

UNIVERSITY OF CALIFORNIA

SIERRA FOOTHILL RESEARCH AND EXTENSION CENTER

Beef & Range Field Day



April 19, 2001

Browns Valley, California

THE UNIVERSITY OF CALIFORNIA
SIERRA FOOTHILL RESEARCH & EXTENSION CENTER

Presents:

Annual Beef & Range Field Day

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UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
DEPARTMENT OF ANIMAL SCIENCE, U.C. DAVIS
AGRONOMY & RANGE SCIENCE, U.C. DAVIS
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APRIL 19, 2001

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UC BEEF & RANGE FIELD DAY
Sierra Foothill Research & Extension Center, Browns Valley
APRIL 19, 2001

AGENDA

9:30am Welcome: Reg Gomes, Vice President Agriculture & Natural Resources, University of California

9:45am Overview of Vegetation Management on Rangeland – Roger Ingram, UCCE Farm/Livestock Advisor, Placer/Nevada Counties

10:00am Different Livestock for Vegetation Management – Wolfgang Pittroff, Asst. Professor, Animal Science Dept., UC Davis

10:20am Spatial Considerations for Using Livestock in Vegetation Management – Melvin George, Grazing Management Specialist, Agronomy & Range Science, UC Davis

10:40am Prescribed Fire - Considerations/ Obstacles to using prescribed fire as a vegetation management tool – Peter Hujik, Grasslands Manager, The Nature Conservancy

11:00am Prescribed Fire Impacts on Yellow Starthistle & Medusahead – Mike Connor, Superintendent, UC Sierra Foothill Research & Extension Center

Prescribed Fire Impact on Oaks – Douglas D. McCreary, Program Manager, Integrated Hardwood Range Management Program, UC Berkeley

Wildfire Impacts on Water Quality – Kenneth W. Tate, Rangeland Watershed Specialist, Agronomy & Range Science, UC Davis

Noon **LUNCH - Tri-tip BBQ served by the Yuba-Sutter Cowbelles and SFREC Staff.**

Luncheon Speakers: California Cattlemen's Association Officers will provide an Industry Update

1:30pm Forbes Creek Re-Vegetation – Douglas D. McCreary, Kenneth W. Tate, Dave Labadie, Principal Superintendent of Agriculture, SFREC & Jerry Tecklin, Staff Research Associate, Integrated Hardwood Range Management Program, UC Berkeley

2:40pm Effects of RDM Levels on Annual Range Composition, Production and Water Quality – James Bartolome, Professor, Ecosystem Sciences, UC Berkeley & Kenneth W. Tate

3:00pm Prescribed Fire for Barbed Goatgrass Control – James Bartolome & Aimee Betts, Graduate Student, Ecosystem Sciences, UC Berkeley

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Planned Herbivory for Vegetation Management

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The problem

Invasive weeds and fire fuel load are two of the most important environmental problems in California. These problems are the result of human interference with ecosystems. Their solution requires planned human interference with ecosystems, i.e. ecosystem management.

It is not possible to treat fire fuel load and invasive separately. The reasons are two-fold: One, fire fuel reduction opens space for the establishment of invasive weeds, and two, they share management methods and problems.

There are no consolidated data on the economic cost of these two problems (I will summarize them henceforth as 'problem vegetation'). A recent CAST report suggests that the damages for the entire US by invasive weeds may reach 20 billion dollars per year. Comprehensive cost figures for the fire fuel problem are not available, and more difficult to assess. They comprise cost of control and prevention, fire fighting, property damage, and the great unknown of 'collateral ecological damages'. These damages include: accelerated erosion and its effects on sediment load (water quality, water catchment and management, fisheries) and habitat loss.

Most vegetation managers do not intuitively consider 'planned herbivory' when thinking about biocontrol of problem vegetation. Rather, the term 'biocontrol' is reserved for 'natural enemies' of problem vegetation, for example insects and fungi that directly damage specific problem vegetation species. It is ironic that herbivores, which undoubtedly eat vegetation, including problem vegetation, are not considered biocontrol agents. Among the reasons, it may be suspected, is the fact that actually very little is known about planned herbivory. Biocontrol agents are supposed to be specific, and herbivores are frequently viewed as indiscriminate consumers of biomass, in random proportion of species. But, everybody who ever managed grazing livestock is familiar with the exquisite selectivity of goats, sheep and cattle. Yet, how do we put it to use? Even though the term 'planned herbivory' is used liberally, and by some even to market services, there is not much in terms of a scientific basis to support the claim that planned herbivory can be exercised with predictable results. If we had mastered 'planned herbivory', we would be able to:

- Predict the effects of planned grazing on vegetation
- Predict the effects of problem vegetation on animals.

In both areas, we face serious knowledge gaps.

Herbivores and their diets

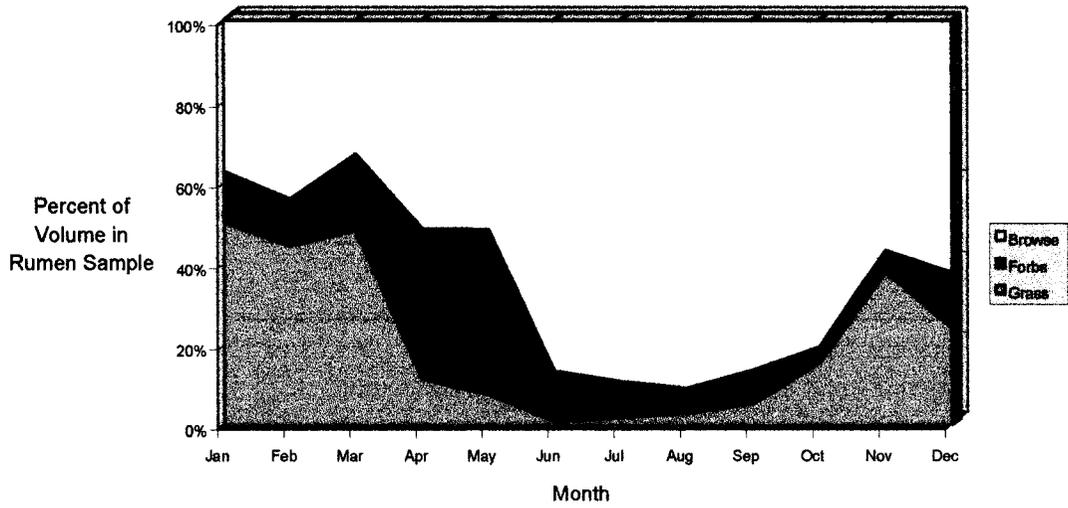
For all practical purposes, planned herbivory presupposes the use of domesticated herbivores, specifically ruminants. Ruminants have been classified into three distinct feeding types:

- Concentrate Selectors (CS)
- Intermediate Types (IM)
- Grass/Roughage Eaters (GR)

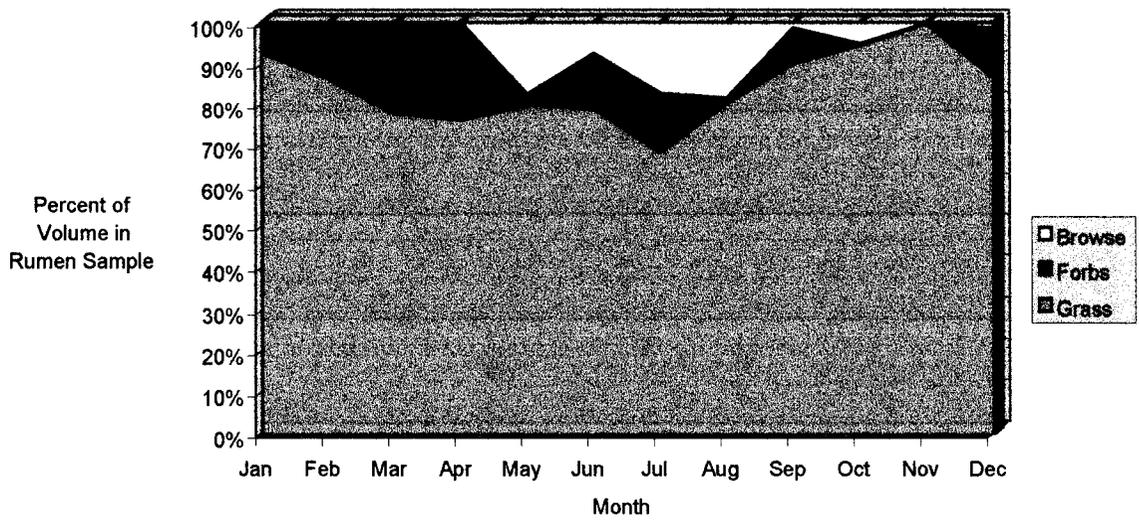
Several criteria, derived from anatomic, morphological and physiological features of ruminant species are used for this classification. Domestic herbivores fall into the categories of Intermediate Types (goats) and Grass/Roughage Eaters (sheep, cattle). Major differences are: *feeding rhythm*: IM animals eat more frequently than GR animals; *rumen anatomy & function*: the rumen of GR animals is especially adapted to the digestion of large amount of fibrous feeds; *prehensile organs*: lips, tongue, teeth and dental pad, for example, of goats, are more suited for the apprehension of browse than the corresponding parts of cattle.

It is important that these anatomical and functional differences, while apparent, are gradual, and thus cause *dietary overlap* between different herbivore species. This means, that parts of the diet are common between different herbivore species. The fact that dietary preferences, and thus dietary overlap, change between seasons, and in response to stocking rate, is the basis for the systematic exploitation of dietary overlap in *mixed species grazing* and, in the future, in planned herbivory. The former strives to optimize utilization of range forage resources, while the latter attempts to target specific problem vegetation species with maximum efficiency. The following graph illustrates the dynamics of dietary overlap between two species of herbivores across the year (data from Hopland Research and Extension Center, Longhurst et al., 1979).

Deer Dietary Profile



Sheep Diet Profile



Dietary overlap, planned herbivory and vegetation management.

If planned herbivory is to be used in vegetation management, we must develop the capacity to predict effects on problem vegetation. Too often, vegetation management by domestic livestock is understood as 'eliminating biomass'. Assuredly, it is not.

