UNIVERSITY OF CALIFORNIA
AGRICULTURE & NATURAL RESOURCES

SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Beef & Range Field Day

APRIL 17, 2003

Browns Valley, California

UNIVERSITY OF CALIFORNIA
AGRICULTURE & NATURAL RESOURCES

SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Presents:

Annual Beef & Range Field Day

UNIVERSITY
of
CALIFORNIA

APRIL 17, 2003

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

APRIL 17, 2003

AGENDA

	Morning Master of Ceremonies – Jim Oltjen, Management Systems Specialist, Animal Science, UC Davis
9:30am	Welcome – Mike Connor, Superintendent, UC-SFREC
9:45am	Cow Pats to Nutrition -- Roger Ingram, Livestock/Farm Advisor, UCCE Placer/Nevada Counties & Angie Jinks, Graduate Student, Animal Science, UC Davis
10:10am	Management of Rangeland Weeds -- Glenn Nader, Livestock & Natural Resources Advisor, UCCE Yuba/Sutter/Butte Counties
10:35am	Riparian Friendly Grazing -- Theresa Ward, Livestock & Natural Resources Advisor, UCCE Stanislaus County
11:15am	Porter Creek Area - (3,15 min sessions) 1. Fire impact on range species -- Neil McDougald, Range & Livestock Advisor, UCCE Madera County and Replacement Value of lost forage -- Dustin Flavell, Beef/Range Research Associate, UC-SFREC 2. Fire and Grazing Impacts to Oaks – Doug McCreary, Program Manager, Integrated Hardwood Range Management Program, UC Berkeley 3. Grazing riparian areas – Theresa Ward
	Afternoon Master of Ceremonies – Larry Forero, County Director & Farm Advisor, UCCE Shasta County
12:30pm	LUNCH – Tri-tip BBQ – Served by the Yuba-Sutter Cowbelles and SFREC Staff
	During Lunch: California Cattlemen's Association Officers Industry Update
1:45pm	Travel to Sc-13 S
2:15pm	Cows in Space (Grazing Behavior) -- Mel George, Rangeland Management Specialist, Agronomy & Range Science, UC Davis
2:35pm	Ungrazed Buffers for Filtering Runoff -- Ken Tate, Rangeland Watershed Specialist, Agronomy & Range Science, UC Davis
2:55pm	Pathogen Loading from Wildlife -- Rob Atwill, Environmental Animal Health Specialist, Veterinary Medicine Teaching & Research Center, UC Davis (Tulare)
3:15pm	Return to SFREC HQ and adjourn

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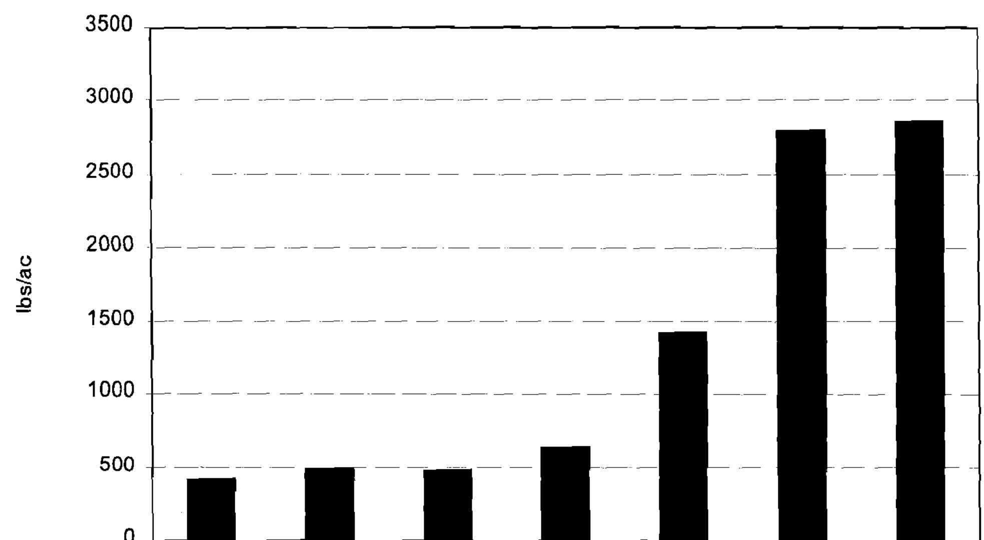
Cow Pats to Nutrition

Roger Ingram, UC Farm Advisor – Livestock and Natural Resources
UCCE Nevada & Placer Counties

Rangelands in California are dominated by annual grasses, legumes, and forbs. Growth begins with germinating rains in the fall and peaks in May as plants put all their energy into forming a seed bank for next year's crop. California livestock producers spend six months out of the year (December – May) attempting to grow as much quantity as possible. The following six months (June – November) are spent rationing out standing feed until the next growing season. This standing feed must be monitored for loss of crude protein later in the season to determine potential protein supplementation needs.

Annual Forage Growth
Annual forages germinate with fall rains and grow slowly from November – February. This slow growth is due to short day lengths and cold nighttime temperatures. Sometime in March, as days lengthen and temperatures warm, rapid growth begins if there is adequate soil moisture. Monthly average forage growth data from the Sierra Foothill Research and Extension Center (SFREC) shows forage quantity increasing 67% from December – February, 123% from March – April, and 100% from April – Peak Standing Crop.

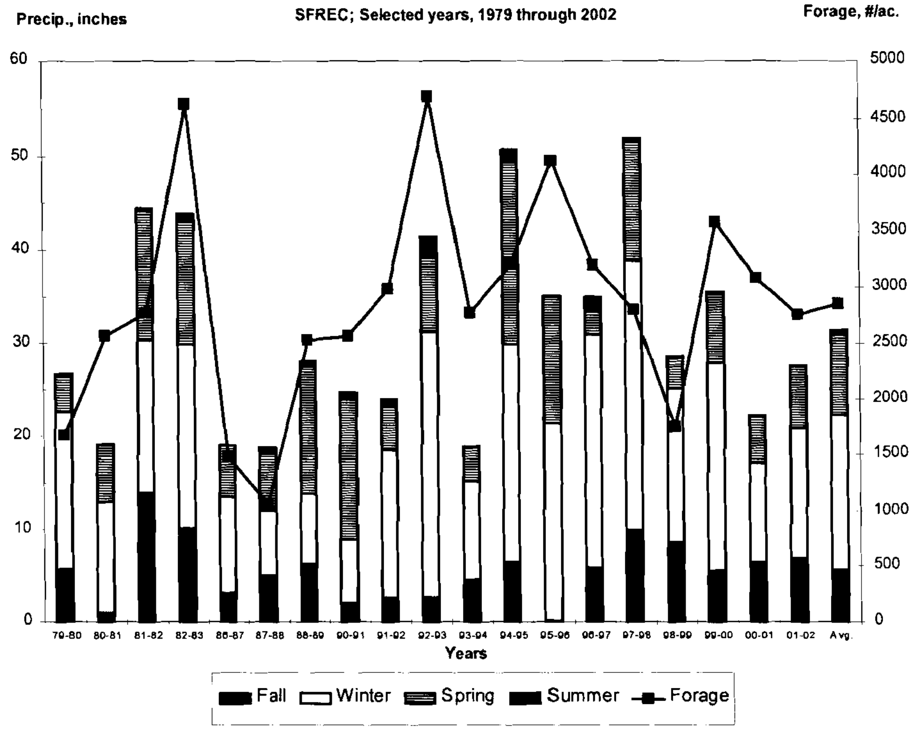
SFREC Forage Growth by Month



	Dec	Jan	Feb	Mar	April	May	Peak
■ Avg/mo	419	487	486	643	1432	2795	2859

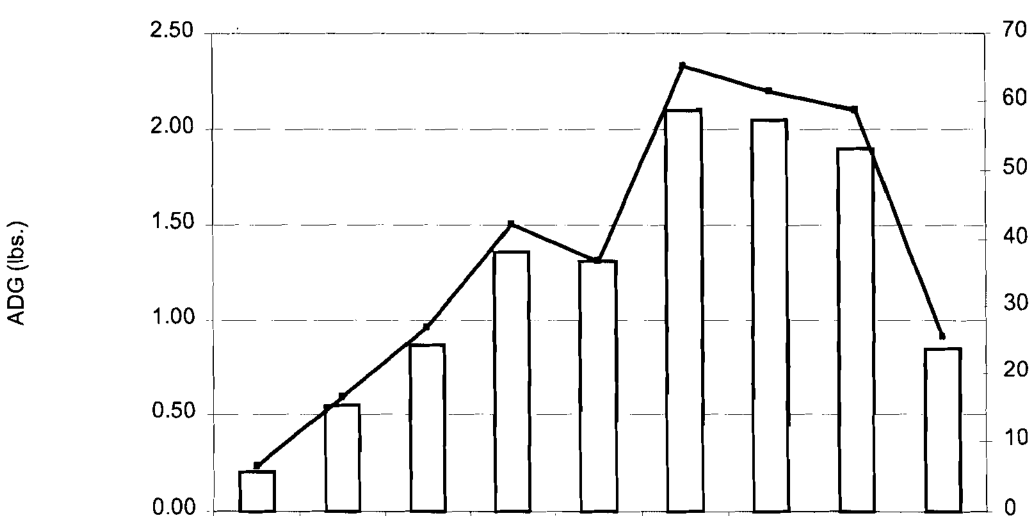
However, these average forage values vary from year to year based on both total precipitation and its distribution throughout the four seasons. Rainfall amounts by season, total precipitation and forage production are shown in the following graph. There is no real pattern as each year tends to take on its own unique characteristics. Two general trends will hold constant: higher than average rainfall will result in either average or higher than average forage production; and the majority of growth will occur March – May.

PRECIPITATION & FORAGE YIELD
SFREC; Selected years, 1979 through 2002



Grass growth is then consumed by animals for production. Past average stocker gains on SFREC range shows that the highest weight gains occur during the rapid growth from March-May as indicated below. During this period, stockers gained 185.5 total pounds which is 77% higher than the 105 pounds gained from December – February.

ADG ON ANNUAL RANGE- SFREC
Stocker calves, avg. 4 years



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
ADG/Month	0.20	0.55	0.87	1.36	1.32	2.10	2.05	1.90	0.85
Lbs/Month	6.2	16.5	26.9	42.2	36.9	65.1	61.5	58.9	25.5

Annual Range Forage Quality
The two most limiting nutrients in range forage are energy and protein. Energy and protein levels rise and fall with the seasons of the year. Both energy and protein peak in late winter and then decline from April – October. Levels climb again with the onset of fall rains. Two tables below show how energy and protein varies in grasses, forbs, and clovers throughout the year.

Tables 1 and 2 below on energy and protein were taken from ANR Publication 822, *Annual Forage Quality.*

The first table shows energy levels and how they change throughout the year. Early vegetative would be fall and Dry would be late summer. Notice how energy levels decline throughout the year. Metabolizable energy (ME) is the energy left for the animal to use after accounting for feces, urine, and methane gas. It is expressed as mega-calories / kilogram (Mcal/kg). Total Digestible Nutrients (TDN) estimates the proportion of the forage that can be digested. In both cases, a higher number would indicate a higher energy level.

Table 1. Energy levels of annual forage						
	Metabolizable energy (Mcal/kg)			**TDN (%)**		
Stage of maturity	**Annual grass**	**Filaree**	**Bur clover**	**Annual grass**	**Filaree**	**Bur clover**
Early vegetative	2.8	3.5	3.3	77	97	91
Late vegetative	2.7	3.4	3.2	74	94	89
Early flowering	2.6	3.3	3.1	72	91	86
Late flowering	2.4	3.0	2.9	67	84	80
Mature	2.2	2.6	2.6	61	72	72
Dry	2.1	2.5	2.5	58	69	69
Dry, leached	2.1	2.4	2.4	58	67	67

Cows run on this energy. Their primary energy source in grass is cellulose. Cows can not digest cellulose. Microbes that live in the rumen are able to break down and ferment cellulose. They convert the energy into a usable form – volatile fatty acids. Livestock producers to keep rumen microbe levels high in order for rapid breakdown of forage to occur.

