UNIVERSITY OF CALIFORNIA
SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Beef & Range Field Day

"Managing Hardwood Rangelands to Maintain and Enhance Water Quality"

April 20, 1995

Browns Valley, California

THE UNIVERSITY OF CALIFORNIA
SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Presents:

Annual Beef & Range Field Day

"Managing Hardwood Rangelands to Maintain and Enhance Water Quality"

COSPONSORED BY:
UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
DEPARTMENT OF ANIMAL SCIENCE, U.C., DAVIS
DEPARTMENT OF AGRONOMY & RANGE SCIENCE, U.C., DAVIS

APRIL 20, 1995

Beef & Range Field Day

SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

April 20, 1995
"Managing Hardwood Rangelands to Maintain & Enhance Water Quality"

AGENDA

Morning Moderator: John Maas, Extension Veterinarian, UC Davis

9:30 Introduction - Mike Connor, Superintendent, Sierra Foothill Res. & Ext. Center

10:00 California Rangeland Water Quality Management Plan - G. Gough, Director of Government Relations, CCA

10:20 Risks of Pathogen and Nutrient Transmission from Grazing Livestock... R. Larson & M. George, Agronomy & Range Science, UCD

10:40 Assessing the Risk of Surface Water contamination of Cryptosporidium parvum... - R. Atwill, VetMed Teaching & Research Center, UCCE Tulare

11:00 An Example Rangeland NPS Management Plan - M. Joyce, UC/DANR Summer Intern, 1994 Sierra Foothill R&E Center

11:20 Nutrient Cycling in Grazed and Ungrazed Oak Woodland Rangelands - R. Dahlgren, Land, Air & Water Resources, UCD

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11:45 LUNCH BREAK - BBQ BEEF TRI-TIPS Served by the Yuba-Sutter Cowbelles

Afternoon Moderator: Roger Ingram, Farm Advisor, UCCE Nevada-Placer Counties

Travel to Watershed Study Site

1:00 Effects of Grazing on Small SFREC Watersheds- B. Allen-Diaz, Ecosystems Science, UC Berkeley

Travel to "Slick's Canyon" Area

1:30 Riparian Restoration Study - D. McCreary, Natural Resources Specialist, SFREC

1:50 Problem Assessment on Rangeland Watersheds - M. Connor, SFREC

Rangeland Monitoring Discussions
(Rotate among these concurrent sessions)

Session 1: Residual Dry Matter Monitoring - J. Clawson, Extension Range Specialist, (Retired), UCD

Session 2: Monitoring With A Camera - G. Nader, Livestock & Nat. Res. Advisor, Lassen County

Session 3: Stream Channel Measurements - R. Larson, Agronomy & Range Science, UCD

3:15 Meeting Wrap-Up "Planning & Monitoring for Watershed Protection - M. George, Range & Pasture Specialist, UCD

Co-Sponsored by: U.C. Cooperative Extension & Departments of Animal Science & Agronomy & Range Science, U.C. Davis

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Risks of Pathogen and Nutrient Transmission from Grazing Livestock to Surface Water Sources Based on Existing Literature

Royce Larsen and Mel George

Introduction

Concern about water quality, including nutrients and transmission of water born diseases from grazing livestock to humans via water, has increased in recent years. It is generally thought that nutrient problems associated with free grazing livestock is insignificant. While several diseases can be transferred to humans via infected cattle, documented cases are rare. In response to these concerns water districts are changing livestock management practices in watersheds that feed domestic water supplies based on the perceived threat of disease transmission. This situation raises several questions. What is the risk of nutrient and pathogen movement from a grazed watershed into surface water sources? The risk depends on transmission of the pollutant from upland manure deposition via overland flow or on direct deposit of bovine feces into streams and other surface water sources.

Manure Sources

Total fecal output of cattle will range from 0.5 - 0.75 percent of body weight per day, on a dry weight basis (Johnstone-Wallace and Kennedy 1944). This fecal output will contain an average of $3.8*10^{10}$ fecal coliform (FC) and $7.2*10^{8}$ fecal streptococcus (FS) (Moore et al. 1988), and an average of 0.34 lb N/day, 0.11 lb P/day, and 0.24 lb K/day (Moore and Willrich 1982). FC and FS are non pathogenic bacteria use to indicate the possible presence of pathogens in fecal material.

Free ranging cattle will defecate an average of 12 times per day (Johnstone-Wallace and Kennedy 1944). These fecal deposits from cattle are indiscriminately distributed throughout a pasture (Hafez and Schein 1962). This non uniform distribution can result in approximately 0.4-2.0 percent of the area covered by fecal deposits (MacLusky 1960). The area covered by feces may be even less for an open range when compared to a pasture. Buckhouse and Gifford (1976) found 0.2% of a semi-arid range covered with bovine feces with a stocking rate of 2 ha/AUM in Southeastern Utah. However, in certain areas e.g. water troughs, gates, fence lines, and bedding areas, feces concentrations may be a lot higher (Hafez and Schein 1962). Although, it would require an unrealistic stocking density of 0.09 ha/hd to achieve 4% fecal coverage in a pasture. A more realistic stocking density of 3.7 ha/hd for one year would result in <1% of the area covered by feces (Sweeten and Reddell 1978)

Pathogen and Nutrient Characteristics

Bacteria in fecal material may remain viable for at least one grazing season or over a year (Buckhouse and Gifford 1976). Bacteria may be released from fecal deposits for at least 100 days under rainfall conditions.

The age of fecal deposits influences the number of bacteria that are released under rainfall conditions. Hundred-day old fecal deposits can produce FC counts exceeding recreational water quality standards, but are significantly lower than 2-day-old fecal deposits (Kress and Gifford, 1984). This leaves the potential for bacterial contamination long after the cattle have been removed from the site.

However, there is still a question as to whether pathogens will survive in fecal deposits similarly to indicator organisms, especially protozoal parasites. In addition, little is known about the availability of nutrients from bovine feces through natural rainfall releases, or with availability over time.

It should be noted that all warm blooded mammals can carry pathogens. Wildlife can also contribute to bacteria loading into streams (Stuart et al. 1971).

Watershed Studies

Stephenson and Street (1978) studied grazing impacts on a stream in a Southwest Idaho rangeland. They found that in pastures with free grazing cattle and low management, maximum fecal coliform concentrations increased soon after cattle were turned in and remained high for several weeks to 3 months following removal. They noted that bacterial concentrations decreased downstream in areas with steep gradients and increased roughness, suggesting that certain stream segments were self-purifying.

In Colorado, Johnson et al.(1978), found that cattle did not contribute to statistically different physical and chemical parameters for a grazed and ungrazed pasture. Although, bacterial counts increased in the grazed pasture, they dropped to similar levels as the ungrazed pasture in a relatively short period of time.

Milne (1976) studied a cattle and sheep wintering operation along a small creek in Montana. He concluded that nitrogen and phosphorus loading was very low, and was typical of a pure mountain stream. Chlorides were found to increase as he went downstream, however the largest increase was below a farming area not associated with livestock activity. Milne (1976) also found very little bacterial contamination associated with dispersed livestock, but a large increase in bacteria was observed where the cattle were concentrated.

Jawson et al. (1982) studied a grazed and nongrazed watershed in the Pacific Northwest. They found that FC and FS were not different between the two watersheds, with both exceeding

10,000/100 ml. They did find some correlation between recentness of grazing and indicator bacteria in runoff.

Tiedemann et al. (1987) looked at 13 forested watersheds under different treatments. A correlation between grazing and FC concentrations was significant, with FC concentrations were 6 times higher with cattle present than with cattle absent.

Skinner et al. (1984) found that FC and FS could not be accounted for by differences in grazing treatments, but is partially explained by the presence of beaver dams.

Gary and Adams (1985) found that high elevation cold water streams grazed by cattle and sheep showed very little FC pollution.

Coltharp and Darling (1975) looked at grazed and ungrazed watersheds in Northern Utah. They found that cattle and sheep grazing significantly increased FC and FS concentrations immediately downstream from grazed areas. However, they only found slight increases in physical (Temperature, Ph, turbidity) and chemical (nitrates, phosphates) parameters measured. These slight increases were not significant.

Buckhouse and Bohn (1983) compared levels of fecal contamination to different grazing systems in Northeastern Oregon. They found large numerical differences between grazing systems, but they were not statistically significant. Bacterial concentrations generally decreased the first year livestock were removed, though the changes were not statistically significant. They concluded that interpretation of coliform data from non-point sources must be handled with caution, noting that a number of sources for variation exist.

There seems to be lot of variation in pathogen indicators and nutrients in wildland streams making interpretation difficult. Some general trends exist. It appears that peak fecal coliform concentrations are related to runoff events. As grazing intensity increases, bacterial indicators increase and nutrients remain about the same in wild land streams with free grazing livestock.

Upland runoff

To be considered a health hazard, pathogens and nutrients in fecal material have to reach the stream before any contamination can be caused. Bacteria from feces can reach a stream by either direct deposit or by overland transport from a runoff event.

Fecal coverage in the uplands is usually very low (<1%), and rainfall events large enough to cause overland runoff in semi-arid environments are very infrequent. U.S. Weather Bureau records indicate that overland flow events occur less than 1% of the time in most of the Western U.S. Although, there are risks from large storms (i.e. 10, 25, or 50 year events) occurring which can cause surface runoff. Even though upland runoff events may be low, irrigation return flows from wintering operations and pastures may occur frequently.

The relationship of source-distance and transport from free grazing livestock is not well understood in rangeland environments, and more information is needed (Springer et al. 1983).

Buckhouse and Gifford (1976) found that bacteria did not travel farther than 1.0 meter in a sandy loam range site. Larsen et al. (1994) found a 83% reduction in FC within 0.61 m, and 95% reduction within 2.13 m on a grass buffer strip.

Sweeten and Reddell (1978) suggested that the annual yield of total N and total P from rangelands is negligible. They mentioned that control of runoff was not needed.

Direct Fecal Deposition

Another mechanism for bacterial and nutrient pollution from grazing cattle is from direct in-stream fecal deposition.

When cattle are present in riparian areas they can deposit fecal material directly into the stream (Johnson et al. 1978). Direct instream fecal deposition may be as much as 0.5 defecations/cow/day (Gary et al. 1983). The number of direct instream deposits may also change by season with ~0.4 defecations/cow/day during the summer, and ~0.2 during the fall, winter, and spring (Larsen 1989).

In small streams with low flows, the majority of the bacteria in the deposited feces will rapidly settle to the stream bottom and can be re-suspended at a later time (Biskie et. al. 1988). Bacteria and nutrients can persist in the stream bottom sediments (Stephenson and Rychert 1982) and accumulate overtime. Peak flows, cattle trampling, etc. can re-suspend these contaminates. The severity of this accumulation depends on the amount of manure deposited into the stream and the dilution ratio of the stream. In contrast, cold snow melt fed, mountain streams may not support a large reservoir of bacteria in the stream bottom sediments (Gary and Adams (1985).

Following the removal of cattle, one to several months may be needed for coliform counts in a stream to return to background levels (Johnson et al. 1978, Tiedemann et. al. 1987).

