal (head, heart, tongue, carcass, offal, etc) through the slaughter and packing house process. If an animal is brought to the slaughter house without proper documentation the owner will be fined about $300, the animal with be euthanized, and will be sent to a rendering plant and reduced to meat and bone meal which is then incinerated.

The cost of the French animal identification system is shared between the farmer and the government. The producer pays 3 Euros (about $3.90) per animal per year and keeps all the necessary records and documentation related to the individual animal identification. The government supplies the ear tags and the passports, maintains the data base, and provides veterinary services for documenting animal deaths and other activities related to animal identification. These costs amount to about 10% of France's animal health and welfare budget and total about $160 million for fiscal year 2002. This for a country about 1.3 times the size of California. Also for comparison purposes, France has about 4,600 veterinarians working full time or part time for national animal health and welfare programs. In California there are only about 500 veterinarians registered to use the Brucellosis vaccine. Therefore, that number plus the CDFA and USDA veterinarians would be only a fraction of what another developed society has in terms of professional resources. Obviously, the French model which was developed over a 25+ year period and well supported by the taxpayer will not be immediately applicable to the U.S.

Another example of a cattle identification system is the state of Sonora in Mexico. Sonora is about one half the size of California and has about 700,000 beef cows (almost the same as in California). The state of Sonora has had an animal identification program for more than a decade. In Sonora most all of the cattle are beef cattle. They graze on arid to semi-arid rangelands and are managed in an extensive manner. This is very similar to many of our western beef operations. The cattle are handled once or twice per year depending on the individual operation. They have used an animal identification system similar to our Brucellosis vaccination program. They use a single metal ear tag for each animal that is unique for the state of Sonora and the herd of origin. It has a similar format to the Brucellosis tags used in the U.S. for decades. The herd of origin data is stored by the Sonora state government and can link an individual animal to the owner/premise of origin. Thus, animals can be traced to the herd of origin within Sonora. Additionally, some herds use hot-iron brands for ownership identification, this provides a backup for herd of origin trace back. Compared to the French system this is a very simple animal identification method. You need to understand that this is very labor-intensive. The state of Sonora employs a large number of what we would think of as "brand inspectors". They are the individuals who keep track of all the tags, cattle movements, and brands or ear notches. This information is matched to the herd of origin and records all the animals leaving those herds and their destinations. All calves and adult cattle must have an ear tag applied and recorded before they can leave their herd of origin. This is very similar to the brand inspection laws in western states with brand laws such as California.

The ranchers in Sonora pay for this animal identification system with some help from their state government. There are more than 2000 "brand inspectors" in Sonora, many of them part-time. These are people who reside in the local communities and know the local cattle industry on an intimate basis. The ranchers pay for these services as the western U.S. ranchers pay for their brand inspection services. The data animal identification are transmitted to the state of Sonora government and maintained in a data base for future access. This brand inspection/animal identification tag system is excellent for trace back to herd of origin and is also very effective in determining ownership in this region where cattle are extensively managed. The state veterinarian can trace an individual animal to its herd or origin in less than 5 minutes in most cases.

These are two very different cattle identification programs that have been discussed. The French system is very well-organized, very efficient and very expensive. The Sonoran system is very cost-effective and is aimed at ownership and trace back to herd or origin. How do these examples help the U.S. to determine its future?

We have a number of problems that need to be solved with any animal identification system we initiate. We have to be effective in terms of ownership issues. We have cattle industries that are different in the western U.S. versus east of the Rockies. In the West we need brand laws or similar mechanisms to determine ownership, in the East brands are not even a consideration. The need for production records and individual animal identification will increase, not diminish. The need for trace back for disease outbreaks will continue with us for the foreseeable future. Also, our trading partners, whether foreign or domestic will continue to be interested in source verification. We will need cattle identification systems.

Now, we have to consider some tough questions. Who will pay for the programs? Who do the programs benefit and who has the most to lose? If the identification system costs are born entirely by the producers, it is my opinion the beef industry could be bankrupted. The already subsidized dairy industry will also be negatively impacted but not crippled. Who will maintain the data bases and ownership information? Our FOIA laws do not exist in either France or Mexico, so they do not see this as an issue. This is a make-or-break issue for the litigious U.S. system. What are the potential liability issues for the producer that first places the identification on the animal? These are the same conceptual concerns as for the FOIA issues. Hopefully, our program will evolve with input from the grass roots segments of the various industries as well as the regulatory communities. We all need to actively participate for a successful system to evolve.