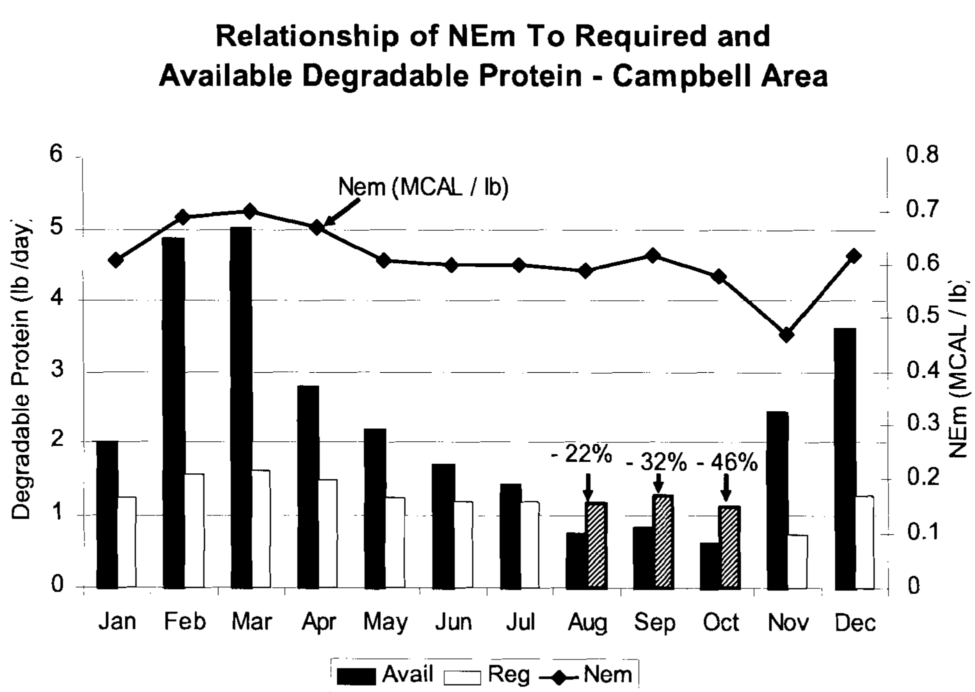
There is more to the story than just quantity of grass (energy) available. Protein is another prime component. Protein in grass is 80% degradable and 20% escape. The portion of protein that rumen microbes can break down is called degradable. Escape protein can not be broken down by the microbes and passes through the rumen intact where it is digested in the animal's intestine.

Think about it, the only way 80% of the grass protein can be utilized by the cow is if the microbes do their job. The rumen microbes must be healthy and multiply to large numbers in order to ferment cellulose and convert it to energy. The diet consumed must contain enough degradable protein to meet the microbes requirement or they will not grow and multiply in sufficient numbers to ferment and break down energy. Table 2 below shows what happens to crude protein content throughout the forage year.

Table 2. Crude protein (%) content of annual vegetation			
	Annual Grass	Filaree	Bur Clover
Early vegetative	18	27	28
Late vegetative	15	25	27
Early flowering	15	22	26
Late flowering	10	16	22
Mature	6	10	19
Dry	5	7	18
Dry, leached	3	5	17

Taking annual grasses as an example, protein will peak in later winter. By the time the seedhead has formed, the protein level can decline by 33%. As we move later in the summer, protein levels continue to decline by 50%. Fall can see a further decline of 40%. If the protein level falls below that required by the microbes, their population numbers fall in the rumen. This means less microbes are available to break down and ferment cellulose (energy) and consumption drops. To get the animal to consume the energy in the forage, we must make sure we satisfy the microbe's protein requirement. This may mean supplementation as protein levels drop below 8%. A key management factor to consider is when does protein supplementation need to occur?

The graph below illustrates the point. Failure to provide protein supplementation in August, September, and October of 1997 would have resulted in a drop of consumption ranging from 22-46%. Lack of protein means lack of microbes resulting in less energy consumption.



Both graphs below are taken from **ANR Publication 821,** ***Balancing Beef Cow Nutrients and Seasonal Forage Quality on Annual Rangeland***. These graphs compare protein levels in a normal year with a long dry season and an early green season. Protein requirements for fall and spring calving cows are also shown.

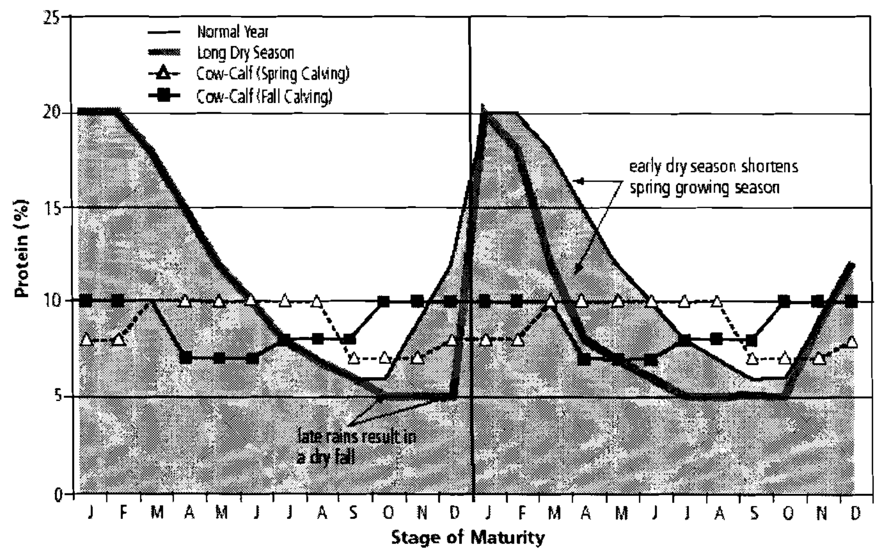


Figure 2.
Examples of annual rangeland forage protein for a normal year, a year with a dry fall, and a year with an early dry season, with cow protein requirements for fall- or spring-calving cows superimposed.

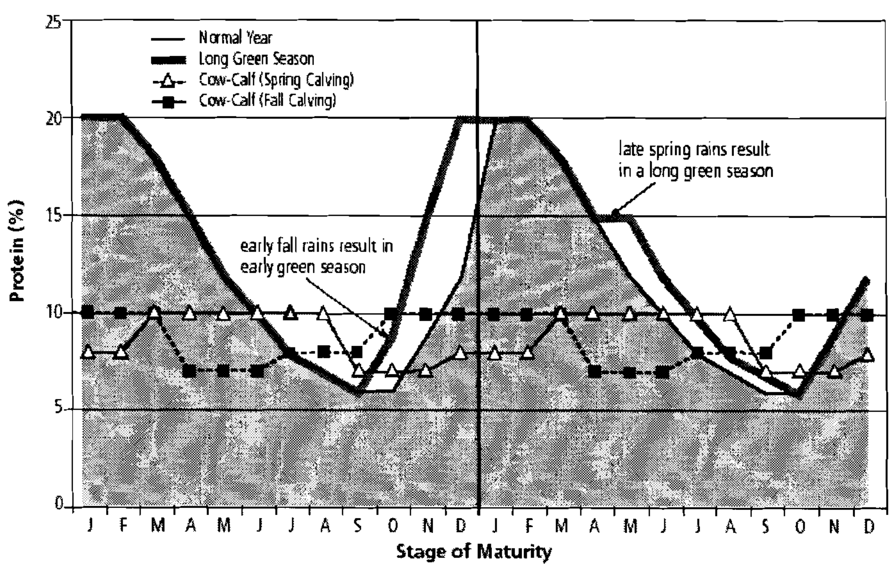


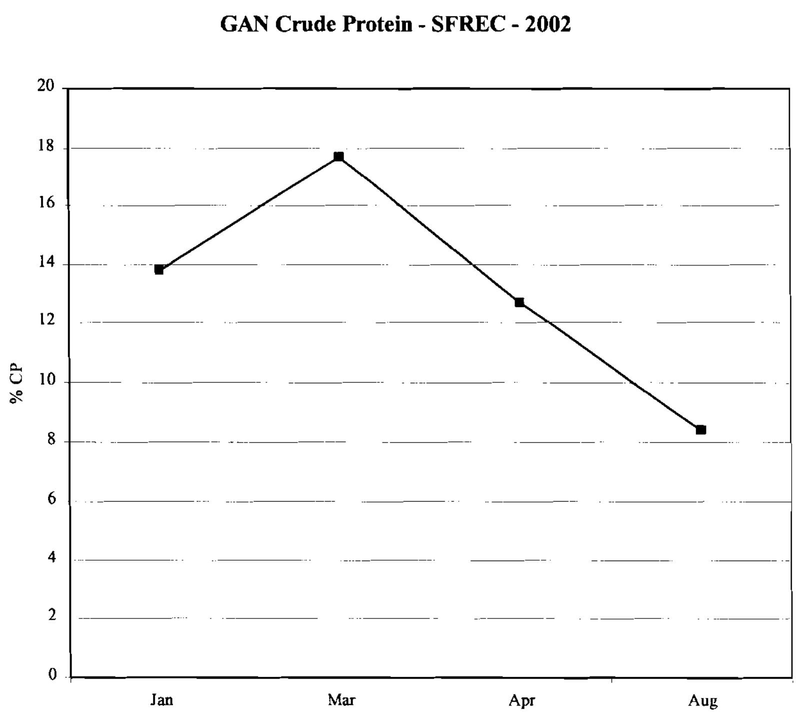
Figure 3.
Examples of annual rangeland forage protein for a normal year, a year with an early green season, and a year with a long green season, with cow protein requirements for fall- or spring-calving cows superimposed.

How Can We Determine When Protein Supplementation is needed

There are three options to determining when protein supplementation is required: forage samples, manure samples, or visual appraisal of manure pats. Forage sampling means going out and clipping and sending the sample into a lab for analysis. This can be a useful tool, but does have some limitations. The clipping should take into account all the major grazing sites within the paddock, select the proper proportions of grass, forbs, legumes, and brush, and mix all of these dietary components in the proper sequence to get the proper associative effects. There are plenty of factors to consider when taking forage samples and error is inherent in the process.

We can also sample the manure to get an idea of protein levels in the forage. This manure can be sampled and shipped to the Grazingland Animal Nutrition (GAN) lab of Texas A & M University. Samples are dried, ground, and passed through a near infrared spectrophotometer. A reading is produced which is then plugged into an equation used to predict crude protein, digestible organic matter (energy), fecal nitrogen, and fecal phosphorous. Research is underway by the UC Animal Science Department to help the GAN lab to develop improved accuracy of the equation used for California's annual vegetation.

Manure sampling has taken place at the Sierra Footill Research and Extension Center (SFREC). Samples were taken in January, March, April, and August which depict the rise and fall of protein levels. Below is a graph of the results:



The other method for estimating crude protein is height of the manure piles. The GAN lab at Texas A & M developed a method to correlate appearance of manure piles with protein levels. Low flat piles mean indicate high protein levels. The higher and more layered manure piles appear, the lower the protein levels.

During manure sampling at the SFREC, photos of the manure were taken to see if the same relationship occurs. Based on the limited sampling of one year, it appears the trend holds true.

Sample Date: January 2003 **Crude Protein = 15.1%**	
Sample Date: March 2002 **Crude Protein = 17.4%**	
Sample Date: August 2002 **Crude Protein = 8.5%**	

Summing Up

California's rangelands increase in quantity quality between November and May. Quality with regards to energy and protein build to a peak in late winter and then start to decline. The level of decline of energy is not as steep as protein. Care must be taken to monitor forage crude protein levels to determine when to supplement with degradable protein to feed the rumen microbes, not the cows. Keeping high rumen microbe levels when protein is low will allow the cow to get at all the available energy in the forage. Failure to supplement will result in lowered consumption once crude protein levels start to decline lower than 7-8%.

Monitoring of crude protein levels can be accomplished through forage sampling, manure sampling and visual appraisal. Manure sampling should be undertaken to correlate height of manure piles on your ranch with actual results from the GAN lab.

For More Information:

ANR Publication 821, *Balancing Beef Cow Nutrients and Seasonal Forage Quality on Annual Rangeland* and ANR Publication 822, *Annual Forage Quality* are available at the Center for Rangeland Research and Information website: **http://agronomy.ucdavis.edu/calrng/range1.htm**

California Grazing Academy is held annually and covers as part of the course range nutrition, supplementation strategies, and body condition scoring of cows. **Contact Roger Ingram at 530-889-7385 or rsingram@ucdavis.edu.** You can also find further information at: **http://ceplacer.ucdavis.edu/Livestock/**

Low-Cost Cow-Calf Nutrition Course. This is an excellent 3 day course taught by Dr. Dick Diven. The course emphasizes nutrition strategies which will help livestock producers get the most out of the nutrients in their forages. Dick can be contacted at 520-544-0864 or **rhdiven@aol.com**. A website with information about the course and many newsletter articles is available at **www.lowcostcowcalf.com.**

Ranching for Profit. This intensive week-long course covers a variety of topics including range nutrition topics in this paper. Ranching for Profit is the business school of ranching and integrates nutrition, grazing, and ecology with a economic foundation. David Pratt teaches the course which is held in various western states. Dave can be contacted at 707-429-2292 or **pratt@ranchmanagement.com**. A website with course information and newsletter articles is available at **www.ranchmanagement.com**.

From fecal pats to nutrition: Using near-infrared reflectance spectroscopy of feces to determine nutritional diet quality

Angie Jinks, Graduate Student
Animal Science, UC Davis

Due to the Mediterranean climate of California, range forage quality declines throughout the dry summer months. This presents a challenge to cattle producers who must determine when, how and how much to supplement to offset decreasing forage digestibility and crude protein. These two factors, if deficient, can limit growth and milk production, increase days open and decrease breeding percentages.

The nutritional quality of range forages is notoriously difficult to measure due to the high variability inherent to range. A wide variety of nutritional sources are available on most ranges in the form of grasses, shrubs and weeds. As selective grazers, cattle choose among the available plants. Current methods available for testing forage quality test nutrients available, rather than nutrients consumed, despite the fact that nutrients are not consumed in the same ratio as they are available.