Vegetation management must be ecosystem management. Plant community development defines ecosystem function, for example in terms of habitat quality for animal and plant species of concern, and in terms of watershed management. Therefore, for planned herbivory to be effective, we must know the times when domestic biocontrol agents (i.e., goats, sheep, cattle) are likely to target specific plants and leave alone others. Thus, we need to understand the dynamics of dietary overlap. Unfortunately, very little is known about dietary overlap between domestic herbivores in California problem vegetation. Even worse, very little is known about the dietary properties of most problem vegetation species in California.

Several methods are available to study dietary overlap. Direct observation, analysis of feed samples collected through esophageal fistulae, micro-histological analysis of feces (by identification of remnants of individual species in the feces), and terminal sampling (slaughter and analysis of rumen contents) have been used. Recently, a marker-based method has come into more widespread application. The latter method employs the fact that plants contain several largely indigestible chemicals, which are present in proportions characteristic for individual species. By comparing the proportion of these chemicals in the feces with the quantities present in the vegetation consumed, an estimate of diet composition is possible.

All these methods have problems. Terminal sampling collects *one* sample. Variation in diet selection between seasons, and also between days, cannot be assessed by this method and results are not reliable. Only a large number of terminally sampled animals could improve the accuracy of the results. Direct observation is subject to observer bias and does not allow for an acceptable quantitative estimate of diet composition. Esophageal fistula sampling is problematic because the animals present difficult health problems in particular in brushy vegetation. Samples are collected usually once daily and may not be representative of the diet. Marker-based methods suffer from the fact that often more plants species than usable markers are present. Further, the recovery of the markers in the feces is incomplete, thus distorting the estimate of diet composition.

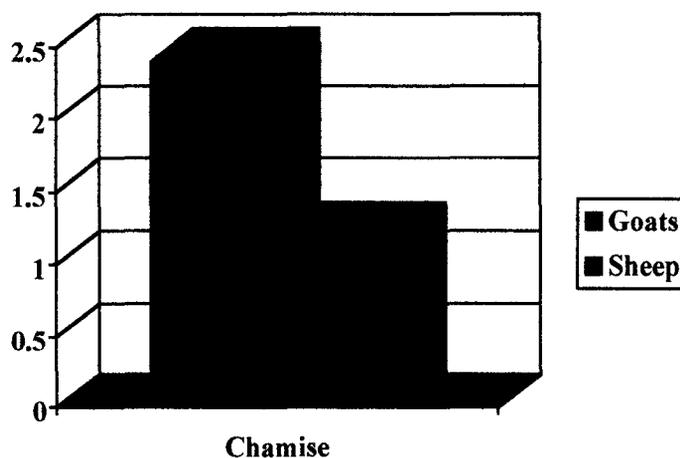
In order to obtain comprehensive information about dietary overlap, experiments must be conducted that collect data on diet composition across all seasons, and as a function of different stocking rates. Dietary overlap may, but not necessarily does, increase with increasing stocking rate.

The above points have several implications for management. First, the estimation of dietary overlap required in vegetation management must be *quantitative* in nature. This requirement rules out those methods that are weakest in determining *how much* of each species is consumed. Second, a simple dietary overlap estimate based on a species index, as it is frequently found in the literature, will not allow to calculate appropriate stocking

rates for mixed species grazing. Third, the quantitative estimation of dietary preferences of livestock to be used in vegetation management is the first research priority.

Why does dietary overlap change between seasons? Both animal requirements and plant nutritive properties change throughout the year. Changes in plants are probably much more important as a cause for variation of dietary preference, but animal-related factors (changes in nutrient requirements) certainly play a role.

Problem vegetation limits its consumption by herbivores by producing plant secondary compounds (PSC), which are aversive and/or toxic. The best-known example of course is Yellow Starthistle, which causes a neural disorder in horses, but does not harm ruminants. It is astonishing how little is known about the properties of PSC's of problem vegetation in California and their effects on livestock. PSC levels vary by plant part, by season, by soil type, by precipitation and by degree of herbivory. Almost nothing is known for California problem vegetation species in this regard. For example, various manzanita species are important elements of the fire fuel load in California Chaparral. From other members of the Arctostaphylos family we know that they contain high levels of tannins, which can cause toxic effects and limit consumption by various direct and indirect mechanisms. However, for the species present in California, no data on tannin content are available. In Australia and South Africa, non-nutritive supplementation strategies for animals consuming tannin-rich vegetation are in widespread use ('brush-up'). For the development of similar management practices in California, we must first understand the nature and effects of the toxins present in our plants. In our research program, we are investigating differences between sheep and goats in their consumption of brush species and the causes of these differences. The next graph, intake in grams dry matter of Chamise per kg body weight per day in sheep and goats, is an example. We suspect that the likely reason for this difference is the ability of goats to process a toxin present in Chamise more efficiently than sheep (data from Hopland Research and Extension Center, work in progress).



Once we have established information about dietary preferences of different livestock species, and understand the effects of problem vegetation on animals, we can develop prescribed grazing protocols. Such protocols must be designed to:

- Achieve the desired effects on problem vegetation;
- Minimize the negative effects of grazing and browsing on protected vegetation;
- Ensure optimal health management for the animals employed.

Outlook.

There is little doubt that livestock can be employed as a highly effective biocontrol agent for vegetation management. There is abundant evidence from many grazing studies that fire fuel can be reduced, and that invasive weeds can be pushed back by grazing. However, in order to develop livestock grazing and browsing into an effective biocontrol agent, we must develop much better understanding of the effects of vegetation on animals and their response in terms of dietary preferences and performance. We also must be able to integrate this knowledge with information about the effects of herbivory on plant communities, habitat quality, and watershed function. Only an integrated research and development program, combining different disciplines, can generate this information. Such a program needs to be conducted in close collaboration with vegetation management practitioners.

Spatial Considerations for Using Livestock in Vegetation Management

Melvin George, Rangeland Management Specialist,
Agronomy & Range Science, UC Davis

Livestock grazing and browsing will become a more widely used vegetation management option as the use of chemicals and fire become more restricted. Like chemicals, fire and mechanical methods of vegetation management, grazing can only be effective if the proper amount is applied at the right time and in the right place. While properly placed fences can control the timing and amount of grazing, they are seldom in the right place on rangeland grazing units. Frequently grazing to manage vegetation will have to rely on livestock distribution practices other than fencing. Successful treatment of a target vegetation patch with free ranging livestock will require more precise application of grazing management practices based, in part, on a better understanding of livestock foraging behavior.

The act of grazing a single plant is the product of a series of instinctive responses and behavioral actions leading up to a bite (Stuth 1991, <http://cnrit.tamu.edu/rlem/textbook/textbook-fr.html>). Each landscape unit (pasture, allotment, paddock) is composed of a complex of different habitats or distinct groupings of plant species in communities. Habitats are delimited by the type of plant species present, their spatial arrangement, and structural configuration. Habitats can be further delineated into patches which contain more homogeneous groupings of species. A patch might be a group of shrubs or the open grass interspace in an oak woodland. When the animal has oriented itself in a habitat it must decide when to lower its head and establish a feeding station along its grazing path. Within the feeding station, the animal must then select from among the individual plant species those it will consume and beyond that which plant parts will be eaten.

Bailey et al. (1996) describe 6 spatial scales for large herbivores in a foraging hierarchy. Each scale is functionally defined based on characteristic behaviors that occur at different rates. These levels are associated with different units of space that vary in absolute dimension with the body size and foraging strategy of the herbivore. The smallest scale is a *bite* and is clearly defined by a sequence of herbage prehension, jaw and tongue movements, and severance by head movement. *Feeding station* is an array of plants available to a herbivore without moving the front feet. *Patch* is a cluster of feeding stations separated from others by a break in the foraging sequence when animals reorient to a new location. A *feeding site* is a collection of patches in a contiguous spatial area that animals graze during a foraging bout; it may contain 1 or more plant communities. Foraging bouts are defined by a change in behavior from grazing to resting, ruminating or behaviors other than foraging. A *camp* is a set of feeding sites that share a common foci where animals drink, rest, or seek cover. Typically, movements between camps involve the whole social unit and may occur every few weeks. *Home ranges* are collections of camps and are defined by fences, barriers, extent of migration, or transhumance. In some pastures and in other situations, there may be only 1 camp within a home range.

Spatial choices that place an animal or herd in a landscape prior to taking a bite are based on the kind, level and quality of resources found there. Abiotic factors (e.g. slope, air temperature and distance from water) and biotic factors (e.g. forage quality and quantity, species composition, plant morphology and canopy cover) influence the spatial choices of range livestock (Senft et al. 1987, Smith 1988). Understanding how livestock use a given landscape is fundamental to solving grazing distribution problems and to managing vegetation with livestock. Can we effectively and predictably attract cattle into a medusahead or starthistle patch during the window of time when grazing can reduce or manage these weeds? Or conversely can we effectively and predictably attract livestock away from riparian-stream systems? Can animal spatial choice be influenced by animal culling and selection practices? How does livestock distribution change in response to seasonal changes in forage quality? How important is landscape temperature in determining animal distribution? These are just a few questions that need to be addressed as we develop strategies for managing vegetation with livestock and for reducing the undesirable impacts of grazing. Several researchers in the west are tackling some of these questions.

The seasonal influence of stock water and supplement as livestock attractants in foothill rangelands was the subject of a recent joint UC Davis and Oregon State University study at the San Joaquin Experimental Range (SJER) in Madera County (Harris et al. 2000). These studies have shown that water and supplement are strong but variable attractants in the landscape. During the rainy season when streams are flowing and forage is lush, stock water developments are visited infrequently but properly placed supplement sites are strong attractants. During the summer dry season livestock visit stock water daily following their morning grazing bout and supplement is a strong attractant.

Recent studies (Baily and Welling 1999, and Baily et al. 2000) in Montana have also shown that supplement is strong attractant on foothill range except when placed in cold sites. Observers found fewer cows at supplement sites when mean daily wind chills were less than 25 F. When temperatures were below freezing cattle avoided the supplement barrels when wind was blowing more than 12 mph. When air temperature was above freezing wind had little effect on supplement use. Studies at SJER suggest that cattle actively seek thermal comfort in summer and winter, avoiding cold sites in the winter and seeking cool sites in the summer. In January 2001 one hundred temperature sensors were placed throughout three pastures to develop a temperature profile of the landscape. On a clear morning there were differences of 10 to 15 C across the landscape. Differences were less on cloudy and rainy days. Knowing the seasonal temperature profile of a topographically diverse grazing unit may be extremely useful in the effective application of livestock distribution practices.