Efficacy of wetlands to enhance water quality of tailwater from irrigated pastures

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Wetlands are commonly expected to provide important water quality benefits through wetland processes including 1) sedimentation and burial (P, pathogens), 2) microbial transformations to gaseous forms (denitrification, methanogenesis), 3) plant uptake of nutrients, and 4) predation within the food web (pathogen consumption) (Mitsch and Gosselink 1993). Due to the steady irrigation water supply during dry California summers and the loading rate of pollutants in the tailwater, flood irrigation systems provide an ideal opportunity for utilizing natural wetlands as riparian buffers to improve the quality of tailwater as it exits a pasture. Treating non-point source pollution at the catchment scale with riparian buffers and wetland systems is extremely important because once elevated pollutant levels reach streams, it becomes much more difficult to mitigate their impact on the aquatic environment (Stone et al. 2003).

In initial research collected from May to September 2004, I quantified and compared water treatment efficiencies (indicated by constituent loading input relative to output from the wetland) provided by two 0.5 acre, natural wetlands (one channelized/incised and one minimally-degraded/non-incized wetland) at Sierra Foothills Research and Extension Center (SFREC). Significant load reductions in total suspended sediment (TSS), nitrate and *E. coli* were seen in effluent of the non-degraded, non-channelized wetland regardless of the water inflow rate (Table 1). However, the degraded wetland, characterized by an incised channel along its entire length, provided slight load reductions in *E. coli* while other constituents were not significantly reduced. Retention of pollutants ranged between 50 and 70% at the higher inflow rates (about 2 cfs) in the non-degraded wetland and was even greater at the reduced water inflow rates. These trends strongly support our original hypothesis that a healthy vegetated and non-channelized wetland can provide important water quality benefits to flood irrigation runoff.

Hydrology of the wetland is a primary factor which influences its effectiveness in decreasing pollutant loads (Mitsch and Gosselink 1993). More specifically, the hydraulic residence time (the amount of time water remains within a wetland) is directly associated with the removal effectiveness of many pollutants (Stern et al. 2001). Channels and preferential flow paths often form in natural wetlands so that the hydraulic residence time is reduced and the majority of flow is not fully exposed to wetland processes. In channelized, degraded wetlands, there is a potential to restore connectivity of the water with the wetland by altering incoming water flow paths to minimize flow through incised channels. Upcoming research will test mechanisms by which this connectivity with the wetland can be restored. I expect to see both an increase in hydraulic residence time and an increase in pollutant removal efficiency from more evenly distributed flow.

	E. coli		Nitrate- N		TSS	
FLOW RATE	Non-channelized wetland	Channelized wetland	Non-channelized wetland	Channelized wetland	Non-channelized wetland	Channelized wetland
Low (30%)	91	45	47	20	70	Net source
Medium (70%)	79	28	55	2	85	Net source
High (100%)	64	20	33	Net source	73	Net source

Table 1. Percent reduction in constituent loads after irrigation tailwater flows through either a channelized wetand or a relatively non-channelized wetland at low, medium and high irrigation inflow rates.

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Fire Effects on Oaks and Oak Woodlands

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Introduction

Everyone who lives in California is aware that fires occur regularly in our state and can have devastating consequences. Despite of our long-standing efforts to suppress and control fires, we are still at the mercy of the Mother Nature and during extreme fire weather, there is little we can do to prevent, or even contain, fires that do start. What is especially troubling is that large, catastrophic wildfires resulting in significant property losses seem to be occurring with increasing regularity. A variety of vegetation communities have burned in recent years, but oak woodlands are certainly one of the plant types that has been, and will no doubt continue to be, affected by these conflagrations. One reason why wildfires are increasing in severity is the build-up of fuels during the last century, at least partially the result of fire-suppression activities. We have vigorously put out fires that do start, including some that would only have consumed ground vegetation. As a result, there are more fuels on the landscape today, and the fires that do start are more likely to become large in scope.