What Practices are Used to Reduce Riparian Grazing?

Grazing management strategies used for riparian zone protection, rehabilitation, and/or maintenance include exclusion of livestock, alternative grazing strategies, changes in kind and class of animals, managing riparian zones as special use pastures, and several livestock distribution practices. Deciding which practice(s) to initiate depends on the objectives set for the ranch or allotment and conditions in the watershed.

Attraction: Providing shade, drinking water, salt, or supplements away from riparian zones can reduce the time livestock spend in this community. However, these practices require changes in management and in the case of water developments can be expensive.

Culling Practices: If attraction practices are partially successful, but some individuals continue to concentrate in the riparian area, culling has been suggested to rid the herd of "riparian huggers" or "bottom dwellers." Certain cattle breeds and strains have been shown to spend significantly less time in the riparian zone. Swanson (1985) and Roath (1980) indicated that within breeds, or even herds, certain individuals are "bottom dwellers" and others "ridge climbers." Males are considerably more aggressive and destructive than females and their calves, and yearlings may be more willing to forage widely and leave the bottomlands (Swanson, 1985).

Barriers: Cattle are known to avoid sites where access is difficult, especially if suitable forage is available elsewhere. Thus, sensitive streambank sites can be protected by discouraging cattle use. Techniques include use of barriers such as rock fields or boulders, shrub thickets (especially willow), dense timber stands, and fallen trees. The overall goal would be to protect sensitive sites and to encourage use of less sensitive areas with easier access. The presence of intact riparian vegetation downstream of heavily used sites can help absorb impacts and buffer the resulting sedimentation and related impacts.

Livestock Herding: If attracting cattle from heavy use areas is not practical or does not work, herding or fence construction must be considered. Herders can regulate the amount of time livestock spend in riparian zones (Claire and Storch, 1977). Storch (1978) reported that this was the most effective and practical range management technique on the Malheur National Forest in eastern Oregon, where livestock were herded on a daily basis. May and Davis (1982) suggested locating driveways and trailing areas away from riparian areas and using bridges and rock revetment to minimize impacts when riparian areas cannot be avoided.

Fencing: Fencing can be used to separate heavy use areas from areas of light to moderate use. Fencing may be used to segregate riparian pastures, facilitate grazing systems, and for exclusion. Separation of riparian areas or bottomland from steeper or rougher uplands are commonly recommended as a means of control livestock distribution.

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Assessing the Risk of Surface Water Contamination of *Cryptosporidium parvum* From Beef Cattle Production: Implications For Land Use Restrictions

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Cryptosporidium parvum (*C. parvum*) is a tiny protozoal parasite that can cause gastrointestinal illness in a wide variety of mammals, including humans, cattle, sheep, goats, pigs, and horses. It also occurs in various wildlife species such as deer, raccoons, opossums, rabbits, rats mice, and squirrels. In cattle, clinical disease and shedding of the parasite is usually limited to calves under one month of age, but there are a few reports of subclinical shedding in adult cattle. In humans, clinical disease and shedding appears to occur at all ages, but is most common among children. The predominant clinical sign is profuse, watery diarrhea lasting up to several weeks in normal (immunocompetent) calves and humans. While this disease is usually self-limiting in immunocompetent calves and humans, it can be prolonged and life-threatening among immunocompromised people such as AIDS patients since an effective treatment for eliminating this parasite from the gastrointestinal track still does not exist. A few antibiotics may show some promise in reducing the amount of oocyst shedding in AIDS patients, but further clinical trials are needed to fully evaluate their efficacy. This lack of an effective treatment and the fact that this parasite was implicated in recent large-scale water-borne outbreaks of gastroenteritis in humans (400,000 cases in Milwaukee, Wisconsin, 1993; 13,000 cases in Carrollton, Georgia, 1987) has prompted public health officials and state and federal agencies to consider ways to reduce drinking water contamination of this parasite. Some of this attention has focused on identifying the primary sources of *C. parvum* in surface water. Furthermore, the US Environmental Protection Agency intends to include *C. parvum* in the proposed Enhanced Surface Water Treatment Rule (*Giardia lamblia*, *Legionella* and coliform bacteria, and enteric viruses are already regulated) and have warned that such an inclusion will likely result in new restrictions being placed on the location and management of livestock operations situated within watersheds. Presented below is a summary of the medical ecology of *C. parvum* in calves and in humans and the existing scientific evidence that addresses the claim that calves put humans at significant risk for water-borne infection of *C. parvum*.

In calves and in humans, this parasite is transmitted by the fecal-oral route. Infection typically begins when a susceptible individual ingests water or food contaminated with the oocysts (eggs) of this parasite. The parasite then invades the epithelium of the intestine, replicates, and through sequential reproductive cycles can result in up to 10^9-10^{10} oocysts being shed in the feces per day. Shedding of oocysts can last for 3-12 days in calves and for an average of 18 days (range of 9-50 days) in humans. Given the large number of oocysts shed per day, the immediate environment can become quite contaminated with these oocysts. These oocysts are immediately infective to another individual, allowing for the rapid spread of this parasite within a group of susceptible individuals.

Oocysts shed from one species of mammal appear to be infectious to other species of mammals. Oocysts from humans have been shown to be infectious to calves, lambs, goats, cats and dogs. Oocysts from cats, calves and pigs appear to be infectious to humans. People working with diarrheic calves infected with *C. parvum* have themselves become infected with *C. parvum*, presumably from the calf. However, working with diarrheic calves is not common for the general public. A second *Cryptosporidium* species, *C. muris*, has been identified in the abomasum of adult cattle, but to date it has not been shown to be infectious to humans.

The critical issue is how would *C. parvum* from calves gain access to surface waters and end up in drinking water supplies. The essential steps must include calves becoming infected and shedding the oocysts in their feces. These oocysts must then enter a surface water supply and remain infective as they journey downstream to water treatment plants and distribution systems.

How common is it for calves with access to surface water to shed this parasite? Very little work has been done in beef calves, with most research conducted on dairy calves. In Manitoba, Canada, 22% of beef calves from 148 herds known to have problems with neonatal diarrhea were found to shed *C. parvum*. In England, 36-39% of diarrheic beef calves tested positive for *C. parvum* while only 8% of healthy beef and dairy calves tested positive. In San Bernardino county, California, 5.6% of predominately Holstein dairy calves were found to be shedding *C. parvum*. More specifically, the prevalence of shedding was 21% in calves with diarrhea and 2% in healthy calves. From across the United States, 22% of 7,369 dairy calves tested positive for this parasite. This parasite appears to be relatively common in dairy calves, but little is known of the distribution of *C. parvum* in beef cattle herds, particularly in those herds located on open range with access to important California watersheds.

Little is know about the prevalence of shedding among wildlife species with access to surface waters or what contribution humans themselves make to surface water contamination. In a survey of 100 raccoons, 13 juveniles had oocysts in their feces. Cryptosporidial infection has been confirmed in a large variety of neonatal captive deer, including mule and fallow deer. Experimental infection has been demonstrated in opossums. Thirty percent (35/115) of wild mice trapped at a dairy shed oocysts. Oocysts obtained from mice have been shown to be infective to calves, perhaps indicating a mouse-calf cycle. The prevalence of shedding among groups of people is highly dependent on which country, which population, and can range from 0-60%, with the higher proportion of shedding among diarrheic individuals. What relationship between shedding in humans and surface water contamination is unknown.

How long do *C. parvum* oocysts survive in the environment once they are shed in feces? Oocysts that dry out become non-infective in just a few hours. If fecal material thoroughly dries before reaching water, the oocysts would presumably become non-infectious for animals and humans. Ten or more days of freezing causes over 90% of oocysts to become non-infective.

Oocysts in distilled water became non-infective if heated to 72.4°C or higher for 1 minute or if heated to 64.2°C or higher for 2 minutes. What if fecal material is deposited directly in a stream? One study found that after 33 days in river water, 34-40% of purified oocysts became non-infective. After 176 days, 89-99% of the oocysts had become non-infective. In conclusion, it may be that most oocysts do not survive the journey from calves to surface water to water treatment plant to human consumption.

What evidence directly links the presence of *C. parvum* in surface water supplies to livestock production? Environmental studies to date have not attempted to determine if the *Cryptosporidium* found in surface water is *C. parvum* or some other *Cryptosporidium* species not infectious to humans yet detected by the laboratory assay typically used for environmental testing. For example, *C. muris* is shed by cattle and mice and *C. meleagridis* is shed by turkeys, both of which are not infectious to humans and both of which are detected by the immunofluorescent assay produced by Meridian Diagnostics Inc. With this in mind, 77% of general surface waters collected from the western United States were found to have oocysts, with a geometric mean ranging between 0.91 and 28 oocysts/L. In comparison, one study found no difference in the concentration of *Cryptosporidium* oocysts from protected surface waters (0.3-4.0 oocysts/L) as compared to surface waters subject to agricultural run-off (0.1-2.0 oocysts/L). Moreover, 68% of these oocysts had become non-viable. Another study measured 5,800 oocysts/L in irrigation canal water running through agricultural acreage with cattle pastures (beef or dairy not specified), compared to 127 oocysts/L in river water subject to human recreation and 0.8 oocysts/L for stream water exposed to ranch land runoff. The number of oocysts required to infect a person is unknown, but 10 oocysts were sufficient to cause clinical infection in two infant non-human primates. If a similarly low dose can produce clinical infection in humans, only a few oocysts would need to remain viable in drinking water to pose a risk to humans. Finally, concentrations of *Cryptosporidium* oocysts from pristine surface waters have been found to contain 0.005-18 oocysts/L, indicating that this organism occurs naturally in pristine watersheds. This would suggest that wildlife will need to be carefully examined for their role in contaminating surface water with this parasite.

The scientific evidence supporting the claim that cattle are a significant source of *C. parvum* for surface water is incomplete and contradictory in some cases. Therefore, it would be premature at this time to claim that cattle production is the leading source of *C. parvum* in surface water. If, in the words of US EPA, we are to "minimize the potential for source water contamination" by *C. parvum*, then we must first identify the primary quantitative source(s) of this parasite in the environment, be it livestock, wildlife, or humans.

An Example of A Rangeland NPS Management Plan

Ranch: Sierra Foothill Research and Extension Center
Location/Address: 8279 Scott Forbes Road, Browns Valley, CA

Melissa Joyce
Mike Connor

The Sierra Research and Extension Center (SFREC) is one of nine research and extension centers owned by the University of California Division of Agriculture and Natural Resources. The University of California purchased the 5720-acre property in the early 1960s as a facility for studying beef cattle production and range management practices.

A Rangeland Water Quality Management Plan (RWQMP) has recently been proposed to the State Water Resources Control Board to control nonpoint source pollutants such as sediments and nutrients from rangelands. The RWQMP requests voluntary nonpoint source plans from ranch managers and owners to control or reduce water quality impacts from grazing activities. This nonpoint source management plan was prepared according to RWQMP guidelines and represents a proactive step by the University of California to protect the Center's water quality.