Foraging behavior is learned behavior passed from one generation to the next but there may also be genetic differences in foraging behavior. The opportunity to alter a herd's distribution patterns through breed selection is being investigated by researchers at the Northern Montana Agricultural Research Center near Havre, MT. In a recent study researchers found that 3/4 Tarantaise - 1/4 Hereford cows tended to make better use of rough terrain while 1/4

Tarantais - 3/4 Hereford cows tended to be bottom dwelling riparian huggers. Further studies of the genetic basis of foraging behavior are planned.

Last spring USDA funded a four year, three state research and extension demonstration project (UC Davis, Montana State University and Oregon State University) that proposes to improve our ability to predict livestock distribution patterns and to manipulate distribution through the precise application of traditional grazing management practices. The results of these studies will be integrated into existing extension and classroom education programs.

One of the studies in this project is just beginning at UC SFREC and will investigate the influence of several abiotic and biotic factors on livestock distribution during different seasons of the year. In this study six cows equipped with global positioning collars in each of four small herds (20 to 25 cows each) will be tracked by recording their positions every 15 minutes during a one week period.

The four small herds of 20 - 25 cows each (Herds A, B, C, D) will be rotated through several pastures at SFREC during a single year to accommodate one or more research projects. Four to seven times annually these herds will graze pastures 1, 2, 3, and 4 as part of the station rotation sequence. Each herd will always graze in the same pasture (Herd A in Pasture 1, Herd B in Pasture 2, etc.). Our goal will be to have seven one week grazing sessions in each pasture. At a minimum the pastures will be grazed during rapid spring growth, end of growing season, dry season, and early in the growing season.

The pastures are paired. Pastures 1 and 2 will be grazed during one week and pastures 3 and 4 will be grazed the following week. Pasture 1 (F1-41 & F1-44) and Pasture 2 (F1-42 & F 1-43) are largely open grassland with a few trees and shrubs at the east end. Pasture 3 (H7) and Pasture 4 (P1-21) has oak trees distributed throughout the pastures.

Spatial analysis techniques will be employed to determine the influence of slope, distance from water, canopy cover (shade), shrub density, rockiness, accessibility, roads and trails, air temperature, forage quantity and quality, presence of undesirable weeds, and presence of biting insects on animal movements, feeding and bedding sites. From this study we hope to improve our ability to predict and manipulate livestock distribution in foothill rangelands so that vegetation management using livestock can be improved and undesirable livestock impacts can be reduced.

Literature Cited

- Bailey, Derek W., John E. Gross, Emilio A. Laca, Larry R. Rittenhouse, Michael B. Coughenour, David M. Swift, and Phillip L. Sims. 1996. Mechanisms that result in large herbivore grazing distribution patterns. *J. Range Manage.* 49:386-400.
- Bailey, D.W. and G.R. Welling. 1999. Modification of cattle grazing distribution with dehydrated molasses supplement. *J. Range Manage.* 52:575-582.
- Bailey, D.W., E.T. Miller, and G.R. Welling. 2000. Cattle use of foothills rangeland near low-moisture molasses blocks. Abstr. 53st Annual Mtg. Soc. Range Manage.
- Harris, Norman R., Douglas E. Johnson, Melvin R. George, and Neil K. McDougald. 2000. Abiotic and biotic factors influencing cattle distribution on the San Joaquin Experimental Range (California). Remote Sensing Research and Applications to Range Management Symposium. Abstr. Annu. Mtg. Soc. for Range Manage. 53:41.
- Senft, R.L., M.B. Coughenour, D.W. Bailey, L.R. Rittenhouse, O.E. Sala and D.M. Swift. 1987. Large herbivore foraging and ecological hierarchies. *BioScience* 37:789-799.
- Smith, M.S. 1988. Modeling: three approaches to predicting how herbivore impact is distributed in rangelands. New Mexico State Univ. Agr. Exp. Sta. Res. Rep. 628.
- Stuth, Jerry W. Foraging Behavior. *In: Heitschmidt, Rodney K. and Jerry W. Stuth (ed.). 1992. Grazing Management, An Ecological Perspective. Texas A & M University, College Station, TX.*

Yellow starthistle and Medusahead Control Activities at Sierra Foothill Research and Extension Center

Mike Connor, Dustin Flavell, Dave Labadie and Tammy Karnow
ANR: Sierra Foothill Research & Extension Center

We are currently following a management plan at Sierra Foothill Research and Extension Center which attempts to control three important weeds - yellow starthistle (YST), medusahead, and barbed goatgrass - over about 1000 acres of the Center. YST is the major target because it is widespread and invasive, but we are also focusing on barbed goatgrass. While not as common here as starthistle, the weed is highly invasive and we are trying to control it before it becomes more widespread. Medusahead has been a problem here for years, and we are using fire in an attempt to manage this weedy grass.

Since these weeds are not only present at SFREC, but are common throughout much of California's foothill rangelands, we are studying control methods and the physiology of the species as well as practicing practical control and management. The goatgrass work will be addressed this afternoon; I will discuss our studies with YST and medusahead.

Yellow Starthistle

Transline. We have been conducting several multi year trials studying YST control. In small plot trials, Transline (clopyralid) was applied during the late winter in 1997 and 1999, skipping 1998. Application was by ground sprayer at the rates of 1/8 pt./ac. in 1997 and 1/4 pt./ac. in 1999. The chemical was mixed with 18 gal./ac. of water. Control was excellent and appeared to be complete with the heavier rate (Table 1). These results agree with our other work here and research other locations (DiTomaso et al. 1999a). Interestingly, there seemed to be a carry-over effect into 1998 from the application in 1997. This carry-over has shown up in some, but not all, of our other plots. If the effect is real, it is presumably because of the reduction in seed production due to the near complete control of YST the previous year.

Table 1. Effects of Transline on Yellow Starthistle

<u>Treatment</u>	Year 1997		Year 1998		Year 1999	
	Canopy %	Plants/SF	Canopy %	Plants/SF	Canopy %	Plants/SF
Control	6.0 b	2.3 b	44 b	11 b	16 b	6.4 b
Transline	0.5 a	0.1 a	25 a	2.8 a	0.0 a	0.0 a

Treatment means in the same column followed by different letters are significantly different at $P < 0.05$

In field scale trials, 1/4 pt./ac. of Transline in 10 gals./ac. of water was applied by helicopter in the February or March of 1999, 2000, and 2001. We attempted to spray before herbaceous plants had grown to four inches in height, and on a calm day. Treatment fields were from 15 to 140 acres in size. Treatments included Transline three consecutive years: 1999, 2000 and 2001 (TTT); Transline in 1999 followed by a prescribed burn in 2000 and Transline in 2001 (TBT); prescribed burning in 1999, followed by Transline for two consecutive years: 2000 and 2001 (BTT); or no treatment (C). Treatments were randomly assigned to fields, with two replications. To test the results, five 200-foot-long transects were permanently established in open grasslands in each of the eight fields. Composition of important species or classes of species is determined along each transect in February or March and again in late May or early June of each year at maturity of annual grasses, but prior to prescribed burning. The fields are rotation grazed to a moderate level throughout the fall, winter and spring seasons. Grazing is excluded one month prior to plot observation to assist in plant species identification.

The fields had similar composition of YST prior to the trial, based on observations made in March 1999 (Figure 1). Transline was effective in the field scale trial as it was in the small plots. Observations showed less than 0.5% starthistle composition in June in treated plots.

In February of 2000, the observed composition of YST in all treatments was low, except in the fields that had been burned the previous year. In May 2000, those treatments that had received Transline that year, TTT and BTT, demonstrated effective control of YST with composition at 4% or less. Interestingly, treatment TBT fields, which received Transline in 1999 but not in 2000, contained significantly less starthistle than did the control. A carry-over effect of a reduced seedbank resulting from excellent control the year before may be the reason.

In the spring of 2001, all treatments were essentially equally effective, with a 1 to 2% composition of starthistle vs. 9% in the untreated control fields.

Prescribed burning. Prescribed burning is being tested as part of the integrated, multi year starthistle control program discussed above. Prescribed burns were conducted on June 16 and 17, 1999 and July 2, 2000. Center personnel assisted California Department of Forestry and Fire Protection (CDF) burn units in lighting the burns, and we stood by through the night to make sure there was no escape. The burns were moderately cool; most were started in the evening and allowed to burn into the night. We attempted to burn after maturity of annual grasses, so that they had set seed, but prior to viable seed production in YST. The target was 2 - 5% bloom in starthistle. The objective is for the fire to girdle the starthistle plants, killing them before they produce viable seed, a technique that has been shown to be successful in prior research (DiTomaso et al. 1999b). Coordination of permissive burn days, air quality “windows”, available burn allotments, weather, and availability of CDF units was difficult. Starthistle reached a more advanced stage of maturity than the desired 2- 5% and perhaps as much as 25% flower by the time some burns took place. In spite of that, we appeared to get a good kill and virtually no flowering of starthistle was observed following the burns.

The first impacts on YST of the 1999 burn showed up in the observations made in February 2000 (Figure 1). All treatments except the burned fields (treatment BTT) contained similar concentrations of starthistle seedlings, 3 - 5% of the plant composition. In the fields burned in 1999, YST made up a significantly larger portion of the plant composition at 16%. Starthistle and other forbs (especially rose clover and filaree) competed very successfully in the absence of thatch and residual plant material following the fire. We think this is desirable: a high rate of germination of starthistle may speed depletion of the seedbank. In May, 2000, treatment BTT showed a substantially higher, but not statistically different, level of YST than did the TTT fields. This difference, if real, may be due to a less effective aerial application of Transline which appeared to occur in 2000 in those fields due to windy weather during application. Alternatively, burning the previous year may not have controlled starthistle as well as it appeared.

Observations in the spring of 2001 showed the treatments that included burning, either in 1999 or 2000, to be as effective at this point as those that had received Transline both years.