Natural Fire Frequency and Native American Use of Fire

Native California oaks evolved in a Mediterranean climate where natural fires burned regularly. Research on fire frequency in oak woodlands at the Sierra Foothill Research and Extension Center (SFREC) and elsewhere has shown that fire frequencies of 8 to 15 years were common in foothill oak woodlands until the early- to mid-20th century. Since that time, however, fire frequency has been much less, but the risks of high intensity, catastrophic wildfires have become higher.

Prior to the arrival of Europeans, Native Americans used fire as a management tool. The understories of woodlands were regularly burned for a variety of reasons, including facilitating access, stimulating the growth of materials used for weaving baskets, improving habitat for game animals, making it easier to collect acorns, and killing insects that damaged acorn crops. Frequent low-intensity burning of woodlands probably resulted in the creation and maintenance of cohorts of large oak trees. Repeated burning would likely have killed brush and small trees and there would have been efforts to protect large trees since they are generally the best acorn producers. In the lower elevation valleys, repeated burning would have promoted more open savannah-like stands with widely spaced valley oaks, and a mosaic of fine-grained vegetation patches, with relatively little shrub cover. This is certainly what the early European explorers reported seeing in the central valley of California in the early part of the 19th century.

Fire Suppression in the 20th Century

As noted above, there has been a policy of active fire suppression in California during much of the 20th century that has altered historic fire frequencies, fuel loads, and fire dynamics. That is, the significant reduction of fire as an ecosystem process has had important consequences, allowing an accumulation of fuels that had previously been consumed during regular, low-intensity fires. In addition to causing a build-up of woody vegetation in the understory, the suppression of fires has also promoted an increase in tree density. Further, some open, savannah-like woodlands have converted to vegetative communities with a greater shrub component. In some locations, there have also been significant increases in dead and down woody material and an increase in "ladder" fuels connecting ground vegetation to the tree canopies. This has resulted in oak woodlands that are more susceptible to severe, crown-consuming fires, although such large fires are not a recent phenomenon in the state, and certainly have occurred in California's shrublands for centuries. But when wild fires do start in California today – especially during extreme fire weather - there is a greater likelihood that the conflagration will become so intense that tree canopies will be ignited and the trees will be consumed. Clearly weather conditions play a critical role in determining the size and scope of fires. But since California regularly experiences extreme fire weather, with strong east winds usually accompanied by high heat and low humidity, it is not a matter of "if" but "when" such fires will start. Such weather is common in the fall when Santa Ana winds blow hot, dry wind off the desert, especially in Southern California. Fire risk is exacerbated because such winds occur at the end of a 6-month drought period when fuels are exceedingly dry. Fires that start during these conditions have a far greater chance of becoming large in scope. The combination of fuel loading, weather conditions, and slope of the terrain are the key components in determining the intensity of such wildfires.

Prescribed Fire

One tool that has been used to reduce fuel-loading and therefore decrease the likelihood of catastrophic crown fires is prescribed burning. Fires are intentionally set under controlled conditions to burn surface fuels. However, even these low-intensity fires have the potential to damage trees, including oaks. Unfortunately, until recently there was little interest in the effects of either prescribed or natural fires on oaks, since these species were not considered commercially important and the common perception was that they were too abundant anyway. Consequently, there has been relatively little research addressing the consequences of fires on the various hardwood species comprising the woodland forests, or protecting trees from damage during controlled burns. In the last two decades, however, the critical role that hardwoods play in forests has been increasingly recognized and appreciated. Hardwoods are not only vital to numerous species of wildlife, but play vital roles in nutrient and water cycling, stabilizing soil, and reducing erosion.