Near infrared-reflectance spectroscopy (NIRS) has been gaining the attention of scientists in a variety of fields since the late 1970's. Although the technology can be used to predict chemical composition of a many different substrates including forages, fecal spectroscopy is unique because it provides a prediction of what was actually consumed by cattle on range.

NIRS technology consists of shining light in the near-infrared region on a dried and ground fecal sample. Chemical bonds within the sample are excited by the light, and vibrate and stretch in a measurable and predictable manner. The intensity of light reflected off these bonds is measured across many different wavelengths, and is used to predict the chemical composition of the sample.

The ability to predict chemical composition from spectra requires a set of fecal samples matched to forages of known quality. This set is known as a calibration set. Forages of known composition are plotted against predictions from fecal samples based on spectra, producing a regression equation. This equation is then used to predict unknown fecal samples.

The Texas A&M Grazingland Animal Nutrition Laboratory together with the Ranching Systems Group began offering commercial fecal NIRS in 1994. Data from a variety of different digestion trials were used to write a regression equation for prediction. To date, the lab has data from several trials within Texas and states throughout the Midwest and parts of Canada. Data from far west and east states are not currently included.

The purpose of this trial is three-fold:

1. To determine whether the Texas A&M fecal NIRS system works under California condition (i.e. With California range forages)
2. If necessary, to rewrite the regression equations to improve prediction of forage quality under California conditions.
3. Use information collected from the trial to form a library of feeding values and forage quality for producers and range systems not directly tested in the trial.

Starting in June, 2002, an average of five cross-bred Angus steers were fed harvested range forage from two California sites. Harvest occurred at six-week intervals at each site, with the sites offset by three weeks. Harvest continued at each site until one harvest following the first germinating rain. The two harvest sites were the Sierra Field Research and Extension Center (SFREC) and Two Rock, near Petaluma.

Harvested range forage was chopped and fed at maintenance level at eight hour intervals. Soybean meal was supplemented to bring total nitrogen in the diet to three percent. Steers were fed for a fourteen day adjustment period, followed by a five day total fecal collection period. Fecal samples were collected at feeding and were composited on a percentage basis by day across steer, by steer across day, and by period across steer and day. All composite samples were taken in triplicate. Forage and soybean meal samples were taken at chopping and during the fecal collection period.

After compositing, fecal samples were frozen. One sample was then mailed by two-day mail to the Texas A&M GAN Lab for NIRS analysis. A second copy of the sample was then dried at 50°C for 72 hour before being ground using a Wiley Mill through a 1mm screen. Dried fecal samples were analyzed for crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), and ash using standard proximate analysis (wet chemistry) procedures. Dry matter was determined at the time of compositing. Dry matter digestibility and digestible organic matter were calculated for comparison to NIRS values.

Forage and soybean meal samples were also dried and ground through a 1mm screen. Wet chemistry analysis included crude protein, ADF, NDF and ash.

Data analysis is in progress. Results should be available by early summer.

Starthistle Management and Control

By
Glenn Nader
Butte/Sutter/Yuba Livestock & Natural Resources Farm Advisor

It has been estimated that a stand of starthistle can produce 50-200 million seeds per acre. It only requires about 2 million seeds per acre to repopulate that stand the next year. There is a difference of opinion on the viability of starthistle seed. Idaho researchers found that it persisted for 10 years, while others have found 99.5% germinate in three years. Microbial degradation of the seed by pathogens in a California study appears to account for 40% loss in the seedbank each year. Exposure to increased sunlight causes more germination. This is why disking an area can produce more starthistle seedlings and thatch and heavy litter decreases the number of plants observed. Starthistle's deep taproot allows it to be very effective at harvesting moisture. Research at Sierra Foothill and Extension Center has calculated that eight inches of the available 12 inches of moisture (66%) was used up by starthistle. This means that it will take more rainfall to saturate soils on rangeland site occupied by starthistle. Although the toxic constituent of starthistle for horses is unknown, the entire plant is apparently toxic, either fresh or dried. A large quantity (600 + pounds) must be eaten, typically over a period of 1-3 months before poisoning is evident.

Review of Control Methods

Tillage

Starthistle has a deep (3-6 ft) root. Poor control can occur from tilling too early. When the soil is moist, tillage can increase the sunlight that stimulates new starthistle germination and removes the other competing vegetation. Late and multiple tillage is the most successful.

Mowing

Successful control of yellow starthistle by mowing depends on both proper timing and plant growth form. Branching habit of yellow starthistle is highly variable and is partly dependent upon the level of competition for light with other species. Tall grass or litter will force the branching to occur above the normal mower cutting height, increasing the successful control by mowing. Erect, high-branching plants are effectively controlled by a single mowing at early flowering (2-5% flower), while sprawling low branching plants were not satisfactorily controlled even by multiple mowing. Mowing too early stimulates starthistle growth. Mowing to be effective must cut below the lowest branch of the main stem. Check your starthistle plant to determine if a 4-inch height of the standard mower will cut below any branching. A weed eater can be used effectively in small sites to cut below the branching near the ground at the 2-5% flowering stage. Mowing fails frequently because of the narrow window of time that it can be used. Even under conditions where the effectiveness of mowing is optimal, expect some plants to recover. Retreatment will nearly always be necessary.

Competition

Hardinggrass plantings have been observed to decrease starthistle populations in coastal areas, but this species is also a non-native and can be invasive. Siskiyou County Farm

Advisor, Dan Drake, has observed that pubescent wheatgrass and rose clover plantings have decreased starthistle populations. Observation by Craig Thomsen and Fred Thomas at the Sierra Foothill Research & Educational Center in Browns Valley, also indicated that annual clover seedings have decreased starthistle. There was a question of what happened to remaining starthistle in the presence of clover nitrogen enrichment of the soil. Some researchers postulate that there may be fewer but larger plants?

Fire

Researchers have been experimenting with fire to control starthistle in June/July at the early flowering stage. A single year treatment is unsuccessful at decreasing starthistle and also goat grass, but can significantly reduce medusahead populations by removing thatch or residual dry matter (RDM). The fire is fueled by the dry annual grasses and girdles the green starthistle plant. After the second year of treatment there was an 85% reduction in starthistle plants coupled with an increase in native forbs. After the third year treatment there was a 96% control of starthistle. One year of absence of burning has allowed the starthistle to greatly rebound. This has illustrated the dynamics of the seed and repopulation by starthistle. Burning has been effectively used in the first year of treatment that optimizes the starthistle seed base by working on the biology of bare ground increasing germination and follow with two years of herbicide treatment of Transline. Remember, forage biomass production decreases by 50% the year after a fire.

Grazing

Grazing can be an effective way to manage starthistle. When green, starthistle can contain 11-28% crude protein depending on its stage of maturity. Goats are the best control grazers followed by sheep and then cattle. Grazing early (February /March) and allowing late season grazing rest (May -June) can favor starthistle production.

Postemergence Herbicides

Yellow starthistle is difficult to control with postemergence herbicides. This is primarily due to the ability of starthistle seeds to germinate continuously throughout the winter and spring and into the summer when moisture is available. As a result, a single application of 2,4-D, dicamba (Banvel), or triclopyr (Garlon 3A or 4) is typically insufficient to control season long seedling production. One late application, at the end of the rainy season, is not sufficient as many plants are too large and escape injury. The most effective strategy for yellow starthistle control with these compounds is to use repeated applications throughout the season. However, this is expensive, increases herbicide load in these sites, and may prove to be ineffective should late season rains occur. The rates of these herbicides that provide effective control are listed in the table below. Clopyralid (Transline) is also a very effective post emergence herbicide. However, it also has excellent pre emergence activity. Thus, it is discussed separately below under the section Preemergence and Postemergence Activity.

Herbicide	Trade name	Product per acre	Rate per acre (lb ae/A)
2,4-D	Weedar 64 and many others	2 to 4 pts	1 to 2
dicamba	Banvel	1 to 2 pts	0.5 to 1
triclopyr	Garlon 3A or 4	1.5 to 3 pts	0.75 to 1.5
glyphosate	Roundup	2/3 to 2-2/3 qt	0.5 to 2

All these growth regulator herbicides are selective on only broadleaf species and can be used in late winter or early spring to control seedlings without harming grasses. Once plants have reached the bolting stage, most effective control can be achieved with glyphosate. The best time to treat with glyphosate is after annual grasses or forbs have senesced but prior to yellow starthistle seed production. Glyphosate is also an important tool in a follow-up control strategy to prevent yellow starthistle escapes from producing seed. Glyphosate provides excellent control of yellow starthistle at all stages of development, even when plants are in the early flowering stage. The use of glyphosate is not recommended when desirable perennial grasses or broadleaf species are present.

Seedlings: Excellent control of seedlings can be achieved at 2/3 qt Roundup Pro per acre or spot application with 1% solution. No additional additives are necessary.

Mature plants: Plants in late rosette or bolting stage can be controlled with 1-1/3 to 2-2/3 qts per acre or complete coverage with 1% solution. No additional additives are necessary. Unlike seedlings, 2/3 qt Roundup Pro per acre will not effectively control large rosettes. Under optimum growing conditions, control of yellow starthistle in the spiny of early flowering (<5% of flower in bloom) stages can also be achieved at 2 qts. per acre. All treatments should be made before plants exceed the 5% flowering stage. Beyond this stage, numerous viable seed will already have produced. Control is less effective when older plants show physical signs of drought stress.

Treatment Considerations: Roundup Pro is an ideal treatment for late season yellow starthistle control in annual grasslands. Its use is not advised when perennial grasses or desirable perennial broadleaf species are present, except when used as a spot application. When Transline has been previously applied, Roundup Pro can be used in a broadcast or spot treatment follow-up program to control escapes before they produce seed, or to prevent the proliferation of potential Transline resistant plants. Early season application of Roundup Pro to seedlings will not provide control of later germinating seeds. Under these conditions, repeated treatments are necessary.

Preemergence Herbicides

A number of selective or non-selective preemergence herbicides will control yellow starthistle, including clopyralid (Transline), simazine (Princep), diuron (Karmex), atrazine (Aatrex), sulfometuron (Oust), chlorsulfuron (Telar), bromacil (Hyvar), tebuthiuron (Spike), and oxyfluorfen (Goal). All these compounds are registered for use on either right-of-ways or industrial sites, but only Transline can be used on rangelands and pastures.

Preemergence and Postemergence Activity

Transline is a growth regulator herbicide registered for use in non-crop areas, including pastures and rangeland. It has been demonstrated to be very effective for the control of yellow starthistle, as well as other invasive composites (Sunflower family), but does not injure grasses. The increased efficacy of Transline on yellow starthistle can be partially attributed to its postemergence and preemergence activity. A few composites, such as spikeweed (Hemizonia pungens) are not injured by Transline. In addition to composites, Transline injures most legumes, particularly annuals such as burclovers and vetches. Some legumes, including lupines and rose clover are relatively tolerant to Transline.

Injury can be avoided on perennial legumes when Transline is applied during their dormant phase. Other plant groups which may be susceptible to Transline include some members of the nightshade family (Solanaceae), the knotweed or smartweed family (Polygonaceae), and teasel (Dipsacus spp.). In contrast, many other broadleaf species, including crucifers and filarees, appear to be relatively tolerant to the herbicide. Transline can be applied both aerially (helicopter or plane) or by ground equipment. Under optimal conditions, 1/4 pt/acre (1.5 oz ae/A) of Transline can provide excellent control of yellow starthistle from December through April. However, under drought conditions, higher rates are necessary. Thus, for consistent control of yellow starthistle, rates between 1/4 and 1/2 pt/acre are preferable. For more information see conversion chart on page 8. Aerial applications should be made with the higher rates. Even when previous years skeletons are present, similar rates will effectively control seedlings. When the desired objective is to enhance rangeland forage quantity while reducing yellow starthistle, earlier applications dates (January to February) are ideal. Although Transline will provide effect control of starthistle to the bolting stage (April or later), the competitive effects of starthistle this late in the season will result in low quantities of grass forage.

Surfactant Use

Use of a surfactant did not improve the control properties of Transline on starthistle until the foliage began to turn bluish, because of the heavy wax production and when the plant begins to produce more hairs or when the temperature increases.

Long-term control

Any control approach should be continued for at least three years to reduce the yellow starthistle seedbank. Whenever possible, every effort should be made to expose an infested site to high light during the germination period. This will increase the rate of germination and deplete the seedbank more rapidly. Fall or winter grazing, burning, or mowing will provide increased soil surface light during the germination period. By comparison, tillage will bury seeds and prolong the dormancy period. The presence of high populations of biological control agents (weevils and flies) does not appear to significantly impact yellow starthistle populations when used as the sole means of control. However, the presence of these organisms in combination with Transline applications may provide a more long-term or sustainable control. Although no evidence is yet available to support this integrated approach, landowners are encouraged to sustain high levels of the biocontrol organisms.

Precautions

Continuous use of Transline will likely have a long-term detrimental effect on the legume population in a particular area (e.g., burning or mowing). Consequently, other control options should be rotated in the overall yellow starthistle management strategy. In addition, herbicide resistance developed in a Washington population of yellow starthistle exposed to several applications of picloram (Tordon). This population was cross-resistant to Transline. Although, the resistance plants have not spread, the potential exists for the development of resistance to Transline in California if the herbicide is used year after year, with no other method employed. Resistance can be minimized by incorporating other control strategies or by utilizing late season applications of Roundup Pro to control escapes from application skips or resistant plants.