Medusahead

Herbicide treatment did not significantly affect medusahead composition in the small plots in either 1999 or 2000. Blocks, representing different locations in the trial site, differed significantly. They ranged from 12 - 57% in medusahead composition in 2000 and 4 - 52% in 1999. Medusahead composition varied more by location (block) than by treatment. These trials indicate that control of YST could result in increased levels of medusahead in locations where medusahead was a major component of the species mix at the beginning of treatment.

In the field scale trial, either one or two years of Transline application (treatments TTT or TBT) resulted in high levels of Medusahead in 2000, about 29% or 19% composition, respectively, compared to non-treated (C) areas (5% composition). Prescribed burning substantially reduced medusahead levels: the treatment utilizing burning the first year followed by Transline the second year (BTT) resulted in the lowest levels of medusahead, substantially less than in other treatments, but not significantly different from controls. Compared to the non-treated control, Transline application appeared to increase medusahead populations.

Our burning procedure was geared toward control of starthistle, rather than medusahead. If the latter had been our primary target, we would have tried for earlier burn dates. The recommended timing for a burn to control medusahead is after the seed has set, when most other annual grasses have matured so that they will carry a fire, yet before medusahead seed heads have shattered. When the seed heads are located above ground level, they are subjected to the hottest part of the burn. Our burn appeared to be effective against medusahead even though it occurred a few weeks later than the ideal time.

We will continue to monitor these treatments for several years.

Cost of Treatment

The approximate costs per acre per year for treatments are as follows:

Aerial spraying	
Transline	\$ 12.00
Helicopter application	<u>14.50</u>
	\$ 26.50

Spot spraying in small new invasions or following field-wide control. This assumes about 1/10 of an area, e.g., 100 acres of a 1000 acre field, is actually sprayed. Labor is high because the entire area must be checked, although only 1/10th is treated. Costs given are for the area actually treated.

Chemical	\$ 12.00
Labor	12.00
Equipment maintenance	<u>1.00</u>
	\$ 25.00

Prescribed burning. We enjoyed substantial assistance from CDF lighting and controlling the fire. CDF Washington Ridge Conservation Camp crews built some fire breaks in rough terrain.

Fuel, oil, repairs for equipment	\$ 2.50
Labor for fire breaks, fire control, cleanup	17.50
Permits (subject to change in the future or by county)	.50
Seed, fertilizer for fire breaks and selected areas	<u>2.50</u>
	\$ 23.00

Conclusions and Recommendations

Transline successfully controls yellow starthistle during the year of application at the field scale as well as the small plot level. Multiple years of treatment are necessary because a seed bank has been established which lasts for several years. Research indicates that at least three years of treatment are necessary, followed by spot treatment to pick up re-invasions.

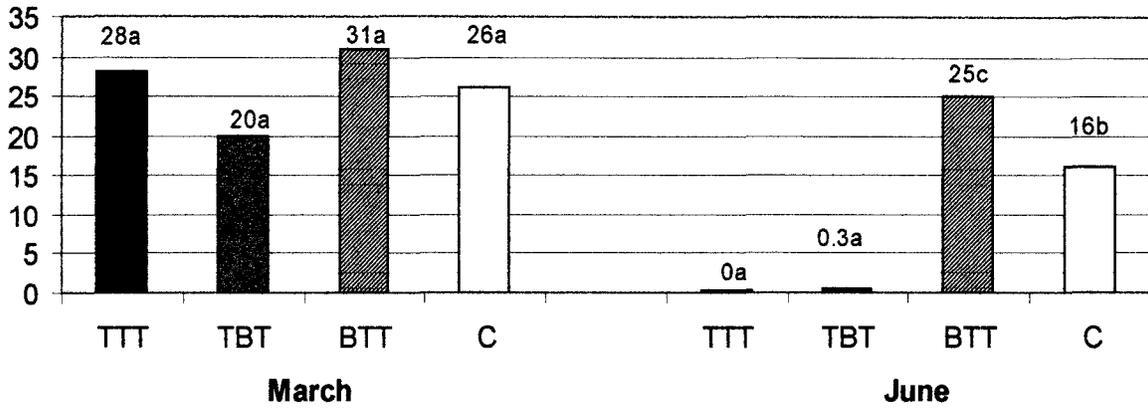
Prescribed burning can effectively serve as at least one year's treatment in a multiple year treatment program. While our conclusions regarding burning for YST control are based on just one year of data, they agree with research done elsewhere.

Medusahead, if present in large enough concentrations, may at least partially replace YST that is removed by chemical treatment. Integration of prescribed burning into a treatment program appears to be effective in reducing medusahead populations, and it may discourage medusahead replacement of controlled yellow starthistle.

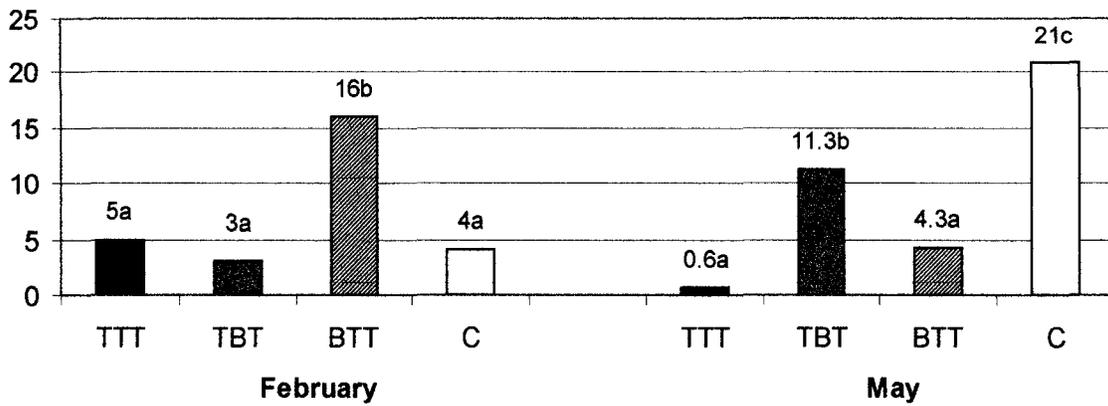
We will continue to monitor the results of these treatments for several years.

Fig. 1 TRANSLINE, PRESCRIBED BURN EFFECTS ON YELLOW STARHISTLE

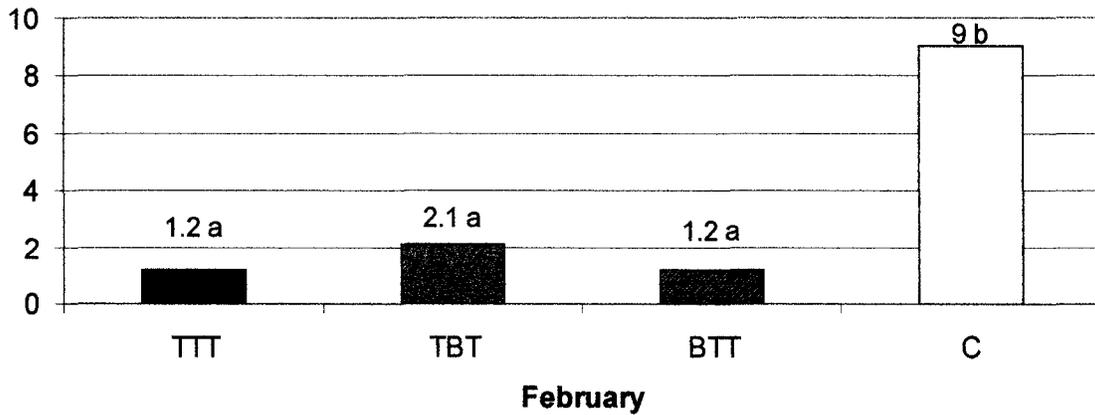
Year 1999



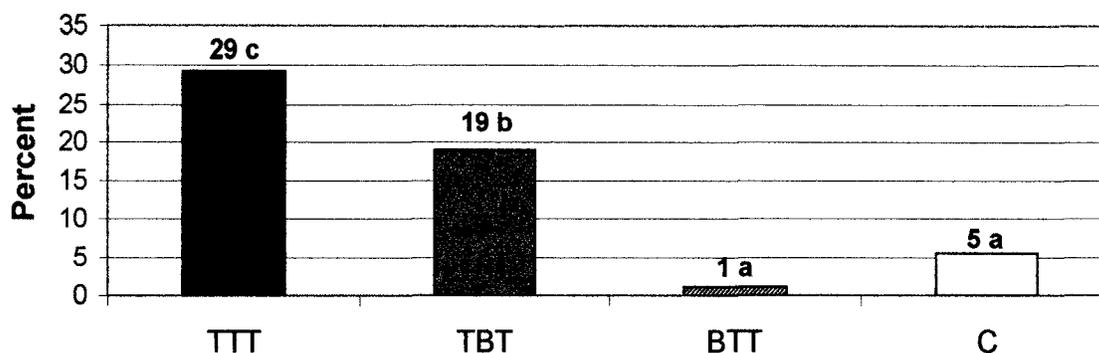
Year 2000



Year 2001



**Fig. 2 MEDUSAHEAD COMPOSITION
Year 2000**



Other Reading

DiTomaso, J.M., G.B. Kyser, S.B. Orloff, S.F. Enloe and G.A. Nader. 1999a. New growth regulator herbicide provides excellent control of yellow starthistle. *California Agriculture* 53(2):12-16.

DiTomaso, J.M., M.S. Hastings, and G.B. Kyser. 1999b. Prescribed burning for control of yellow starthistle (*Centaurea solstitialis*) and enhanced native plant diversity. *Weed Science*, 47:233-242.

Effects of Fire on Oaks in the Sierra Foothills

Doug McCreary, Natural Resources Specialist
University of California Cooperative Extension

In many portions of California, the threat of catastrophic fire has increased in recent years as a result of decades of fire suppression and dramatic increases in combustible fuels. Rapid population expansion into foothill regions where wildlands now interface with homes and businesses has further increased this threat, as well as the potential for devastating property loss. Research on fire frequency in oak woodlands at the Sierra Foothill Research and Extension Center (SFREC) and elsewhere has shown that fire frequencies of 8 to 15 years were common in foothill oak woodlands until the mid-1950's. Since that time, however, the frequency has been much less, but the risks of high intensity, catastrophic wildfires have been higher.