Fire Research by the IHRMP

The Integrated Hardwood Range Management Program (IHRMP) has been conducting research to better understand the impacts of both wild and prescribed fires on oak woodland communities, and for the past 6 years has been conducting a study in oak woodlands in San Luis Obispo County to help determine the impacts of woodland fires on resident animals. This study monitored a variety of terrestrial vertebrates both before and after a prescribed fire. It found that even though grass cover was reduced by 70% and downed wood and woodrat houses by 30% as a result of the fire, there were no substantial or long-term negative impacts to over 150 species of birds, small mammals, amphibians, and reptiles monitored 2 years before and 4 years after the fire. This study demonstrated that many small, resident vertebrates merely go below ground during a fire and emerge unscathed once the flames have passed; they therefore can readily survive fires. Such information is critical for understanding the effects of low-intensity prescribed burns that may become an important management tool as we try to prevent catastrophic fires in the future.

Other IHRMP research has focused on the impacts of fires to the trees themselves, including a study following a wildfire in Tehama County, and a study here at the Sierra Foothill Research and Extension Center (SFREC) that assessed blue oak trees both before and after a prescribed fire. These studies found that even in relatively hot ground fires, large oaks are rarely killed, as long as the fire is not so hot that it kills the cambium all of the way around the trees, thus girdling them. However, the chances of the fire killing the above-ground portion of the tree is inversely related to tree size. Small trees are more susceptible since they have thinner bark, increasing the risk of lethal injury to the cambium. These studies also found that even in hot fires that kill the tops of the oaks, the vast majority of trees will resprout from their base, initiating shoot growth that often leads to the establishment of new trees.

Another study conducted here at the SFREC examined acorn production to determine if it is was adversely affected by fire. Over 100 trees within the boundaries of prescribed fires conducted during the summer at the SFREC either one or two years previously were evaluated in early fall to determine whether acorn production was affected. We could detect no significant reduction in the number of acorns, indicating that even when trees are exposed to elevated temperatures accompanying burning in the summer, the physiological processes necessary for acorns to grow and develop can still occur afterwards. However this study did not address the consequences of burning in the spring, when we would expect damage to acorns to be greater, since trees are flowering and acorns are just starting to develop.

Conclusions

Fires in California's oak woodlands will continue to occur and there is no recourse for the residents of the state but to learn to live with fire as best we can. However, there are things that can be done to minimize the negative effects of fire and the IHRMP plans to continue to convey information to the state's residents about appropriate steps to take. For instance fuel loads can be reduced; new construction can be located in areas that are easier to protect; homes can be built with more fire-safe materials; and buffer zones can be created around structures by clearing vegetation and other combustible materials. Finally, vegetation in burned-over areas, including oak trees, can be restored. The IHRMP is working to ensure that those living in or managing oak woodlands are aware of these steps. Adopting them will help reduce the loss of life and property that has become all too familiar in our state. It will also help ensure that our native oak trees and the values they provide, will be conserved for future generations.

Fire Effects on Soil Properties

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Oak woodlands encompass 7.4 million acres in California and represent the interface between multiple land uses including agricultural, urban, and wildland (Griffin, 1977; Standiford and Howitt, 1993). Oak woodland watersheds play a major role in the drinking water supply system for the State, with almost all the State's surface water passing through these ecosystems as direct rainfall or snow melt from higher elevations. Two-thirds of all drinking water reservoirs in the State are located within grazed oak woodland/annual grassland ecosystems.

Oak woodlands are used extensively for cattle grazing, providing approximately 75% of the forage produced on California's rangelands. Grazing and prescribed fire are critical vegetation management tools allowing managers to maintain economically feasible agricultural enterprises, maintain open space, reduce fuel loads, improve habitat for certain wildlife species, and manage weed infestations. Grazing and prescribed fire are the most cost effective vegetation management tools available to most rangeland managers. Recently there has been a great deal of concern regarding the impacts of rangeland management on water quality. The transport of pathogens, nutrients, sediment, and dissolved organic carbon (DOC) from these landscapes to surface water bodies are of primary concern in this region. The objectives of this study were to document the effects of prescribed fire on physical and biogeochemical properties of soils in two settings inherent to oak woodlands, open grassland and under oak canopy.