CENTER DESCRIPTION

Environmental Setting

Climate: The SFREC has a Mediterranean climate characterized by hot, dry summers and mild, rainy winters. Annual precipitation ranges from 10 to 44 inches with an average of 28 inches. Most precipitation occurs as rainfall between October and May. The coolest months are December and January, averaging temperatures in the low 50s°F. The hottest months are July and August, averaging temperatures in the low 90s°F. Rainfall limits forage growth more than temperature. Historical precipitation and 1993-94 weather data are included in Appendix A.

Soils and Topography: The Soil Conservation Service lists four soil series as the most common at the Center: Auburn, Sobrante, Argonaut, and Timbuctoo. The Auburn series is the most extensive and almost always intermingled with the other three series. All four soil series developed from greenstone and are now covered with annual grasses, forbs, and oak woodland vegetation. SFREC topography is typical of the rolling Sierra Nevada foothills. Most slopes range from 15 to 50 percent though steeper slopes are found in the southern part of the Center bordering the Yuba River. Small scattered areas are also more gently inclined, with slopes ranging from 2 to 15 percent. Appendix A includes a soil map, brief soil descriptions, and a topographic map.

Vegetation: Three vegetation types exist at the SFREC: annual grassland, oak woodlands, and riparian corridors. Common annual grass species include soft chess, other annual bromes, and wild oats; common forb species include filaree, rose and subterranean clover, and yellow star thistle. Grasslands also house some perennial grasses such as purple stipa and California melic. Common oak woodland species include blue oak, live oak, black oak, and foothill pine. Woodland shrub species include buck brush, poison oak, toyon, and white leaf manzanita. Riparian areas commonly support such species as valley oak, cottonwood, alder, Mission fig, willow, cattail, blackberry, and sedges.

Watersheds: The SFREC contains almost the entire watersheds of six small permanent streams within its boundaries: Haworth Creek, Forbes Creek, Slicks Creek, Schubert Creek, Campbell 1, and Campbell 2. A seventh larger permanent stream, Porter Creek, passes through the Center. Englebright Reservoir lies on the southeast corner of the SFREC, and the Yuba River forms the Center's southern boundary. Dry Creek lies just beyond the northwest boundary and flows to the southwest.

Both Campbell creeks empty directly into Englebright Reservoir. Schubert and Haworth Creeks meet the Yuba River downstream of the reservoir dam. Slicks and Forbes Creeks flow into Porter Creek which joins Dry Creek outside of the Center boundaries. Dry Creek meets the Yuba River west of the SFREC. Appendix A includes a map of stream locations with areas where cattle have stream access noted.

Wildlife: Past research at the Center has documented an assortment of birds and wildlife: 145 bird species, 12 reptile species, 4 amphibian species, and 35 mammal species. Common wildlife include black-tailed deer, wild turkey, California quail, red fox, turkey vultures, acorn woodpeckers, rattlesnakes, and cottontail rabbits.

Endangered Species: No plants listed as threatened or endangered are known to exist at the SFREC. The Center does house valley oaks which have been listed by the California Native Plant Society as a "species of limited distribution." Three bird species found at the SFREC have been listed by federal or state agencies as threatened or endangered: the bald eagle, the bank swallow, and the California black rail.

Physical Improvements: The SFREC contains 5,720 acres fenced into 81 fields including approximately 4,945 acres of dry annual rangeland and about 150 acres of irrigated pasture. About 353 acres are developed with facilities, roads, and housing, and 272 acres have been designated as natural areas where no livestock grazing occurs.

Some rangeland has been improved for forage production including various degrees of clearing and some seeding. About 1,550 acres are totally cleared, approximately 1,365 are partially cleared or thinned, and roughly 2,805 acres remain unmodified oak woodlands. Appendix A includes a map of cleared, partially cleared, and uncleared areas.
Fifty-two troughs and five ponds have been developed to provide stock water away from streams. These watering sites are indicated on the stream map provided in Appendix A.

Livestock and Grazing Operations

Livestock Numbers: The SFREC maintains a fall-calving herd of about 475 head including commercial cows, bulls, replacement heifers, and stockers (unweaned calves are not included in this count). The herd is managed to fulfill range management and research needs; herd size may vary but is expected to remain on average at about 475 head. Appendix B includes a table of cattle numbers for the last ten years.

Field Use: Cattle are moved between summer and winter fields and fields used for special purposes such as calving and breeding. Appendix B includes a general grazing rotation map. Both estimated carrying capacities and actual field use are also presented in Appendix B for each grazing unit. Carrying capacities are estimates calculated by a method proposed by the Cooperative Extension using canopy cover and slope.[1] Field use figures are based on past grazing intensities and estimates of future forage availability. Actual field use and time of use may vary depending on research needs, weather, forage, and unforeseen events, such as fire.

Fields are managed to leave a minimum of 750 pounds per acre residual dry matter (RDM)[2]. Occasionally, some fields may contain less than 750 pounds per acre RDM for any single year depending on rainfall, forage availability, experimental requirements, and/or weed control measures.

Weed Control: Weed control primarily consists of local spraying for star thistle, verbana, poison oak, and California blackberries with LV-4 (2,4D, a low volatile ester). Spraying for blackberries occurs only in permanent pastures, not in riparian areas. Spraying occurs in February, March, and April. Occasional light spraying may continue in May, June, and July. Round-Up™ is also used around headquarters and in ditches to control weeds. In 1993, Forbes field (a cleared area) was burned and, in 1994, grazed below 750 pounds per acre RDM to control medusahead, a weed species that had infested the area.

Irrigation Practices: Irrigated pasture is used primarily in the summer months but may be used in the fall if feed remains. During the summer, pasture is both flood and sprinkler irrigated. Cattle use is rotated every 10 to 12 days on average. Pastures may be replanted every 7 to 10 years. "Resting" pasture is disced and planted in oats in October, grazed in February and again in April or May, and turned under and left dry until September. In September, the land is disced again, fertilized, and replanted to irrigated pasture. Established pastures are usually fertilized twice a year: in May with about 200 pounds of 16-20-0 per acre and in August with 100 pounds of 46 percent urea per acre.

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[1]University of California, Department of Agronomy and Range Science, Cooperative Extension, "Estimating Livestock Grazing Capacity on California Annual Rangeland," Range Science Report No. 29, April 1991.

[2]Residual dry matter is the dry weight of biomass per acre present at the beginning of a new growth cycle.

GOALS

This nonpoint source management plan is intended to achieve the following goals:

Production Goal: To maintain, on average, a 475-head herd for beef cattle and range management research.

Landscape Goal: To protect and/or enhance existing water quality to prevent future impairments to beneficial uses from grazing-related activities by proper management of uplands and promotion of riparian vegetation where feasible.

Lifestyle Goal: To promote sustainability of Center resources to provide for long-term educational and research needs.

ASSESSMENT OF CURRENT CONDITIONS

Impaired Beneficial Uses of Water

The State Water Resources Control Board (SWRCB) recently issued the 1994 Draft Water Quality Assessment[3] which catalogs the state's water bodies and their water quality. All streams at the Center eventually flow into Englebright Reservoir or the lower Yuba River. Englebright Reservoir is listed as having intermediate water quality. The lower Yuba River is listed as having good to intermediate water quality. Good or intermediate water quality indicates no impairment of beneficial uses.

Nonpoint Pollution Sources

Because no impairment of beneficial uses exists in water bodies receiving Center waters, a nonpoint source management plan is not required by the Regional Water Quality Control Board. However, possible nonpoint sources were assessed to achieve the stated landscape goal of protecting or enhancing existing water quality through a voluntary program.

Erosion/sedimentation: In 1984, the Soil Conservation Service prepared a Soil Conservation Plan for the SFREC. The plan states that soil erosion should not be of concern as long as 500 to 700 pounds per acre RDM remains after grazing. Current management leaves a minimum of 750 pounds per acre RDM; erosion is not believed to be an extensive problem.

Localized erosion is a concern in some areas of the SFREC including the headquarters corral, areas below culverts, some roads, supplemental feeding areas, minor trampling of some stream banks by cattle, and a firebreak in the Campbell area.

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[3]State Water Resources Control Board, "Draft Water Quality Assessment," May 24, 1994.

Nutrient loading: Nutrient loading is a greater concern for impounded water bodies (e.g., lakes and reservoirs) than for flowing streams or rivers. Two streams in the Campbell area flow directly into Englebright Reservoir. Both these streams have dense riparian vegetation along their banks. Current grazing management ensures that a minimum of 750 pounds per acre RDM remains after grazing upland fields and pastures. Both riparian and upland vegetation will act as filters to reduce nutrient-loading to the streams and subsequently Englebright Reservoir.

The corral near Center headquarters drains into a ditch that allows flow directly into Porter Creek. Because of the length of Porter Creek and heavy riparian vegetation along its lower reaches, excess nutrients would likely be removed before the stream joins Dry Creek and subsequently the Yuba River. However, diverting corral runoff to filter through adjacent fields before reaching the creek is a relatively simple matter, and drainage modifications would reduce the potential for future water quality impairments.

Pathogen loading: Water-borne pathogens are primarily a concern where water is used for drinking or water-contact recreation. Englebright Reservoir is used for water-contact recreation, and the lower Yuba River supplies drinking water, though municipal intakes are several miles downstream of the Center.

Defecation by cattle directly into streams is the primary grazing-related source of pathogens. Cattle are excluded by fencing from some stream reaches. Supplemental feeding and salting areas are located to discourage cattle from concentrating near streams. Fifty-two troughs and five ponds provide stock water away from streams. Many fields containing streams are not grazed in summer when green riparian vegetation encourages cattle to congregate in and near creeks. The SFREC also has an active livestock health program to reduce the level of pathogens from cattle that may be released into streams (see "Livestock Health Practices" section for more detail). The management measures described above are believed to be effective at minimizing pathogen loading into the Center's streams.

Temperature Impacts: SFREC streams are too small and shallow to support cold-water fish. Both the Yuba River, which bounds the Center to the south, and Dry Creek, which is dammed just north of the SFREC by the Browns Valley Irrigation District, support many cold-water fish species including salmon and steelhead. Englebright Reservoir, with the help of cold water releases from the upstream New Bullard's Bar Reservoir, also supports cold-water fish species. These reservoirs are the primary influence on water temperature in the Center's vicinity. In addition, the small volume of water entering the Yuba and Englebright from Center streams (especially in summer months) and shading by riparian vegetation along most stream stretches indicate that temperature impacts due to grazing-related activities at the SFREC are insignificant.

Management Practices

Grazing Practices: A comparison of estimated carry capacities and actual field use indicate that upland range is near capacity but not overgrazed. Obvious signs of overgrazing (e.g., networks of gullies, pedestaling of plants, etc.) are also absent at the Center.

Riparian Corridors: Some riparian areas are fenced to prevent cattle access but most are managed as part of adjacent fields (see Appendix A). Past clearing in the Forbes, Slicks, and Porter areas have left streams in these fields denuded of riparian vegetation along significant stretches. Forbes Creek is completely bare of riparian vegetation along many stretches except for intermittent trees and shrubs. Slicks Creek is currently the site of a stream restoration project that includes planting of willows, cottonwoods, and oaks along the lower 2000 feet of this creek. Areas clear of riparian vegetation along lower Porter Creek are located in irrigated pasture. Cattle are moved frequently in and out of these fields, and heavy growth would impede cattle management. Understory brush was removed along a short stretch of Porter Creek bordering dry rangeland.