One of the reasons there is currently considerable interest in using prescribed fire as a management tool is that it offers a method of reducing fuels and, consequently, the risk of large and damaging wildfires. But any burning in the low elevation Sierra foothills often impacts oak trees. Unfortunately, until recently there was little interest in the effects of either prescribed or natural fires on oaks, since the major species were not considered commercially important and the common perception was that they were too abundant anyway. Consequently, there has been relatively little research addressing the consequences of fires on the various hardwood species comprising the woodland forests, or protecting trees from damage during controlled burns. In the last two decades, however, the critical role that hardwoods play in forests has been increasingly recognized and appreciated. Hardwoods are not only vital to numerous species of wildlife, but play vital roles in nutrient and water cycling, stabilizing soil, and reducing erosion. It is therefore important to understand the effects of both natural and prescribed fires on native hardwoods so that the important values associated with these species are not inadvertently lost.

Here at the SFREC we have initiated a project to examine the effects of prescribed fire on oaks. One hundred and fifty blue oak trees within the perimeter of two prescribed burns conducted last summer were tagged and evaluated. Trees were selected to represent a range of size classes and apparent damage levels and each tree was rated for the extent of foliage, bud and bark damage immediately after burning. A number of other variables were also recorded including the height and canopy diameter of each tree, the presence or absence of ladder fuels, and stand density. While these trees are just now being reassessed, previous observations following other fires suggests that oaks are very resilient and can survive burning, and that it is difficult to determine the severity of damage from initial visual appearance alone. Within a week or two following either prescribed or natural fires the foliage on many trees turns completely brown and the trunks can be blackened. Although the trees may look terrible initially, the majority are not killed – or even seriously injured. In most cases, these trees leaf out normally the following spring, and within a couple of years it can be difficult to even identify trees that

were previously burned. For instance, in a study in Tehama County conducted last year, less than 5% of trees failed to leaf out the spring following a wildfire, even though all of the leaves on many trees were singed and brown immediately after the fire. Thus it is clear that the appearance of the foliage following fire is not a very good indicator of the severity of damage and whether or not trees will recover.

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

The results of these projects suggest that native California oaks are relatively resistant to either prescribed or natural fires and have developed mechanisms to withstand adverse impacts and are able to survive, reproduce and grow.

Water Quality following 1997 Williams Incident Wildfire - Yuba County, CA

Glenn Nader, Ken Tate, Randy Dahlgren, David Lewis, and Pete Sands
Agriculture & Natural Resources, University of California

The Fire

The Williams Incident fire occurred in September 1997 in the Oregon House and Dobbins communities of Yuba County. A total of 5300 acres were consumed at variable fire intensities. Due to erosion concerns, 1500 acres of high fire intensity burned areas on steep slopes were seeded with grasses and clovers by air.

Water Quality Monitoring following the Fire

Water quality monitoring was conducted on an intermittent stream draining a small (< 100 acre) watershed within the Thousand Trails Campground for two rainfall seasons (1997-98 and 1998-99) following the fire. Samples were collected using an automatic sampling device. Samples were collected every hour during storms and weekly between storms. Samples were analyzed for the concentration of total suspended solids (TSS), nitrate (NO₃) and ammonium (NH₄). Sample turbidity was also determined. This watershed was not seeded.

Comparison of Post Fire Water Quality to other Rangeland Watersheds in CA

Because there is no pre-fire water quality data for the Thousand Trails (TT) watershed, it is difficult to quantify the exact effect the fire had on water quality. Without pre- and post-fire data from an unburned control watershed, it is also difficult to account for the effect of yearly precipitation variation. For instance, 1997 water year (El Nino) annual rainfall at Sierra Foothill Research and Extension Center (SFREC) was 52 inches while 1998 (La Nina) rainfall total was 29 inches.

Our sampling was not a designed experiment, rather it was opportunistic sampling to quantify water quality from the TT watershed following wildfire for comparison to water quality data from other watershed in the area. This information is of value to us as we prepare to conduct watershed scale prescribed fire and grazing experiments across the State, as well as to local and state entities wrestling with the possible environmental impacts of wildfire.

To provide some perspective on the water quality data collected from TT following the fire, we compare this data to that from 3 small, un-burned rangeland watersheds located within 5 miles of the TT watershed on SFREC (watersheds SF-1, 2, and 3). The SFREC watersheds have fairly similar soils and topography to the TT watershed, but the TT watershed contains more chaparral species than the SFREC watersheds. SFREC watersheds 1, 2, and 3 are 100, 250, and 310 acres in size, respectively. Watershed 1 is ephemeral while watersheds 2 and 3 are intermittent. Water sample collection, handling, and analysis of Thousand Trails samples was conducted in the same manner as on our SFREC watersheds.

Sediment and Turbidity

Figure 1 illustrates the intensive sampling frequency employed to collect water quality data from TT and SF-2 watersheds, with particular focus on storm events. Over 100 water samples were collected each year on each watershed reported in this paper. Significantly higher turbidity readings were realized on the TT watershed compared to all three SFREC watersheds. The high suspended sediment and turbidity readings at TT compared to SFREC indicates that accelerated erosion and significant transport of ash likely occurred during both years following the fire. We did observe hydrophobic soils in the TT watershed following the fire that could account for reduced infiltration of rainfall and increased overland flow and erosion.

Nitrogen

Essentially no nitrogen in the form of ammonium (NH_4) was detected from the TT watershed, or any of the other watersheds (Figure 4 and 5). This is not too surprising NH_4 as is tightly bound to soil and organic matter. While detectable levels of nitrogen in the form of nitrate (NO_3) were realized from the TT and all other watersheds, mean concentrations were not excessive (Figure 4 and 5). Relative to all other watersheds, nitrogen concentrations were intermediate. This is surprising given the highly mobile nature of NO_3 . Again, there could have been a significant increase in NO_3 following the fire that we cannot determine without baseline data. However, even if there were increases, the levels of NO_3 and NH_4 in TT streamflow are not remarkable when compared with other rangeland watersheds.

Fire v. Water Quality Research

We are currently collecting baseline data from our 11 experimental rangeland watersheds across the State to allow for controlled and replicated examination of fire, vegetation, grazing, hydrologic and water quality relationships. As the urban-wildland interface continues to grow in California's annual, oak woodland, and chaparral rangelands we will need knowledge about the water quality ramifications of fuel management by grazing and prescribed fire versus wildfire.

Figure 1. SFREC Watershed 2 and Thousand Trails Watershed Turbidity Measurements 1999 Water Year.

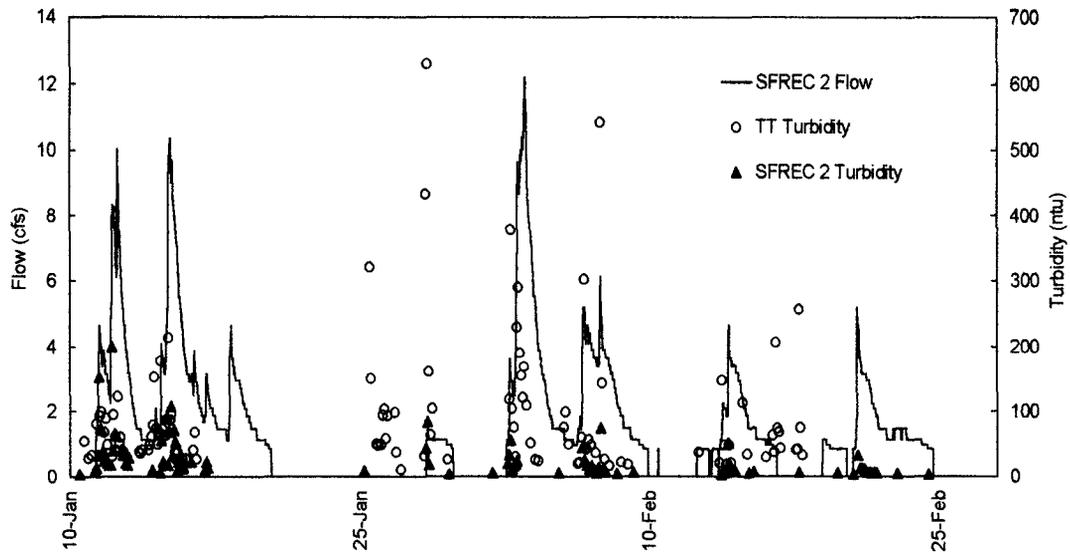


Figure 2. Mean TSS Concentration and Turbidity for SFREC and TT Watersheds 1999 Water Year

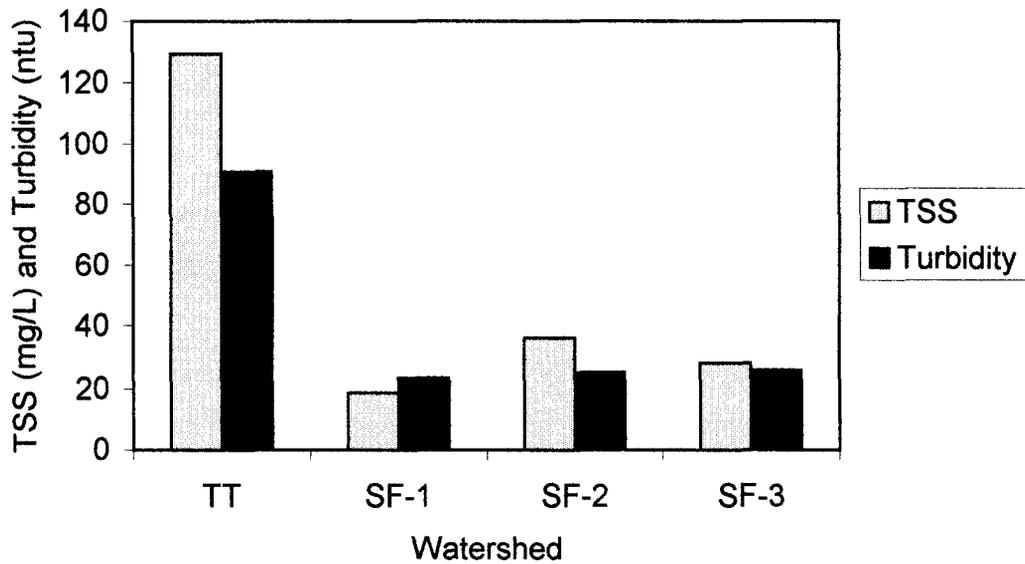


Figure 3. Mean TSS Concentration and Turbidity for SFREC Watersheds and TT 2000 Water Year