Results

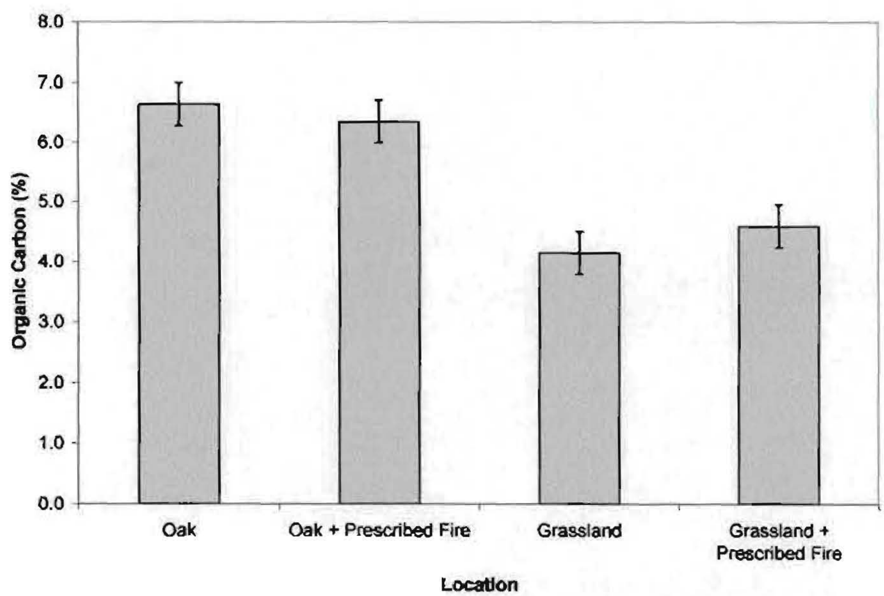

Figure 1. Effects of prescribed fire on soil organic carbon under oak canopy and open grass systems. No change in soil organic carbon was observed after fire in each system indicating that burn temperatures and fire intensity were low. Maintaining soil organic matter is important because it acts as a slow release fertilizer, maintains aggregate stability, increases water infiltration and helps prevent erosion.

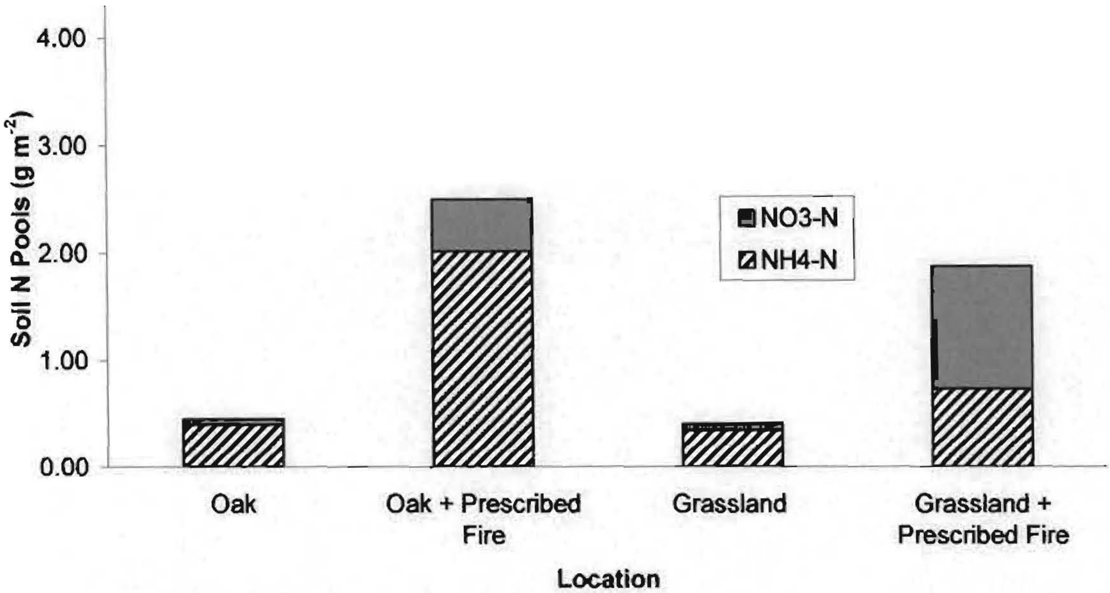

Figure 2. Effects of prescribed fire on soil nitrogen pools under oak and open grass systems. Since soil organic matter did not change significantly after burning we attribute increases in N after fire to the combustion of standing biomass and litter. Ammonium is the direct product of combustion. Nitrate arises through nitrification, a microbial transformation of ammonium.