Livestock Health Practices: Good livestock health practices reduce the level of pathogens in livestock, thus reducing pathogen loading into rangeland water bodies. The SFREC has a very active program for prevention and cure of disease in the Center's cattle herd. Calves are inoculated against seven (eight for heifers) bacterial or viral diseases. Mature animals annually receive protection against eight infectious diseases and internal parasites. Other prevention includes frequent health checks by trained personnel. For the relatively few animals that become ill, protocols exist for prompt treatment. Treatment includes the use of antibiotics, and veterinarians are consulted when necessary.

Endangered Species

The SFREC houses one listed endangered species (bald eagle) and two listed threatened species (bank swallow and California black rail). Current management is not believed to impact any of these species or their habitat. Bald eagles are only incidental users of the Center, and bank swallow burrows are likely located in areas too steep for cattle grazing. The black rail population appears to have thrived at the SFREC under current cattle management.

MANAGEMENT PRACTICES FOR IMPLEMENTATION

The SFREC already has many "best management practices" in place as described by RWQMP and Soil Conservation Service documents. If existing management measures were considered insufficient to meet planning goals, possible alternative measures were evaluated with respect to feasibility, effectiveness, compatibility with current management, and cost.

Four alternative management measures were selected for implementation: 1) diverting corral drainage through adjacent pastures to reduce nutrient and sediment loading to nearby Porter Creek; 2) restoring and revegetating Forbes Creek; 3) controlling localized erosion with gravel placement and other structural measures; and 4) controlling localized erosion by critical area planting. Existing and alternative management measures addressing identified concerns are outlined on the next page.

Management Category	Existing Management Measures	Alternative Management Measures	Source(s) Addressed
Grazing Management	Minimum RDM 750 pounds/acre (528A)[4]		Upland erosion and sediments
	Animal exclusion from some riparian areas (472)		Pathogens
Structural Improvements	Troughs and ponds (614)		Pathogens; erosion/ sediments; nutrients
	Revegetation of lower Slicks Creek (580)		Streambank erosion; upland sediments and nutrients; temperature
		Divert corral drainage	Erosion/sediments and nutrients
		Gravel placement and measures to control localized erosion (410)	Erosion/sediments
Land Treatments	Allow understory brush to return along part of Porter Creek (314)		Upland sediments and nutrients
		Plantings for localized eroded areas (342)	Erosion/sediments
		Restore and revegetate Forbes Creek (204)	Streambank erosion; upland sediments and nutrients; temperature

[4]Numbers in parentheses refer to Soil Conservation Service Field Office Technical Guide Practice numbers.

Management Category	Existing Management Measures	Alternative Management Measures	Source(s) Addressed
Livestock Management	Livestock health practices		Pathogens
	Supplemental feeding and salting		Nutrients and pathogens

MONITORING

Monitoring efforts are aimed at documenting current upland and riparian conditions as well as documenting changes over time. Three monitoring methods will be used: 1) photo monitoring of riparian and upland areas, 2) an annual streambank stability and cover survey, and 3) residual dry matter assessments. Monitoring results will be evaluated annually. The effects of short-term weather and management actions will be acknowledged. If monitoring indicates downward trends in riparian or upland areas, or unsatisfactory progress toward specific objectives on this plan, management changes will be considered. Monitoring protocols and a map of monitoring site locations are included in Appendix C.

Photo Monitoring: The SFREC has a set of 24 photo points which have been maintained since 1962. Photos are taken at these locations every two or three years. The photos are mostly mid- to long-distance and include few riparian areas. Nevertheless, they can indicate major vegetation changes and possible erosion, and they will be reviewed periodically as part of the monitoring process.

Twenty-one photo points were recently established along the Center's seven streams and riparian zones, including a control photo point in the ungrazed Schubert natural area. Photo points include short-, mid-, and long-range views. Locations were chosen by walking the streams and noting any specific problem areas (e.g., trampled streambanks, steep cutbanks, areas bare of vegetation). Photo points were established at specific problem areas; if no such areas were noted, photo points were selected for easy access and best view of the riparian area. Three locations were chosen to document vegetation height in typical grazed upland areas. Photo points were marked with specially painted and numbered fence posts. Photos will be retaken twice a year: in May, near the end of winter grazing, and in September, near the end of summer grazing.

Streambank Stability and Cover Survey: To identify any new problem areas, an annual visual survey of streambank stability and cover will be performed. Six streambank stability monitoring sites were established near photo points and were permanently marked. In May of each year, streambank stretches at these sites will be classified into one of four categories based on a method suggested in an Environmental Protection Agency (EPA) publication[5]: covered and stable; covered and unstable; uncovered and stable; and uncovered and unstable.

Residual Dry Matter Assessments: Residual dry matter (RDM) estimates will be recorded annually after winter or summer grazing in twelve fields. RDM will be determined using a comparative analysis technique whereby the RDM in the entire field is approximated by estimating the percentage of the field in various RDM classes.

Owner: University of California **Date:** January 3, 1995

Prepared by: Melissa Joyce, DANR Summer Intern
Mike Connor, Superintendent

Appendix A: Environmental Setting Information
- Historical Precipitation Records
- 1993-94 Weather Data
- Soil Map
- Topographic Map
- Map of Stream Locations and Watering Sites
- Map of Cleared, Partially Cleared, and Uncleared Areas

Appendix B: Livestock Management Information
- Historical Cattle Numbers
- Grazing Rotation Map
- Field Use and Carry Capacity Estimates

Appendix C: Monitoring Information
- Monitoring Protocols
- Monitoring Site Locations

[5]Idaho Water Resources Institute for the Environmental Protection Agency, "Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams," Streambank Stability, p. 96-107.

Nutrient Cycling in Grazed and Ungrazed Oak Woodland Rangelands

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Increased land-use intensity is apparent throughout California and oak woodland ecosystems are no exception. A large portion of our oak woodland ecosystems are grazed and many woodlands are being cleared for oak firewood and to enhance grazing. The potential for site disturbance and land degradation in intensively managed oak ecosystems is great. If nutrients are removed from an ecosystem at a rate greater than they can be made available by natural processes (e.g. weathering of rocks, nitrogen fixation, atmospheric deposition), the productivity of the ecosystem will decrease, forage production and/or quality may be reduced, and oak seedling reestablishment may be compromised.

In order to better understand California oak woodland ecosystems and their response to disturbance, we initiated a detailed study examining the role of atmospheric, hydrologic, biological, and geochemical processes in regulating nutrient cycling. This research project was sponsored by the Integrated Hardwood Range Management Program with great assistance from our colleagues at the Sierra Foothill Research and Extension Center. The major objective of this research was to determine the effect of oak clearing and grazing on nutrient dynamics in a representative oak woodland ecosystem.

The investigation was conducted in the Schubert watershed at the University of California, Sierra Foothill Research and Extension Center. To examine nutrient dynamics, ecosystem waterflows (e.g. precipitation, canopy drip, soil solutions and stream water) were sampled for a five year period. These waterflows provide a dynamic pathway for redistribution of elements within the ecosystem. Because these solutions reveal current processes, their composition is sensitive to management practices and ecosystem disturbances. Soil solutions also reflect the plant-available nutrient status and therefore provide a basis for comparing differences in nutrient availability between various subsystems within the ecosystem.

Role of Oak Trees in Nutrient Cycling

Are oak trees an important component for sustaining ecosystem productivity in California oak woodlands? Our research shows that oak trees play a major role in maintaining the nutrient status of these ecosystems. A typical blue oak (*Quercus douglasii*) in the Schubert watershed with a diameter at breast height of 39 cm[††††††] has a dry weight of 1,429 kg (Table 1). Nutrients stored within the above-ground biomass of a typical blue oak follows the order: calcium > nitrogen > potassium > magnesium > phosphorus. Each year, a typical blue oak will return approximately 1, 0.1, 2, and 0.8 kg of nitrogen, phosphorus, calcium and potassium, respectively, to the soil surface in the form of litterfall (e.g. leaves, twigs and acorns) and canopy throughfall (canopy drip). While these values may appear low, multiplying by all the oak trees in a watershed results in very large quantities of nutrients.

Nutrients contained in litter returned to the soil when leaves, acorns and other plant parts fall from the tree are slowly released by microbial decomposition resulting in replenishment of nutrient pools beneath the oak canopy. Concentrations of major nutrients in the soil solution beneath an oak canopy are 2-10 times higher than in soil solutions of adjacent grassland soils indicating a more nutrient rich soil environment beneath the tree canopy.

The distribution of roots within the soil profile also plays an important role in nutrient dynamics. At the Sierra Foothill Research and Extension Center, annual grasses were observed to have the majority of their roots in the upper 30 cm of the soil profile while oak roots were found primarily at depths greater than 30 cm. In grassland soils, nutrients leached below the shallow rooting zone of annual grasses are removed from the ecosystem into stream or ground waters. In contrast, the deeply rooted oak trees are able to capture the majority of the nutrients before they are lost from the ecosystem by leaching. Therefore, removing oak trees from the ecosystem creates the potential for a progressive loss of nutrients through leaching.

Effects of Oak Tree Removal on Nutrient Cycling

To simulate the effects of oak tree removal by timber harvest or firewood cutting, two blue oaks were removed in the late summer of 1992. Soil solution data indicate that oak tree removal results in a rapid shift in soil solution nutrient concentrations toward that of the adjacent grassland soils (Fig. 1). These data indicate that plots from which the trees were removed are quickly reverting to nutrient conditions similar to grassland plots. The long-term trend is for rapid loss of nutrients from soils beneath oak canopies following oak removal. An important question raised by these data is: Why is there such a rapid decrease in nutrient concentrations following tree removal? The rapid loss of nutrients results largely from the loss of litterfall inputs which contribute large amounts of nutrients in the form of organic matter to the soil surface. Nutrients in the organic matter are slowly released by decomposition and mineralization through the action of microorganisms.

The loss of soil nutrients is confirmed by studies examining forage production following oak tree removal. These studies consistently show increased forage yield immediately following tree removal due to removal of competition for nutrients, water, and light by the oak trees.

[†] 1 inch = 2.54 cm; 1 kg = 2.2 pounds; 1 kg/ha/yr = 0.89 pounds/acre/year; 1 mg/L = 1 part per million (ppm).

However, forage yields show a steady decline following the initial peak and fall to open grassland levels after approximately ten years. This indicates that the effects of oak trees on the soil nutrient status are short-lived following their removal and that nutrient reserves are quickly depleted by leaching.