TRANSLINE RATE CONVERSION CHART			
FLUID OUNCES	5.4	6.8	8
Pints	1/3	2/5	1/2

The Future of Biocontrol

Many landowners want the same success with starthistle that occurred with the insect that controlled Klamath weed. Presently, there have been five seed head feeding insects released. Given that starthistle is estimated to produce 50 to 200 million seeds per acre and its populations has expanded in California for more than 100 years it may not be realistic to expect biocontrol agents released during the past five years to provide satisfactory control. It may take a long time for these agents to get a foot hold and catch up to large populations of starthistle. Dr. Joe Balciunas of USDA Ag. Research Service has just returned from a month of surveying for other starthistle control agents in its native home of Turkey. He stated that starthistle there is limited in size and number and is hard to locate. Biocontrol of starthistle should be considered a long term solution. This method may provide the only answer to control on rangelands where of herbicides cost may be too expensive.

Insects

The USDA Ag Research Service conducts the foreign screening of insects that attack starthistle and Calif. Dept. of Food and Ag coordinates the release sites through the county Ag Commissioners. Nursery sites are established and once the starthistle pest increases it is redistribution to other areas. A committee of Ag commissioners decide on the location of the release sites.

Bud Weevil (Bangasternus orientalis)

Introduced in 1988, it has the widest distribution of any yellow starthistle pest. It has been released in 49 counties and has populated all of the sites. Siskiyou and Placer are the counties with the best collection sites. It lays its eggs on the starthistle bracts and the larvae eat the receptacle. They produce only one generation per season, which limits its ability to impact all the different flowering periods. They do not destroy all the seed heads on a plant or all seeds within a seedhead. A private company has been collecting them in Placer County and plans to market them. It is not recommended to purchase these pests, since they have a wide distribution and with time they will increase in number. In addition, the bud weevil is not considered an effective biocontrol agent.

Gall Fly (Urophora sirunaseva)

The gall fly was first released in Placer county in 1984. It is now established in 40 counties. It is a good flyer and can move up to 16 miles per year. Gall flies have increased their populations in Siskiyou and Placer counties. They lay eggs on the seed head, which creates a gall that causes an energy drain on the receptacles. This results in a lower production of viable starthistle seeds. Field surveys have indicated that it is having a limited impact on starthistle. Release sites are on the map below. Like the bud weevil, gall flies are not considered an effective biocontrol agent.

Hairy Weevil (Eustenopus villosus)
It has one generation per year, emerging in May, mating and ovipositing eggs inserted inside closed flowerhead buds in June. It does well in hot dry areas but does not do well in foggy areas. Unlike other yellow starthistle natural enemies, hairy weevil adults also cause extensive damage by feeding on young closed buds. It is now established in 47 counties in California. Thus far, the hairy weevil appears to be more effective in preventing seedhead production in yellow starthistle than both the gall fly or bud weevil.

Peacock Fly (Chaetorellia australis)
It deposits its eggs on the seed head and the larvae hatch it bores inside. They produce three generations per year. This is an added advantage to this pest. One problem is that it emerges early (April) before starthistle flowers. CDFA has had seven releases and seven recoveries. They have found them 100 miles away from the Trinity/Humboldt release site. This species needs cornflower for colonization and establishment and is unlikely to have much of an impact on yellow starthistle control in California.

Seedhead Fly (Chaetorellia succinea)
This fly was accidentally introduced with the Peacock fly in 1991. It has become widespread throughout northern and central California. Chaetorellia succinea produces more than one generation a year. Its larvae can destroy most of the seeds in a head, much like the hairy weevil. Along with the hairy weevil, this fly is the most promising of the natural enemies yet released for yellow starthistle control.

Some of these pests are produced commercially. Below are the names of retail outlets listed in Suppliers of Beneficial Organisms in North America by the Dept. of Pesticide Regulation (1994 edition).

Bangasternus orientalis & Urophora sirunaseva
Bio Collect
5481 Crittenden Street
Oakland, Ca. 94601
Phone (501) 436-8052
Fax (501) 532-0288

Bangasternus orientalis only

Biological Control of Weeds
1418 Maple Drive
Bozeman, Montana 59772
Phone (406) 586-5111
Fax (406) 586-5111
email: biocontrol@montana.campus.mci.net

Peaceful Valley Farm Supply
P.O. Box 2209
Grass Valley, Ca. 95945
Phone (916) 272-4769
Fax (916) 272-4794

Bangasternus orientalis and Eustenopus villosus
Caltec Agri Marketing Services
P O Box 576155
Modesto, CA. 95357
Telephone: 1-800-491-BUGS
Fax: 209-575-0366

RIPARIAN FRIENDLY GRAZING

T.A. Ward, K.W. Tate, E.R. Atwill, D.F. Lile, D.L. Lancaster
N. McDougald, S. Barry, R.S. Ingram, H.A. George, W. Jensen
W.E. Frost, R. Larsen, J.M. Harper, M.R. Horney, G.G. Markegard
S. Larson, R. Phillips, R. Delmas, J. Farley , L.C. Forero
UNIVERSITY OF CALIFORNIA

SUMMARY

Working cooperatively with the range livestock industry, a survey of 300 rangeland riparian sites has lead to the development of: 1) a simple riparian health assessment method, 2) feasible grazing management recommendations to improve riparian health, 3) consistent guidelines for monitoring changes in rangeland riparian health, and 4) demonstrations sites to illustrate these results. These tools will assist managers to conduct, monitor, and document riparian friendly grazing. These results illustrate a unique problem solving approach which capitalizes on producer's knowledge of their property and its management, and utilizes the technical and statistical skills of the researcher.

INTRODUCTION

Concerns about livestock grazing impacts on rangeland riparian health include impacts on riparian vegetation, stream channel stability, hydrology, water quality, and habitat. The concerned grazing manager's questions are: 1) Is my grazing management degrading riparian health? 2) If my grazing management is degrading riparian health, what practical grazing management tools can I employ to resolve this problem?, and 3) Did my grazing management changes improve riparian health?

The collective experience of University of California Cooperative Extension (UCCE), U.S. Forest Service (USDA-FS), U.S. Bureau of Land Management (USDI-BLM), the Natural Resources Conservation Service (USDA-NRCS), and the livestock industry is that there are many ranches and grazing allotments where riparian resources are being enhanced in the presence of livestock. These real world demonstrations of riparian friendly grazing offer the best learning and teaching opportunities. We conducted an applied research and extension education project which enrolled approximately 300 private and publicly owned grazed riparian sites across California. The goal of this project was to identify relationships (positive and negative) between specific grazing management practices and riparian health, and to extend this information to grazing managers, scientists, and the interested public.

At each site, two visual habitat assessments were completed (US Environmental Protection Agency's Habitat Assessment Field Data Sheet (HAFDS) and USDA Natural Resource Conservation Service's Stream Visual Assessment (SVA)) as well as a visual assessment of hydrologic condition (USDI Bureau of Land Management's Proper Functioning Condition (PFC)). The results discussed below will deal with the habitat assessments, specifically with EPA HAFDS assessment. Analysis was conducted on a site specific basis, determined by the stream and vegetation types. For the length of this paper, only the first level of analysis is discussed which includes all sites.

Riparian Grazing Recommendations to Improve Riparian Resources...

Our initial analysis of the dataset collected has provided valuable information about the relationships between common grazing management practices and riparian health. We are very excited that many simple, practical grazing management practices can have a positive impact on riparian health (EPA HAFDS Score; 0 = Unhealthy and 20 = Perfect Health). Table 3 reports the grazing management practices found to be significantly ($p<0.10$) related to riparian health. Equation 1 illustrates the final model reported in Table 3. The relationship (Equation 1) between each grazing management practice and riparian health revealed in our survey are also illustrated graphically for each grazing management practice (Figures 1-6). Supporting information from the riparian grazing management literature is also discussed. This information is currently being developed as both a peer-reviewed extension publication and a research journal paper.

Equation 1. Model Predicting Riparian Health (EPA HAFDS Score) by Grazing Management
EPA HAFDS = 15.70 - 0.25(Stocking Density as AU/ha) - 0.33(Grazing Frequency as times/yr) + 0.02(Herding as day/yr) + 0.05(Time Maintaining or Placing Off-Site Attractants as days/yr) + 0.003 (Rest Between Grazing as days) + 0.11(Grazing Frequency * Stocking Density).

Collectively, these grazing management practices can be utilized to improve riparian health on rangelands. While all of these recommendations are not feasible on every ranching operation, combinations of these practices are. Opportunities to: 1) reduce stock density, 2) reduce frequency of grazing, 3) increase rest between grazing, 4) increase efforts to herd livestock from riparian areas, and 5) increase the development and maintenance of off-site livestock attractants should be investigated and implemented on pastures containing riparian systems.

Stock Density
Holding all other grazing management factors constant, as stock density increased, riparian health decreased (Figure 1). As the number of livestock increases in a management unit, the potential for negative impacts to riparian health increase. The riparian zone will receive more grazing pressure on the vegetation, both herbaceous and woody species, and will receive more animal impact, or hoof impact, which in turn has the potential of degrading stream banks, increasing sedimentation, and degrading water quality (Kauffman and Krueger, 1984; Fleishner, 1994; Belsky et al., 1999; Rinne, 1999). Decreasing the stock density in a pasture should allow for smaller potential impacts to be incurred on the riparian area. Skovlin (1984) found that adjustments in grazing intensities often affect a greater response on a system than changes in the grazing system its self. Van Poollen and Lacey (1979) also point out that changes in both intensity and grazing system could be additive. Therefore reducing the stock density, in addition to changing the frequency of grazing, and rest between grazing do have a potential to lessen the impacts of livestock grazing.

Frequency of Grazing
As the frequency of grazing increases, riparian health decreases. As a system is repeatedly grazed within the same year, a decrease in riparian health can be expected. One possible interpretation is that grazing systems such as High Frequency Low Intensity (Vallentine, 1990) would decrease riparian health. This might be the case; however, it is important to note that the frequency of grazing alone does not define a grazing system. The definition of a rotational grazing system is based upon rest from grazing, timing, intensity, and duration of grazing as well as frequency of grazing. If this is kept in mind, the reduction in riparian health as a result of repeated grazing is logical. Daubenmire (1953) describes the effect of repeated grazing on both annual and perennial communities as a decrease in plant populations. As grazing pressure is increased through repeated grazing on annual communities, livestock can reduce the plants' ability to set seed for the following year, and therefore reduce the number of annual plants present at a site. Perennial communities may be impacted by repeated grazing in the reduction of root reserves, also resulting in loss of vegetation.

Interaction of Frequency and Stock Density

A significant interaction exists between frequency of grazing and stock density (Figure 2). Heavier stock densities will have lower riparian health scores as frequency of grazing decreases to one. In other words, heavier stock densities in combination with little rotation of livestock degrade riparian health more compared to lighter stock densities with little rotation of livestock.

Rest Between Grazing

As rest between grazing increases, riparian health increases (Figure 3). Rest is a crucial component in defining grazing systems and has long been recognized for its importance in minimizing grazing effects on upland range plant communities (Kauffman and Krueger, 1984; Holechek et al., 1989; Vallentine, 1990). Rest from grazing allows the vegetation a chance to re-grow, maintain individual plant vigor and plant community composition and structure. The plant community plays an important role in the health and function of riparian areas and thus the associated stream. Healthy riparian vegetation is needed to stabilize banks, provide habitat for wildlife, and filter contaminants from overland flow (Kauffman and Krueger, 1984; Fleishner, 1994; Belsky et al., 1999; Rinne, 1999). Constant grazing pressure does not allow riparian vegetation to re-grow and perform its vital functions in a riparian area, especially in regard to stream bank stability. The compressive strength of a soil allows it to resist compression under pressure (Kleinfelder et al., 1992), thereby resisting stream bank erosion from animal impacts. The presence of vegetation increases the compressive strength through very fine roots (VFR), which also is a component of root length density (RLD) (Kleinfelder et al., 1992). Kleinfelder et al. (1992) discovered that there is a nonlinear relationship between VFR and compressive strength, suggesting that a substantial increase in compressive strength can be obtained from a moderate amount of root growth. Following the same pattern, an increase in RLD corresponds to an increase in compressive strength. Manning et al. (1989) have also identified that the RLD is more closely related to erosion control than simple belowground biomass. Therefore providing rest and allowing the vegetation an opportunity to maintain its VFR will maintain stream bank stability in relation to both compressive strength and RLD.

Herding

Increased time spent herding livestock to improve distribution and reduce time spent in the riparian area was associated with an increased riparian health. As one attempts to improve livestock distribution through herding, it would be expected that the preferred area, often the riparian area, would receive less use and therefore have a higher aquatic habitat potential. Skovlin (1984) stated that even reducing grazing intensities on uplands would not result in a proportional response on preferred meadows without proper distribution. Therefore, even after reducing stock density, it can still be expected that the livestock will have a tendency to congregate on the riparian area unless distribution practices, such as herding, are implemented. Herding can be utilized to introduce livestock to areas that are traditionally underutilized, and reduce concentrations on preferred areas (Cook, 1966, Bailey et al., 1996).