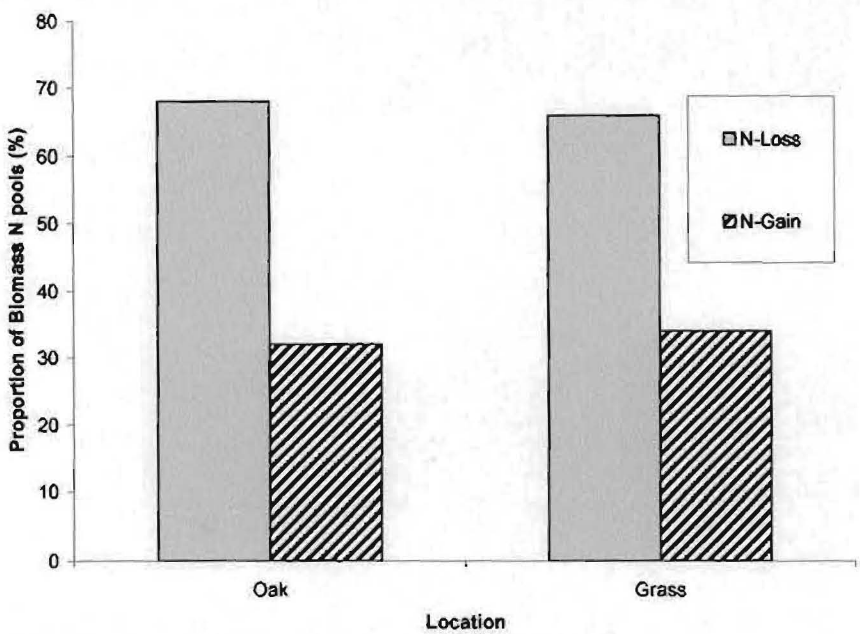

Figure 3. Effects of fire on the fate of Nitrogen in above ground biomass. Under oak, 32% of the N in biomass was supplied to the soil after burning, corresponding to a 20.2 kg ha^{-1} increase. The remaining 68% of biomass N was lost due to volatilization. In open grass 34% of the N in the above ground biomass was supplied to the soil after burning, corresponding to a 14.6 kg ha^{-1} increase. The remaining 66% of biomass N was lost through volatilization. The N supply from combustion was low, probably because the site was grazed before the fire and this reduction in biomass was not accounted for.