Effects of Oak Tree Removal on Stream Flow

Stream flow gauges were installed on the small stream draining the Schubert watershed in 1978. Since 1980, continuous stream flow records have been obtained with the objective of measuring changes in the volume of water or stream flow pattern due to watershed management practices. In particular, we were interested in determining if stream flow increased when oaks were removed from the watershed. Increased stream flow of up to 30% has been shown in some forested watersheds due to the decrease in evapotranspiration following tree removal. We have water flow data for four years prior to the removal of approximately 30% of the oaks from the 103 ha Schubert watershed and 11 years of post-cut water flow data. There is no indication that either base flow, the flow that occurs during the summer months when there is no rain, or total stream flow increased after cutting. We cannot simply compare annual stream flow because annual rainfall is different every year; however, we can compare the ratio of runoff to rainfall (Fig. 2). The figure shows that there is no pattern of higher runoff/rainfall ratios after cutting compared to before cutting. Our conclusion from this study is that careful removal of oaks does not significantly change stream flow patterns or amounts. Careful removal includes leaving oaks near riparian zones and on slopes over 30%.

Effects of Grazing on Nutrient Cycling

Moderate intensity grazing, as practiced at the Sierra Foothill Research and Extension Center, had no apparent adverse effects on nutrient cycling when compared to an adjacent non-grazed area. Only sodium and chloride concentrations were increased in soil solutions by grazing. Supplemental feeding of salt to cattle could account for these increased levels. High nitrate concentrations in the grazed-oak canopy site were measured and probably result from preferential use of the shaded area beneath the oak canopy by the cattle. By grazing and processing the forage, the cattle short-circuit the natural nutrient cycle and increase the rate at which nutrients are released from organic matter. This leads to rapid regrowth of forage which limits nutrient losses by leaching. In addition, cattle are responsible for nutrient transfers from the open grassland areas to the soils beneath the oak canopy. By shading up beneath oak canopies, cattle preferentially return nutrients to soils beneath the canopy through excrement deposition.

Stream Water Quality

Soils beneath the oak canopy are characterized by having significantly higher organic matter concentrations due to annual litterfall returns (approximately 8500 kg/ha/yr beneath blue oak trees). In addition to the positive effect of organic matter on the soil nutrient status, higher organic matter concentrations lead to lower soil bulk density and greater porosity. This in turn provides increased infiltration rates for rainfall which reduces surface runoff, water erosion and stream water sediment loads. With the exception of a few large storm events, suspended sediment concentrations in the Schubert watershed were generally less than 200 mg/L and were less than detection at low flow conditions. Annual suspended sediment fluxes were very low (<45 kg/ha/yr) with the highest concentrations occurring during the highest flow events. Thus, given the moderate intensity grazing regime practiced in the Schubert watershed, erosion (generation of suspended sediments) rates are not accelerated above typical geologic rates by grazing practices.

Stream water chemistry is regulated by interactions between hydrological, geochemical, and biological processes. At low flow conditions, concentrations of calcium, magnesium, chloride, sulfate and silica appear to be controlled by weathering rates and equilibrium with the bedrock. During storm events, potassium, ammonium, and nitrate are regulated by biological and hydrological processes associated with lateral flow of soil solutions through the upper soil horizons. Elemental losses in stream water from the Schubert watershed are shown in Table 2. Losses of the most limiting nutrients (nitrogen, phosphorus, and potassium) were very low (<2 kg/ha/yr) indicating their retention in the watershed, primarily by biological processes. Elements which are abundant in the bedrock (e.g. calcium, magnesium, chloride, sodium, and silica) show the greatest losses from the watershed.

Conclusions

Oak trees play a critical role in sustaining ecosystem productivity through their role in cycling nutrients to the soil surface, preventing nutrient leaching losses, increasing water infiltration, and attenuating water erosion and stream sediment concentrations. Moderate intensity grazing does not appear to have any serious detrimental effects on nutrient cycling in these oak woodland ecosystems. Oak tree removal will lead to a significant loss of nutrients from these ecosystems leading to a long-term decrease in ecosystem productivity. Careful removal of oaks does not significantly change stream flow patterns or amounts.

Table 1. Nutrients contained in a typical blue oak tree in the Schubert watershed of the Sierra Foothill Research and Extension Center.

Tree component	Dry Weight (kg)	N	P	Ca (kg/tree)	Mg	K
Stem >15 cm	517	2.16	0.10	5.07	0.28	3.08
Branches 3-15 cm	545	4.10	0.22	14.82	0.58	3.25
Branches 1-3 cm	115	1.38	0.10	7.39	0.22	0.85
Twigs <1 cm	141	2.11	0.22	8.20	0.40	1.53
Leaves	41	1.28	0.10	1.88	0.20	0.49
Bark	70	0.60	0.03	11.09	0.08	0.22
Total	1429	11.63	0.77	48.45	1.76	9.42

Table 2. Elemental and suspended sediment fluxes in the Schubert watershed of the Sierra Foothill Research and Extension Center.

Year	N	P	Ca	Mg	K	SO_4 (kg/ha/yr)	Cl	Na	Si	Sediment
1991	1.88	0.002	37.7	16.6	0.37	8.22	20.0	10.1	15.8	17.5
1992	0.54	0.022	45.4	20.1	0.70	9.15	23.9	12.5	26.9	44.6
1993	1.39	0.001	97.1	40.0	1.01	18.02	46.8	28.3	36.5	28.5

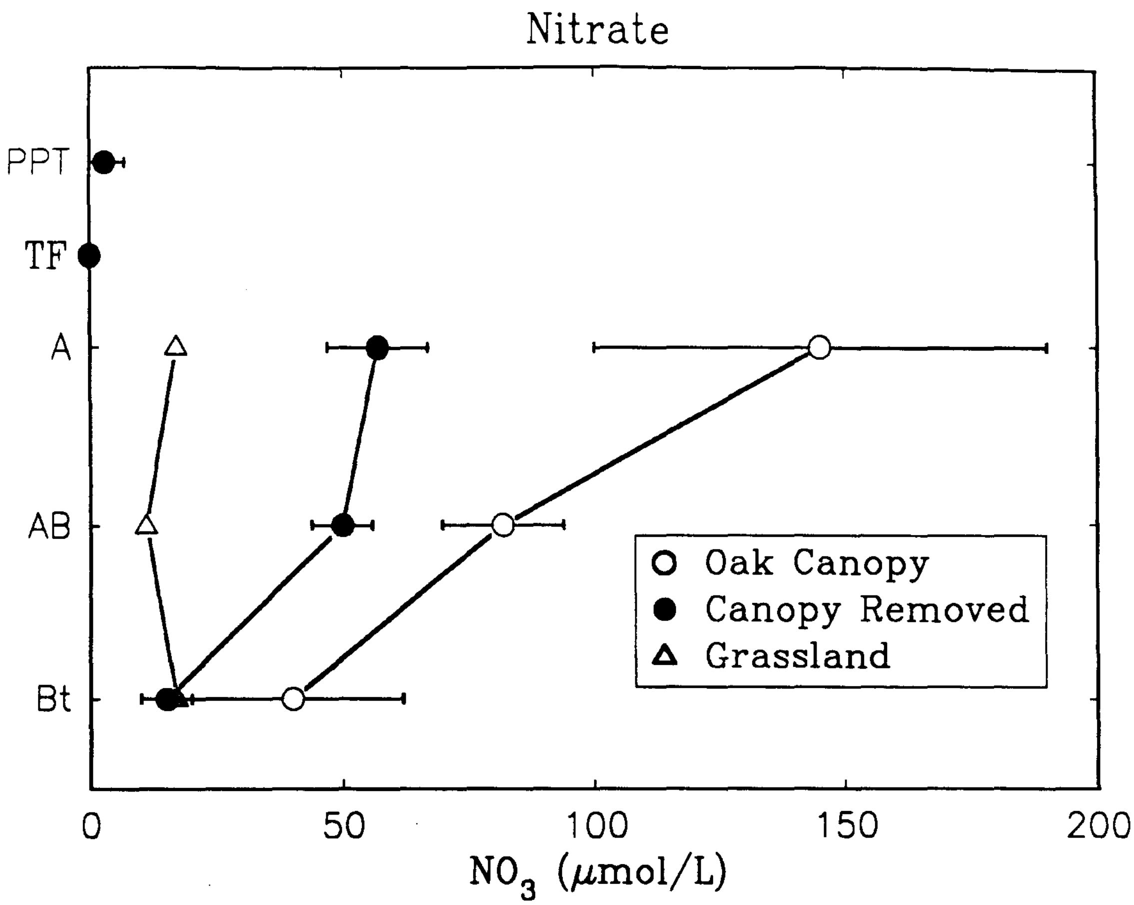

Figure 1. Nitrate concentrations in precipitation (PPT), canopy throughfall (TF), and the A, AB, and Bt horizons of soils beneath the oak canopy, with oak tree removal four months prior to sampling, and in adjacent grasslands with no tree canopy. Nitrate concentrations (1 part per million [ppm] equals 16 μmol/L) are appreciably higher beneath oak trees and concentrations rapidly decline following oak tree removal.

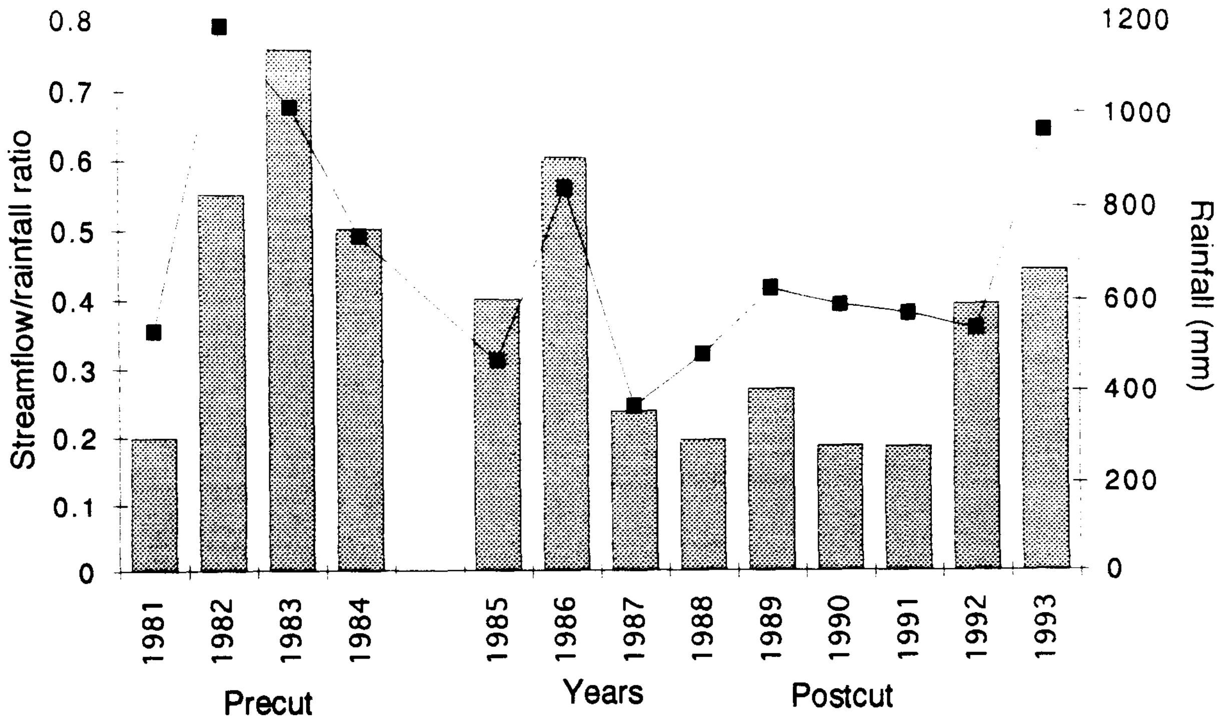

Figure 2. Annual precipitation amounts and the streamflow/rainfall ratio during the 1981-1984 precut and 1985-1993 postcut years in the Schubert Watershed. Removing approximately 30% of the oak trees had no significant effect on the streamflow/rainfall ratio. The streamflow/rainfall ratio is generally higher during years with greater rainfall amounts.