Off-site Attractant Time

Increasing the time spent providing off-site attractants was associated with an increase in riparian health (Figure 4). Off-site attractants include water, feed such as hay or grain, salt, minerals, or other supplements such as protein. Gillen et al. (1984) found that cattle preferred areas within 200 meters of water, and avoided areas greater than 600 meters from a water source. In a pasture where the only water source may be the stream, this would tend to concentrate livestock near the stream, resulting in a disproportionate amount of time livestock spend in the riparian area. Bailey et al. (1996) agree with Gillen et al. (1984) in that distance to water is a primary determinant of grazing distribution patterns. Creating a water source away from the stream encourages livestock to move away from the riparian area and utilize more of the uplands in the pasture. Gillen et al.

(1984) also found salt placement to be a useful distribution practice for deferred-rotation grazing. The authors found that livestock preferred areas within 600 meters of the salt supplement. Dehydrated molasses was also found to have an effect in improving livestock distribution. Bailey and Welling (1999) and Bailey et al. (2001) found greater utilization around supplements, even if the supplement was placed in a traditionally underutilized area. Bailey et al. (2001) also found that by moving the supplement to different areas of the pasture, they could improve the distribution and utilization of the pasture. The time that a manager spends on providing off-site attractants has been shown to improve distribution in the literature, and is shown here to have a positive association with riparian health.

Example Use of this Information

Providing site-specific information regarding the relationships between management and riparian health allows the manager to make more informed management decisions regarding riparian grazing. For example, consider a grazing manager that has 120 cow-calf pair, 12,000 acre allotment on a National Forest with a grazing period of May 1 to October 30. One stream that crosses the allotment is of special concern regarding habitat for trout, and the manager would like to improve the riparian health while still grazing the allotment. The information above tells us the manager could expect herding, time spent placing/installing/maintaining off-site attractants, and rest between grazing will have significant positive relationships with aquatic habitat/health. Currently, herding and off-site attractant time is minimal, with typically 3 full days being spent on herding, and only half a day being spent on placing salt on the allotment. The expected riparian health score (HAFDS) under this management would be 15.25. The manager is not at this point able to increase the rest between grazing, but can make improvements in both herding and off-site attractant time. Figure 5 illustrates the increase the manager can expect from increasing time spent on herding and the time spent on off-site attractants to what would be feasible for the allotment, there is a potential increase in riparian health score of approximately 1.5 points over time. If there are changes in the turn on and off dates, and potential for rest between grazing in increased, then there is potential to increase the aquatic habitat even further (Figure 6).

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Figure 1. Effect of stock density on riparian health where Herding= 15d, OATime= 5d, Rest Between Grazing= 182d, Frequency=1

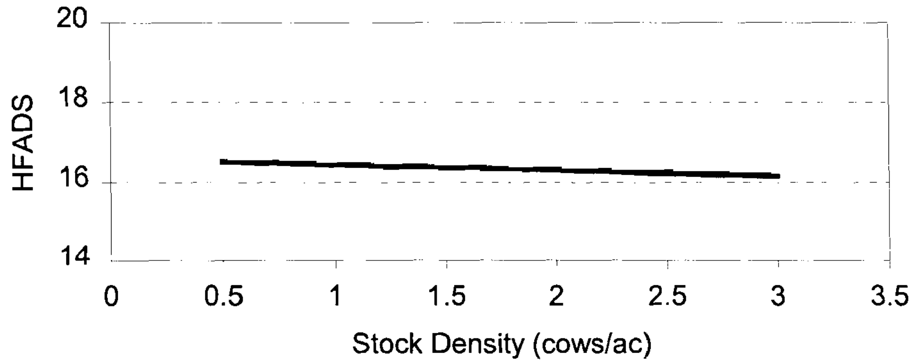


Figure 2. Combined effects of stock density and frequency of grazing where Herding = 15 d, OATime = 5 d, Rest Between= 90 d

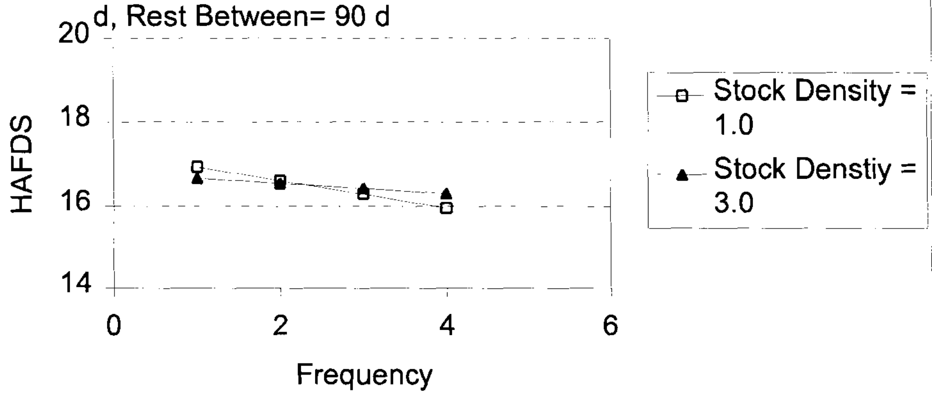


Figure 3. Effect of days rest between grazing on riparian health where Herding= 15d, OATime= 5d, Stock Density= 2.0, Frequency= 1

Figure 4. Effect of time spent on off-site attractant management on riparian health where Stock Density = 2.0, Herding = 15d, Frequency= 1, Rest Between Grazing= 182d

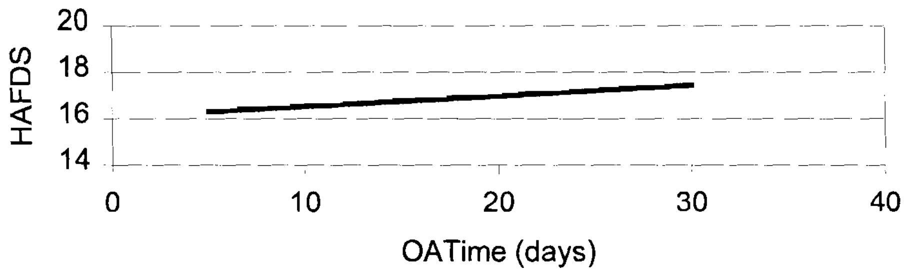


Figure 5. Potential to increase riparian health by increased herding and OA time on example site where rest between grazing = 183d

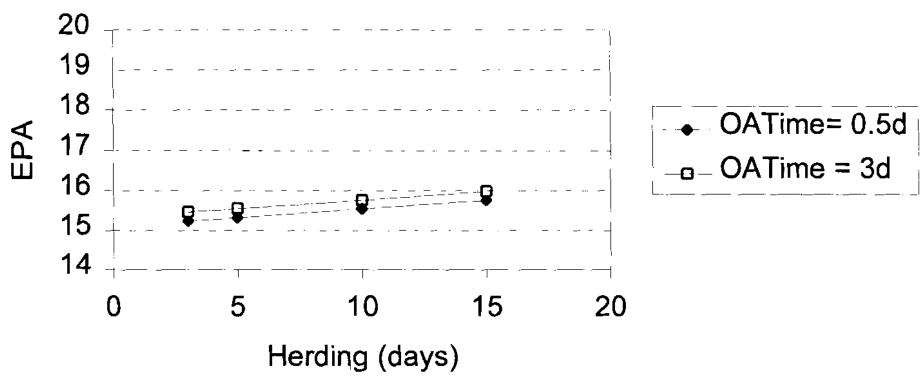
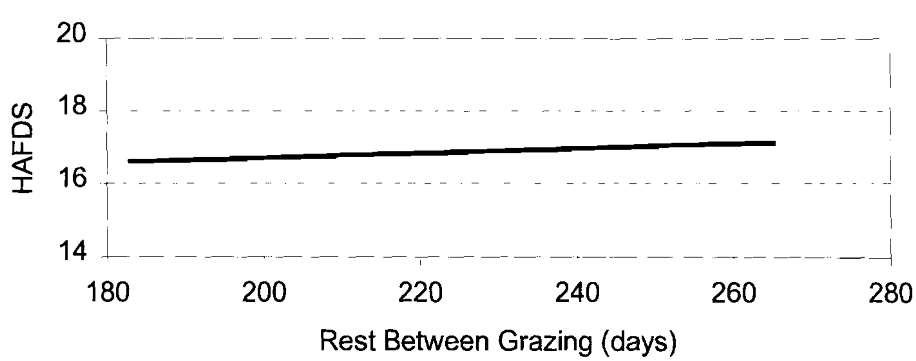


Figure 6. Potential to increase riparian health by increased rest between grazing on example site where herding = 25d and OATime = 5d



Estimating the Cost of Replacing Forage Losses from Wildfire on California Annual Rangelands

Neil K. McDougald and William E. Frost
Presented by Dustin K. Flavell

Wildfire impacts rangeland by burning up the forage present on the land at the time of the fire, as well as by reducing forage production and affecting length of adequate forage-growing periods and species composition for the next two years. Only in the third growing season will forage on burned sites be similar to adjacent unburned sites. The first growing season following a fire, about 50 to 70 percent as much forage will be produced and the species composition will shift primarily to forbs. The second growing season after a fire about 20 percent less forage will be produced. After a high-intensity fire that leaves white ash, less than 25 percent as much forage will be produced on a burned site as on an unburned site for each of the next 3 years and possibly longer, if reseeding is not done. In some cases, however, managed fire can result in a net increase in forage production over time when used to control brush and weed infested rangeland.

When grazed lands are burned, lost forage generally must be replaced through feeding hay to the livestock. A science based methodology to estimate the cost of replacement forage is provided in Estimating the Cost of Replacing Forage Losses on Annual Rangeland, University of California, Division of Agriculture and Natural Resources publication number 21494. The publication includes a worksheet to determine the replacement value of usable forage lost and includes three completed worksheet examples. The worksheets take into account the forage productivity of the site, residual dry matter, harvest efficiency of grazing livestock and the number of acres affected. Other less vigorous approaches can be used to arrive at an agreed upon value of forage lost from wildfire. The California Fire Plan developed by the Department of Forestry and Fire Protection in 1996 provides the cost impact of burning one acre of grazed rangeland by cover type and ownership in different geographic regions in California. Other approaches involve simply doubling or tripling the annual rental rate.

Initial forage loss can be determined by the clipped plot method described in Monitoring California's Annual Rangeland Vegetation, University of California, Division of Agriculture and Natural Resources publication number 21486. Samples are collected in unburned sites adjacent to the fire. The number of sites to sample will vary with the topography and amount of woody canopy cover. The recommended amount of residual dry matter is provided in California Guidelines for Residual Dry Matter (RDM) Management on Coastal and Foothill Annual Rangelands, University of California Division of Agriculture and Natural Resources publication number 8092. The standard assumes that the amount of residual dry matter remaining in the fall, subject to site conditions and variations in weather, will influence subsequent species composition and forage production. Livestock managed under a continuous grazing system generally harvest 50 percent of the available forage. The usable amount lost to the livestock producer from fire is therefore, one-half of the available forage with the other 50 percent being utilized by wildlife, trampled, shattered, decomposed, etc..

Estimating the Cost of Replacing Forage Losses on Annual Rangeland

Neil K. McDougald, William E. Frost & W. James Clawson
Presented by Dustin K. Flavell

Valuable forage is often lost on annual rangelands because of wildfires, cultivation, road construction, and excavation. Estimating the cost of such losses cannot be based upon traditional grazing rental rates for livestock because the impact on forage production is more far reaching than the impact of grazing. All residual dry matter is removed and, except in the case of fire, the soil profile is changed. Besides the loss of the current year's forage, the following growing seasons' forage production, length of adequate forage-growing periods, and species composition are affected.

For example, after a fire or disturbance has removed all vegetation, about 50 to 70 percent as much forage will be produced the following season, and the species composition will shift primarily to forbs. The second growing season following a disturbance, forage production will be about 20 percent less than on undisturbed sites. Only in the third growing season will forage production be similar on both sites (Hervy 1949, Zavon 1982, McDougald and Frost 1989, 1990). After a high-intensity fire that leaves white ash, less than 25 percent as much forage will be produced on the burned site than on an unburned site for each of the next 3 years, and possibly longer, if reseeding is not conducted (Frost 1988). To appraise the impact of this disturbance on annual rangeland, it is necessary to assess the impact on the site, its likely productivity, and the cost of replacing the forage lost.

In areas typified by the San Joaquin Experimental Range six easily recognized, fairly broad range sites make up usable rangeland (Bentley and Talbot 1951). Precipitous slopes; large, nearly barren rock outcrops; and areas with dense brush or interior live oak cover are excluded from consideration. The six range sites identified are:

Swale sites – gentle drainage bottoms, which produce the greatest amount of forage

Gentle slope – located just above the swale; slope less than 10 percent

Open-rolling sites – gentle uplands with few rock outcrops or brush; intermediate in annual forage productivity

Rocky, brushy sites – uplands; low in annual forage productivity

Steep, rocky, brushy, north slope sites – over 30 percent slope; least productive site

Steep, rocky, brushy, south slope sites – over 30 percent slope; about twice as productive as north slopes

Adequate amounts of residual dry matter (RDM), the dry plant material left on the ground from the previous year's growth, must be left at the end of the grazing season to protect the site and to provide a favorable microenvironment for the following year's forage production (Clawson, McDougald, and Duncan 1982). Therefore, the difference between the amount of forage produced on a site and the RDM is the amount available for rangeland users. Because livestock generally harvest 50 percent of the available forage (Smith, Leung, and Love 1986), the usable amount lost to the livestock producer is one-half of the available forage with the other 50 percent being utilized by wildlife, decomposition, trampling, etc. Typical forage production, an RDM standard, estimated available forage, and usable forage for sites at SJER are presented in table 1.

An alternative to using average forage production values for a given site would be to sample forage production on similarly burned and unburned sites. Techniques available for determining forage production include clipping of plots (Cook and Stubbendieck 1986), the comparative yield method (Haydock and Shaw 1975), and use of a pasture probe (George et al. 1989), etc. Another alternative would be to use forage production estimates taken from the Soil Conservation Service ecological site description (range site guides). This forage production estimate could then be used in place of the average annual forage production value in table 1.

Table 1. Average annual forage production, residual dry matter (RDM) standards, usable forage, and forage lost to livestock producer for 6 range sites typical of the San Joaquin Experimental Range, Madera County, California*

Range site	Average annual forage production (lb/ac)	RDM standard (lb/ac)	Available forage (lb/ac)	Harvest efficiency (%)	Usable forage (lb/ac)
Swale	4,400	600	3,800	50	1,900
Gentle slope	3,000	800	2,200	50	1,100
Open, rolling	2,100	800	1,400	50	700
Rocky, brushy	1,400	1,000	400	50	200
Steep, rocky, brushy, north slope	1,200	1,000	200	50	100
Steep, rocky, brushy, south slope	1,800	1,000	800	50	400

*Adapted from Bentley and Talbot 1951.

The time of year the pasture is traditionally utilized determines the value of the forage lost as the nutrients contained in that forage must be replaced by supplemental feeding, which by definition is the supplementing of nutrients the grazed forage lacks. On California's annual rangelands, dry feed during summer and early fall lacks protein, phosphorus, and vitamin A. In fall and early winter, new forage growth is high in moisture and energy is often inadequate for desired livestock performance. Feed supplements are used commonly in the form of dry concentrated feed, liquids, or blocks formulated to provide a source of protein (or nonprotein nitrogen), phosphorus, vitamin A, and, sometimes, other minerals (i.e., copper and magnesium). At the beginning of the new forage season, protein and energy are most often supplied in the form of hay. Oat hay can supply an adequate amount of energy, but it is a poor source of protein and vitamin A. Alfalfa hay, on the other hand, is a good source of all these nutrients (table 2).

Table 2. Dry matter percentage, total digestible nutrients (TDN) percentage, protein content, and phosphorus percentage for oat and alfalfa hay and range forage

Feed	Dry matter (%)	TDN (%)	Protein content (%)	Phos-phorus (%)
Alfalfa hay	90	60	17	0.22
Oat hay	90	54	9	0.21
Late dry forage	90	45	3	0.15
Early green forage	30	20	6	0.08
Early green forage	90	60	18	0.25
Late spring forage	60	45	10	0.18
Late spring forage	90	60	15	0.25

Calculations to determine the value of forage lost are included in a set of worksheets, (a Sample Worksheet plus Examples 1-3). These calculations take into account the forage productivity of the site, the reduction in productivity due to a disturbance, the RDM standard necessary to protect the site, the harvest efficiency of grazing livestock, and the number of acres affected.

Three examples are presented to clarify the process outlined previously. For the examples that follow oat hay was used as the supplemental feed when the pasture was used summer or fall and alfalfa hay when the pasture was used in spring. Oat hay is comparable, in terms of TDN to late dry forage, although it is higher in protein content (table 2). Alfalfa hay is comparable to green forage in TDN, protein content, and phosphorus. If the reduced forage production on a site is less than the RDM standard, that site is ignored when calculating usable forage.

WORKSHEET

Replacement value of usable forage depends on: site productivity, area impacted, season of use, harvest efficiency and cost of substitute feeds. The formula below is a quick method to appraise the replacement value of useable forage lost.

If no grazing had occurred on this area and it was intended for fall use all of the usable forage has been lost and must be replaced. Use equation (A).

If the area had been grazed, but not to the RDM standard, use (AA) to determine the amount of usable forage lost.

A. Beginning Inventory

	Site	Forage Produced (lb/ac)		RDM (lb/ac)		Harvest Efficiency (Percent)		No. Acres		Usable Forage Lost (lb)
1		(	-	)	X		X		=	0
2		(	-	)	X		X		=	0
3		(	-	)	X		X		=	0
4		(	-	)	X		X		=	0
5		(	-	)	X		X		=	0
6		(	-	)	X		X		=	0
								Total Pounds		**0**

0 — Total Pounds Usable Forage Lost

0.0 — Total Tons Usable Forage Lost (A)

AA. Partial Use Prior to Disturbance

	Site	Standing Crop (lb/ac)		RDM (lb/ac)		Harvest Efficiency (Percent)		No. Acres		Usable Forage Lost (lb)
1	F1-21	(4002	-	800)	X	50%	X	12	=	19,212
2	F1-14	(4848	-	800)	X	50%	X	16	=	32,384
3	F-2	(2410	-	800)	X	50%	X	122	=	98,210
4	F1-22	(4002	-	800)	X	50%	X	21	=	33,621
5	F1-11	(4848	-	800)	X	50%	X	35	=	70,840
6	H-8	(4002	-	800)	X	50%	X	82	=	131,282
								Total Pounds		**38,5549**

38,5549 (Total Pounds Usable Forage Lost) ÷ 2000 = 192.8 (Total Tons Usable Forage Lost) (AA)

B. First Growing Season

	Site	Forage Production		1-% Reduction (percent)		RDM (lb/ac)		Harvest Efficiency (Percent)		No. Acres		Usable Forage Available (lb)	
1	F1-21	[(4002	X	60%)	-	800]	X	50%	X	12	=	9,607	(1)
2	F1-14	[(4848	X	60%)	-	800]	X	50%	X	16	=	16,870	(2)
3	F-2	[(2410	X	60%)	-	800]	X	50%	X	122	=	39,406	(3)
4	F1-22	[(4002	X	60%)	-	800]	X	50%	X	21	=	16,813	(4)
5	F1-11	[(4848	X	60%)	-	800]	X	50%	X	35	=	36,904	(5)
6	H-8	[(4002	X	60%)	-	800]	X	50%	X	82	=	65,649	(6)

	Typical Usable Forage Produced		Usable Forage Avail. (lb)		Usable Forage Lost (lb)
(1)	19,212 — Site 1 (lb) (A1)	-	9,607	=	9,605
(2)	32,384 — Site 2 (lb) (A2)	-	16,870	=	15,514
(3)	98,210 — Site 3 (lb) (A3)	-	39,406	=	58,804
(4)	33,621 — Site 4 (lb) (A4)	-	16,813	=	16,808
(5)	70,840 — Site 5 (lb) (A5)	-	36,904	=	33,936
(6)	131,282 — Site 6 (lb) (A6)	-	65,649	=	65,632

Total Pounds 200,300
First growing season usable forage lost

200,300 (Total Pounds Usable Forage Lost First Growing Season) ÷ 2,000 = 100.2 (Total Tons Usable Forage Lost First Growing Season) (B)

C. Second Growing Season

	Site	Forage Production		1-% Reduction (percent)		RDM (lb/ac)		Harvest Efficiency (Percent)		No. Acres		Usable Forage Available (lb)	
1	F1-21	[(4002	X	80%)	-	800]	X	50%	X	12	=	14,410	(1)
2	F1-14	[(4848	X	80%)	-	800]	X	50%	X	16	=	24,627	(2)
3	F-2	[(2410	X	80%)	-	800]	X	50%	X	122	=	68,808	(3)
4	F1-22	[(4002	X	80%)	-	800]	X	50%	X	21	=	25,217	(4)
5	F1-11	[(4848	X	80%)	-	800]	X	50%	X	35	=	53,872	(5)
6	H-8	[(4002	X	80%)	-	800]	X	50%	X	82	=	98,466	(6)

	Typical Usable Forage Produced (lb)		Usable Forage Avail. (lb)		Usable Forage Lost (lb)
(1)	19,212 (Site 1 (lb) (A1))	-	14,410	=	4,802
(2)	32,384 (Site 2 (lb) (A2))	-	24,627	=	7,757
(3)	98,210 (Site 3 (lb) (A3))	-	68,808	=	29,402
(4)	33,621 (Site 4 (lb) (A4))	-	25,217	=	8,404
(5)	70,840 (Site 5 (lb) (A5))	-	53,872	=	19,968
(6)	131,282 (Site 6 (lb) (A6))	-	98,466	=	32,816

Total Pounds 103,149
Second growing season usable forage lost

103,149 (Total Pounds Usable Forage Lost Second Growing Season) ÷ 2,000 = 51.6 (Total Tons Usable Forage Lost Second Growing Season) (B)

D. Substitution Value

The substitution value is based upon normal season of use, delivery & feeding cost.

1. Dry Forage Period Season of Use

Substitution value per ton = $85.00 (D1)
Purchase, delivery & feeding cost per ton of oat hay

2. Green Forage Period Season of Use

Substitution value per ton = $110.00 (D2)
Purchase, delivery & feeding cost per ton of oat hay

E. Total Cost

((A) or (AA) 192.8 (Beginning tons Lost) X (D) $85.00 (Substitution Value per Ton)) +

(B) 100.2 (Tons Lost First Growing Season) X (D) $110.00 (Substitution Value per Ton)) +

((C) 51.6 (Tons Lost First Growing Season) X (D) $110.00 (Substitution Value per Ton)) = (E) $33,086.00 (Total Replacement Value of Usable Forage Lost)

Fire and Grazing Impacts to Oaks

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Native California oaks evolved in a Mediterranean climate where natural fires burned regularly. Research at the SFREC in the early 80's by UCB student Mitch McClaran indicated that prior to European settlement in the mid-1800's, fires occurred in this area approximately every 25 years. During the decades following the Gold Rush, fires were even more frequent. Since the early 1900's, however, fires have been aggressively suppressed, resulting in less frequent fire intervals.

Unlike most conifer species, oaks have evolved mechanisms allowing them to survive periodic burning. Moderate intensity fires often scorch all the leaves on woody plants. For most conifers, such damage is usually lethal. Oaks, on the other hand, suffer little long-term damage from scorching. If the fire happens early in the growing season, the trees may regrow new leaves before autumn and, by the end of the growing season, it may be difficult to tell which trees were scorched in the fire. Such trees may even produce a new crop of flowers, though it is unlikely this unseasonal flowering would produce any viable acorns.

If fires occur in the summer, like the **Field Fire** last June at the SFREC, the oaks usually do not produce a complete crop of new leaves until the following spring. While some new foliage growth may occur in the summer or early fall following the fire, the soil is generally too dry to support wide-scale foliage growth at this time of year. Following such fires, the trees usually appear dead since all leaves are brown and brittle and the boles may be blackened. But this does not mean the oaks are dead.

More severe fires can kill the tops of the oaks. The critical factor seems to be whether or not the cambium has been heated to lethal temperatures. The cambium is that area immediately under the bark where cell division and radial diameter growth occur. If the tree has been "girdled" at the base, meaning the cambium has been heated so severely that it has been killed all the way around, the top of the tree will die. However, it is often difficult to tell if the cambium has been killed by merely looking at the outside of the trunk. Fires that have scorched the bole and turned it black are not necessarily hot enough to kill the cambium – especially on larger diameter trees that have thicker bark. This is because bark is a good insulating material and the thicker it is, the better. However if the fire has been hot enough to actually burn into the bark and reduce its thickness, the cambium is usually killed. One can often determine the severity of damage by cutting into and under the bark to observe the cambium. Healthy cambium is white and moist while dead cambium is usually brown and dried out.

Even if the tree has been girdled all the way around and the top of the tree has been killed, most oaks will sprout from their base the following year. Sprout-origin trees initially produce many sprouts. As these age, they thin out, although even mature trees that started as sprouts usually have multiple trunks. Generally live oaks are more vigorous sprouters than deciduous oaks, and smaller diameter trees are more likely to sprout than large diameter ones. Oaks in moister areas also generally sprout better than those growing on dry sites.

It has been suggested that fire suppression in the last century may have contributed to some of the oak regeneration problems we have today. According to this theory, frequent fires may have created conditions more favorable to oak regeneration. These include eliminating competition, creating a more favorable seedbed for acorns to germinate, and reducing populations of animals that eat acorns or seedlings. Also, since oaks sprout and many other plants don't, fires could give oaks a "head start" and enhance their chances of survival. There is not much evidence to support this theory and most people believe that poor oak regeneration is caused by factors other than fire.

The finger of blame for poor oak regeneration is often pointed at livestock since the introduction of widespread grazing in the state roughly coincided with the time when regeneration patterns seemed to have changed. Both cattle and sheep also eat acorns and oak leaves. But there are locations where grazing has taken place more or less continuously for the last hundred years, but regeneration is adequate. There are also locations where grazing animals have been excluded for decades, yet there still appear to be factors preventing the oaks from coming back. Though it is hard to be definitive, it appears that there are a variety of factors contributing to poor oak regeneration and different factors are more or less important at different sites. Intensive grazing certainly contributes to poor regeneration in some situations, but may have little impact in other locales.

During the last several years we have tried to develop techniques to promote oak regeneration in pastures grazed by cattle. This is important since the primary economic activity on the vast majority of oak woodlands in California is ranching. It is therefore vital to develop regeneration approaches that are compatible with grazing. Research at the Center has indicated that season of grazing can influence damage to young oak seedlings. Lillian Hall, a UCD range student, found that grazing in the green season was less damaging to planted oaks since there was abundant forage and the cattle had little interest in the seedlings. In the dry season, however, damage to oaks was greater since the seedlings were often the only green plants in the pastures and the cattle seemed to preferentially eat them.

We have recently evaluated the effectiveness of treeshelters in protecting planted oaks from cattle. Treeshelters are double-walled plastic tubes that act like mini-greenhouses and protect young oaks from a variety of damaging animals. In a trial that has been underway here for the past 5 years, we have evaluated the performance of planted oaks protected with treeshelters in both grazed and ungrazed pastures. Results indicate that while cattle do tend to clip off some of the shoots that grow up and out of the tops of the 4-foot shelters, thus reducing their overall height and the size of the crown, few plants were killed by the cattle. However, it is critical that the shelters be secured with heavy metal fence posts since the animals do, at times, rub against them and wooden posts would likely break off. While metal posts can be bent and pushed sideways, they can easily be straightened when the cattle are moved. Grazing in these pastures also had another benefit for the oaks. The thatch or dead litter that became quite thick in the ungrazed pasture was mostly eliminated in the areas where the cattle grazed. This greatly reduced the number of voles or meadow mice (*Microtus californicas*) in the area since these animals prefer ground with cover and protection. Eliminating this cover reduced the population and, as a consequence, vole damage to seedlings – which can be a serious obstacle to the survival of planted or natural oak seedlings – was greatly reduced. Overall, these results suggest that treeshelters may be a valuable tool for regenerating oaks in areas grazed by livestock.

Visual Assessment of Riparian Health

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The Visual Assessment of Riparian Health is a new publication that is available as a free download at http://anrcatalog.ucdavis.edu/merchant.ihtml?pid=5560&step=4. The publication goes through each item that is to be examined in the riparian area with photographs to use as examples. The following is a brief excerpt from the publication on the use of visual assessments. For the complete publication, please see the web site.

There are numerous ways to document a riparian area, ranging from simple photographs to more in depth, cross-sectional surveys. Visual assessments can be a straight forward and simple method for rangeland managers in making a rough evaluation of the overall health of riparian areas. Visual assessments are not intended to be comprehensive, data-driven evaluations, nor are they intended to be monitoring tools for the long-term documentation of riparian health. The power of a visual assessment is that it provides a simple and rapid tool that allows a local manager to make a timely and cost-effective evaluation of the overall health of the riparian area(s). If the initial visual assessment indicates a problem, a more detailed analysis can be performed to identify the likely cause(s), the possible linkage of the problem to management (current, past, or upstream) or natural disturbances (floods, fires, etc.), the possible change in management to correct the problem, and the type of monitoring needed to document that the problem has been corrected or needs additional management effort.

In a minimal amount of time, managers can be trained in the prudent use of visual assessment methods, thus greatly increasing the number of California's range-land riparian areas being assessed and managed. The critical component is the avail-ability of a simple riparian assessment tool, designed for use by trained range managers and specific to rangeland riparian areas. There are currently several visual assessments available, each with some level of applicability to rangelands. The Environmental Protection Agency (EPA), Natural Resource Conservation Service (NRCS), Bureau of Land Management (BLM), and California Department of Fish and Game (CDFG) have each produced a method for visual assessment. Three of these four assessments concentrate on habitat parameters for trout and macroinvertebrates, while the other concentrates on hydrological functioning of the creek, with a combined total of 52 questions (For more information on being trained in and using visual assessments, contact your local UC Cooperative Extension, NRCS, or Resource Conservation District [RCD] office.) While each of these visual assessment methods is quite good, together they provide a comprehensive look at the major effects of stream health on rangeland riparian areas (aquatic habitat, hydrological function, stream bank stability, and riparian vegetation). By combining the four existing assessments into one, we present here a riparian health assessment developed specifically for use on Californian rangeland riparian areas.

Our first objective in compiling this new assessment tool was to make it simple and rapid. By reducing overlap among the four existing assessments and eliminating those questions that were not applicable to California rangelands, we were able to create an assessment for high gradient creeks with 9 questions and one for low gradient creeks with 10 questions.

Our second objective was to select questions for the assessments based on data that compare existing methods to a large cross-section of California rangeland riparian areas, as well as on our experiences in field-testing each of the existing methods with range managers.

Cows in Space

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Introduction

A great deal has been learned about foraging behavior and livestock distribution in the last several decades. We hope to apply and fine tune this knowledge to reduce the impacts of beef cattle on riparian areas, surface water and wildlife habitat. Likewise, to use cattle as a tool to manage weeds we need to be able to attract cattle into patches of undesirable species.

Beef cattle and other grazers focus on water sites and sites that provide thermal comfort, foraging away from these focal points to meet their nutritional needs. Most ungulates first harvest food, then move either to loafing and bedding sites to ruminate and digest the food ingested in a previous grazing bout (meal), and/or to areas for predator avoidance. The distance covered by the animal during foraging depends on digestive capacity, rate of passage, forage harvest rate, grazing velocity and level of hunger. Once satisfied the animal returns to a thermal, water or bedding site depending on their needs and priorities.

Time spent grazing depends on forage availability, forage quality, and thermal balance. Animals reduce daily grazing time as digestibility of available forage declines and retention time of ingesta increases. When daytime temperatures are within the thermal comfort zone of cattle, most grazing takes place during daylight hours. During hot weather cattle reduce afternoon grazing and increase night-time grazing. Most researchers report little grazing and traveling after darkness. However, recent nighttime observations at San Joaquin Experimental Range in Madera County indicate that grazing and change of bedding sites do occur during darkness on some nights.

The objective of this study at UC SFREC is to understand where beef cattle distribute themselves in a typical foothill oak woodland or annual grassland during a 24 hour period and how this may change seasonally. Studies on private ranches are underway to document the effectiveness of protein supplement sites as attractants for beef cattle at different distances from stock water and riparian areas.

Methods

Four pastures, arranged in pairs were grazed for one week each during four seasons (January, March, April-May and August) of the year. One pair of pastures was an open woodland and the other pair had been cleared and was mostly devoid of trees except in the riparian corridor. Two herds of 20 cows grazed one pair of pastures one week and the other pair the following week during January, March, April-May and August. Six of the cows in each herd were equipped with global positioning collars that were programmed to take a position fix every 5 minutes for each one-week grazing period.

These positions were downloaded from the collars, corrected and loaded into a geographic information system (GIS). Using the GIS the positions will be overlaid on aerial photos, slope class maps or other layers for visualization and analysis of grazing, resting and traveling time and location. Two years of data collection was completed in late March 2003. Data from this study is currently being analyzed.

Preliminary Results

1. Distribution is heavily influenced by slope which has been found by many researchers.

2. Cows tend to return to graze in locations grazed in the past. This results in frequently used patches and seldom used patches reducing the carrying capacity of the pasture. Infrequent use results in a build up in litter that interferes with efficient foraging. Conversely, the frequently used sites do not have a build up of litter and can be used very efficiently by grazing animals year after year.

3. As forage near the water site is used cattle distribution increases.

4. Beef cows appear to return to the same bedding site each night.

5. The timing of morning and afternoon grazing bouts change with the seasons and are separated by a period of rest and rumination.

UNGRAZED BUFFERS FOR FILTERING RUNOFF

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Irrigated pastures serve a critical role in the economic stability of California's livestock industry by providing low cost, high quality summer forage. Surface water runoff from irrigated pastures can transport pollutants to nearby waterbodies. There is limited information on the pollutant trapping efficiency or nutrient holding capacity of vegetated buffers within these systems, making it difficult to make informed recommendations for size and long-term management of buffers. Buffer recommendations should be based upon an understanding of the relationships between grazing management, irrigation management, short-term buffer trapping efficiency, and long-term buffer capacity for the suite of pollutants common to pastures. The objectives of this project are to:

- **A.** Quantify the effectiveness of non-grazed buffers to attenuate NO_3, NH_4, total N, PO_4, total P, fecal coliforms, *E. coli*, and sediment in surface water runoff from grazed, flood-irrigated pastures over two years.
- **B.** Employ the N isotope method to quantify nitrogen dynamics within pastures, buffers and runoff water, as well as to determine whether buffer capacity for nitrogen decreases over time as buffer vegetation matures and plant species composition changes in the absence of grazing.
- **C.** Extend the results of this research to ranchers, UCCE advisors, natural resources agency staff and water resource regulators.

The project is being conducted on grazed, irrigated pasture at the UC Sierra Foothill Research and Extension Center near Browns Valley. Study design is completely random with 3 treatments applied to 9 pastures for 3 replicates. Buffer treatments are a 3:1 pasture area (240 m^2) to buffer area (80 m^2) ratio, a 6:1 pasture (240 m^2) to buffer area (40 m^2) ratio, and a no buffer control. The 3:1 and 6:1 ratio treatments have buffer widths of 16 and 8 m, respectively. Irrigation water is applied to the top of each plot and surface water runoff is collected and measured at the base of each plot. Plots are grazed by beef cattle prior to each irrigation trial.

Six irrigation trials were conducted during the summer of 2002. ^{15}N-labeled KNO_3 was applied and sampled across all 9 plots, allowing us to quantify how much N was lost as runoff, accumulated by the pasture, and attenuated by the buffers. Surface water runoff was measured and water samples collected at 0, 15, 30, 60, 90, and 120 minutes following commencement of runoff during each trial. Samples were analyzed for concentration of nitrogen, phosphorus, generic *E. coli*, fecal coliform, and other pollutants. Load of each pollutant lost per irrigation was calculated from runoff amount and concentration data. Preliminary results for indicator bacteria are presented here. Figure 1 reports the treatment mean concentration of generic *E. coli* and fecal coliform at each sample time, across all 6 trials. Figure 2 reports the treatment mean runoff rate at each sample time, across 6 trials. While still preliminary, these results indicate little attenuation of these indicator bacteria by either buffer treatment. Figure 2 clearly illustrates that the buffer treatments are having little effect on runoff rate, thus it is not surprising there is reduced bacteria transport with the buffer treatments. Irrigation water application rate during these trials was set to mimic the rates commonly applied in this landscape. Figure 3 reports the relationships found between runoff rate, fresh fecal load prior to irrigation, and *E. coli* load from a plot. Our preliminary conclusion is that irrigation application rate should be reduced to agronomic demand and the potential of buffers re-evaluated. We will conduct this follow-up research in summer 2003. Additional statistical analysis will be conducted on the 2002 data.

Figure 1.

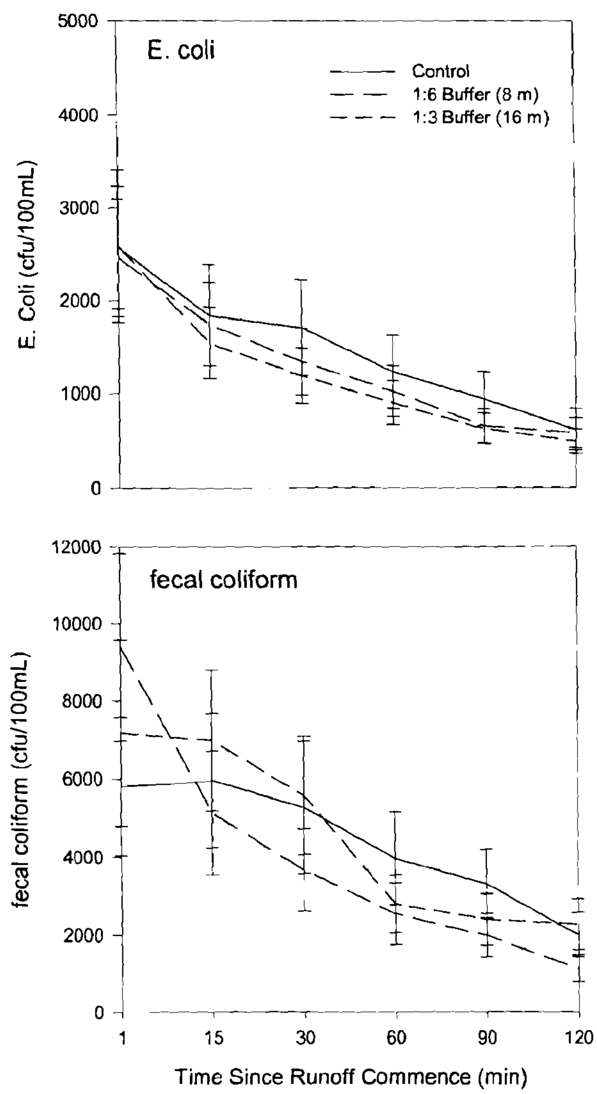


Figure 2.

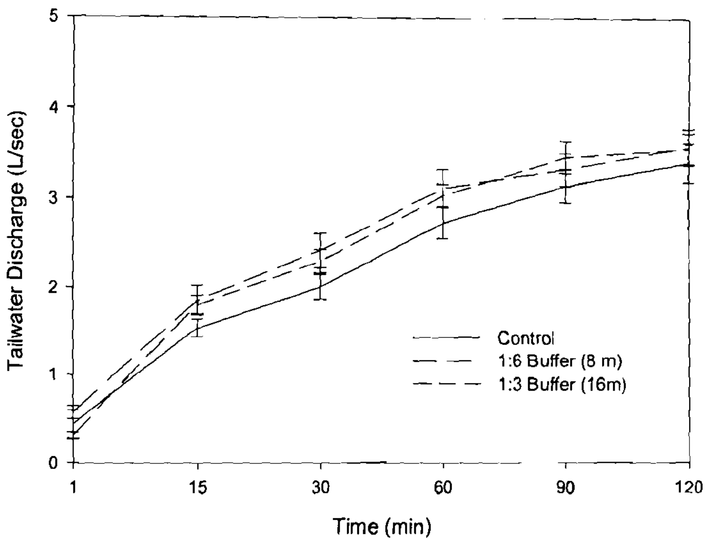
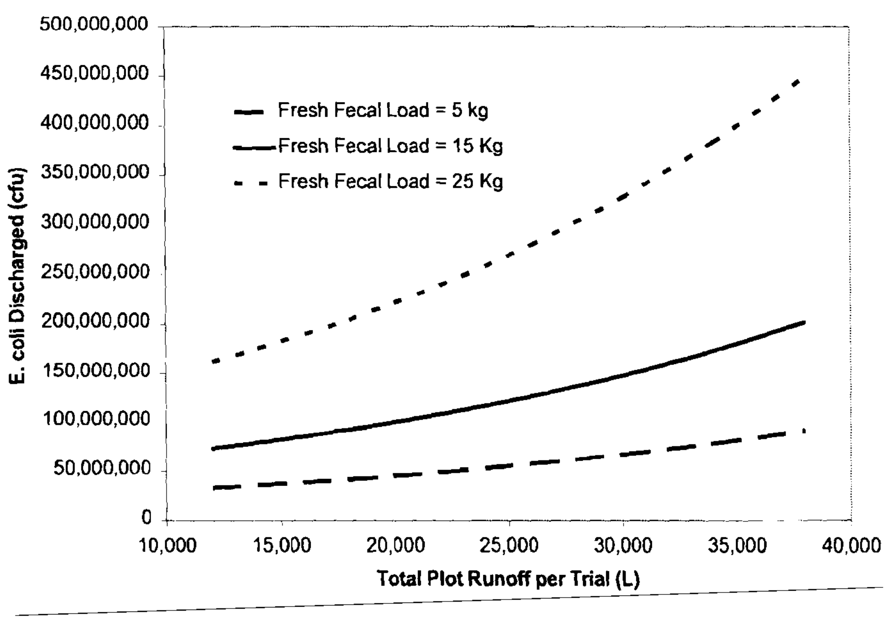


Figure 3.



ESTIMATING ENVIRONMENTAL LOADING RATES OF THE WATERBORNE PATHOGENIC PROTOZOA, *CRYPTOSPORIDIUM PARVUM*, IN CERTAIN DOMESTIC AND WILDLIFE SPECIES IN CALIFORNIA

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INTRODUCTION

Cryptosporidium parvum (*C. parvum*) is a protozoal parasite that can cause gastrointestinal illness in a wide variety of mammals, including humans, livestock, companion animals, and wildlife. New species of *Cryptosporidium* are constantly being discovered, such as *C. canis* and *C. felis*, but their significance relative to the large role that *C. parvum* plays in livestock and human cryptosporidiosis is still unclear. In the majority of livestock species, clinical disease and shedding of *C. parvum* typically occurs in youngstock under a few months of age, but fecal shedding of oocysts can also occur in healthy older animals which can then serve as a source of infection for these younger animals. In humans, clinical disease and shedding can appear at all ages, but is typically more common among children. The predominant clinical sign is profuse, watery diarrhea lasting from a few days to several weeks in normal (immunocompetent) individuals, but can be prolonged and life threatening among immunocompromised hosts such as AIDS patients. Modes of transmission range from direct fecal-oral transmission, as might occur between infected and susceptible calves during lay behavior, or ingestion of food or water inadvertently contaminated with oocysts from the feces of an infected host.

Waterborne transmission of the pathogenic protozoa, *Cryptosporidium parvum*, has emerged as an important public health concern. Because the infectious stage of *C. parvum* (oocysts) is resistant to conventional water treatment processes, public health agencies and water districts are actively seeking methods of reducing surface water contamination with this parasite. Protection of source water such as rivers and lakes has the potential to reduce the risk of transmission to humans and animals through drinking water, as well as through human recreational contact with untreated water. Given that the parasite readily infects a large number of mammalian hosts (Fayer et al. 1997), there are a number of possible contributing sources of oocysts present for any given watershed. Unfortunately, the primary quantitative sources of waterborne *C. parvum* oocysts are not well defined, and our methods of prioritizing point and non-point vertebrate sources of this zoonotic parasite are lacking.

Our objective is to develop a standardized methodology for comparing environmental loading rates for different populations of vertebrate hosts for *C. parvum*. Such a comparison would help form the basis of a rational decision making process for evaluating land use practices and vertebrate populations with respect to their relative environmental loading rates for important waterborne microbial pathogens. Both domestic and wild animal populations are infected by and can shed in their feces the infectious stage of this parasite. Attempting to characterize or assess the risk of point and non-point source protozoal contamination requires numerous parameters to be estimated, the most important being a valid and precise estimate of the oocyst loading rate per animal unit (Atwill et al. 2001; Hoar et al. 2000). The oocyst loading rate, which can be defined as the total number of oocysts excreted by a defined cohort of animals for a specific period of time, can be calculated directly by measuring the kinetics of total oocyst shedding, that is, duration and intensity per Kg feces, multiplied by fecal production. This direct measurement method is very difficult for free-ranging wildlife and some species of livestock. An alternative approximation for determining the oocyst loading rate for cohorts of mammals is to measure the prevalence of infection and the intensity of shedding using cross-sectional surveys of the mammalian population, and then relying on experimental or laboratory estimates of fecal production (Hoar et al. 2000). We applied these concepts to a variety of domestic and wild animal species to generate a set of comparative loading rates for the waterborne pathogen, *C. parvum*.

METHODS

For livestock, fecal samples were obtained either per rectum during herd visits or from freshly voided samples on pasture or rangeland. For wildlife species, the animal was dispatched according to the American Veterinary Medicinal Association's guidelines for harvesting wildlife, and fecal samples then obtained post-mortem. Fecal samples were shipped or delivered on ice to the Veterinary Medical Teaching and Research Center, Tulare, CA, where they were refrigerated at 4 C until examined for presence of *C. parvum* by means of a direct immunofluorescent assay as described elsewhere (Atwill et al. 1999). This assay generates an estimate of number of oocysts per fecal smear. In order to rescale this parameter to oocysts per gram of feces, we estimate the mean mass of a fecal smear (usually 17.0 to 18.0 mg) from 20 to 30 slides and the percent recovery of the immunofluorescent assay through spiking known negative fecal samples with known oocysts concentrations, as described in Atwill et al. 1998 and Pereira et al. 1999. Estimates for total fecal production wet weight per animal unit were either estimated from experimental feeding trials (California ground squirrels, coyotes), the literature (beef and dairy cattle), or were very crude estimates of using 2 to 4% of mean body mass (striped skunks, yellow-bellied marmots). Estimates of daily fecal production for the different species is the parameter with the greatest error at this time and in need of future improvement. The final equation for oocysts per gram of feces was: [(mean oocyst concentration per fecal smear)/(mean smear weight multiplied by percent recovery)]. The final equation for oocyst loading rate per animal unit was: [(mean oocyst concentration per Kg feces multiplied times total daily fecal production (Kg))].

RESULTS

The following results are a tally of the estimates of the mean daily *C. parvum* oocyst excretion rate (or environmental loading rate) per animal per species. The phylogenetics of this genus of protozoa are in a state of flux for the time, so exact species designation of *Cryptosporidium* from these various hosts may be revised in the future. In parentheses following the loading rate are the two parameters, mean oocyst concentration per Kg feces, total daily fecal production (Kg), that generated the estimate of the daily loading rate of *C. parvum*-like oocysts. These estimates should be considered crude estimates at this time, but they do allow a rough species-to-species comparison of how different vertebrate animals load a watershed with *C. parvum*.

1. San Joaquin Dairy Cattle (Holstein, *Bos taurus*)

Cows: 4,000 oocysts per day (67 oocysts/Kg; 60 Kg feces)

Calves: 3,000,000,000 oocysts per day (3,000,000,000 oocysts/Kg; 1 Kg feces)

2. California Beef Cattle (mixed breeds, *Bos taurus*)

Cows: 6,000 oocysts per day (150 oocysts/Kg; 40 Kg feces)

Calves: 600,000 oocysts per day (150,000 oocysts/Kg; 4 Kg feces)

3. California Horses (various breeds, *Equus caballus*)

Adults: similar to adult beef and dairy cattle

Foals and weanlings: not done adequately

4. Striped skunk (*Mephitis mephitis*)

Adults: 140,000 oocysts per day (2,800,000 oocysts/Kg; 0.05 Kg feces)

Juveniles: 88,000 oocysts per day (4,400,000 oocysts/Kg; 0.02 Kg feces)

5. California ground squirrels (*Spermophilus beecheyi*)

Adults: 78,000 oocysts per day (6,500,000 oocysts/Kg; 0.012 Kg feces)

Juveniles: 41,200 oocysts per day (10,300,000 oocysts/Kg; 0.004 Kg feces)

6. Coyotes (*Canis latrans*)

Adults: 41,000 oocysts per day (205,000 oocysts/Kg; 0.2 Kg feces)

Juveniles: 35,000 oocysts per day (505,000 oocysts/Kg; 0.07 Kg feces)

7. Yellow-bellied marmot (*Marmota flaviventris*)

Adult: 208,000 oocysts per day (10,400,000 oocysts/Kg; 0.02 Kg feces).

Juvenile: not done

DISCUSSION

Several inferences can be generated from this list of estimates of environmental loading of *C. parvum*. First, there exists a very wide difference between the excretion rate of oocysts by young-stock compared to adult animals for cattle populations. For example, for dairy cattle in the San Joaquin Valley, dairy calves can produce as much as 750,000 times more oocysts compared to dairy cows, despite that fact that dairy cows defecate 30 to 60 times more feces per day compared to calves. The ramifications of this difference in shedding across different age groups is that the vast majority of *C. parvum* oocysts produced by a dairy herd occurs in a very limited age group, that being calves from 1 to 30 days of age. This facilitates the management of *C. parvum* contamination on dairies because the manure from only a small subset of the population needs to be carefully managed, that being young calves. For beef cattle, given their seasonal calving patterns, the majority of protozoal contamination is limited to the time when young calves are present in the herd, allowing for very strategic grazing practices to be implemented. In contrast, both younger and older members of the wildlife populations examined in this study appear to shed appreciable amounts of oocysts, with adults in some populations shedding more oocysts compared to the young. This suggests that not only is the entire wildlife population at risk of contaminating watersheds with *C. parvum* if population densities are excessive, but that we do not have a seasonal reprieve of protozoal contamination as we do with some livestock populations such as beef cattle, horses, and mules (Atwill et al. 1998; Atwill et al. 1999; Atwill et al. 2000; Hoar et al. 2000). Given the fact that juveniles and adult wildlife shed oocysts, we can assume that pastures and rangeland are seeded with *C. parvum* prior to beef calving, thereby potentially serving as a source of infection for susceptible beef calves. Finally, it is worthy to note that both young and older striped skunks, coyotes, California ground squirrels, and yellow-bellied marmots produce more oocysts per individual animal than either beef cows or dairy cows. Much regulatory attention is being placed on the role that livestock play in contaminating watersheds with *C. parvum*. Assuming that collective our goal is to protect water quality and to minimize waterborne transmission of this parasite, it would be prudent to equally focus on the role that wildlife play in loading watersheds with this pathogenic protozoa if we are going to successfully protect the public's health from this pathogen.

ACKNOWLEDGMENTS

We would like to express our sincere thanks to the dedicated staff of the Wildlife Services, USDA, Kern County Mosquito and Vector Control District, and numerous private and governmental trappers throughout the State of California for assisting in this project. In particular, we are indebted to Joe Bennet and Scott Little, WS-USDA, for their tireless efforts on this project.

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