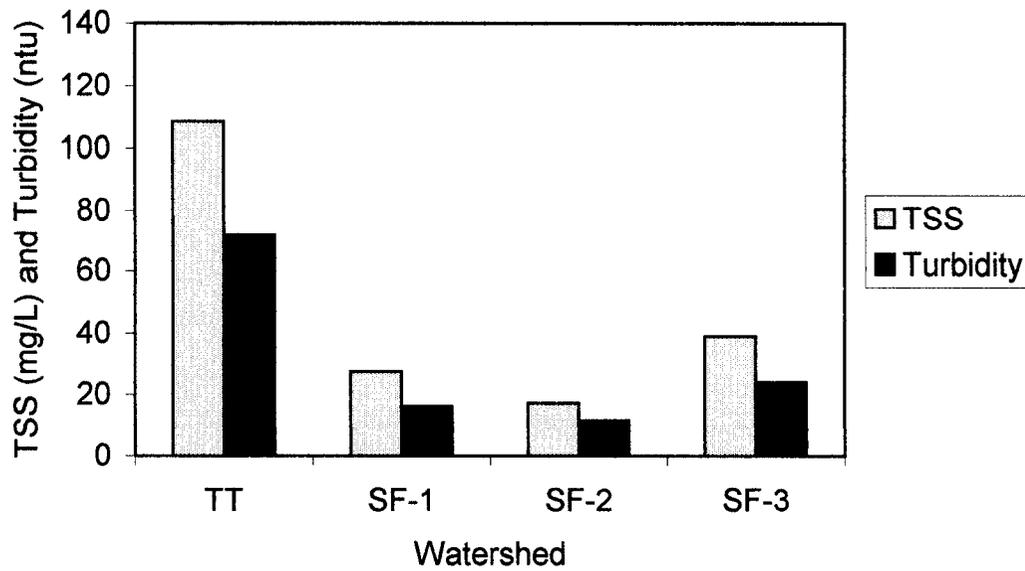


Figure 4. Mean Nitrogen Concentrations for SFREC and TT Watersheds 1999 Water Year

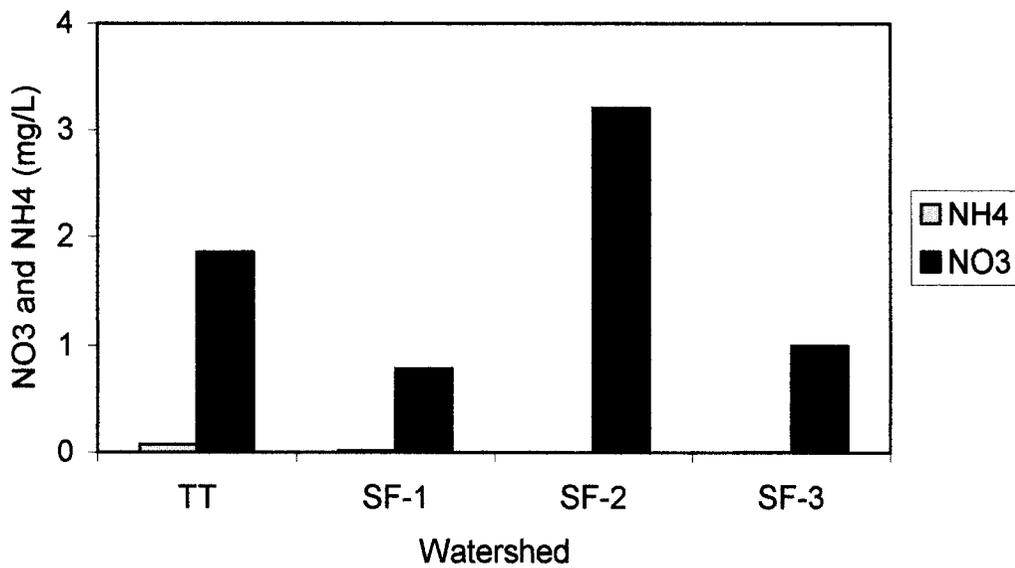
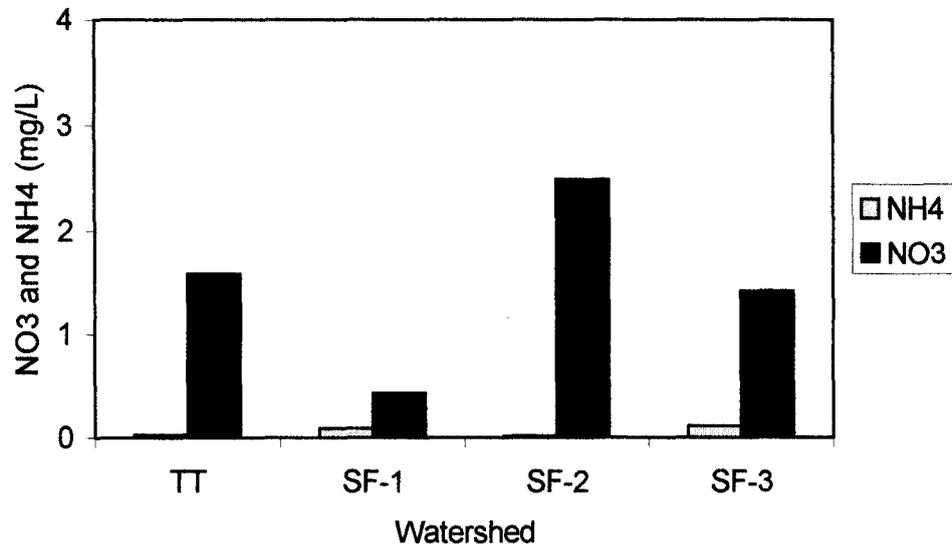


Figure 5. Mean Nitrogen Concentrations for SFREC and TT Watersheds 1999 Water Year



Forbes Creek Revegetation and Erosion Reduction Project

Doug McCreary, Glenn Nader, Ken Tate, Jerry Tecklin,
Dave Labadie and Theresa Ward
Agriculture & Natural Resources, University of California

In the 1960's, an area known as Forbes Hill at the SFREC was cleared of all woody vegetation. This required several years and was accomplished through a combination of herbicides, mechanical removal, and burning. The purpose of this clearing was to improve access for cattle management, to increase forage production for the cattle herd, and to create a set of reasonably uniform pastures for various animal and range trials. Another result of the clearing was to increase the flow of water in a perennial stream known as Forbes Creek. The removal of the woody plants along the creek also seriously reduced the wildlife habitat value and exposed the stream banks to grazing animals, increasing the potential for erosion.

A spring box and underground water collection system was constructed along Forbes Creek in the early 1980's to provide a permanent water source for livestock in several of the Forbes pastures. The water from the spring box flowed to a pump that transported it to a series of watering troughs higher on the hill. To build this system, the creek was diverted approximately 50 feet to the west of its natural course for approximately 200 feet. Unfortunately, this diversion initiated some serious downcutting in the newly formed channel, which has increased over time -- especially during major storm events and high water flows. At present, there are areas along this gully that are 10 feet deep. It was decided that the best method of reducing further erosion and repairing the creek would be to redirect the water back into the original channel that carried the water before the spring box was built. However, redirecting the water could not be done immediately, since most of the soil around the current spring box was fill that could easily wash away. It would therefore be necessary to stabilize this area before changing the course of the channel.

In 1997, the area surrounding the spring box was recontoured to make it more gentle-sloping, and was reinforced with shot rock placed by a backhoe. Soil was then placed on top of the rock, tamped in, and seeded with annual rye. Along the stream, several hundred willow and cottonwood cuttings were planted using a heavy metal dibble. Before rock placement and planting, six transects perpendicular to both the old and new channels were established. These were approximately 60 feet long and served to identify permanent monitoring points for vegetation, canopy cover and stream morphology (cross-section and profile). A series of photo-points along each transect was also established and each was subsequently photographed twice a year, as well as before and after grazing (see below).

The stream was also fenced approximately 25 feet on either side of the current and former channels to control access by cattle, but not deer. Cattle were excluded from the planting area for two years to allow the establishment of the riparian vegetation. Controlled grazing was then resumed during the early and late green seasons when soil moisture was low, yet there was green upland forage available. Approximately 75 container oak seedlings were planted upslope (and outside the fenced area) from the stream to eventually provide some shade for cattle. These were all protected with treeshelters.

The main objectives of this project were to:

- 1) Prevent further erosion in the downcut channel, and encourage sedimentation in the channel bottom through water diversion, placement of rocks to dissipate energy during high flows, and planting of woody riparian species;
- 2) Reestablish riparian vegetation above, below, and in the downcut channel by fencing out livestock, seeding with annual rye, and planting of hardwood cuttings;
- 3) Precisely monitor changes in stream morphology and vegetation resulting from revegetation and erosion reduction efforts;
- 4) Demonstrate to ranchers, land managers, agency personnel and interested public low-cost techniques for successfully reducing and/or preventing erosion problems on hardwood rangelands in California, and procedures for monitoring the effects of management activities;

This project has been underway for four and a half years now and has accomplished most of its objectives. The rock placement was very effective in stabilizing the banks around the spring box and sufficient water was diverted from an upstream access point to promote successful establishment of woody plants and the expansion of existing riparian vegetation. In the absence of grazing for two years, this riparian vegetation has become well established and is now flourishing, in spite of fairly extensive browsing and rubbing damage to the trees from deer. While the creek diversion has effectively kept the planting area wet, some water also flows into the temporary channel. In spite of a number of serious winter storm events, there has been no apparent erosion in either the eroded channel or the reinforced area around the spring box.

In 1999 careful, prescribed cattle grazing of the fenced area was resumed, with little adverse impacts to the planted willows or cottonwoods, and minimal damage to stream banks. We were somewhat less successful in our attempts to establish oaks several hundred feet from the stream, since extensive rubbing by cattle on the treeshelters damaged or killed a number of seedlings. We plan to install temporary electric fencing around seedling clusters this year to protect these planting areas from livestock damage.

We feel this project has been extremely successful in restoring a degraded riparian area and reversing an erosion problem that had been going on for two decades. Overall cost has been modest, suggesting this is a practical approach for managers of hardwood rangelands with similar erosion problems.