Riparian Restoration Study

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On many hardwood rangelands in California, there is concern that the regeneration of several species of native oaks is inadequate. That is, there appears to be insufficient seedlings and saplings to replace the older trees that die or are removed. There is also concern that some riparian areas in oak woodlands have been, or are being, degraded from certain land management practices, including improperly managed grazing and tree and brush removal. Since riparian habitats are known to be extremely important areas for wildlife, as well as filters for sediments and nutrients, there is widespread interest in developing techniques for restoring degraded riparian areas on hardwood rangelands in the state. However, to date, there has been relatively little research on this subject. This project was initiated to begin testing several approaches for restoring woody vegetation to areas near a perennial stream at the Sierra Foothill Research and Extension Center (SFREC) that were cleared of woody vegetation approximately 25 years ago. Another principal goal of this project was to develop a demonstration area for conducting field tours for land owners and managers, as well as for the general public, to show people how well various riparian restoration approaches work, what kind of growth can be expected from plantings, and what changes in wildlife habitat and stream morphology are likely to result.

This project began in the late fall, 1993, with the collecting of blue, valley and interior live oak acorns at the SFREC, as well as the harvesting of cuttings of cottonwood and willow. The acorns were grown in small containers for 5 months before outplanting. The cuttings were placed in aerated water baths for several weeks to initiate rooting. All seedlings and cuttings were planted in spring, 1994, along a 2000 foot section of upper Slick's Canyon. A Eleven members of a local group, the E.C. Powell Fly Fishers Club, assisted in the planting of the oak seedlings.

Five treatments were established, including:

1) individual plantings protected with tree shelters
2) planted plots with livestock excluded using barbed wire
3) planted plots accessible to livestock
4) plots not planted, but livestock excluded
5) plots not planted and livestock not excluded

Each treatment consisted of a 100 foot section of creek and was replicated 5 times. In the planted plots, 30 willow cuttings (2 species), 30 oak seedlings (3 species), and 10 cottonwoods were planted on both sides of the creek in suitable planting locations.
The willows and cottonwoods were placed in 12 inch deep holes formed using a heavy metal

dibble, while the oaks were planted in 10 inch deep holes excavated with post hole diggers. The four-foot tree shelters were secured to metal fence posts that were driven 18 inches into the ground. Wire was placed over the tops to prevent birds from falling down inside.

All seedlings and cuttings were evaluated in both early summer and early fall, 1994 for survival. Overall survival of the 840 plants was initially quite high, and ranged from 79% for plants protected with shelters, to 57% for those in unfenced plots. Unfortunately, in mid-summer one of the heaviest grasshopper infestations in recent memory occurred, resulting in defoliation and bark removal of almost all plants that were not in shelters, as well as a significant percent of those that were. During the last evaluation in October, survival ranged from 28% for the unfenced plots, to 57% for those protected with tree shelters. While some of the mortality appeared to result from browsing by livestock (unfenced plots) , deer and rodents (fenced and unfenced plots), the majority appeared to be the result of grasshopper herbivory.

The heavy winter storms in January, 1995, also impacted the plots, and many of the seedlings and cuttings were flooded for prolonged intervals. The most obvious effect of this was the deposition of sediment near the plantings, especially on the outside of the tree shelters. We have not yet determined what effect this will have on the growth and/or survival of the plantings.

As part of an attempt to develop some baseline information about wildlife use of the area, we began regular assessments in mid-summer of bird species observed along the creek. We were quite surprised to find a population of black rails, a species listed as threatened by the California Department of Fish and Game, and normally only found in coastal marshes. This is a very secretive, difficult to observe bird, which has never previously been recorded in the Sierra foothills. We are continuing to closely monitor this species to determine if it is a resident or migratory, and whether or not the flattening of most of the tules during the heavy winter storms altered the habitat so much that the rails will no longer be able to live here.

We plan to continue monitoring this plot for the next five years to determine if the treatments being evaluated are suitable for restoring perennial streams such as this one.

Problem Assessment on Rangeland Watersheds

Mike Connor and Melissa Joyce

The California Rangeland Water Quality Management Plan requires that water quality be addressed on California ranches.[1] In some cases a ranch water quality management plan will be necessary or desirable. Such a plan will include an assessment of current conditions to determine any problems that exist that might result in water quality impairments. A plan is being written to guide the management of natural resources at the Sierra Foothill Research and Extension Center[2]. This paper discusses the water quality assessment portion of that plan as an example for developing a rangeland water quality management plan.

The Federal EPA, through the state Regional Water Quality Control Boards, is requiring cleanup of non-point sources (NPS) of water pollution affecting impaired water bodies. The first step in a rangeland management plan designed to meet NPS requirements is to determine whether water from the rangeland flows into water bodies with impaired water quality.

The State Water Resources Control Board (SWRCB) recently issued the 1994 Draft Water Quality Assessment[3] which catalogs the state's water bodies and their water quality. It is available at libraries and from the Regional Water Quality Control Boards. All streams at the Center eventually flow into Englebright Reservoir or the lower Yuba River. Englebright Reservoir is listed in the assessment document as having intermediate water quality. The lower Yuba River is listed as having good to intermediate water quality. Good or intermediate water quality indicates no impairment of beneficial uses.

Because no impairment exists in water bodies receiving Center waters, a non-point source management plan is not required by the Regional Water Quality Control Board. If the only objective of the management plan was to meet EPA requirements, then little immediate action would be necessary. At SFREC, however, possible non-point sources were assessed to determine any management changes required to achieve the stated landscape goal of protecting or enhancing existing water quality through a voluntary program.

Erosion/sedimentation: In 1984, the Soil Conservation Service prepared a Soil Conservation Plan for the SFREC. The plan states that soil erosion should not be of concern as long as 500 to 700 pounds per acre RDM remains after grazing. Current management targets a minimum of 750 pounds per acre RDM; erosion is not believed to be an extensive problem. Localized erosion is a concern in some areas of the SFREC including the headquarters corral, some roads, supplemental feeding areas, and minor trampling of some stream banks by cattle. Road culverts often result in erosion because they concentrate runoff into a single channel. Culverts are causing some localized erosion and sedimentation at SFREC.

Nutrient loading: Nutrient loading is a greater concern for impounded water bodies (e.g., lakes and reservoirs) than for flowing streams or rivers. Two streams on the Center flow directly into Englebright Reservoir. Both these streams have dense riparian vegetation along their banks. Current grazing management ensures that a minimum of 750 pounds per acre RDM remains after grazing upland fields and pastures. Both riparian and upland vegetation will act as filters to reduce nutrient-loading to the streams and subsequently to the Englebright Reservoir.

The corral near Center headquarters drains into a ditch that allows flow directly into Porter Creek. Because of the length of Porter Creek and heavy riparian vegetation along its lower reaches, excess nutrients would likely be removed before the stream joins Dry Creek and subsequently the Yuba River. However, diverting corral runoff to filter through adjacent fields before reaching the creek is a relatively simple matter, and drainage modifications would reduce the potential for future water quality impairments. Similar actions to limit nutrient loading include careful location of feeding areas away from streams.

Nutrients levels in waterways are difficult to measure and their effects are not always clear. We expect that the management methods discussed here will greatly reduce the levels of nutrients from cattle that reach streams.

Pathogen loading: Water-borne pathogens are primarily a concern where water is used for drinking or water-contact recreation. Englebright Reservoir is used for water-contact recreation, and the lower Yuba River supplies drinking water, though municipal intakes are several miles downstream of the Center.

Defecation by cattle directly into streams is the primary grazing-related source of pathogens. Cattle are excluded by fencing from some stream reaches. Supplemental feeding and salting areas are located to discourage cattle from concentrating near streams. Fifty-two troughs and five ponds provide stock water away from streams. Many fields containing streams are not grazed in summer when green riparian vegetation encourages cattle to congregate in and near creeks. The SFREC also has an active livestock health program to reduce the level of pathogens from cattle that may be released into streams. The management measures described above are believed to be effective at minimizing pathogen loading into the Center's streams.

Temperature Impacts: SFREC streams are too small and shallow to support cold-water fish. Both the Yuba River, which bounds the Center to the south, and Dry Creek, which is dammed just north of the SFREC by the Browns Valley Irrigation District, support many cold-water fish species including salmon and steelhead. Englebright Reservoir, with the help of cold water releases from the upstream New Bullard's Bar Reservoir, also supports cold-water fish species. These reservoirs are the primary influence on water temperature in the Center's vicinity. In addition, the small volume of water entering the Yuba and Englebright from Center streams (especially in summer months) and shading by riparian vegetation along most stream stretches indicate that temperature impacts due to grazing-related activities at the SFREC are insignificant.

While water temperatures are not critical at the Center, we wish to enhance woody riparian vegetation for wildlife habitat and aesthetic values. Important reaches of some Center streams are lacking woody vegetation. This will be improved by some planting and protection of woody species.

In summary, in order to develop a rangeland management plan, any existing problems have to be identified. It is important to realize that many existing management methods are effectively reducing water pollution. These methods may already adequately meet many Water Quality Control Board requirements, especially if local water bodies are not impaired. There also may be some simple and relatively inexpensive management procedures that can be adopted that can substantially reduce water pollution from a rangeland watershed.

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Residual Dry Matter

Bill Frost, Mike Connor, Neil McDougald and Jim Clawson
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Residual dry matter (RDM) is the dry herbaceous plant material from the previous years growth which is left on the ground. Leaving adequate amounts of RDM provides; favorable microenvironments for early seedling growth; soil protection; adequate soil organic matter; and a source of low quality, low moisture fall forage for livestock and wildlife.

Research has shown that leaving too little RDM results in reduced forage production the following year, in addition to increasing the risk for soil erosion. Leaving too much RDM has also been shown to reduce subsequent forage production, though it provides good soil protection. Suggested guidelines have been developed for the amount of RDM which should be left to provide adequate soil protection while optimizing subsequent year's forage production[1]. At areas similar to the UC Sierra Foothill Research and Extension Center these amounts are:

Lower or flat slopes	Gentle slopes	Steep slopes
400 lbs/acre	600 lbs/acre	800 lbs/acre

Measurement of RDM can be accomplished through a variety of means. Direct clipping and weighing can be an accurate means for determining RDM, but is the most time consuming method available. Ocular estimation (educated guessing) is the most rapid method, but it subject to inaccurate determinations if the person estimating has not had a lot of experience and checking by some direct measurement technique. A compromise method is the comparative yield method[3], which utilizes a series of 5 standard plots, against which all other plots are ranked (compared). At the end of the sampling 15 plots are ranked and clipped and a regression equation computed to develop a formula for estimating the amount of RDM present.

Mapping of RDM provides a valuable tool for both livestock and rangeland resource management[2]. The RDM maps are a means by which the total forage remaining on a pasture or ranch can be assessed, as well its distribution. This information can be utilized to make management decisions, such as movement of livestock between pastures or the location of supplemental feeding sites or water developments to best utilize the remaining forage while maintaining soil protection. Long term RDM mapping in conjunction with actual use records (number of livestock and length of grazing period) provide good estimates of the livestock carrying capacity.

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MONITORING WITH A CAMERA

Rick Delmas[1], Kevin Farwell[2], and Glenn Nader[3]

It is often said that a picture is worth a thousand words. Photographs taken consistently over the years provide an easy, convenient, and inexpensive method by which ranchers can establish a visual representation of resource conditions. You can use photos to supplement transect data and to present data to audiences of varied backgrounds. There are two basic types of monitoring pictures: landscape photographs and close up photographs. You should consider using both types when monitoring.

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Landscape Photographs

Landscape photographs document change over time. Try to find old family or ranch photographs that show historical vegetation conditions. These historical photos provide you with previous range conditions. New pictures from the same locations allow you to immediately illustrate vegetational changes.

Location: West Valley Allotment, Modoc National Forest, Old Blue Lake Road, looking Northeast towards Eagle Peak, Modoc County, California.

If you cannot find historic photo sites, establish new ones. Sites where landscape photographs should be taken include:

- riparian areas
- upland areas
- burns
- revegetation areas
- stream diversions such as rock dams
- areas of concern
- areas likely to be discussed in allotment or ranch management planning
- fence lines

Landscape photos should be taken from the same designated point (marked by a steel post or other type of permanent marker). The steel post may be placed to direct by the use of a compass the position of the camera for the photo. Include a distinctive landmark in the background (peak, rock outcrop, tree, etc.) or another steel post set 20 feet away to line up on for the photograph. A compass direction and previous photographs are helpful in lining up photographs in subsequent years.

The following should be recorded on each photograph:

- date (a camera that dates pictures works well)
- camera lens size (i.e., 50mm)
- type of film used (i.e., Slide ASA 100)
- photo point number (i.e., pasture/allotment)
- actual use (i.e., on-off dates)
- comments (i.e., rainfall, time of day, etc.)
- any unusual event that occured that year

Caution, writing on your photos can cause damage; use the adhesive labels in Appendix I.

Close-Up Photographs

Close up photographs show specific characteristics of an area such as soil surface, ground cover by vegetation, and organic litter. Permanent photo plots can be marked by angle iron or rebar. You should paint the stakes with a bright colored spray paint for ease of locating the plot in subsequent years. You may mark the plot in the photograph by using two 6-foot folding rulers, or a 3 x 3 foot square made of PVC pipe that is distinctly marked in 1- inch increments on at least one side, (see page 23 for PVC instructions). The folding ruler or PVC pipe helps illustrate plant density and scale in the photograph. A non-white photo ID card (see, Appendix II) showing date, photo point number, and the allotment/pasture should be placed flat on the ground on the outside edge of the plot. Make sure that the ID card is included in the picture. A witness post may be placed by the road with a corresponding compass bearing in order to locate the witness post at the photo point (plot). Take the picture from the north side of the plot by standing over the plot without casting a shadow on the plot, and with your toes touching the edge of the plot. Consistency in taking pictures from the north side of the plot prevents a shadow from being cast on the plot.

Setting Up A Permanent Photo Point

At each site take a close-up and at least one landscape photograph. Initial planning is necessary when establishing close-up and landscape photo points. It is important that photographs taken are comparable over time and provide meaningful information. Before establishing a photo point here are a few items to consider:

- Do you have historic photographs?
- Are all vegetation types represented (i.e. riparian, upland)?
- Has there been a major event (fire, flood, etc.) that needs to be recorded?

When establishing a permanent photo point, the following should be recorded in a notebook:

- Allotment/pasture, and photo point number
- Photo point location marked on map and description of the area so the plot can be found easily by others.
- Compass direction of the photo taken from the witness post
- Initial comments and notations on vegetation and other pertinent reasons for photo point.

Equipment needs for establishing photo points:

- Map (U.S. Geological Survey quad map)
- Compass
- Steel Posts (or other permanent markers), rebar
- Hammer
- Spray Paint

Enter pasture through the gate, cross Big Creek and look for the witness post in the rock pile on the hill slope above the creek. Post is one mile from the gate.

When to Monitor with Your Camera

No matter when you choose to monitor you should be consistent from year to year. The exact day is not important since seasonal conditions vary from year to year. Instead, try to time your monitoring to correspond to a stage of growth of a particular plant (i.e. the heading out of cheatgrass, the flowering of bitterbrush), or before and after grazing (on and off dates). Monitoring after grazing has the advantage of documenting the amount of forage left.

Equipment Needs For Photographic Monitoring

Only a few supplies are needed for photographic monitoring. A 35mm camera, small enough to fit in a coat pocket, with the ability to date slides or pictures is best. Slides are usually of better quality, however, prints may be more convenient to illustrate changes to others in the field. For an additional cost, prints can be made from slides. A film speed of ASA 100 is recommended for outdoor photography. Note the film type and speed and use the same type of film each year.

Equipment Needed:

- 35mm Camera
- Film
- Felt Tip Pen
- Notebook
- Non-White Photo Description Card (Example in Appendix II)
- Photo Plot Frame (2, 6-foot carpenters rulers, or PVC pipe; list of materials and frame instructions on page 23)

Storage Of Photographs

After developing the slides or photographs write information (date, pasture/allotment) on the edge of the slides. If photographs are stored in a photo album, place adhesive labels (Appendix I) on the back describing the location, date, etc. Place slides in a binder using photo or slide storage sheets that are non-pvc, non-acidic to protect them from damage.

When the photographs are processed, file the prints and negatives in a monitoring recordbook. A convenient way to file both negatives and prints is to use a 5 x 7-inch manila envelope, which can be punched for a three-ring binder or kept in a file.

Each photo point should have its own envelope. Negatives should be kept in a secure place. Prints may also be displayed in an album or on pages in a binder (with photochemically safe pages, no pvc emissions). An example is included in the appendix to help you get started. Monitoring data should be kept compiled and stored in a safe place. The use of a "monitoring recordbook" is strongly recommended for safe keeping photographs and other data.

Analyzing Your Photos

Landscape pictures are generally classified as qualitative data. Dramatic changes are clearly evident over time. Subtle changes may require in-depth study of landscape photos to ascertain if a change has occurred and what direction the change may be headed. Close-up photos can be used either as a qualifying or quantifying measurement of the direction of the resource. If slides are used, you can project the image on a paper background and trace bare soil in the plot and calculate the area of which it encompasses. This can also be done with enlarged prints, but with less detail. New computer technology is being investigated to see if a system for analysis of photos can be developed. Remember to review your goals and see if the changes in the rangeland resource depicted in your picture are moving you closer towards achieving your goal.

Example Of A Data Sheet

Photo Point Number (Allotment/Pasture)________
Date________
Lens Size_______
Film Type_______
Actual Use(On-Off Dates)___________
Comments (Rainfall, Time of Day, etc.)_________

Commonly Asked Questions And Other Tips

<u>How many photos should I take initially?</u>

Plan ahead the areas you feel are important to photograph. Photo point locations near roads may be faster to take but may not provide the most representative sampling of the resource condition you are trying to show. Some photo points may be eliminated or added after evaluating photographs and locations. You should have at least one landscape and close-up for each vegetational type (riparian or upland) pasture.

What other data should I record?

- Actual use (period of grazing)
- Rainfall
- Other significant occurrences (such as gates being left open)
- Timber harvest
- Dry water holes (may have important present year impacts and should be noted so that in future years these facts are not lost)
- Recreational impacts

Keep as simple as possible. Consistency of monitoring is more important than documenting every detail.

What is a Witness Location?

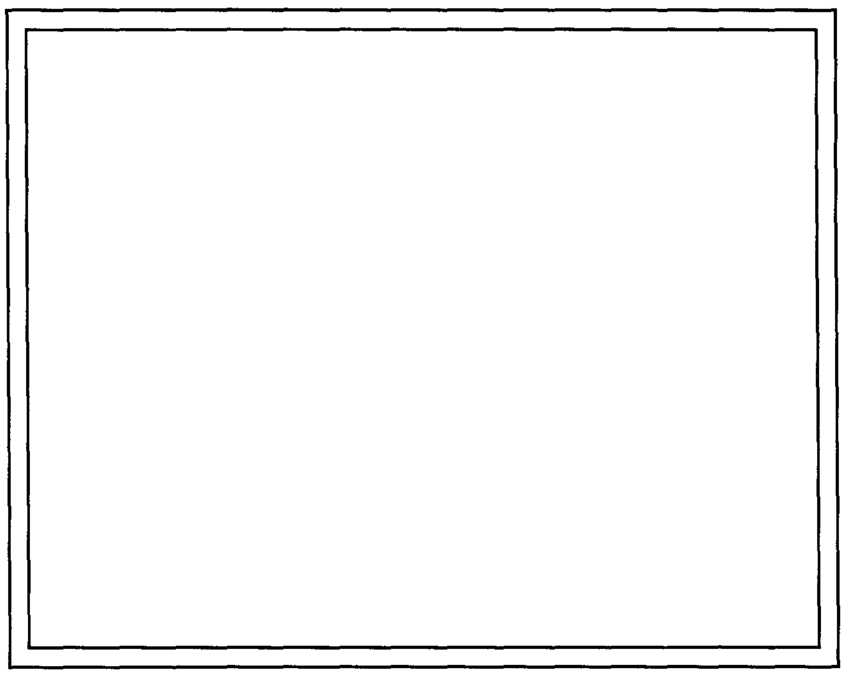
A witness location is a post or tree with a metal tag nailed to it located near a road from which a compass direction is taken to locate a photo plot.

PVC Photo Plot Frame Materials List

4 -- 35.5” lengths of 1/2 inch schedule 4- PVC pipe (Total required = 144” or 12 feet).

4 -- PVC 1/2 inch schedule 40 90° elbows.

Electrical tape -- 1 inch wide, to mark 1” intervals on 2 sides of the PVC pipe frame.



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Stream Channel Measurements

Royce Larsen and Mel George

Stream channel characteristics are commonly used to evaluate impacts of livestock and other land use activities on stream channels. In the absence of natural or man caused disturbances channel characteristics vary little over time but may respond rapidly to management practices in the watershed. Monitoring of stream channel cross-sections will allow linkages to be made between grazing management, runoff events, and stream channel erosion. Monitoring of vegetation and livestock trampling in and near the channel will link vegetation loss and livestock use to streambank stability and erosion.

Channel width, depth, area, and width to depth ratio can be estimated from these stream channel cross-sections. Channel width is the width of the active stream channel. In the absence of flowing water it is typically delineated by scour lines, vegetation limits and bank slopes. This is intended as a measure of the extent of recent channel migration, with unstable channels being wider than stable channels. Channel depth is measured as the distance from the top of the channel bank to the water surface, (for intermittent streams depth is measured to the channel bed) and provides a measure of channel incision. Bankfull height is the height above the water surface (or channel bed surface for intermittent streams) at which the channel loses its ability to contain the stream. This provides a measure of the degree to which banks confine the stream, since streams with destablized banks will typically have lower bankfull heights than streams with stable banks. These channel characteristics, see Figure 1, for monitoring are widely used to assess livestock grazing effects on perennial streams (Platts et al. 1983, Platts et al. 1987, MacDonald et al. 1991, Bauer and Burton 1993) and ephemeral streams (Siekert et al. 1985).

Vegetation Measurements

Ground cover and bare ground are indicators of bank stability and erosion risk. Combining estimates of livestock trampling and rodent activity with ground cover estimates provides an indicator of livestock and rodent impact on stream banks. The channel cross-section should be divided into channel bottom, channel banks, and floodplain. Ground cover, animal activity and channel bottom soil/rock particle size classes should be recorded along the same transect used for cross-section measurements.

Cross-Section Measurements Protocol

The measurement procedure depends on the information needed. For some monitoring needs, a permanent photo point taken yearly may be sufficient. For more quantitative information, measurements are needed. These measurements are done with the transect method.

The number of transects measured depends on the statistical needs of the study or monitoring project. One or a few transects are better than none. However, for sound statistical studies, 10-15 transects for each stream reach studied/monitored may be necessary. The interval between transects should be approximately 1 to 1.5 stream channel widths. The transects should be marked with permanent stakes that are referenced to a permanent bench mark at each stream reach. Large boulders, steel fence posts, or trees may be used as permanent bence marks.

Consistency in measurements in very important. For example, all cross section measurements could be taken from left to right, using the left sake as the beginning point. The left and right stakes should be located outside the top of banks (figure 1).

The number of measurements taken per transect depends on the information needed. For example, if the location for top of bank, width, and depth are needed then only 4 or 5 measurements are needed. However, in an accurate description of the stream profile is needed, then measurements should be taken at least every six inches across the channel from the left stake to right stake (figure 1). An accurate description of the stream profile is needed if erosion or aggradation is being measured. The number of measurements for each transect vary depending on the distance between the stakes for each cross section.

Measurements are taken by stretching a tape, connected to tension scale, across the stream (figure 1). The tension scale is used to insure minimal sag in the tape. A steel tape, that will not elongate, should be used. Once the tape is stretched across the stream, you can measure from the tape to the bank or stream bottom. If more accuracy is needed, a surveying level and stadia rod can be used.

Measurements should be recorded to the nearest 0.01 foot. If a surveying level is used it should be setup in one location to take all the readings for a single reach (i.e. 10 cross sections) and should be located at the same point each time the readings are taken. The surveying level should be referenced to the permanent bench mark each time the measurements are taken.

At least two people are needed. One to read the surveying level, one to hold the stadia rod and record data.

This is just a brief summary of measurement techniques for stream channel cross sections. For more information read Platts et al. 1987, Bauer and Burton 1993, and Beddel and Buckhouse 1994.

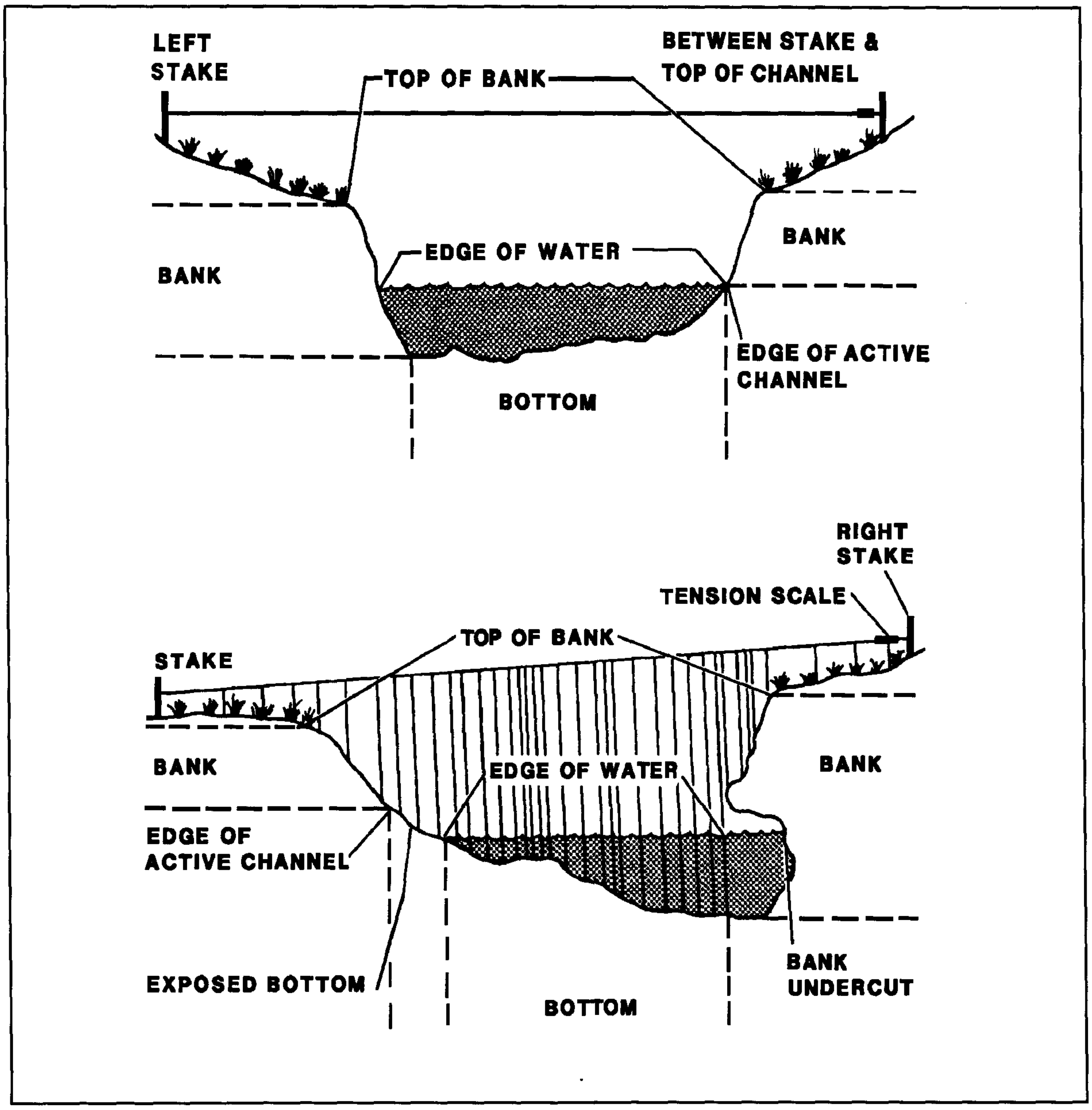

Figure 1. Example of stream channel morphological descriptions and measurement techniques. Taken from Platts et al. 1987.

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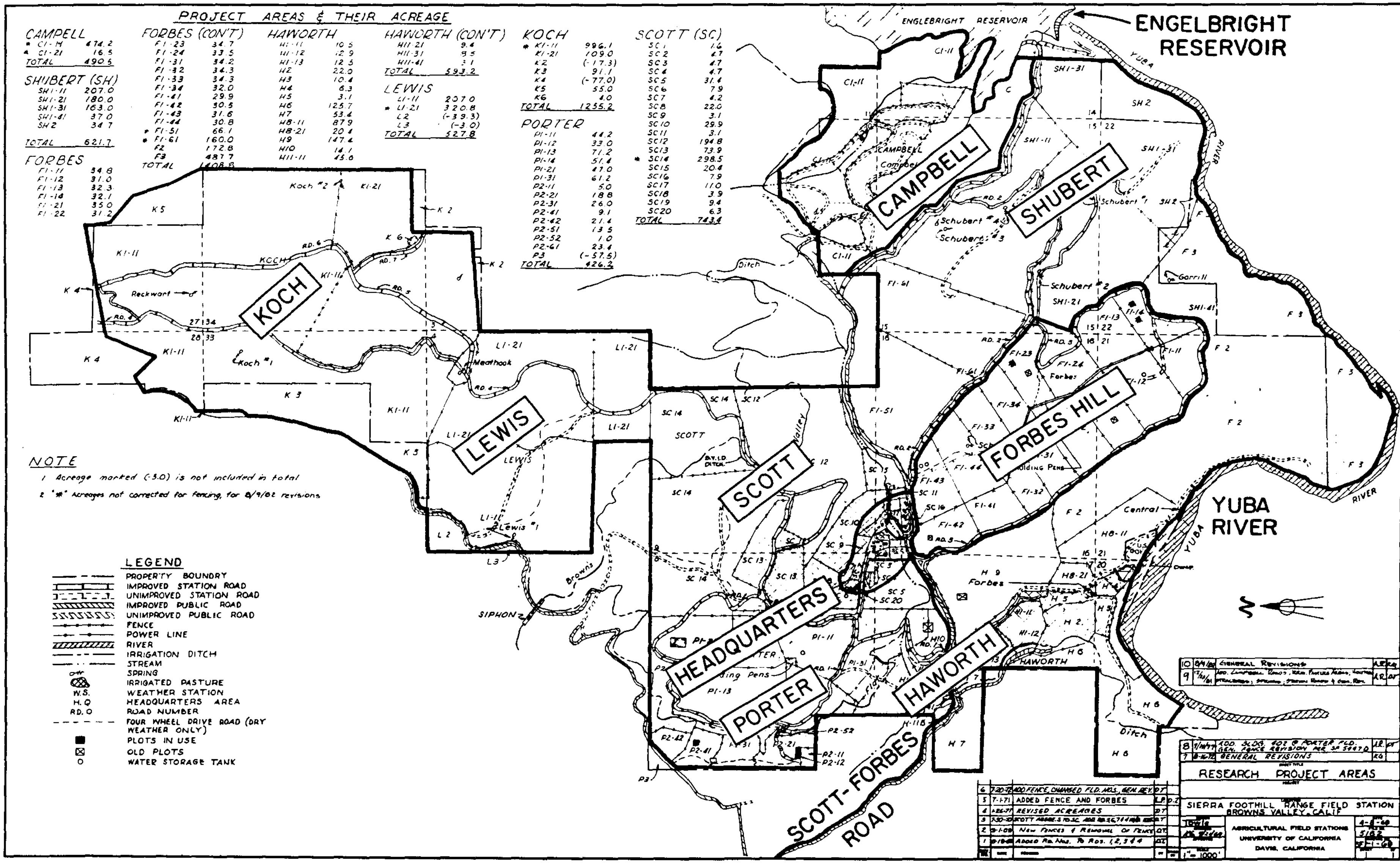

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