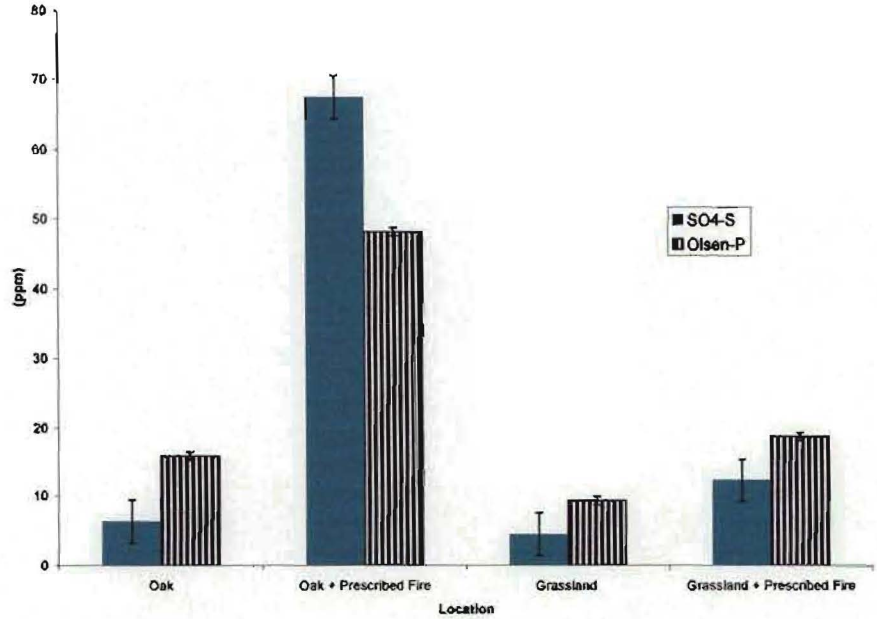

Figure 4. The effects of prescribed fire on sulfur and phosphorous concentration under oak and open grass systems. Burning converts the organic pool of soil P and S to sulfate and orthophosphate. Sulfur and phosphorous have higher volatilization temperatures (>500°C) compared to nitrogen (200°C) thus the levels of S and P returned to the soil after burning were high particularly under oak. Post fire levels of P and S were higher under oak because grazing is a selective process resulting in the removal of grasses, but not leaves and litter common to the surface of oak canopy soils.

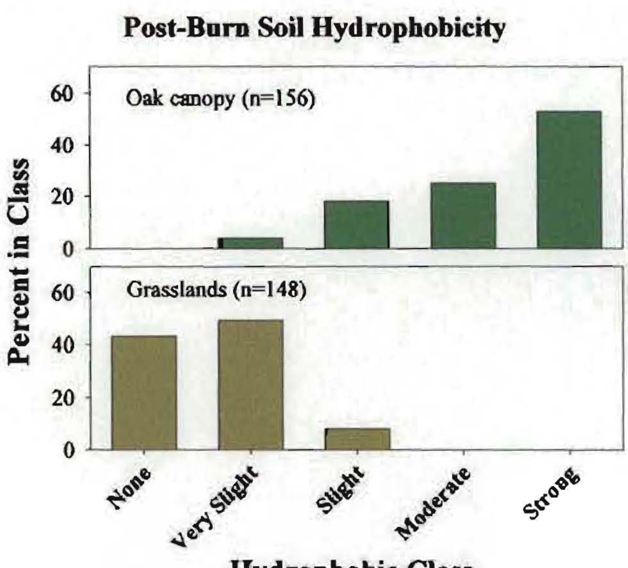

Figure 5. Effects of prescribed fire on water repellency of soils. Grassland soils displayed slight to no evidence of water repellency after fire. Soils under oak canopy displayed slight to strong degrees of water repellency. Hydrophobicity under oaks is likely due to the release of waxes and resins from the combustion of oak leaves. Water repellency after fire is usually temporary. This will be tested again next year.

Conclusions

Fire temperature plays a major role in the degree of nutrient and carbon loss from biomass. At SFREC, soil organic carbon levels were not changed by fire. This is important because soil organic matter is critical to the health of rangeland soils. The combustion of above ground biomass increased the available N, P, and S. Especially under oak canopy soils where less biomass was removed by grazing.

The fire appeared to have created water repellent conditions under oak canopy, however, these areas were of limited extent and should not influence surface runoff within the entire watershed. Since very little N was supplied by the fire, this management practice should not affect stream water quality. P in streams should also be low, since P is a non-mobile nutrient. This may not be the case, however, if the erodibility of soils has increased. Since post-fire soil organic matter levels were similar to pre-treatment levels, soil erosion should be minimal. We are waiting for the 2004-2005 stream water quality data in order to support this hypothesis. Timing of prescribed fire will likely be an important factor for water quality concerns.

Guidelines for Residual Dry Matter (RDM) Management on Foothill Rangelands

Primary Collaborators at SFREC: James W. Bartolome, J. Michael Connor, Glenn Nader, Ken Tate, Barbara Allen-Diaz, Amiee Betts, Randall D. Jackson

Background: Residual Dry Matter (RDM) is widely used by land management agencies as a standard for determining level of grazing use on annual range and associated savannas and woodlands (Bartolome et al 2002). Residual dry matter is the old plant material left standing or on the ground at the beginning of a new growing season. It indicates the combined effects of the previous season's production and use by grazing animals of all types. The standard assumes that the amount of RDM remaining in the fall, subject to the dominant factors of site capability and variations in weather (George et al 2001), will influence subsequent species composition and forage production.

A series of experiments by Heady dating from the 1950's showed that the amount of fall RDM dramatically influenced forage productivity and composition at the high rainfall (37 inches/yr) Hopland Field Station site (Heady 1956). To determine the effects of RDM representative of heavy to moderate grazing on annual range at different sites, Heady established nine experimental plots in the late 1960's and early 1970's which were maintained from three to five years (Bartolome et al 1980). This study showed that RDM significantly influenced range productivity in areas with average rainfall greater than 15 inches/yr, subject to the over-riding controls of site and yearly weather. Maximum productivity within the 15 to 40 inch annual precipitation zone occurred with 750 lbs/acre of RDM in fall. Although previous studies showed that forbs were favored by low RDM and grasses by higher RDM, the effects on botanical composition in Heady's statewide experiment were mixed (Jackson and Bartolome 2002). Those experimental sites incompletely represented the annual range region and were limited to flat ground without any woody plant cover.

A recently completed experiment at SFREC suggests that a range of 600 -1200 lbs/acre of RDM maximizes both forage production and species richness on open annual range in the 15 to 40 inch rainfall zone. The study validated existing guidelines for open grassland and also showed that slope and slope aspect had only minor interactive effects with RDM on forage amount and composition. A research project now in its third year at SFREC will be the first to test the available RDM guidelines for areas with woody plant cover.

McDougald et al. (1991) developed a RDM-based scorecard that can be used to quickly estimate grazing capacity. The scorecard was developed by combining site characteristics (rainfall, canopy cover, and slope) that affect animal use to estimate grazing capacity. The scorecard approach can give useful estimates of grazing capacity from the pasture to landscape scales and is easily coupled to geographic information systems (GIS), allowing efficient mapping of forage availability (Standiford et al 1999).

RDM Guidelines: An RDM standard is expected to provide a high degree of protection from soil erosion and nutrient losses. Applications of specific RDM standards based on a limited research base and on experience have demonstrated the effectiveness of this approach to grazing management. Because of the limited amount of research information, standards and scorecards will normally need to be developed using local experience and the general guidelines in UC Extension Pub 8092. Numerous agencies have successfully applied the RDM-based method for managing grazing intensity over the past 20 years.

For RDM management purposes the California grassland and associated oak woodland and savannah can be divided into three types (George et al 2002): 1) Dry Annual Grassland (Table 1 - Annual plant dominated, average annual rainfall less than 12 inches); 2) Annual Grasslands/Hardwood Range (Table 2 - Annual understory with variable oak or shrub canopy, average annual rainfall between 12 and 40 inches); 3) Coastal Prairie (Table 3 - Perennial grasses common, variable woody overstory, rainfall variable). Tables 1-3 contain recommended minimum RDM guidelines in the form of a scorecard.

Estimating Residual Dry Matter: A variety of means are available for the estimation of RDM. An easy and quick method visually compares photo standards with conditions on the landscape prior to the first effective fall rains, usually late September or early October. Reference photos of grazing intensity standards have been developed for the Central Valley foothills using photos from the San Joaquin Experimental Range (Bentley and Talbot, 1951, Bartolome et al 2002). Clipping small plots is the primary means for measuring residual dry matter. A combination of clipping and estimating residual dry matter is often used. RDM measurements are best conducted in the late fall (Oct-Nov) prior to the first significant rain, although late summer or early fall estimates can also be used after correcting for grazing or decomposition losses.

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Table 1. Minimum RDM guidelines for Dry Annual Grassland in lbs/acre

	Percent Slope			
Percent woody cover	0-10	10-20	20-40	>40
0-25	300	400	500	600
25-50	300	400	500	600
50-75	NA	NA	NA	NA
75-100	NA	NA	NA	NA

Table 2. Minimum RDM guidelines for Annual grassland/Hardwood range in lbs/acre

	Percent Slope			
Percent woody cover	0-10	10-20	20-40	>40
0-25	500	600	700	800
25-50	400	500	600	700
50-75	200	300	400	500
75-100	100	200	250	300

Table 3. Minimum RDM guidelines for Coastal Prairie in lbs/acre

	Percent Slope			
Percent woody cover	0-10	10-20	20-40	>40
0-25	1200	1500	1800	2100
25-50	800	1000	1200	1400
50-75	400	500	600	700
75-100	200	250	300	350