Residual Dry Matter Impacts on Water Quality and Biomass Production

James Bartolome and Aimee Betts, Division of Ecosystem Science, U.C. Berkeley

Project Collaborators: Randy Jackson (Staff Research Associate, U.C. Berkeley), Glenn Nader (Livestock and Natural Resources Farm Advisor, Sutter/Yuba/Butte Counties), Ken Tate (Rangeland Watershed Specialist, U.C. Davis), Bill Frost (Natural Resource Advisor, Central Sierra), Mike Connor (Superintendent, Sierra Foothill Research and Extension Center)

Project Justification and Design: California has a Mediterranean-type climate, which means a cool, wet winter and a warm, dry summer. In the Mediterranean climate, grass growth is limited by the lack of soil moisture in summer and by cold temperatures in the winter. This leads to a characteristic plant growth curve. The basic shape of the curve is similar from year to year, but the timing and amounts vary. Spring is referred to as the adequate green forage season and livestock nutritional needs are met. In summer, protein may become limiting; while in fall and winter, energy and protein may both be limiting to animal performance. Seeding with annual legumes has profitably enhanced production in some areas, but the opportunities for increasing forage productivity are limited. Annual dominated ranges do not respond significantly to intensive grazing management systems.

California range research starting in the 1930's determined that the variation in quality and quantity of forage is primarily controlled by a few environmental factors. Forage production is higher in regions with higher average rainfall, and productivity in a given year also varies with the timing and amount of precipitation. The amount and type of woody overstory also influences understory forage. Scattered oaks enhance forage production, while denser stands, especially of live oaks or brush, suppress production. The amount of residual dry matter (RDM) left on the ground in fall has an impact on the quality and quantity of forage produced later in the year, and is used as a guideline for allowable grazing intensity. Because livestock prefer flatter ground, steeper slopes usually have higher RDM levels and contribute less forage than flat ground. The grazing capacity scorecard was developed by combining rainfall control, canopy influence, RDM standards, and slope effect on animal use.

Residual Dry Matter (RDM) is used a standard for determining level of grazing use on annual range (George et al 1996). It can also be used as part of a scorecard to estimate grazing capacity (McDougald et al 1991). The standard assumes that the amount of RDM remaining in the fall, subject to site capability and variations in weather, will influence species composition and forage production. An RDM standard is expected to provide a high degree of protection from soil erosion and nutrient losses. Applications of RDM standards based on a limited research base and on experience have demonstrated the effectiveness of this approach to grazing management.

A series of experiments by Heady dating from the 1950's showed that the amount of fall RDM (or what Heady called natural mulch) dramatically influenced forage productivity and composition at the high rainfall (100 cm/yr) Hopland Field Station site (Heady 1956). In the late 1960's and early 70's, to determine the effects of RDM representative of heavy to moderate grazing on annual range at different sites, Heady established nine experimental plots. They were

arranged along a rainfall gradient from the North Coast (rainfall >200 cm/yr) along the west side of Central Valley, to the driest annual range in the Western San Joaquin Valley (rainfall <15 cm/yr) (Bartolome et al 1980). This study showed that RDM influenced range productivity in areas with annual rainfall greater than 50 cm/yr, subject to the over-riding controls of site and annual weather. The effects on composition were mixed (Jackson and Bartolome, In Press). However, the experimental sites incompletely represented the annual range region and were limited to flat ground without any woody plant cover.

RDM standards, when combined with site productivity and animal distribution information into a scorecard, can give useful estimates of grazing capacity (Standiford et al 1999). However, because of the limited amount of research information, scorecards are normally developed using local experience. Useful would be research that evaluated the effects of RDM on forage productivity and composition with different slopes, aspects, and woody cover for a variety of sites. Information about the effects of RDM on water quality and erosion could help refine management guidelines.

In fall 1998 we began a project at the SFREC evaluating the response of vegetation composition and forage productivity to different levels of RDM on three slope classes and two slope aspects. The study, which is conducted on cleared former oak woodland on Forbes Hill, also will include evaluation of the effects of RDM on runoff and erosion starting in 2001. The experimental pastures are grazed to a target RDM of 1500 lbs/acre. In the fall randomly assigned 10 x 20 foot plots are clipped to three RDM levels: Level 1, 200-400 lbs./acre (heavy use); Level 2, 600-800 lbs./acre (moderate use), and Level 3, 1000-1200 lbs./acre (light use). An additional treatment Level 4 consists of no grazing during the five years of the experiment. Treatments are replicated four times each within six blocks representing slope classes of 0-15%, 15-30%, and > 30% with a southerly aspect and with a northerly aspect. We have so far measured above and below ground productivity four times yearly and composition at peak standing crop.

Results to date:

Plants grew more rapidly early in the season on plots with the highest RDM, producing significantly more above ground biomass at the end of winter than on the lowest RDM level (Figure 1). By the end of the growing season in May this effect disappeared, and intermediate RDM levels produced the highest above ground biomass.

Species richness per plot was significantly lower on the plots with highest RDM levels (Figure 2). *Erodium botrys* (filaree) and *Trifolium hirtum* (rose clover) decreased significantly with the highest RDM level, while *Taeniatherum caput-medusae* (medusahead) increased in cover with higher RDM (Figure 3).

These results support the hypothesis that moderate levels of grazing maintain species diversity and enhance forage productivity. The response over the next few years will be used to further refine RDM-based grazing management recommendations and to develop better estimates for grazing capacity. Starting this year we will be using rainfall simulators to determine effects of the RDM treatment and site factors on water yield and quality.

Fig 1. Above ground biomass
kg/ha

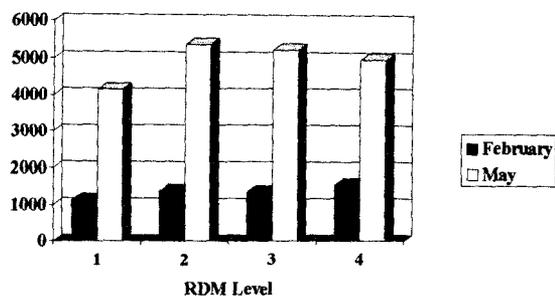


Fig. 2 Number of Species per plot

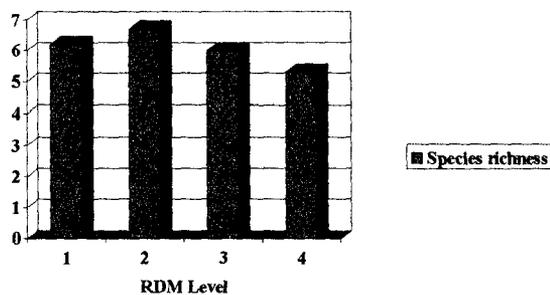
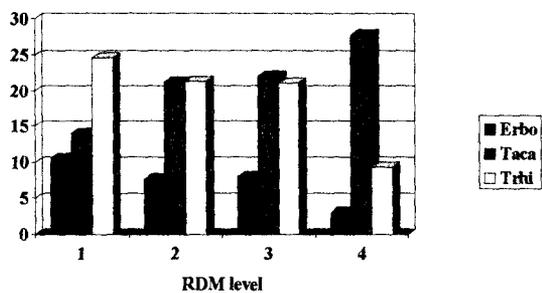


Fig. 3 Cover of Erbo, Taca, and
Trhi



References:

- Bartolome, J.W., M.C. Stroud, and H.F. Heady. 1980. Influence of natural mulch on forage production at differing California annual range sites. *J. Range Manage.* 33:4-8.
- Bartolome, J.W. and M.P. McClaran. 1992. Composition and productivity of California oak savanna seasonally grazed by sheep. *Journal of Range Management* 45:103-107.
- Bentley J.R. and M.W. Talbot 1951. Efficient use of annual plants on cattle ranges in the California foothills. *USDA Circ.* 870. 52p.
- Clawson, W.J., N.K. McDougald and D.A. Duncan. 1982. Guidelines for residue management on annual range. *Univ. Calif. Coop. Ext. Leaflet.* 21327. 4p.
- Frost, W.E., N.K. McDougald, and W.J. Clawson. 1988. Residue mapping and pasture use records for monitoring California annual rangelands. *U.C. Davis. Range Science Report* 17. 8p.
- Frost, W.E., J.W. Bartolome, and J.M. Connor. 1997. Understory-canopy relationships in oak woodlands and savannas. In: Pillsbury, N.H., J. Verner, and W.D. Tietje (Tech. Coord.) *Proceedings of a Symposium on Oak Woodlands: Ecology, Management, and Urban Interface Issues, March 19-22, 1996, San Luis Obispo, CA.* U.S. Forest Service General Tech. Rept. PSW-GTR-160. Pp. 183-190.
- George, M.R., W.E. Frost, N.K. McDougald, J.M. Connor, J.W. Bartolome, R.B. Standiford, J. Maas, R. Timm. 1996. Livestock and grazing management. In: Standiford, R.B. (tech. coord.) *Guidelines for managing California's hardwood rangelands.* University of California, Division of Agriculture and Natural Resources Publication 3368: 51-67.
- Heady, H.F. 1956. Changes in a California annual plant community induced by manipulation of natural mulch. *Ecology* 37:798-812.
- Jackson, R.D. and J.W. Bartolome. A state-transition approach to understanding nonequilibrium plant community dynamics of California grasslands. *Plant Ecology.* (In Press)
- McDougald, N.K., W.J. Clawson, J.W. Bartolome, and W.E. Frost. 1991. Estimating livestock grazing capacity on California annual rangeland. *U.C. Davis Range Science Report* 29. 2p.
- Standiford, R.B., J.W. Bartolome, W.E. Frost, N.E. McDougald. 1999. Using GIS in agricultural land assessment for property taxes. *Geographic information Sciences* 5(1): 47-51.
- Talbot, M.W. and H.H. Biswell. 1942. The forage crop and its management. In: Hutchinson, C.B. and E.I. Kotok. *The San Joaquin Experimental Range*, pp. 13-49. *Calif. Agr. Expt. Bull.* 663.

Prescribed Fire for Barbed Goatgrass Control

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Project Justification and Design: Barbed goatgrass (*Aegilops triuncialis* L.) is one of the many introduced annual grasses in California rangelands (Figure 1). Goatgrass is native to the Mediterranean and east to Pakistan (Clayton and Renvoize 1986). Exactly how it arrived in California remains somewhat a mystery. Conflicting reports implicate cattle brought in from Mexico bringing along goatgrass seed in their fur (Kennedy 1928), as well as contaminated seed shipments from the Old World (Jacobsen 1929). Either way, goatgrass was confirmed to be growing in both El Dorado and Sacramento Counties by 1914 (Kennedy 1928). From these early infestations, goatgrass has spread to locations across much of northern California and southern Oregon (USDA-NRCS 1999). While the populations themselves may be somewhat scattered, once established at a site, goatgrass rapidly forms solid patches that can expand greatly due to dispersal by wind, animals, and humans (Kennedy 1928, Peters 1994).

Goatgrass has been listed as a Class B weed by the CA Department of Food and Agriculture, indicating its potential to be detrimental to crop and forage lands (Anderson et al. 1999). Cattle generally avoid mature plants, and because goatgrass tends to crowd out other forage species, the grazing capacity of an infested pasture can be reduced 40-75% (Kennedy 1928, Jacobsen 1929). The CA Exotic Pest Plants Council has also classified goatgrass as a threat to the wildlands of California (Anderson et al. 1999).

Goatgrass has some unique characteristics that allow it to be successful in California's rangelands. Goatgrass roots grow deeper and occupy more volume than other grassland species (Peters 1994). Goatgrass is also a "late annual": it matures later in the growing season than most other grassland species (Jacobsen 1929, Talbot and Smith 1930). These characteristics allow goatgrass to take better advantage of the water resources that are available in a given year. Goatgrass seedheads produce two types of seeds: one is relatively large and germinates readily the following fall, while the other is smaller and forms a persistent seed bank (Maranon 1989, Dyer 2000). Goatgrass leaves and stems have a relatively high ratio of carbon to nitrogen (Eviner, pers. comm.). Thus, goatgrass litter decomposes relatively slowly, resulting in a large buildup of mulch, or residual dry matter (RDM). This tends to inhibit the germination of other seeds—but not those of goatgrass, which can germinate easily without direct contact with the soil.

Goatgrass also has some interesting interactions with rodents. At Hopland Research and Extension Center in Mendocino County, CA, Valerie Eviner found that gophers were preferentially pushing up large piles of soil from their tunnels directly under goatgrass patches (natural patches, as well as experimentally planted patches; pers. comm.). She suggested that the large root structures of goatgrass were stabilizing the soil, making it easier for gophers to burrow through in those areas. Goatgrass seed also seems to be favored by granivorous rodents (pers. obs., Eviner pers. comm.).

Due to these economic and ecological effects of goatgrass and because goatgrass is not nearly as pervasive as other introduced annuals, there has been a resurgence in interest in controlling goatgrass. Hand-picking is an effective method of removing goatgrass for small patches if all plants and seedheads are removed from the area (pers. obs.). Herbicide application has also proven effective for relatively small infestations, reducing goatgrass from 83% cover prior to application to 30% cover after herbiciding (Peters 1994). The control method that has received the most attention has been burning. Early on in goatgrass' history in California, burning was thought to be ineffective because it was difficult to reach a burn temperature that would kill the seeds (Kennedy 1928, Talbot and Smith 1930). Recent research, however, has shown that if timed properly, burning can significantly reduce goatgrass cover the following year (Betts and Bartolome 2001, DiTomaso et al. 2001). Because goatgrass matures later in the growing season than other grassland species, there is a window of opportunity in the early summer where a fire can kill goatgrass seeds before they mature, while leaving the already-fallen seed of other species relatively unscathed. This reduces the seed bank available for germination the following fall. If the area is burned for several consecutive years, one can exhaust the goatgrass seed bank and potentially eliminate goatgrass from the site (Betts and Bartolome 2001). Burning also reduces the RDM that has built up in heavily infested areas, allowing other species to germinate more readily. In addition, burning exposes any goatgrass seed on the soil surface to predation by granivorous rodents.

In our research at Sierra Foothill Research and Extension Center, we are studying the mechanisms by which goatgrass invades California annual grasslands and its effects on some components of this ecosystem. We are also testing whether fire is an effective control mechanism and how grazing intensity, through RDM manipulation, influences the establishment of new goatgrass patches. Here we report some of our preliminary results from the burn treatments and the experiment on goatgrass establishment.

Burning goatgrass for control

At SFREC, we have installed twenty-four 8 X 2 m² permanent plots, half with goatgrass and half without. In June 1999, all 8 plots in the Forbes 13 pasture were burned, while the other 16 remained unburned. At peak plant biomass in May 1999 and 2000, we measured species percent cover on all plots. These data indicate that the June 1999 burn was highly effective at reducing goatgrass cover in the Forbes plots (Figure 2). Percent cover of goatgrass went from 64% in 1999 down to 8% in 2000 in burned plots. On unburned plots, there was a small but non-significant decrease in goatgrass cover, from 24% to 19%; however, visual observations confirm that on unburned plots, the size of the goatgrass patches increased from 1999 to 2000.

In June 2000, all 24 plots were split in half, and the fire treatment was randomly assigned to half of each original plot. Burns in all plot areas were conducted in late June 2000, before goatgrass seeddrop. We will be testing the efficacy of 1 burn versus 2 burns with the cover data we will collect in May 2001. Qualitatively, we have observed goatgrass growing in the plots with only 1 burn, but we have seen fewer young goatgrass plots in the plots that have burned twice.

Effect of mulch manipulation on goatgrass establishment

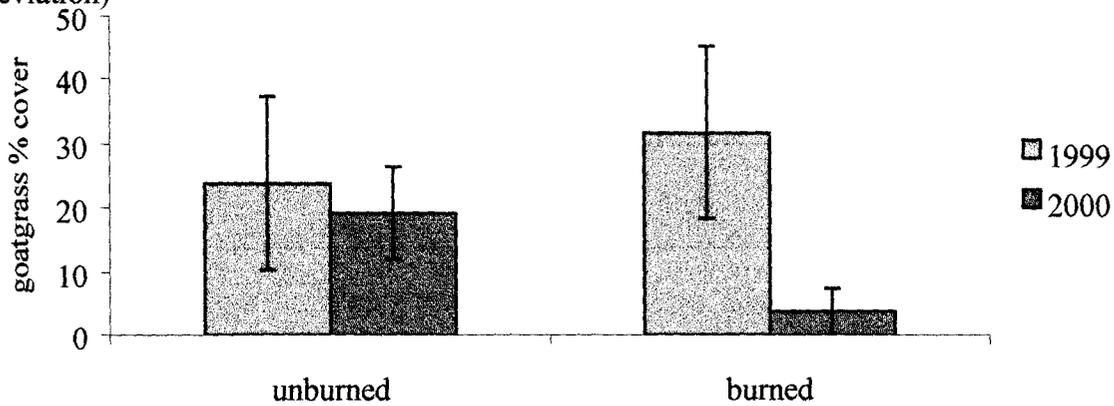
For this experiment, we used portions of the RDM experiment being conducted in the Forbes 13 pasture (see report by Bartolome in this issue for set-up). Goatgrass has not yet invaded these plots. Therefore, in October 1999, we planted goatgrass at 3 densities (2, 7, and 13 seed heads per subplot) in 0.25-m² subplots within each of the 48 RDM plots (144 subplots total). Over the course of the growing season, we monitored the fate of each of these seedheads, and at peak plant biomass in May 2000, we measured several quantitative aspects of the goatgrass plants that survived. We are still analyzing these data, but some interesting trends have shown up. First, within 12 hours of putting the seedheads out, we returned to check on them and found that many of the large seeds at the bottom of the seedhead had been eaten. Seed predation significantly decreased the number of seedheads that germinated. Also, at peak biomass, of the plants that did grow, the ones that grew in the ungrazed exclosures were not only more numerous, but also more lush and robust plants overall. This suggests that the high RDM in these exclosures may have prevented seed predation to a degree, and also that some facet of the high RDM environment promotes these incredibly productive plants. This ties back into the effects of burning on goatgrass plants. It appears that the removal of the accumulated dead biomass itself can significantly reduce the numbers of goatgrass plants through seed predation and reduce the fitness of any plants that do grow there as well.

Over the next month, we will be collecting and analyzing data regarding the success of the June 2000 burn, as well as other data addressing the effects goatgrass is having on the grassland ecosystem in general. In June 2001, we plan to reburn all the plots that were burned last summer and will monitor the effects of this burn on goatgrass dynamics over the next several years.

Figure 1. Mature barbed goatgrass plant and seedheads (from Kennedy 1928)



Figure 2. Effect of burning on goatgrass cover (mean +/- standard deviation)



Literature Cited

- Anderson, L. W. J., J. DiTomaso, G. F. Hrusa, and M. Rejmanek. 1999. Exotic pest plants of greatest ecological concern in California. California Exotic Pest Plants Council, San Juan Capistrano.
- Betts, A. D. K., and J. W. Bartolome. 2001. Control of barbed goatgrass using fire. *in* Society for Range Management Annual Meeting, Kona, Hawaii.
- Clayton, W. D., and S. A. Renvoize. 1986. Genera Graminum: Grasses of the World. Her Majesty's Stationery Office, London.
- DiTomaso, J., K. Heise, A. Merenlender, and G. Kyser. 2001. A successful burning strategy to control barbed goatgrass. *Oaks 'n' Folks* 17:3-4.
- Dyer, A. 2000. Using germination characteristics to help control barbed goatgrass. Rangeland watershed program, Davis.
- Jacobsen, W. C. 1929. Goat grass--a weed pest of the range. *Monthly Bulletin of the Department of Agriculture, State of California* 18:37-41.
- Kennedy, P. B. 1928. Goat grass or wild wheat (*Aegilops triuncialis*). *Journal of the American Society of Agronomy* 20:1292-1296.
- Maranon, T. 1989. Variations in seed size and germination in three *Aegilops* species. *Seed Science and Technology* 17:583-588.
- Peters, A. 1994. Biology and control of barb goatgrass (*Aegilops triuncialis* L.). Masters Thesis. Oregon State University, Corvallis.
- Talbot, M. W., and L. S. Smith. 1930. The goatgrass situation in California. *Monthly Bulletin of the Department of Agriculture, State of California* 19:40-46.
- USDA-NRCS. 1999. The PLANTS database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA.