California Board of Forestry and Fire Protection

Range Management Advisory Committee

Public Workshop, 2019

Workshop Series: Tools for Sustainable Management of California's Fire-Prone Landscapes

Prescribed Grazing for Fuel Reduction

September 16, 2019

California Resources Agency, 1416 9th Street, Sacramento, CA

Prescribed/Targeted Grazing for Wildland Fuels: Abbreviated Bibliography

Organization Websites

- Range Management Advisory Committee Webpage (https://bof.fire.ca.gov/board-committees/range-management-advisory-committee/
- California Rangeland Conservation Coalition Webpage (https://www.carangeland.org/)

Scientific/Academic Resources

- Planned Herbivory in the Management of Wildfire Fuels, Nader et al., 2007 (https://www.carangeland.org/images/Planned_Herbivory_in_the_Management_of_Wildfire_Fuels.pdf)
- Prescribed Herbivory for Vegetation Treatment Projects, Burroughs, Bush, and Conway (RMAC), 2015 (https://bofdata.fire.ca.gov/media/7208/white-paper.pdf)
- Fire in California: Grazing (webpage with information and links to other publications), University of California Cooperative Extension (UCCE) (https://ucanr.edu/sites/fire/Wildfire_Preparation_-_Recovery/Treatment/Grazing/)
- Targeted Grazing Handbook, Karen Launchbaugh, Ph.D. (ed) (https://www.webpages.uidaho.edu/rx-grazing/Handbook.htm)
    - Fuels management is covered in Chapter 12 of this publication
- Society for Range Management, Targeted Grazing Committee public information website (https://targetedgrazing.org/)
- University of Idaho (Karen Launchbaugh, Ph.D.) Ecology & Management course page (https://rangelandprinciples.wordpress.com/topics/ecologymanagement/)
    - Includes course materials, presentations, videos, including targeted grazing information
- USGS research paper: Interactions Among Livestock Grazing, Vegetation Type, and Fire Behavior in the Murphy Wildland Fire Complex in Idaho and Nevada, July 2007. Karen Launchbaugh et al. 2008 (https://pubs.usgs.gov/of/2008/1214/pdf/ofr20081214.pdf)
- UCCE Bay Area Working Rangelands (https://ucanr.edu/sites/BayAreaRangeland/)

Blogs, Industry, and News Articles/Web pages

- Livestock grazing helps California tackle wildfire, Green Blog, University of California Division of Agriculture and Natural Resources, 2019 (https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=29203)
- Demand for Grazing Goats Is Growing Like Wildfire, Sierra Magazine, 2018 (https://www.sierraclub.org/sierra/demand-for-grazing-goats-growing-wildfire)
- Goats to graze near Fairfax for wildfire safety, County of Marin, 2019 (https://www.marincounty.org/main/county-press-releases/press-releases/2019/dpw-goatsgrazing-070119)
- California Wool Growers Association, Targeted Grazing page (https://californiawoolgrowers.org/targeted-grazing/)
- "Match.Graze" (https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=31091)

California Rangeland Resolution Signatories *(April, 2017)*

Agricultural - Natural Resources Trust
Alameda County Board of Supervisors
Alameda County Resource Conservation District (RCD)
Amador RCD
American Farmland Trust
Audubon California
Bay Area Open Space Council
Bear Yuba Land Trust
Blue Ridge Berryessa Partnership
Burrowing Owl Preservation Society
Butte County RCD
Butte Environmental Council
Cachuma RCD
CalFauna Foundation
Calflora
California Association of Family Farmers
California Association of RCDs
California Cattlemen's Association
California CattleWomen's Association
California Chapter of the International Soil and Water Conservation Society
California Climate and Agriculture Network
California Council of Land Trusts
California Deer Association
California Department of Conservation
California Department of Fish and Wildlife
California Department of Food and Agriculture
California Dept of Forestry & Fire Protection
California Farm Bureau Federation
California Grazing Lands Coalition
California Hawking Club
California Invasive Plant Council
California Native Grasslands Association
California Native Plant Society
California Open Lands
California Rangeland Trust
California Resources Agency
California Wildlife Foundation/California Oaks
California Wolf Center
California Wool Growers Association
Cal-Pac Section Society For Range Management
Carter Ecosystem Services
Center for Natural Lands Management
Center for Re-connecting with Nature
Central Coast Rangeland Coalition
Central Sierra Region of Resource Conservation Districts
Central Valley Bird Club
Chimineas Ranch Foundation
City of Livermore
Coarsegold RCD
Committee for Green Foothills
Contra Costa County Board of Supervisors
Contra Costa County RCD
Defenders of Wildlife
Ducks Unlimited
East Bay Regional Park District
El Dorado RCD
Endangered Species Coalition
Environmental Defense Fund
Felidae Conservation Fund
Foothill Conservancy
Friends of Swainson's Hawk
Glenn County RCD
Hollister Ranch
Humboldt State University Rangeland Resources
Institute for Ecological Health
Land Conservancy of San Luis Obispo
Land Trust for Santa Barbara County
Lassen Land & Trails Trust
Marin Agricultural Land Trust
Marin County RCD
Mariposa County RCD
Mendocino County RCD
Napa County Board of Supervisors
National Cattlemen's Beef Association
National Forest Foundation
National Marine Fisheries Service Southwest Region Protected Resource Division
National Wild Turkey Federation
Nevada County Board of Supervisors
Nevada County RCD
Northern California Regional Land Trust
Pepperwood Preserve
Placer County RCD
Placer Land Trust
Planning and Conservation League
Point Blue Conservation Science
River Ridge Institute
Rocky Mountain Elk Foundation
Sacramento River Watershed Program
Sacramento Valley Conservancy
San Luis Obispo County Board of Supervisors
Santa Barbara County Farm Bureau
Sequoia Riverlands Trust
Sierra Business Council
Sierra Foothill Conservancy
Sierra Foothills Audubon Society
Sierra Nevada Conservancy
Sierra RCD
Solano Land Trust
Sonoma County Board of Supervisors
Sonoma Ecology Center
State Water Resources Control Board
SunOne Solutions
Sustainable Conservation
Sutter Buttes Regional Land Trust
Sutter County RCD
Tehama County RCD
Tejon Ranch Conservancy
The Center for Conservation Biology at Stanford
The Nature Conservancy
The Trust for Public Land
The Whole Picture
TomKat Ranch Educational Foundation
Tri-Valley Conservancy
Tuleyome
Tuolumne County RCD
University of California
UC California Rangeland Research and Information Center
Upper Salinas-Las Tablas RCD
USDA Natural Resources Conservation Service
U S Bureau of Land Management
US Fish and Wildlife Service
US Forest Service
VernalPools.org
Western Shasta RCD
Wildlife Conservation Board
Wildlife Heritage Foundation
WildPlaces
Xerces Society for Invertebrate Conservation
Yolo County Board of Supervisors
Yolo County RCD
Yolo Land Trust

CHAPTER 12: Targeted Grazing to Manage Fire Risk

By Charles A. Taylor, Jr.

Charles A. Taylor, Jr. is Professor and Superintendent of the Texas A&M Agricultural Research Station near Sonora, TX.

10 KEY POINTS

- Natural and human-caused wildfires have long shaped North American landscapes.
- A national focus on reducing fire fuels is opening a door for targeted grazing.
- Targeted grazing typically tackles four fire fuel types – grass, shrub, slash, and timber.
- Knowledge of fuel characteristics and species foraging habits lays the groundwork for developing grazing prescriptions.
- Ecological objectives should be an integral part of any fuel-reducing strategy.
- Managing vegetation that contributes to wildfires is a long-term process that requires patience.
- Timing of grazing is critical both for animal health and fuel-load reduction.
- Supplements can help animals remain healthy and fight plant toxins.
- Prescribed burning and targeted grazing can work hand in hand to reduce fire fuel loads.
- An inventory that assesses current plant status will determine the kind and combination of treatments required.

Photo: Gary Wilson, USDA, NRCS

INTRODUCTION

Fire has long shaped North American landscapes. Ignited by lightning and Native Americans, fires burned across vast areas, stopped only by rainfall and natural barriers. Fires burned frequently on dense prairies and shrublands where fuels accumulated rapidly. Steep, rocky, less densely vegetated sites burned less, serving as firebreaks until the right mix of weather and fuel loads provided optimum conditions for fire. Variations in plant communities, combined with variable weather and topography, created landscapes where fire burned in patches or mosaics, resulting in a variety of fuels, fire intensities, and habitats for livestock and wildlife.

Accidental and lightning-caused fires still burn across the natural landscapes, but the land has evolved to include a complex of cities, housing developments, cultivated lands, utility lines, fences, roads, and highways. The 2000 fire season was one of the worst in 50 years, with nearly 123,000 fires burning 8.4 million acres. More than $2 billion in federal dollars and countless dollars from state and local funds were spent to suppress these wildland fires.[7] The average acreage burned nationally has remained high with 2006 surpassing the devastation of 2000, and fire risk continues to mount. Much of this increased fire risk has resulted from community growth in the wildland-urban interface, build-up of forest and woodland fuel loads from years of fire suppression, and fire-prone ecosystems created by the invasion of exotic plants like cheatgrass.[7]

National efforts are beginning to focus on preventing fuel build-up,[5] but public opinion and firefighting activity have continued to foster fire suppression, resulting in the accumulating fuel loads. Meanwhile, the number of livestock grazing Western rangelands has declined dramatically in recent years, allowing grasses and other fine fuels to further accumulate. Sooner or later, fires will break out in these high-fuel areas, likely with devastating consequences.

Vegetation Management Opportunities

The higher the intensity of fire, the greater its impacts on timber, forage, property, and humans. Humans have little or no control over many factors that increase fire severity, but the intensity can be reduced by manipulating the kind and amount of vegetation (Figure 1). Carefully managed grazing is one important tool that can alter the amount and continuity of vegetation to reduce the potential for devastating wildfire (i.e., Fuel Load and Type and Live/Dead Fuel Mix in Figure 1).

Traditionally, mechanical and chemical treatments have been used to manage woody and herbaceous plants that create fuel loads. Mechanical approaches – mowing, chopping, and chaining of unwanted vegetation – can be effective, but the heavy equipment required works only on relatively gentle terrain, disturbs soil and contributes to erosion, and costs hundreds of dollars per acre. Likewise, herbicides can be effective, but concern is growing over their environmental and health risks. Herbicide applications are also expensive, and some have questioned their value in reducing fire risks.

Prescribed burning is gaining favor as a way to reduce fire risk, but it comes with concern of fire escaping and the associated liability. Executing a prescribed fire safely and effectively requires well trained personnel, often in short supply. In light of the cost and potential drawbacks of traditional vegetation management options, grazing offers several benefits. Livestock disturb soil less than mechanical techniques, have a low risk of environmental contamination compared with herbicides, and avoid impairing air quality as with prescribed burning. What's more, targeted grazing is generally the least expensive.

Fuel types and characteristics must be kept in mind when developing prescriptions to manipulate fuel loads with grazing. Fire fuels are classified into four groups – grasses, shrub, slash, and timber. Finer fuels are at greater risk for ignition but tend to burn quickly and produce fires of lower severity. Some plants, like juniper and sagebrush, contain plant compounds that are volatile and easily ignited. They are said to virtually explode when ignited under the right conditions, and fires burning among them can spread rapidly. Denser fuels with larger stem diameters are less likely to ignite, but they burn longer resulting in more damaging ecological effects. Ladder fuels, shrubby forest plants that enable the spread of fire from the ground to the forest crown, are also a concern.

Reducing Fine Fuels in Grasslands

Invasive annual grasses like cheatgrass and medusahead rye now dominate vast areas in the Great Basin region of Idaho, Utah, and Nevada, areas once dominated by bunchgrasses and shrublands. These annual grasses can form dense carpets of fine stems and leaves that are easily ignited and support quickly

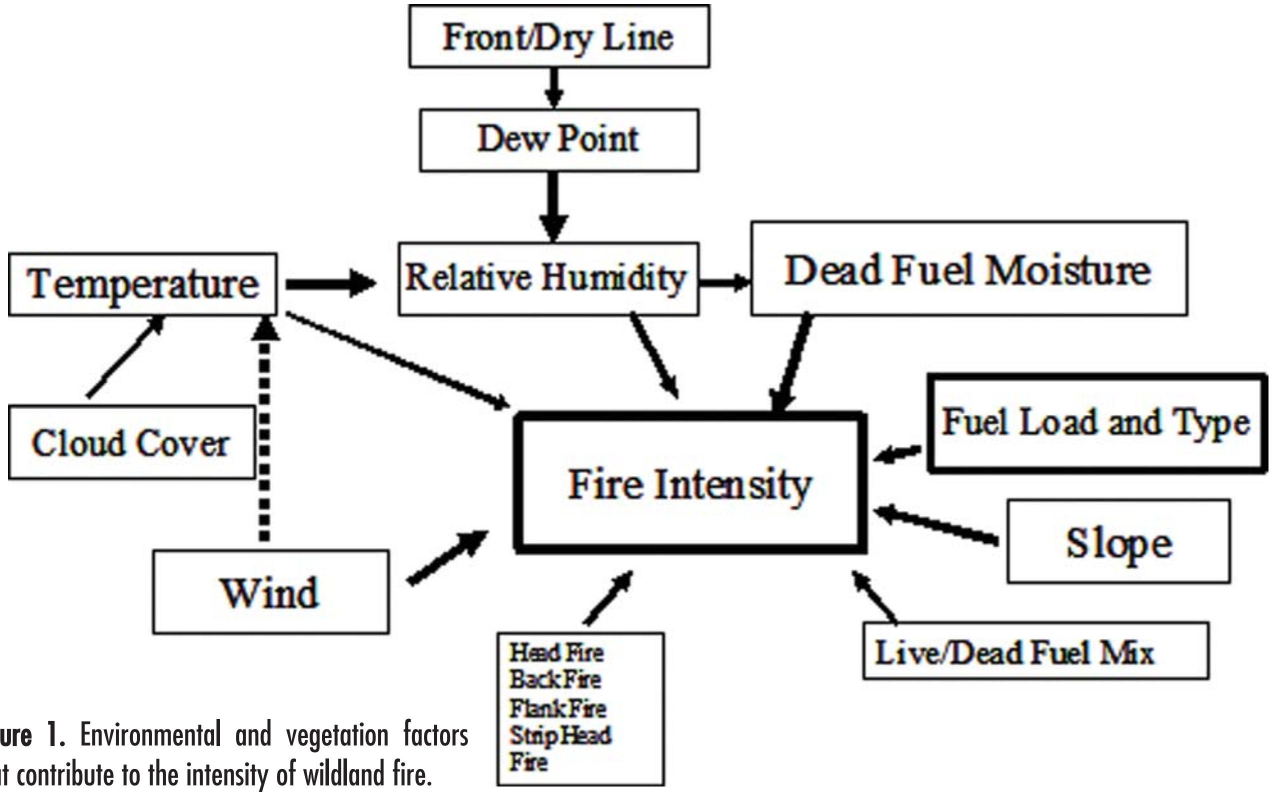


Figure 1. Environmental and vegetation factors that contribute to the intensity of wildland fire.

spreading fires. They also compete with native grasses and shrubs for spring moisture. Simply removing livestock rarely leads to the grasses' demise. However, grazing applied early in the grazing season can substantially reduce the fuel loads from these grasses *(see Chapter 8)*. This concept was applied with sheep grazing around Carson City, Nevada, in a project cleverly coined, "Only Ewes Can Prevent Wildfire." The ewes grazed a fenced corridor at the edge of the city, removing 71 to 83% of easily ignitable vegetation. More than 90% of the nearby homeowners supported the project and preferred the sheep to traditional chemical or mechanical methods of creating firebreaks. This successful project has been expanded to cheatgrass-dominated valleys throughout Nevada.

The East Bay Municipal Utility District has been hiring ranchers for several years to graze cattle on herbaceous vegetation around San Francisco Bay. The district found that livestock grazing is a cost-effective means of biological fuel management to reduce the overall fuel loading of grassland pastures. District plans include grazing before the fire season to reduce grass stubble height and to minimize brush encroachment into grasslands.

Browsing in Shrublands

Goats have been used widely in the foothill chaparral regions of California and Arizona to break up dense shrub stands to reduce the risk of wildfire. In hills around Menlo Park, Oakland, Los Altos, and Berkeley, California, goats have reduced fuel loads in areas too steep for manual labor or mowers. They remove vegetation without disturbing roots or facilitating erosion. These targeted grazing projects are particularly important because they are safe environmentally acceptable, and aesthetically appealing options at the wildland-urban interface.

Juniper is a major ecological and economic problem throughout much of the United States. It reduces livestock carrying capacity and wildlife habitat and increases volatile fire fuel loads. In the Texas Hill Country, goats have been used effectively against juniper encroachment, grazing pastures with young juniper trees and restoring a dominance of perennial grasses. Juniper foliage is laden with volatile plant chemicals called monoterpenes that reduce digestibility and can cause liver damage. Goats have a natural ability to digest and detoxify juniper foliage, so they can be used to prevent solid stands of juniper that could provide fuel for hot, devastating wildfires.

Grazing in Forests

Grazing by sheep and cattle has been applied to forestlands around the world to reduce fire risk.[4] These animals become active participants in agroforestry systems designed to reduce competition among herbaceous understory plants and trees and reduce the likelihood of wildfire. Grazing and browsing can also trim ladder fuels and mimic the fire pruning effect created by the frequent and cool ground fires that historically burned naturally below the forest canopy. Livestock grazing can clearly change the fuel characteristics of forests, although grazing does not always reduce fire risk.[8]

Criteria for Animal Selection

Different species of grazing and browsing animals have different forage preferences. Cattle mainly prefer grass but do consume some forbs and browse. Goats prefer woody browse and grass but will also select forbs. Sheep generally consume mostly grass and forbs and express a lower preference for woody plants. These are general statements: Remember that just because a particular grazing animal prefers and consumes a particular plant in one setting does not necessarily mean that it will react in a similar way when grazing in another plant community. Still, generalities can provide a starting point for developing a prescription for grazing to suppress fire fuels.

Early animal foraging research conducted on the Texas Agricultural Experiment Station near Sonora in the Edwards Plateau Region[2, 3] showed basic foraging patterns. On generally rolling study pastures of about 575 acres, cattle traveled an average of 3.3 miles a day, sheep 3.8 miles, and goats 6.1. Cattle spent most of their time (78%) feeding on grass, 21% on forbs, and only 1% eating woody plants. Sheep and goats grazed grass about half the time, forbs about a quarter, and browse the rest. Most subsequent research suggests that goats consume more browse than either sheep or cattle.

By coupling knowledge of fuel characteristics with the foraging habits of different livestock species, prescriptions can be developed to target specific components of the fuel load. Cattle and sheep grazing has been applied effectively to reduce the risk associated with fine herbaceous fuels like annual and perennial grasses. Goats are better able to manipulate woody vegetation and move among slash in forested situations. Plant compounds that generally create volatile fuels are more readily consumed by goats than by sheep or cattle. It should be noted that targeted grazing is poorly suited for areas with extensive dead woody fuels or slash.

Grazing Strategies to Meet Ecological Objectives

A variety of ecological objectives can be expressed at the landscape level. Examples of these include improving biodiversity, improving water quality and quantity, increasing dominance of native vegetation, reducing erosion, and improving wildlife habitat. Ecological objectives should be included as a part of the overall grazing strategy to reduce fuel loading.

Targeted grazing can be used effectively to reduce fuel loads of grasses and shrublands. Managed livestock grazing is often a favorable option in the wildland-urban interface where homeowners are particularly concerned about fire risk. In these situations, people have heightened concern over herbicide use, are often intolerant of the noise and disturbance caused by mechanical options, and do not find prescribed fire an acceptable alternative so close to their homes.

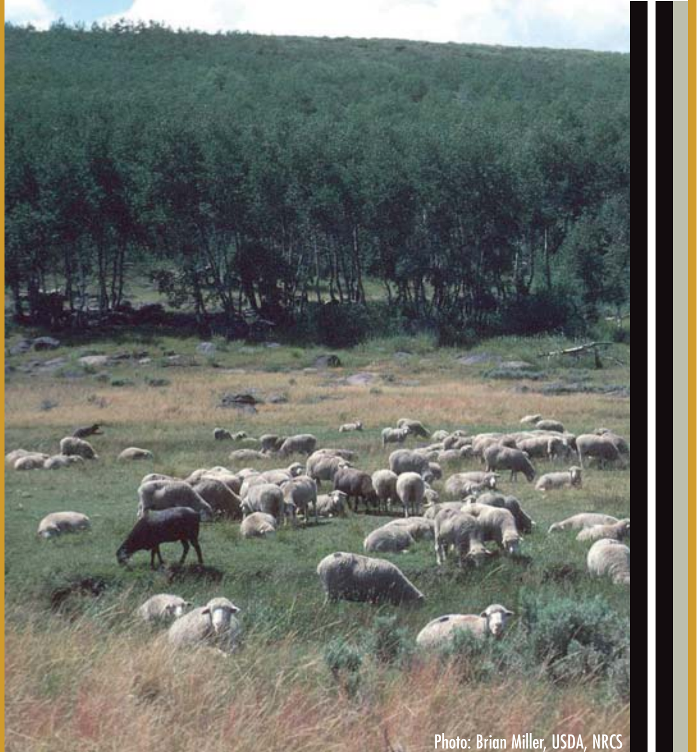
Fuel Load Reduction

In varying degrees, livestock grazing or browsing reduces fuels. Simply put, livestock consume vegetation and vegetation is fuel, so grazing in large pastures and allotments typically reduces the extent and severity of wildfire. In addition, livestock tend to graze some areas more intensely than others creating patchy vegetation that reduces the continuity of fuel loads and the fires that might burn those fuels.

Firebreaks

Firebreaks, strips of land on which vegetation has been reduced or removed, can slow or even stop the spread of wildfire. They also provide safety zones or escape routes for firefighters. Firebreaks can be created with high-intensity grazing by livestock confined to a strip of land with temporary fencing. For example, grazing has been used effectively to reduce the fuel load and break up continuity of the fuel matrix in annual grasslands.

Brush and tree regrowth are a major problem on firebreaks, necessitating continual maintenance. Woody plants combined with grasses produce a fuel mixture that can spread fire rapidly. The most effective firebreak is one dominated by low-growing sparse vegetation. Perennial bunchgrasses or low-growing grasses make ideal cover for firebreaks. The intermediate grazing capacity of sheep and goats allows them to harvest both grass and brush regrowth, keeping the fuel load cropped closely enough to serve as an effective firebreak.



Green Stripping

Controlled and repeated grazing of strips can create areas of green plant regrowth that can serve as a break in fuel continuity and slow the spread of wildfires. Green strips can be created by planting late-maturing plants or by grazing strips at the end of the growing season right before the fire season. Grazing in firebreaks can also be applied late in the growing season to keep grasses in a green vegetative stage and delay senescence.

General Grazing Principles

Using livestock to reduce fuel loads, manage firebreaks, and create green strips requires an understanding of the foraging habits of the animals and the response of vegetation. It is important to carefully select the kinds and classes of animals, the seasons of grazing, and the stocking rate to create the desired plant community response. At the same time, unique site and weather conditions beyond the control of management also affect vegetative response to grazing, making it difficult to anticipate the results of grazing activities. Expecting immediate response can be frustrating. Changing animal numbers will change the amount of forage for each animal, which, in turn, will change diet selection, which could then change nutrient intake and animal production. At the same time, changing the grazing pressure will shift the competitive relationships among plant species, eventually changing the plant community or reducing fuel loads.

Animal Production Considerations

Many fire management prescriptions focus on changing fuel loads immediately before the season of greatest wildfire risk. This generally coincides with a period of peak biomass when forage is nutritious and available and conditions for animal production are good. However, heavy stocking levels may be required to accomplish specific fuel-reduction goals, constraining individual animal performance. When managing fine fuel loads, targeted grazing may be applied as the plants begin to dry and become dormant. This is also the time of decreasing forage quality, and grazing at this time may reduce animal productivity.

When grazing to reduce fuel loads of woody vegetation, consider the potential effect of aversive plant compounds. Most woody plants contain chemicals that can reduce plant palatability and digestion. In some cases the chemicals are toxic. Tannins and terpenes are two common classes of detrimental compounds found in woody range plants. Both reduce the digestibility and palatability of forage and, if consumed in large enough quantities, can harm animals. High quantities can also limit the consumption of woody plants and reduce animal performance.

Most woody plants have some chemical defenses, but herbivores coevolved with these plants for thousands of years and have developed methods for dealing with them. They learn to avoid or minimize the use of plants or rely on their digestive capabilities to process and detoxify the harmful compounds. It is important to provide adequate nutrition for animals browsing woody plants high in tannins, terpenes, and other phytochemicals as detoxification imposes an additional demand for nutrients. For example, a protein supplement appears to benefit goats consuming juniper.[6] In trials on the Texas Agricultural Experiment Station at Sonora, the amount of supplement fed was calculated to supply the same amount of protein as alfalfa pellets fed at 1% of body weight. The three supplements (alfalfa pellets, corn, and cottonseed meal) were fed to provide 0.24 grams nitrogen/kilogram body weight. Cottonseed meal and alfalfa supplements increased redberry juniper intake 40% compared with goats fed a corn supplement and 30% compared with goats fed no supplement. Similar results have been observed for sheep grazing sagebrush. Sheep fed a protein and energy supplement spent more time eating sagebrush than those with no supplement.[1]

Effectiveness and Integrated Management

One of the best ways to address a fire fuel problem is to integrate livestock grazing with prescribed fire, chemical, or mechanical treatments. Developing and successfully implementing such a plan requires basic knowledge of forage and animal production, grazing management, and plant ecology. Anyone considering a fuel-suppression program should consider training in these concepts and techniques.

The first step in planning a fuel-reduction action is to inventory the current amount and condition of herbaceous and woody vegetation. This current status (i.e., species composition, amount of fuel, fuel type, etc.) will determine the kind and possible combination of treatments to apply. By understanding plant composition and fuel characteristics, a manager can match the dietary habits of animals with the vegetation. For example, an inventory of an area designated as a firebreak might show fuel loads of mostly warm-season perennial grasses with a few shrub species. This situation would be ideal for grazing cattle or sheep to reduce fuel loads but still retain enough vegetative cover to prevent excessive erosion. In areas dominated by large woody plants, prescribed fire or mechanical techniques may be required, followed by grazing to maintain appropriate vegetation levels.

Prescribed burning can often be included in the overall management plan as an effective tool to increase forage palatability and reduce woody plant cover. The first rule of prescribed burning is to manage for an appropriate fuel load so the burn will be effective and not excessively risky. Grazing management and prescribed fire are inherently interrelated because grass, forbs, and browse can serve as either fuel or forage. However, when grazing pressure is too great, a prescribed fire may be ineffective. An appropriate grazing scheme must be established to create a viable burning program, which requires management to determine specific goals and objectives. It is important for management to focus attention on the selection of objectives.

Grazing management principles form the basis for developing grazing schemes. For example, if the objective is to reduce volatile woody plant fuel and simultaneously increase herbaceous fuel, then the proper choice of grazing/browsing animal must be selected. The grazing/browsing animal is the piece of the system that is directly managed through: 1) selecting the kinds and classes of livestock; 2) selecting the season of grazing; and 3) setting the degree of use (i.e., stocking rate).

A specific scenario that requires an integrated approach is the mixture of volatile fuels, like juniper- and pinion-dominated rangelands, along with enough herbaceous vegetation to provide a continuous fuel load. Pinion and juniper now cover over 75 million acres of the Western United States. This change in vegetation type leads to decreased species diversity, loss of soil and seedbanks, decreased aquifer recharge, increased soil erosion, and increased probability of high-intensity crown fires. Foraging animals usually avoid juniper and pinion pine. Because goats are more tolerant than other domestic livestock of the terpenoid-laden foliage of juniper and pinion, they can play an important role in integrated management plans. Even though goats consume more juniper than other species of livestock, individual consumption is still relatively low at 0.8 pounds a day per head maximum intake of redberry juniper for an 80-pound goat.[6] Also, juniper and pinion foliage above the browsing height of goats continues to be a fire hazard. Mechanical treatment followed by goats might serve as an optimum management strategy. Prescribed fire might also be incorporated. Burning under cool, safe conditions following the mechanical treatment would keep the target species within the browsing height of goats. With this integrated approach, the fuel load from juniper and pinion would be reduced as would the frequency and intensity of goat browsing needed to maintain a desired plant community.

Photo: Gary Wilson, USDA, NRCS

SUMMARY

In summary, manipulating vegetation using grazing and browsing animals is a complex process. Using livestock to manage vegetation is an ongoing and adaptive process that takes time and patience to master. Even the most researched and clearly stated grazing prescriptions will require monitoring and modification. An effective grazing prescription must be based on an understanding of the ecological potential of the land resource and must apply the principles of grazing management, plant physiology and ecology, prescribed fire, and sound business practices. An effective fuel management plan must also include an inventory and monitoring system to measure current conditions and determine if goals and objectives are being met.

Literature Cited

[1]Banner, R.E., J. Rogosic, E.A. Burritt, and F.D. Provenza. 2000. Supplemental barley and charcoal increase intake of sagebrush by lambs. *Journal of Range Management* 53:415-420.

[2]Cory, V.L. 1927. Activities of livestock on the range. Texas Agricultural Experiment Station Bulletin 367.

[3]Fraps, G.S. and V.L. Cory. 1940. Composition and utilization of range vegetation of Sutton and Edwards counties. Texas Agricultural Experiment Station Bulletin 586.

[4]Gold, M.A. and J.W. Hanover. 1987. Agroforestry systems for the temperate zone. *Agroforestry Systems* 5:109-121.

[5]National Forest Plan. 2005. FY2005 Performance Summary. *Available at:* http://www.fireplan.gov/resources/documents/2005AccomplishmentSummary.pdf. *Accessed 11 August 2006.*

[6]Taylor, C.A., Jr., K.L. Launchbaugh, J.E. Huston, and E.J. Straka. 2001. Improving the efficacy of goating for biological juniper management. Pages 5-17 to 5-34 *In:* C. Taylor [ED.] 2001 Juniper Symposium. Texas A&M University Research & Extension Center, San Angelo, TX.

[7]Western Governors Association, USDA-FS, USDI-BLM, and others. 2002. A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment: 10-Year Comprehensive Strategy, Implementation Plan. *Available at:* http://www.fireplan.gov/content/reports/?ReportID=7&LanguageID=1. *Accessed 11 August 2006.*

[8]Zimmerman, G.T. and L.F. Neuenschwander. 1984. Livestock grazing influences on community structure, fire intensity, and fire frequency within the Douglas-fir/ninebark habitat type. *Journal of Range Management* 37:104-110.

Planned Herbivory in the Management of Wildfire Fuels

Grazing is most effective at treating smaller diameter live fuels that can greatly impact the rate of spread of a fire along with the flame height.

By Glenn Nader, Zalmen Henkin, Ed Smith, Roger Ingram, and Nelmy Narvaez

Wildfires are increasing in number, intensity, and size. Five of the most significant wildfire seasons in the United States since 1960, as measured by total acres burned, have occurred since 2000.[1] The vegetation or fuel profile, a major factor determining fire behavior, is studied in two aspects: vertical and horizontal arrangement, and amount. The vertical arrangement of fuel determines the degree of its mixture with air and, thus, flame height and duration of elevated heat. The continuity of horizontal fuel arrangement determines potential for fire spread across the landscape. These attributes, along with topography and weather conditions (wind and fuel moisture), are what determine the kind of wildfire that is going to occur. Many management and ecological conditions have allowed for the increased fuels. The increasing number of residences being built in forest and rangeland ecosystems provides more ignition sources and restricts the ability to manage fire. Introduction of exotic plants such as cheatgrass also has changed the fire behavior in many sagebrush plant communities.[2]

Fuel treatments are generally placed in two different categories. Fuel breaks are linear fuel modifications that are often situated along a road or ridge. They can range in width from 30 feet to 400 feet and are designed as a tool for fire fighters to stop fires. Landscape area treatments are designed to reduce flame height and change fire behavior over a large area. Long-term landscape treatment efforts are focused on changing the plant community to decrease the flame height when fire occurs. Both approaches require maintenance in order to remain valuable fire management tools. The objective for fuel reduction is to change fire behavior by impacting the following: fuel bed depth, fuel loading, percent cover, and ladder fuels that result in a fire flame less than four feet high. At that level all fire fighting management tools can be used, while maintaining fire fighter safety.

Mechanized Treatments

Mechanized treatments are used by land managers to alter or remove vegetation, including mowing, mastication, and biomass harvesting. Mastication involves the use of a large mechanized device for chopping, and is used in brush and trees to break up the fuel pattern and decrease combustibility by placing fuels on the ground. It changes fire behavior by rearranging the fuel profile through distributing some of the fuel on the ground. This action also causes a reduction of ladder fuels, which decreases potential for vertical extension of fire into tree canopies; crown fires are very difficult for fire fighters to control. Mastication can be used as a pretreatment followed by prescribed fire or grazing treatments. Some of the disadvantages of mastication are the cost of $350 to $800 per acre, ground disturbance, short life of the treatment in some areas, terrain and surface roughness limitations, and soil compaction. Mastication can result in death in some brush species, but many species resprout from the roots and require retreatment. Mechanized treatments also include the thinning of overstory vegetation through biomass harvesting. The harvested biomass is brought to a chipping unit and the resulting material is transported off the site for use in energy power plants. The sale of the biomass chips reduces the cost of this treatment. Thinning can provide desired conditions for both ladder fuels and crown spacing in one treatment. Soil moisture condition is the only limitation on the time of year that the treatment can be conducted. Disadvantages include transportation costs of hauling biomass and removal of nutrients from the ecosystem. In some cases, trees that are removed can be sold as commercial saw logs to offset fuel treatment costs. Mowing is generally used in grass communities to drop the fuel on the ground, where it has less contact with air and thus has lower combustibility. Mowing needs to be done during the end of the green season or it can cause fires from the blades striking rocks when dry grass is present. The costs of mowing range from $25 to $40 per acre.

Herbicides

Herbicides can be sprayed to kill specific plants, but this does not alter the fuel pattern immediately. Herbicide treatment of targeted species has a cost of $25 to $250 per acre. The disadvantages include concerns about its impact on the environment and short-term increases in fuel flammability.

Prescribed Fire

Prescribed fire can be used to change the fuel load and pattern. Prescribed burning can generally be achieved for less than $150 per acre. It is most effective for reducing surface fuels 0–3 inches in stem diameter. Because of air quality concerns and the need for the correct fire weather conditions (wind, air, and plant humidity), there is usually a narrow time period in the season during which burning can be done. A mechanical or hand removal treatment might also be required prior to the reintroduction of fire into the ecosystem to achieve desired fire behavior. The disadvantages of this treatment are reduced aesthetics, tree mortality, impaired air quality, liability concerns, pretreatment costs where applicable, the requirement of qualified people who understand prescribed fire, and treatment variation (it might burn hotter or cooler than planned). Also, it might not be appropriate for some plant communities, such as low-elevation sagebrush, which can be replaced postfire by cheatgrass.

Hand Cutting

Hand cutting and stacking of fuels for burning is very labor-intensive and thus expensive. Costs range from $800 to $2,300 per acre, depending on amount of vegetation. It is the best alternative on steep slopes where mechanized equipment cannot operate.

Grazing

Grazing is best used when addressing the smaller diameter vegetation that makes up the 1- and 10-hour fuels. One-hour fuels are those fuels whose moisture content reaches equilibrium with the surrounding atmosphere within 1 hour and whose stems are less than one-fourth inch in stem diameter. Ten-hour fuels have stems that range from one-fourth inch to 1 inch in stem diameter. Grazing can impact the amount and arrangement of these fuels by ingestion or trampling. It is a complex, dynamic tool with many plant and animal variables, and it requires sufficient knowledge of the critical control points to reach treatment objectives. Those control points involve the species of livestock grazed (cattle, sheep, goats, or a combination); the animals' previous grazing experience (which can affect their preferences for certain plants); time of year as it relates to plant physiology (animal consumption is directed by the seasonal nutrient content); animal concentration or stocking density during grazing; grazing duration; plant secondary compounds; and animal physiological state. Treatments either can be short-term to reduce flammable vegetation or long-term to change vegetation composition by depleting root carbohydrates in perennials and reducing the soil seed bank for annual plants. The objectives are to change the fire behavior through modification of the fuel bed, fuel loading, percent cover, and ladder fuels.

Depending on the plant community, the vegetation of concern or fuel will differ. The grazing approach to fuel treatment differs with the plant life cycle (annual or perennial). With annuals, the treatment is to remove plants while they are still green each year prior to fire season. Grazing before seed set can change seedbed dynamics, and with long-term implementation, grazing can change the species composition. For perennials, repeated grazing that depletes root carbohydrates and causes morality of targeted species is required to change plant composition. Root carbohydrate reserves are at their lowest level just after the period when plants initiate active shoot elongation. If plants are severely grazed early in the growing season, carbohydrate reserves are depleted, and plant vigor is reduced.[3] Removal of bark or repeated defoliation are two other ways to destroy the plant. In brush species, the concept of changing the fuel profile the first year and managing it thereafter with grazing over large areas appears to be most sustainable.

Integration of different treatments could provide the best strategy. Livestock cannot effectively control mature brush plants that either grow higher than the animals can effectively graze or have large diameter limbs. Mastication, underburning, and hand-cutting can be used to manipulate the large-diameter, 100-hour brush fuels, and grazing can be used as a follow up treatment for controlling resprouting species or shifting the species composition to herbaceous plant fuel material. Tsiouvaras suggests that grazing followed by prescribed fire can be used safely to kill the aboveground parts of shrubs and further open the stand.[4] Magadlela reported that adding cutting and herbicide use increased sheep effectiveness by reducing the brush below 20% in one year, but increased the costs.[5]

Goats grazing brush.

Prescribed grazing has the potential to be an ecologically and economically sustainable management tool for reduction of fuel loads. However, much of the information on grazing for fuel reduction is anecdotal. Limited scientific research information is available. Existing data indicate there are two ways by which grazing impacts the fuel load: removal of vegetation, and hoof incorporation of fine fuels. Smith et al. found that 350 sheep (ewes) grazing intensely on sagebrush/cheatgrass in a 2.5-mile fuel break (divided into 20 pastures) in May in Nevada reduced fine fuels from 2,622 to 765 pounds per acre.[6] Vegetative ground cover decreased 28% to 30%, ground litter increased 20% to 23%, and bare ground increased 4%.[6] Tsiouvaras studied grazing on a fuel break in a California Monterey pine and eucalyptus forest in the fall at a stocking rate of 113 Spanish goats per acre for 3 days; brush understory was reduced by 46% and 82% at 20 inches and 59 inches in height, respectively. Forage biomass utilization in the brush understory was 84%. California blackberry showed the largest decrease in cover (73.5%) followed by toyon, coyote brush, honeysuckle, herbaceous plants, and madrone. Poison oak and eucalyptus exhibited very little change. Goat grazing not only broke up the sequence of live fuels (horizontally and vertically up to 59 inches), but also reduced the amount of 1-hour dead fuels by 58.3%, whereas the 100-hour fuels remained constant. The litter depth was also reduced as much as 27.4% (from 2.9 inches before to 2 inches after grazing). Animal trampling resulted in crushing of fine fuels and mixing them into the mineral soil, thus reducing the chance of ignition. Green et al. grazed 400 goats on chaparral in July.[7] The goats utilized 95% of the leaves and small twigs to 0.063 inches diameter from all the mountain mahogany plants.[7] Use of scrub oak was 80%, whereas use of chamise, eastwood manzanita, and California buckwheat was low, and *Ceanothus* was only taken under duress.[7] Under "holding pen" conditions, use of less palatable species approached the use of palatable plants.[7] Lindler reported that goats stocked at 7 per acre for 3 weeks in the summer in a ponderosa pine forest were estimated to remove 15% to 25% of the vegetation, depending on the plant species present and the length of stay in the pasture.[8] The cost of the grazing treatment was $60 to $70 per acre. In comparison, herbicide costs on adjacent sites were $60 to $125 per acre, and 75% to 90% of the vegetation understory in the pine forest was removed. Intensive grazing by cattle to control shrub growth has been demonstrated as being useful for maintenance of fuel breaks.[9–13] Perevolotsky et al. found that mechanical shrub removal and cattle grazing at the peak of green season in Israel 4 years in a row proved to be the most effective firebreak treatment.[14] Heavy grazing for a short duration removed more than 80% of the herbaceous biomass, but reduced regeneration rate of shrubs for only 2 years. They stated that using goats or other browsing animals can increase the amount of shrub material removed by direct grazing, but can decrease actual physical damage to shrubs (cattle will trample and break more brush and graze less due to their size, whereas the opposite is true for goats). Henkin et al. found that under heavy grazing (71–83 cow grazing

Goats grazing blackberry and other brush understory in a pine forest.

Edge of goat grazed area in Ponderosa forest.

days per acre), the basal regrowth of the oaks was closely cropped and the vegetation was maintained as predominantly open woodland. In the paddock that was grazed more moderately (49–60 cow grazing days per acre), the vegetation tended to return to dense thicket.[12]

Each species of animal has a unique grazing utilization pattern that is a function of mouth size and design, past grazing experience, and optimization of nutritional needs.[15] The mouth size controls how closely animals are able to select and then graze a given surface. Animals also differ in their forage preferences and diet composition, thus when developing a fuel reduction grazing program, it is important to select the kind of livestock that will consume the desired species to alter the fire behavior. Provenza and Malechek showed a 50% reduction of tannin in goat-masticated samples compared to unmasticated samples.[16] This illustrates that goats can affect one of the secondary compounds that are present in some brush species, and thus can eat more of that species. When preferred forage is absent or unpalatable, grazing animals are capable of changing their food habitat.

Table 1. Percent of time spent by animals feeding on diverse plant types in Texas[17]

	Animal species		
Forage type	**Cattle**	**Sheep**	**Goats**
Grass	78	53	50
Forbs	21	24	29
Browse	1	23	21

Magadlela et al. found that goats grazing in Appalachian brush defoliated brush early and then grazed herbaceous material later in the seasons.[5] Sheep preferred to graze herbaceous material first, but increased grazing pressure forced sheep to defoliate brush earlier in the season.[5] Goats reduced brush cover from 45% to 15% in one year. Sheep took 3 years to produce the same results. Brush clearing improved when goats followed sheep; total brush was reduced from 41% to 8% in one year. By the end of 5 years of goat grazing, the brush was reduced to 2% cover. Luginbuhl et al. found that multiflora rose was nearly eliminated from the Appalachian Mountains after 4 years of grazing by goats alone (100%) or goats + cattle (92%).[18] Simultaneously, total vegetative cover increased with goats alone (65% to 86%) and with goats + cattle (65% to 80%), compared with the control plot where vegetation cover decreased from 70% to 22%. Lombardi et al. studied the use of horses, cattle, and sheep in Northwest Italy for 5 years and found that grazing reduced woody species cover and stopped the expansion of shrub population.[19] The impact varied with the type of animal. Cattle and horses had a higher impact on the plants through the damage caused by trampling. It was found that the effectiveness of control depended on palatability and tolerance of woody species to repeated disturbance. Juniper and rhododendron were reported not to have been grazed. Hadar et al. reported that the inconsistent response of some plants to grazing could be the interaction between grazing pressure and moisture conditions.[13] They found that heavy cattle grazing (340–394 cow grazing days per acre) during 7 to 14 days at the end of the growing season decreased species richness because of consumption of seeds from the annual plants.

The time of the year that grazing occurs can influence the types of plants consumed, because it impacts the plant physiological status, which controls the nutritional value to the animal. Additionally, the time of year affects the plant's postgrazing mortality. Taylor reported studies using heavy grazing by sheep in Idaho showed that season of use impacted the utilization.[17] Late-fall grazing reduced three-tip sagebrush, whereas grazing during spring increased sagebrush and decreased grasses.

Grazing impact can change with the density of animals and duration of grazing. The shorter the duration, the more even the plain of nutrition is. Over longer periods in a pasture, animals select the most nutritious forage first and consume less nutritious forage later. Stocking density has a great impact on the grazing consumption and trampling of fuels. Fences, herding, topography, slope, aspect, distance from water, placement of salt, and forage density all impact the distribution of animals and their use of the forage. By concentrating the animals into a smaller area for short periods of time, the preference for plants decreases and animals compete for the available forage. Increasing stocking density also increases hoof action and incorporation of the fine fuels into the ground. Spurlock et al. stated that high stocking rates with little supplementation forces goats to graze even less palatable species and plant parts, and as a result, much brush can be eradicated in 2–3 years.[20] Lindler et al. suggests that a stocking rate of 15 goats per acre in a California pine forest is required to effectively treat understory brush.[8]

Table 2. Sheep diet consumption in Texas varied with stocking rate[21]

Stocking rate	Forage type		
	Browse	Grass	Forbs
Light	16	55	28
Heavy	55	39	5

Table 3. Results with sagebrush/grass pastures grazed at different intensities by sheep in northern Nevada[6]

Grazing intensity	Bare soil	Vegetation cover (%)	Litter
Light	+6	–22	+25
Moderate	+4	–28	+20
Heavy	+4	–30	+23

Hadar et al. reported that light grazing increased plant diversity on treated sites.[13] Thus, when proposing a stocking rate for treatment consumption, the environmental impact needs to be considered.

Plants, over time, have developed mechanisms to limit or prohibit grazing. Launchbaugh et al. summarized this plant and animal interaction as follows: plants possess a wide variety of compounds and growth forms that are termed "anti-quality" factors because they reduce forage's digestible nutrients and energy or yield a toxic effect that deters grazing.[22] Secondary compounds (eg, tannins, alkaloids, oxalates, terpenes) can control the plant–animal interactions that drive intake and selection. Animals might expel toxic plant material quickly after ingestion, secrete substances in the mouth or gut to render the compounds inert, or rely on the rumen microbes or the body to detoxify them. The species of livestock selected is important because some species can detoxify compounds or have a smaller mouth that allows them to eat around thorns; this allows them to still obtain nutritional or pharmaceutical products that aid in digestion and detoxification. Breeders can select for animal genetic lines that can adapt to these compounds. Tannins are the most important plant defensive compounds present in browse, shrubs, and legume forages. Concentrations in woody species vary with environment, season, plant developmental phase, plant physiological age, and plant part. Levels in excess of $50\,g \cdot kg^{-1}$ DM can lead to low palatability, reduced digestibility, depressed voluntary feed intake, inhibition of digestive enzymes, and increased toxicity to rumen micro-organisms.[23–27] In some cases, when the plant compound is known, it is possible to intercede. For example, polyethylene glycol (PEG), a polymer that binds tannins irreversibly, can be used to reduce the negative effects of tannins on food intake, digestibility, and preferences.[28] For oxalates, calcium supplementation has shown to ameliorate the diet suppression. Launchbaugh et al. suggests that supplementation of protein, phosphorous, sulfur, and energy can also make a difference in intake of plant material containing secondary compounds.[22] They even postulate that clay can be used to detoxify compounds.[22]

Grazing animals can effectively distinguish between plants that differ in digestible energy or nutrients. The animal's consumption is driven by its physiological state. Nonlactating animals have much lower nutrient requirements than lactating females or growing weaned animals and can consume a wider array of plants to meet nutritional needs. Animals can be forced to eat below their nutritional needs and they will balance their needs by using existing body fat and protein. The animal can tolerate short-term energy or protein deficits, but sustained periods at this status can be reason for concern. For this reason, lactating and young growing animals are not generally recommended for fire fuel control. In a system that is focused on maintaining the fuel profile, one can use growing animals in an annual brush grazing system that focuses on the annual new growth.

Because of the complexity of plant and animal interactions, a project evaluation should be developed that considers measurable and attainable objectives before grazing is used. It should include a review of treatment objectives, outcomes, and environmental impacts. This will dictate the kind of animal needed, grazing intensity, timing of the grazing event, and duration of the grazing period. Variation in animal–plant interaction is driven by forage type, grazing season, yearly season variation, animal interaction with the grazing system (animal density and competition), previous grazing experience, mixture of grazing animals, and pregrazing treatment (integrated approach). The treatment and resulting outcomes cannot conveniently be predicted and might require adaptive onsite management. Treatment standards include stubble height for grass, percent vegetation cover by brush, plant mortality, removal of 1- and 10-hour fuel, and fuel bed depth.

Any grazing plan designed for fuel reduction needs to consider the grazing impacts on parameters other than just simply reduction. The effects of the grazing management should be studied for their impact on water quality, compaction, riparian vegetation, disease interaction with wildlife (bluetongue, pasturella), and weed transmission. The positive aspects of grazing over other treatments also should be weighed, including recycling of nutrients into the products of food and fiber.

Grazing is best used when addressing vegetation with stems of smaller diameters that make up the 1- and 10-hour fuels. These two fuel classes are important because they can greatly impact the rate of spread of a fire, as well as flame height. Many fire managers have viewed grazing in the same context as other single-event mechanical fuel treatments.

These grazing treatments have been expensive to implement because they have a physiological cost to the animal, and require higher costs (such as portable fencing) to reach fuel objectives in one year. Perhaps a sustainable use of grazing would be annual grazing of large areas following mechanical treatment. This provides improved nutrition by presenting smaller regrowth that is higher in nutrition; this allows animal performance to improve while maintaining a specific fuel profile in the grazing area.

There are many issues that need to be considered when examining grazing for fuel reduction. Grazing has a more varied outcome than the mechanical fuel reduction treatments. Until the grazing treatment is perfected into a fully understood tool, the dominant management strategy will be to force utilization by limiting nutrition and/or preference. There is a lack of scientific data available to help managers understand and control the many variables that influence the outcome of fuel removal, and thus reaching defined objectives will be more difficult. The objectives of the treatment must be well-defined and well-described. It is important to understand animal preference as well as proper timing in order to meet the objectives. Some have considered fuel reduction by grazing simply as a method to increase animals on public lands; thus a well-thought-out plan is important. Many do not trust agencies to administer a private sector contractor to conduct the treatment correctly; thus a contract needs to be well-defined within the parameters of the operator's control. In the past, fire managers were willing only to look at the short-term impacts and not the long-term health and fire safety of the site or the effects of a long-term grazing program. Consumptive use, such as grazing, might not be compatible with recreation land use in some areas. A survey by Smith et al. indicated that 90% of residents near a fuel break stated use of sheep was an acceptable method for fuel reduction.[6] Only 10% felt that they were inconvenienced by the treatment. Some responses indicated misconceptions held by residents regarding grazing and grazing management methods; one such example was fear of possible electrocution of animals and humans by electric fences. These misconceptions by the public must be addressed when land managers make proposals for grazing.


Sheep grazing a fuel break in Nevada.

Conclusions

Modification of wildfire fuels is an important issue in many regions of the world. At present, limited research knowledge exists to help guide managers in using grazing animals for fuel management. That knowledge is necessary to direct the timing and intensity of grazing to reach fuel management objectives similar to other methods. Also seasonal variation of nutrition content and secondary compounds of shrubs need to be further defined. Most of the grazing fuel modification study work has been conducted with goats, primarily because of their preference for targeted plant species. Grazing animals can modify wildfire fuels through consumption and trampling. Animals are most effective at treating smaller-sized live fuels and 1- and 10-hour fuels. These fuels influence an important part of fire behavior by providing the flammable material that creates a ladder of fuel in order for a fire to extend up from the ground into the brush and tree canopy. There is a lack of research knowledge upon which to draw in order to refine the grazing treatment to meet fuel management objectives. Many treatments in the past had only a single grazing year focus. This strategy can be effective in a grass ecosystem if timed right, but systems with abundant shrubs often require multiple years to create and maintain a fuel profile that is more desirable.

More research needs to be done to allow effective use of grazing as a fuel reduction tool. Further research also needs to be done on secondary compounds in brush plants, their seasonal variation, and methods to overcome them to achieve target utilization levels. Knowledge of the nutrient status of the plants throughout the year also will assist in indicating the time of optimum utilization of grazing in fire fuel reduction.

References

1. National Interagency Fire Center. 2006. Wildland Fire Statistics. Available at: http://www.nifc.gov/stats/index.html. Accessed January 2006.
2. Davidson, J. 1996. Livestock grazing in wildland fuel management programs. *Rangelands* 18:242–245.
3. Doescher, P. S., S. D. Tesch, and M. Alejandro-Castro. 1987. Livestock grazing: a silvicultural tool for plantation establishment. *Journal of Forestry* 85(10):29–37.
4. Tsiouvaras, C. N., N. A. Havlik, and J. W. Bartolome. 1989. Effects of goats on understory vegetation and fire hazard reduction in a coastal forest in California. *Forest Science* 35:1125–1131.
5. Magadlela, A. M., M. E. Dabaan, W. B. Bryan, and E. C. Prigge. 1995. Brush clearing on hill land pasture with sheep and goats. *Journal of Agronomy and Crop Science* 174:1–8.
6. Smith, E., J. Davidson, H. Glimp. 2000. Controlled sheep grazing to create fuelbreaks along the urban-wildland

interface. Proceedings of the 53rd Annual Meeting of the Society of Range Management; Boise, ID. 6 p.
7. Green, L. R., C. L. Hughes, and W. L. Graves. 1987. Goats control of brush regrowth on Southern California fuel-breaks. *In* First International Rangeland Congress; 14–18 August 1987; Denver, CO. p. 451–455.
8. Lindler, D., J. Warshawer, and D. Campos. 1999. Using goats to control understory vegetation. *Forest Vegetation Management Conference* 20:33–46.
9. Allen, B. H., and J.W. Bartolome. 1989. Cattle grazing effects on understory cover and tree growth in mixed conifer clearcuts. *Northwest Science* 63:214–220.
10. Gutman, M., Z. Henkin, Z. Holzer, I. Noy-Meir, and N. G. Seligman. 1991. Beef cattle grazing to create firebreaks in a Mediterranean oak maquis in Israel. *In* Proceedings of the IV International Rangeland Congress, Montpellier, France. p. 204–209.
11. Masson, P., and C. Guisset. 1993. Herbaceous and shrubby vegetation evolution in grazed cork oak forest firebreaks sown with subterranean clover and perennial grasses. *In* Proceedings of the 7th Meeting FAO European Sub-network on Mediterranean Pastures and Fodder Crops, Crete. p. 201–205.
12. Henkin, Z., M. Gutman, H. Aharon, A. Perevolotsky, E. D. Ungar, and N. G. Seligman. 2005. Suitability of Mediterranean oak woodland for beef herd husbandry. *Agriculture, Ecosystems and Environment* 109:255–261.
13. Hadar, L., I. Noy-Meir, and A. Perevolostsky, 1999. The effect of shrub clearing and intensive grazing on the composition of a Mediterranean plant community at the functional group and species level. *Journal of Vegetation Science* 10:673–682.
14. Perevolotsky, A., R. Schwartz-Tzachor, and R. Yonatan. 2002. Management of fuel breaks in the Israeli Mediterranean ecosystem. *Journal of Mediterranean Ecology* 3(2–3):13–22.
15. Beasom, S. L. 1980. Dietary overlap between cattle, domestic sheep, and pronghorns. *In* R. E. Soesbee and F. S. Guthery [eds.]. Noxious Brush and Weed Control Research highlights. Volume 11. Lubbock, TX: Texas Tech University. p. 40–41.
16. Provenza, F. D., and J. C. Malechek. 1984. Diet selection by domestic goats in relation to blackbush twig chemistry. *Journal of Applied Ecology* 21:831–841.
17. Taylor, C. A. 1994. Sheep grazing as a brush and fine fuel management tool. *Sheep Research Journal* 10:92–96.
18. Luginbuhl, J. M., T. E. Harvey, J. T. Green, M. H. Poore, and J. P. Mueller. 1999. Use of goats as a biological agents for the renovation of pastures in the Appalachian region of the United States. *Agroforestry Systems* 44:241–252.
19. Lombardi, G., A. Reyneri, and A. Cavallero. 1999. Grazing animals controlling woody-species encroachment in subalpine grasslands. *In* Proceedings of the International Occasional Symposium of the European Grassland Federation; 27–29 May 1999; Thessaloniki, Greece. p. 85–90.
20. Spurlock, G. M., R. Plaister, W. L. Graves, T. E. Adams, and R. Bushnell. 1980. Goats for california brushland. Oakland, CA: Cooperative Agriculture Extension, University of California, Leaflet 21044. 30 p.
21. Kothmann, M. M. 1968. The botanical composition and nutrient content of the diet of sheep grazing on poor condition pasture compared to good condition pasture [dissertation]. College Station, TX: Texas A&M University. 68 p.
22. Launchbaugh, K. L., F. D. Provenza, and J. A. Pfister. 2001. Herbivore response to anti-quality factors in forages. *Journal of Range Management* 54:431-440.
23. Robbins, H., A. E. Hagerman, O. Hajeljord, D. L. Baker, C. C. Schwartz, and W. W. Moutz. 1987. Role of tannins in defending plants against ruminants: reduction in protein availability. *Ecology* 68:98–107.
24. Happe, P. J., K. J. Jenkins, E. E. Starkey, and S. H. Sharrow. 1990. Nutritional quality and tannin astringency of browse in clear-cuts and old-growth forest. *Journal of Wildlife Management* 54:547–556.
25. Kumar, R., and S. Vaithyanathan. 1990. Occurrence nutritional significance and effect on animal productivity of tannins in tree leaves. *Animal Feed Science Technology* 30:21–38.
26. Lowry, J. B., C. S. McSweeney, and B. Palmer. 1996. Changing perceptions of the effect of plant phenolics on nutrient supply in the ruminant. *Australian Journal of Agriculture Research* 47:829–842.
27. Bryant, J. P., F. D. Provenza, J. Pastor, P. B. Reichardt, T. P. Clausen, and J. T. du Toit. 1991. Interactions between woody plants and browsing mammals mediated by secondary metabolites. *Annual Review of Ecology and Systematics* 22:431–446.
28. Villalba, J. J., F. D. Provenza, and R. E. Banner. 2002. Influence of macronutrients and polyethylene glycol on intake of a quebracho tannin diet by sheep and goats. *Journal of Animal Science* 80:3154–3164.

Authors are: Livestock & Natural Resources Advisor, University of California Cooperative Extension, 142-A Garden Hwy, Yuba City, CA 95991, ganader@ucdavis.edu (Nader); Research Leader Range Management, Agricultural Research Organization, The Volcani Center, PO Box 6, Bet Dagan, Israel (Henkin); Natural Resource Specialist, University of Nevada Cooperative Extension, PO Box 338, Minden, NV 89423 (Smith); Livestock & Natural Resources Advisor, University of California Cooperative Extension, 11477 E Ave, Auburn, CA 95603 (Ingram); and PhD Candidate in Ecology, Ecology Graduate Group, Animal Science Department, University of California, Davis (Navaraez).

PRESCRIBED HERBIVORY FOR VEGETATION TREATMENT PROJECTS

An informational document prepared by the Range Management Advisory Committee

Bill Burrows, Coordinator, Sunflower Coordinated Resource Management Program.
RMAC Member

Brittany Cole Bush, Project Manager, Star Creek Land Stewards, Inc, & BCB Shepherdess, LLC.
RMAC Member

Kevin Conway, Staff Forester, Board of Forestry and Fire Protection
RMAC Coordinator

June 2015

OVERVIEW

This document has been produced by the Range Management Advisory Committee (RMAC) to provide assistance in implementing prescribed herbivory projects by CAL FIRE Vegetation Management Program (VMP) Foresters and others contemplating fuel reduction projects. Herbivores are currently an underutilized tool for strategically reducing hazardous fuel loads. The information included in this document will give the reader a broad overview of prescribed herbivory, the fuel types that may be treated, basic considerations for project design, and how to locate a contractor to perform the service.

Prescribed herbivory for hazardous fuel reduction is the intentional use of domestic livestock to remove, rearrange, or convert vegetation on wildlands to reduce the costs and losses associated with wildfires and to enhance the condition of forests, rangelands, and watersheds. The types of domestic livestock considered include sheep, goats and cattle. Sheep and goats are the favored animals for VTP projects because of their grazing and browsing habits and their relative ease of transport. Combinations of these animals, depending on project size and vegetation types, can be effective in creating fuel breaks in grass and shrub fuel types, and maintaining fuel breaks in grass, shrub and timber fuel types. Effective use of livestock requires the appropriate combination of animals, stocking rates, and timing.

Determining the goals and objectives of the user are critical in evaluating the potential use of prescribed herbivory, also referred to as “targeted grazing” or “targeted browsing.” In general, CAL FIRE initiated projects will include hazardous fuel reduction as the primary goal of the project. Resource protection, such as noxious weed treatment, may be a secondary goal of projects. This paper provides guidance on

- benefits and limitations of using livestock,
- factors to consider in a site evaluation,
- general animal characteristics,
- best management practices,
- contracting considerations,
- CEQA considerations, and
- resources for more information.

BENEFITS

Prescribed herbivory can offer a variety of benefits in comparison to other types of vegetation treatments. Herbivory is a historic, natural way of removing biomass and can yield a quality protein product for commercial benefit. Herbivores are essentially a “biological masticator” that can reproduce themselves and turn unwanted biomass into a consumable product. In addition to fire prevention benefits, carefully managed grazing can provide important environmental benefits such as increased soil organic matter, control of invasive species, and improved plant and wildlife habitat.

Consider using prescribed herbivory in the project when the following concerns arise:

- Air quality, when compared to the use of prescribed fire.
- Noise, when compared to mechanical and some manual treatments.
- Proximity to structures, when compared to risks of using prescribed fire or mechanical treatments.
- Steep slopes, when compared to prescribed fire, manual, or mechanical treatments.
- Soil compaction and surface disturbance, when compared to mechanical treatments.
- Noxious weed control, when compared to manual or mechanical treatments.

LIMITATIONS

There may be environmental, social, or project constraints that make prescribed herbivory an inappropriate treatment to consider, including, but not limited to, the following:

- Timing constraints on treatment implementation, especially in relation to the size and maturity of the vegetation. Browsers tend to eat the leaves and shoots and leave the larger woody material (one inch or larger) behind. Seasonal variations also affect the palatability and nutritional quality of vegetation.
- Goats may eat the bark of some tree species, which may kill the tree by girdling. This can be controlled through appropriate stocking rates and limiting their duration on site.
- Animals need shelter during wet weather accompanied by freezing or near-freezing temperatures.
- Herbivory will only remove live one- and ten-hour fuels (those less than about one inch). Additional treatments will be necessary if there are larger materials to be treated or a high quantity of dead fuels on-site.

SITE EVALUATION

Several characteristics and parameters of the site must be evaluated prior to designing a grazing/browsing management plan including, but not limited to, the following:

Vegetation Characteristics

Prescribed herbivory should be considered when the targeted vegetation to be removed or modified is grass, forbs, or shrubs. Herbivores may also be appropriate in forested vegetation types when the targeted vegetation is shrubs and brush, such as in fuel break maintenance. Vegetation characteristics to evaluate include:

- Species Composition: Understanding the vegetation species on the ground will aid the contract grazer in identifying the appropriate animal for the job. Any noxious weeds on site should also be identified. This information may dictate the timing of grazing for when the vegetation is most palatable and any noxious weeds are unlikely to be spread.
- Height: Goats can browse only as high as they can get their mouth when standing on their hind legs, or about 7 feet. Any vegetation higher than this is unlikely to be adequately grazed to meet fuel reduction goals.
- Diameter: Goats can browse shrub and tree stems up to approximately 1 inch in diameter. Material of greater diameter will likely be left on site, denuded of any smaller stems, branches, and leaves.
- Density: The relative density or quantity of the vegetation to be removed or modified will aid in determining the number of animals and the length of time necessary to complete the job.

Environmental Characteristics

Herbivores have the potential to damage other resources if their movement is not closely controlled. Potential resources of concern are watercourses, sensitive wildlife habitat, cultural resources, and any desirable vegetation to be left on-site. Special consideration may also need to be provided to neighboring landowners and residents when developing a prescribed herbivory project. Sensitive resources need to be identified and mitigation measures developed for their protection during project development. Any identified sensitive areas should be clearly marked in the field and identified on any project maps. The protection measures need to be included in the vegetation treatment plan and clearly communicated to the herder and project manager, including a pre-operational field visit when appropriate.

Infrastructure

Moving herbivores to the site requires trucks and trailers. Once the animals are onsite, water and containment to the desired vegetation must be addressed.

- Roads: Transportation of herbivores generally is by tractor trailer or pick-up truck with trailer, depending on the number of animals. It is important to note if the site has an adequate turn around and loading/unloading area to facilitate large truck traffic. This does not have to be directly at the project site as animals can be moved moderate distances on foot to the project area. Also note if there are access roads throughout the project area, and if the loading area will be different than the unloading area.
- Water: All herbivores require water on site. This can be from an on-site stock pond, a water supply line to a portable water trough, or can be shipped in by truck. All available water sources in the general project vicinity should be identified during project development.
- Containment: Herbivores will need to be contained to the project boundaries or smaller sub-units within the project area. Controlling animal movement controls the intensity and duration of grazing in the project area, is necessary to protect on and off-site sensitive resources, and to protect the herbivores themselves from predators. This will generally involve some combination of fencing, guard and herd dogs, and an on-site herder. Portable fencing is a common tool for contract grazers, but any existing fences or barriers to animal movement should be identified.

Scale

The size of the project and the amount of vegetation to be removed will have a strong influence on the economics of prescribed herbivory projects. As with mechanical treatments, the move in and set up costs are fixed regardless of project size. Herbivores also become more productive once they are familiar with the vegetative characteristics of the site. Larger projects will likely result in bids that are cheaper per acre or per animal day than smaller projects. However, small projects may still be competitive with other vegetation treatment methods, so the size of the project should not discourage the use of herbivores. The contracting section below goes into further detail on this topic.

ANIMAL CHARACTERISTICS

Generally animals can be divided into two categories, grazers and browsers; each category may overlap significantly depending on species, stage of growth, availability of forage, animal genetics, or previous training of animals. Cattle and sheep fall into the category of "grazers," and tend to prefer the bulk cellulose of grasses and forbs. Goats fall into the broad category of "browsers," and tend to feed on more readily digestible leaves and shoots of shrubs and trees within their reach. All these animals have a limited ability to shift among these feeding strategies.

Browsing multiple species (usually goats and sheep) together on the same site can be very effective for fuel reduction projects, particularly when the target vegetation is a combination of grass, forbs, and shrubs. Taking advantage of the dietary preferences of each herbivore can result in a more complete fuel reduction project. Grazing animals such as sheep will consume the grass and forbs, while browsing animals such as goats will consume the more woody material within their reach (up to 7 feet high).

Fuel reduction will also be dependent on the stocking rate, or the number of animals per unit area (density), over the specified period of time. Prescribed herbivory is generally performed at high stocking densities for short periods of time to encourage the animals to compete amongst each other for limited resources. This strategy encourages the animals to uniformly consume all the vegetation present and not preferentially browse and graze on only the most nutritious vegetation available. This strategy also helps with animal health as the livestock balance the amount of nutritious and less-nutritious vegetation in their diet over short time periods. It is not uncommon to see stocking rates equivalent to 450-900 animals per acre for a 24 hour period.

Consumption per day of both grazers and browsers can be calculated by the following standard guidelines:

- Goats will eat approximately 3% of their body weight per day of the dry matter weight of the forage being consumed.
- Sheep, horses and cattle will eat approximately 2% of their body weight in dry matter per day.

A 100 pound goat would consume approximately 12 pounds of green brush per day. If the project objective is to remove one ton (2,000 pounds) of brush per day from a specified area, it would take approximately one hundred seventy (170) 100 pound goats to accomplish that objective. By calculating the amount of biomass to be removed, the project's necessary mob size (number of animals) and length of the foraging period can be calculated. These guidelines will help during the contracting phase of project development. There is not a typical mob size for multi-species systems; however, one herder can handle up to 1,500 head of goats and sheep and one semi-truck can transport approximately 450 goats and sheep. The ratio of grazers to browsers can be tailored to the targeted vegetation to be removed.

Forage species being targeted for herbivory may not always provide a nutritionally adequate diet for the animals. Energy, mineral, or protein supplements may be required to maintain animal health and productivity. Toxic plants can be a challenge, particularly with sheep. Goats seem to be resistant to most serious toxins but may limit their intake of scrub or forbs depending on the time of year or elevation. The contract grazer will be able to identify any special constraints on the site and may be able to suggest seasonal project timing that will best meet the project's objectives.

BEST MANAGEMENT PRACTICES

There are important best management practices to integrate into the design of a prescribed herbivory project to minimize or mitigate potential environmental or social impacts.

- Identify and establish appropriate buffer zones around environmentally sensitive areas such as riparian zones, sensitive plants, threatened or endangered animal habitat and archaeological resources.
- To prevent introduction of seeds from undesirable plant species to the site, consideration should be given to where the animals are coming from, and whether viable seeds of undesirable species are present. If this is the case, the herd should be fed a weed free diet for three days prior to being introduced to the grazing site. Any supplemental feed brought on site should be free of noxious weeds.
- Use the highest appropriate stocking density to achieve uniform utilization of the targeted vegetation.
- Post signs warning public of danger of electric fences and unleashed guard dogs when the project area is open to the public. Discuss public interactions with the on-site herder and grazing project manager.
- Conduct appropriate public outreach so that the public will understand the project objectives. The general public will be very interested in what the animals are doing. Consider project signage or a one page pamphlet or brochure available on-site describing the overall project, its objectives, and how herbivory is helping to achieve those objectives.
- Confirm that the contract grazer has well thought-out animal care procedures and protocols in place to ensure the animals are cared for in a responsible, humane fashion (ample stock

watering, safety from predators, and careful animal observation and action for sickness or disease).

- Consultation with Certified Range Managers (CRM) when appropriate.
- Develop a monitoring program that determines the effectiveness of the grazing/browsing program compared to the original planned results.

CONTRACTING

The following key points should be addressed in a contract with a prescribed grazer. A sample contract and Request for Proposals (RFP) are included in the appendices of this document for further guidance on this subject.

Finding the right Contract Grazing Operator for the project

There are a number of contract grazing outfits performing prescribed herbivory projects to meet specific objectives (ex. fuel reduction, invasive weed control, etc.), most often using some combination of goats, sheep and sometimes cows. The size and scale of these operators varies, from smaller operations using only a few dozen head to commercial operation of upwards of 2,000 head performing year-round grazing services. Determining the project's acreage and the targeted vegetation type and quantity will help determine the best contract grazer for the project. Often a Request for Proposal (RFP) or Request for Quote (RFQ) defining the project location and scope is announced to the general public and contract grazers are able to provide a bid or quote on the project (see Appendix A for an example RFP). Through this process the CAL FIRE project manager can determine which operator may be the best fit for the project.

A list of contract grazers can be found online through the links provided at the end of this document. Please take note that these are not the sole operators performing these services. Active contract grazers in the area can be found by contacting other organizations in the region that use prescribed grazing as a management tool. Some organizations to check with are local Resource Conservation Districts (RCD), Fire Safe Councils (FSC), or local city and county public works departments.

Site Assessment

Before a contract grazer is able to develop a quote and scope of work for a project, it is common for a tour of the site(s) that are being proposed for grazing. This allows the contract grazer to assess a variety of factors to determine the appropriate number of head, species and ratio of animals needed, water access points, fencing type, truck and trailer access, and camp trailer sites (when an on-site herder is necessary). Inviting proposed contract grazing operators to become familiar with the site will allow for the most accurate cost quote and approach to achieving the project's goals using herbivores for mastication of vegetation. Consider designating a day during the RFP period for potential bidders to tour the project site.

Cost Structures

The acreage, duration, time of year, and the project complexity are taken into consideration when contract grazers develop their quotes. There are two general types of cost structures for contract grazing services.

- The first cost structure is quoting the service fee by placing a charge per head per day. For example, there are 500 head of goats proposed to graze, a contract grazing operator might charge 50 cents per head per day. If the project is to consist of 30 days, the quote would be $7,500 (500 goats x $0.50/day x 30 days). It should be made clear whether transportation costs are folded into the cost per head per day, or is a separate, additional cost.

- The second cost structure, common in areas grazed around urban and suburban peripheries, is a service fee per acre grazed for a proposed project. Smaller acreage often is of greater cost per acre than large acreage, typically due to the transportation needs and impact of changing vegetation characteristics on animal performance. Again, it should be made clear whether transportation costs are folded into the cost per head per day, or is a separate, additional cost. Prices for contract grazing services will vary by region and project, however industry standard in 2014 in the urban periphery of the Bay Area can range from $300-$1,000 an acre for the service of targeted grazing for fire hazard reduction and/or stewardship goals. Most of these parcels being grazed are less than 100 acres and generally are in the range of 5-20 acres.

The highest demand months for contract grazers tend to be during the end of the spring growing season through the late summer months and sometimes early fall, depending on annual rainfall. This also varies from region to region. During those heightened demand months contract grazers often charge a premium for their services. Conversely, during the off-season months of fall and winter service fees may be less as the demand for contract grazing services is reduced during this time of year.

The Contract

Public agencies within the state of California have been using contract grazing for more than a decade and detailed contracts have been developed to address the needs and concerns of both the agency and the contractor. The contract generally stipulates insurance qualifications, labor details, grazing schedules and terms of an annual or multiple year contract. Please inquire with local or regional public agencies known to use contract grazing as a vegetation management tool for sample contracts common in the project area. A sample contract is included in Appendix B of this document as an example of the general items that should be covered in a prescribed grazing contract.

CEQA CONSIDERATIONS

The CAL FIRE project manager should investigate whether a prescribed herbivory project falls under one of the existing programmatic CEQA documents prepared by the Department. If it does, the program EIR will have a checklist that confirms whether the project is within the scope of that EIR, as well as any potentially significant impacts from the project and corresponding mitigation measures. Upon certification of the Vegetation Treatment Program (VTP) Program EIR, most prescribed herbivory projects will be covered by that EIR's checklist.

If the prescribed herbivory project does not fall under a program EIR checklist in whole or in part, it will require the completion of a separate CEQA Environmental analysis. The analysis may result in the filing of a Notice of Exemption or the completion and filing of a CEQA checklist and associated environmental documents (Negative Declaration, Mitigated Negative Declaration, or Environmental Impact Report). The Sacramento Headquarters Environmental Protection staff can provide guidance on the appropriate analysis and documentation.

An example environmental analysis has been provided in Appendix C as a reference for projects that are outside of the scope of existing CAL FIRE programmatic CEQA documents. Most prescribed herbivory projects will fall under a CEQA Class 4 (Minor Alteration to Land) Categorical Exemption. The example environmental analysis provided was conducted by the Bureau of Land Management (BLM) under the National Environmental Policy Act (NEPA). While the NEPA process differs slightly from CEQA, this document provides a look at some of the environmental impacts to consider during the CEQA process.

University of California
Agriculture and Natural Resources

ANR Publication 8527 | May 2018
http://anrcatalog.ucanr.edu
UC PEER REVIEWED

PROFILES OF CALIFORNIA BRUSH
Targeted Grazing to Reduce Fire Fuel Loads in California Chaparral Series Part 1

This publication aids in identifying selected brush species found in the California chaparral community and also presents nutritional content and toxin presence for these plants to help livestock producers develop timing and supplementation protocols for targeted grazing. In addition to photographs of the plants, the publication contains information on the level of crude protein (CP) and acid-detergent fiber (ADF) during the growing season for many plants. ADF is a measure of fiber content in a feed; as ADF increases, digestibility decreases. Table 1 provides the seasonal variation of annual grass, forbs, and clover in the chaparral and valley areas of California. Some plant descriptions in this publication contain a browse rating from *California Range Brushlands and Browse Plants* (Sampson and Jepperson 1963, 45). Some graphs in this publication display total condensed tannins (TCT). High tannin levels can reduce feed consumption and digestibility and decrease production efficiency (Cornell University 2015). However, ingesting low to moderate amounts of tannins can help cattle and sheep retain nitrogen. Overall, brush species have low nutritional value and present challenges to targeted grazing management.

CASEY DYKIER, University of California Cooperative Extension/Renewable Resource Extension Act Intern; **DEVII RAO**, University of California Cooperative Extension Livestock and Natural Resources Advisor, San Benito, Monterey, and Santa Cruz Counties; **GLENN NADER**, University of California Cooperative Extension Livestock and Natural Resources Advisor Emeritus, Sutter-Yuba and Butte Counties; **ROGER INGRAM**, University of California Cooperative Extension Livestock and Natural Resources Advisor, Placer-Nevada Counties; **JOSH DAVY**, University of California Cooperative Extension Livestock, Range, and Natural Resources Advisor, Tehama, Colusa, and Glenn Counties; **JEREMY JAMES**, Director, University of California Cooperative Extension Sierra Foothill Research and Extension Center; and **AN PEISCHEL**, Owner, Goats Unlimited

Table 1. Crude protein and crude fiber content of annual grasses, fliaree, and bur clover at seven stages of maturity.

Stage of maturity	Crude protein (%)			Crude fiber (%)		
	Annual grass	Filaree	Bur clover	Annual grass	Filaree	Bur clover
Early vegetative	18	27	28	24	12	16
Late vegetative	15	25	27	25	14	17
Early flowering	15	22	26	26	16	19
Late flowering	10	16	22	29	21	23
Mature	6	10	19	33	26	26
Dry	5	7	18	34	28	28
Dry, leached	3	5	17	35	30	29

Source: Hart et al. 1932; Gordon and Sampson 1939.

How Browse Plants are Rated

An overall browse rating of excellent, good, fair, poor, or useless is given in the discussion of each prominent species or variety for cattle, horses, sheep, goats, and deer. These ratings are based on the following.

- Degree of cropping within easy reach, taking into account season of the year.
- Abundance and distribution of the species and its nutritional value.
- Abundance of twigs and leaves and whether the plant is deciduous or evergreen.
- Reproductive capacity, whether solely by seed or also vegetatively by sprouting, as when cut or burned.
- Objectionable anatomical structures such as spines or prickles that are annoying or injurious to grazing animals.
- Whether the plant is poisonous to grazing animals at any season of the year.

Although this publication uses the best current source of browse ratings for California, more research in this area is needed in the future. If further information is desired regarding plant secondary compounds, toxic plants in California, or supplementation to alleviate toxic effects review Part 2, “Targeted Browsing of California Brush,” in press.

Non-Poisonous Brush Species

Several brush species may have poor palatability and digestibility; some are also quite high in protein and are desirable to livestock.

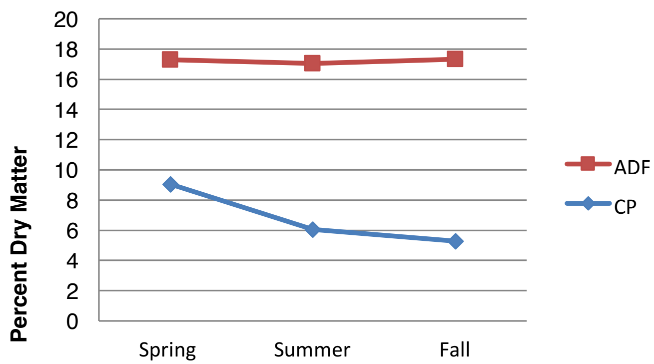
California yerba santa (*Eriodictyon californicum*)

Plant family: Boraginaceae, Waterleaf Family.
Toxic compounds: None.
Signs: NA
Treatment: NA
Time to graze: Spring, CP = 9%.
Management: NA

California yerba santa is a fragrant, erect shrub, 2 to 8 feet tall, that keeps its leaves year round. The branches are smooth and sticky. Leaves are 2 to 6 inches long and are smooth and gummy on top with finely toothed edges. The flowers are lavender, pale blue, or sometimes nearly white, with dense hairs on the outside and grouped in loose clusters that bloom from May to June.

The name "yerba santa," or "holy plant," was given by the Spanish, as it was a major medicinal herb used in the Spanish missions.

California yerba santa has a browse rating of fair to poor for deer and poor for sheep and goats. Deer consume California yerba santa moderately in the spring. Crude protein is highest in the spring and drops below 6% in summer and fall (Narvaez 2007). However, the oils and compounds that create its distinctive scent may decrease palatability.



California yerba santa plant. *Photo:* © 2013 Margo Bors.

California yerba santa flowering stem. *Photo:* © 2013 Margo Bors.

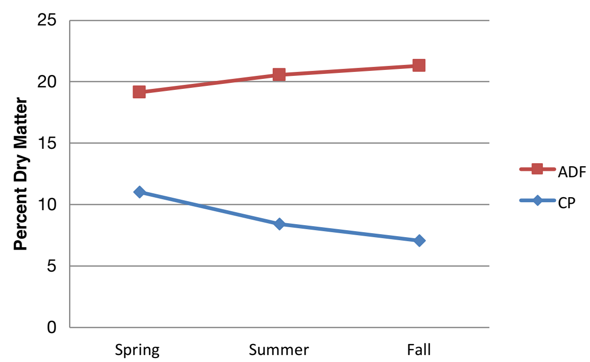
Coyote brush (*Baccharis pilularis*)

Plant family: Asteraceae, Sunflower Family.
Toxic compounds: None.
Signs: NA
Treatment: NA
Time to graze: Spring, CP = 11%.
Management: NA

Coyote brush is a common shrub found in lower-elevation open hills and mountain slopes. It is upright and compact, 2 to 10 feet tall. Its dark green, round leaves, ½ to 1½ inch long, are leathery and coarsely toothed.

Coyote brush has a browse rating of fair to poor for sheep and goats and poor to useless for cattle. Coyote brush does provide forage and vitamin A in dry grass areas. The Eastern variety, *Baccharis cordifolia*, contains alkaloids, but coyote brush is not known to be toxic.

Coyote brush has its highest protein level in the spring and maintains 7% CP even in fall. Occasional burning followed by sheep and goat grazing destroys the sprouts and seedlings.



Coyote bush flowering stem. *Photo:* © 2011 Aaron Arthur.

Coyote bush flowering stem. *Photo:* © 2009 Margo Bors.

Coyote bush stem. *Photo:* © 2002 Lynn Watson.

Blackberry (*Rubus* spp.)

Plant family: Rosaceae, Rose Family.
Toxic compounds: None.
Signs: NA
Treatment: NA
Time to graze: Summer or year round. Supplementation may be needed in winter.
Management: NA

There are eleven species of blackberry (native and introduced) in California, of which four are considered weeds on grazed rangelands: thimbleberry (*R. parviflorus*) and California (*R. ursinus*), Himalayan (*R. armeniacus*) and cutleaf (*R. laciniatus*) blackberry. Thimbleberry has round, smooth stems and simple leaves. Himalayan blackberry, the most problematic, has five leaflets that are toothed and oval. Cutleaf blackberry has five deeply lobed leaflets. California blackberry has three leaflets. In general, blackberries lose their leaves in fall; however, many keep some leaves year round. Blackberries have white or pink flowers in large clusters. They can reproduce from regrowth, rhizomes (underground shoots), and seeds.

Goat and sheep are the preferred species for browsing blackberries. Goats prefer blackberries any time of year and consume them more readily than do sheep. They also readily consume early-season growth and blackberry seedlings. One browsing strategy for

Cutleaf blackberry. *Photo:* UC ANR.

California blackberry. *Photo:* UC ANR.

controlling blackberry is browsing year-round with a stocking rate of three to four sheep per acre. This strategy may require supplemental feeding of hay during the winter to maintain body condition (Launchbaugh et al. 2006). Another strategy is to concentrate a larger number of animals in both spring and summer to deplete blackberry root reserves.

Himalayan blackberry has about 15% CP and 63% total digestible nutrients (TDN) year round (Peters, Filley, and Hulting 2010). In early summer, plants use root reserves for new growth and after midsummer begin to store sugar in the rhizomes. Browsing in this window may best deplete root reserves. Some studies are concerned with the tannin content of blackberry and raspberry fruit and have reported tannin levels from 2 to 6% dry matter (Gudej and Tomczyk 2004). However, these studies used cultivated varieties and a different method of evaluating them than did studies such as that cited above.

Thimbleberry. *Photo:* UC ANR.

Himalayan blackberry. *Photo:* UC ANR.

Poison oak (*Toxicodendron diversilobum*)

Plant family: Anacardiaceae, Sumac Family.

Toxic compounds: Urushiol, an oily organic allergen found in plants.

Signs: Not toxic to livestock. In humans, red skin, watery blisters, and itching occurs 1 to 5 days after exposure.

Treatment: Wash with cold water within 15 minutes of exposure or use dish soap or over-the-counter poison oak products within 2 hours. Some people are not sensitive.

Time to graze: When leaves are not oily (Peischel 2003); CP is high in early spring.

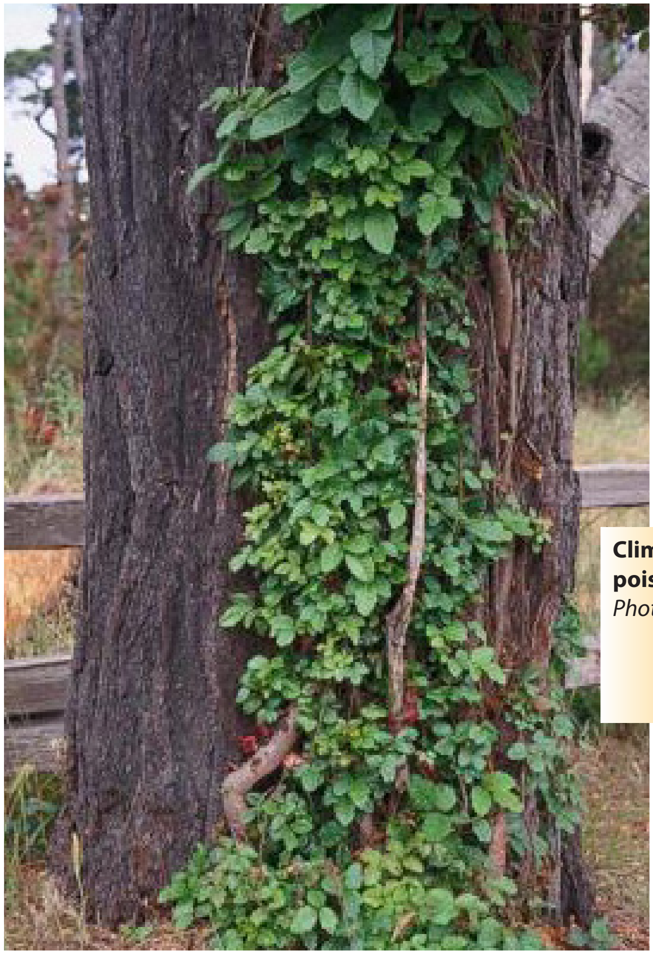
Management: NA

Poison oak plant. *Photo:* UC ANR

Poison oak fruit. *Photo:* UC ANR.

Poison oak is a 1 to 6 foot shrub, or a vine that grows up trees. Leaves have three leaflets that turn red to orange in the autumn and fall off in winter. It has small white flowers and produces small white to green fruit in late summer. Urushiol is a mixture of compounds; allergic reaction to it requires direct contact with the plant or oil on animal fur or objects. Poison oak is not poisonous to livestock. It has a browse rating of good to fair for horses and deer and fair to poor for cattle, sheep, and goats. It is quite nutritious, with CP in young foliage around 35% and 8% when the leaves change color in autumn (Sampson and Jespersen 1963). Livestock prefer poison oak to many other brush species. Sheep and goats like the very young new shoots on second-year growth. Goats prefer to graze in late winter to early spring or late summer to early fall (Peischel 2003).

Poison oak leaves. *Photo:* UC ANR.



Climbing poison oak. *Photo:* UC ANR.

Deerbrush (*Ceanothus integerrimus*)

Plant family: Rhamnaceae, Buckthorn Family.
Toxic compounds: None.
Signs: NA
Treatment: NA
Time to graze: Spring, CP = 27%.
Management: NA

Deerbrush grows between 1,000 and 7,000 feet and is most abundant in the ponderosa pine belt. It loses its leaves in the winter. It is a shrub 3 to 12 feet tall, with long green or yellowish drooping branches. The flowers are white to dark blue in clusters 2 to 6 inches long that bloom from May to July.

Deerbrush is an important summer browse species. Samples have shown that CP averaged 27% in April and about 13% in August. It has a browse rating of excellent to good for sheep, goats, and deer, and good to fair for cattle.

Deerbrush plant. *Photo:* © 1995 Saint Mary's College of California.

Deerbrush inflorescence. *Photo:* © 1995 Saint Mary's College of California.

Brush That Contains Tannins

Tannins can cause harmful conditions such as oak poisoning, which is more common in cattle than in sheep and goats. It causes constipation, dehydration, edema in the neck, and eventual kidney damage. Tannins bind to protein in the rumen, making them indigestible. Therefore, protein supplementation will help reduce the harm caused by browsing brush that contains tannins. Goats have tannin binding proteins in their saliva that allows them to tolerate higher levels of tannin. Calcium also binds with tannins, so calcium supplements may prevent intoxication. Tannin concentrations above 4% in the diet cause animals to eat less.

Blue oak (*Quercus douglasii*)

Blue oak tree. *Photo:* © 2009 Keir Morse.

Plant family: Fagaceae, Oak Family.

Toxic compounds: Tannins.

Signs: Anorexia, rumen stasis, constipation, diarrhea, increased urination, subcutaneous (s.c.) edema of the neck, brisket, abdomen, perineum, weakness, and recumbency (Burrows and Tyrl 2013).

Treatment: Provide fluid and electrolytes (Burrows and Tyrl 2013).

Time to graze: Spring.

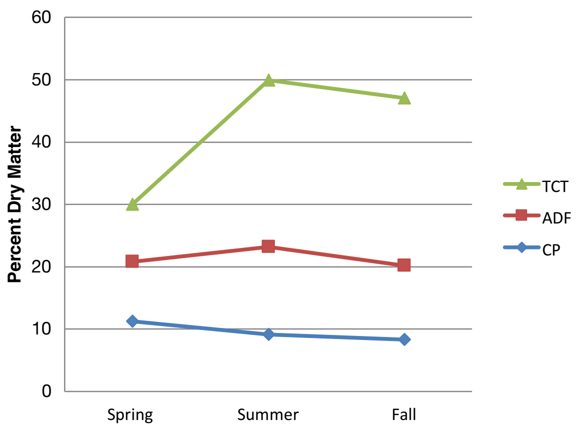
Management: Protein supplement; watch toxicity in cattle.

Blue oak trees grow from 20 to 60 feet tall. The leaves are generally 1 inch to 3 inches long, bluntly toothed, blue green above, and pale beneath. The trunk has white bark that is shallowly checked into small, thin scales.

Blue oak has a browse rating of excellent to good for deer, fair to poor for sheep and goats, and poor for cattle. Young sprouts and acorns are palatable to all types of livestock. One study found that during fall, blue oak made up 15% of black tail deer diet in Tehama County (Sampson and Jespersen 1963). Mature acorns are distinctly low in CP but high in fat, fiber, and oils.

In 1985, during a heavy snowfall of 6 to 9 inches in the northwestern Sacramento valley, cattle had nothing to eat for 3 days but young sprouts and leaves from fallen blue oak branches; on sixty ranches, over twenty-five hundred cattle died (Fuller 1988).

Blue oak tannin content is 20% lower in the spring than in the summer and drops only slightly in the fall. The best time to graze blue oak is in the spring, when CP is highest as well.



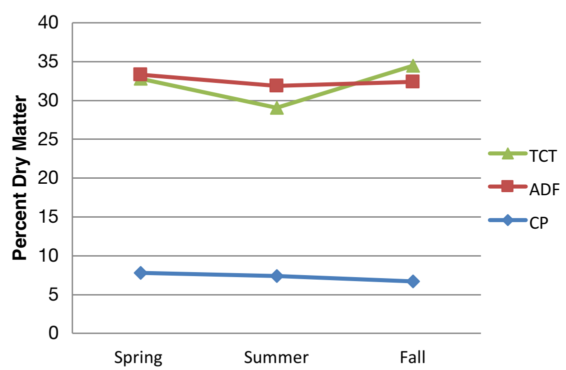
Blue oak acorns. *Photo:* © 2008 Keir Morse.

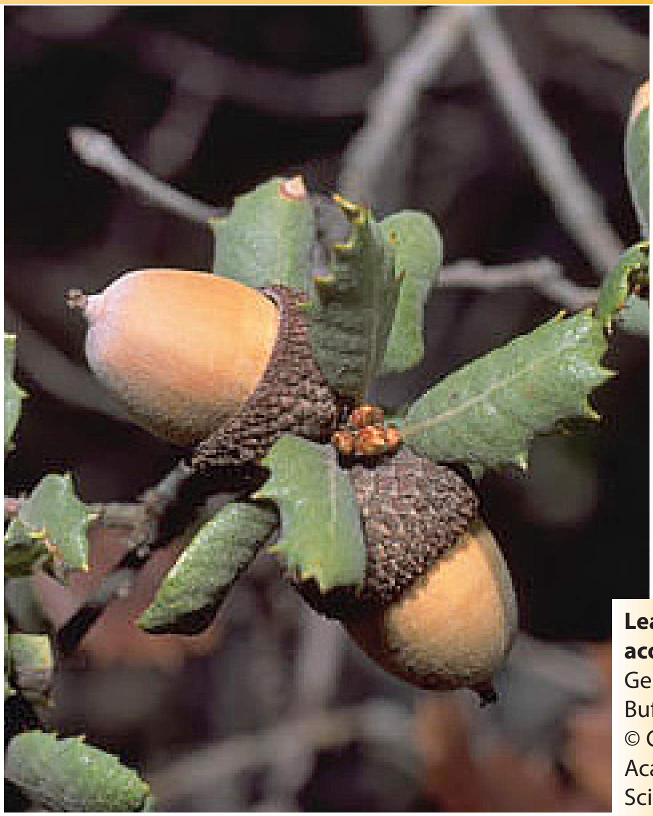
Leather oak (*Quercus durata*)

Plant family: Fagaceae, Oak Family.
Toxic compound: Tannins.
Signs: Anorexia, rumen stasis, constipation, diarrhea, increased urination, s.c. edema of the neck, brisket, abdomen, perineum, weakness, and recumbency (Burrows and Tyrl 2013).
Treatment: Provide fluid and electrolytes (Burrows and Tyrl 2013).
Time to graze: Any.
Management: Protein supplement.

Leather oak is found in the North Coast ranges, Sierra Nevada Foothills, San Francisco Bay Area, and San Gabriel Mountains. It is a shrub that is 3 to 9 feet tall and keeps its leaves year round. The leaves are spiny and the edges roll under. The acorn matures in 1 year, with a cup about ½ to ¾ inch wide and a nut about ⅝ to 1 inch long.

Tannin and CP content change very little by season in leather oak; they tend to be slightly lower in summer. Compared with blue oak, leather oak maintains lower levels of tannin year round but also has lower levels of CP.





Leather oak acorns. *Photo:* Gerald and Buff Corsi © California Academy of Sciences.

Leather oak tree. *Photo:* © 2002 Timothy D. Ives.

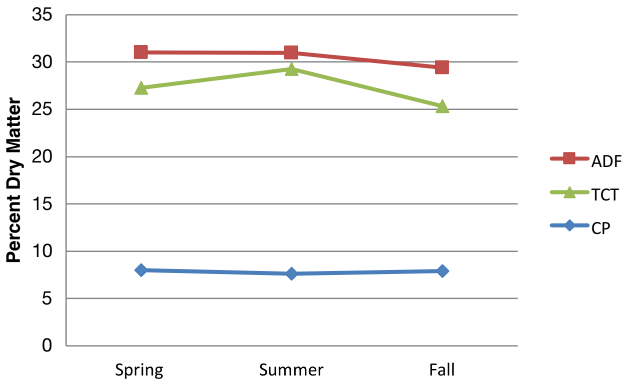
Interior live oak (*Quercus wislizeni*)

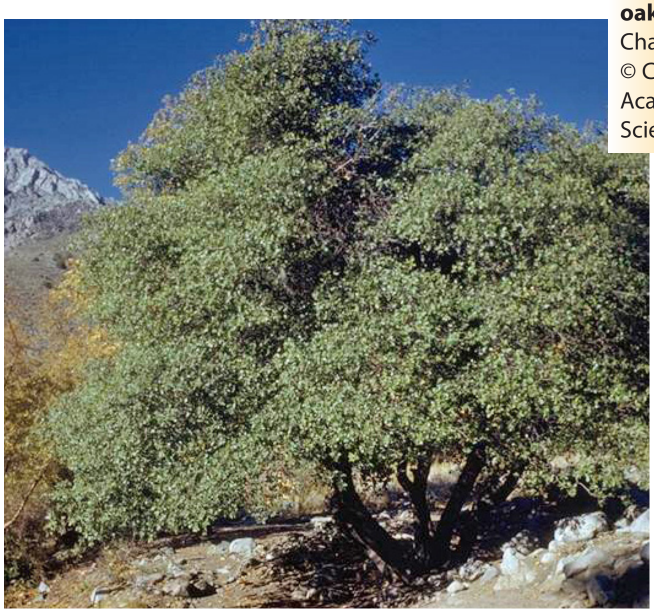
Plant family: Fagaceae, Oak Family.
Toxic compound: Tannins.
Signs: Anorexia, rumen stasis, constipation, diarrhea, increased urination, s.c. edema of the neck, brisket, abdomen, perineum, weakness, and recumbency (Burrows and Tyrl 2013).
Treatment: Provide fluid and electrolytes (Burrows and Tyrl 2013).
Time to graze: Any.
Management: Protein supplement.

Interior live oak is a shrub 3 to 8 feet tall that keeps its leaves year round. The leaves are stiff, dark green, shiny, and ¾ to 2 inches long. The acorns mature the second autumn and are sharply pointed.

Interior live oak has a browse rating of excellent to good for deer, fair to good for goats, fair to useless for sheep, and poor for cattle. The first 2 years of growth are desired by deer, especially in the spring and summer because they are more digestible at that stage of growth.

Tannin and CP levels change very little by season; tannins tend to be slightly higher in summer. Interior live oak is very similar to leather oak.





Interior live oak tree. *Photo:* Charles Webber © California Academy of Sciences.

Interior live oak acorn. *Photo:* © 2008 Keir Morse.

Manzanita (*Arctostaphylos* spp.)

Plant family: Ericaceae, Heath Family.

Toxic compound: Tannins.

Signs: Lower body condition due to weight loss.

Treatment: Protein supplement and possibly energy supplement if there is little other forage to consume.

Time to graze: Summer or fall.

Management: Protein supplementation.

Manzanita is a bush or small tree that keeps its leaves year round. The tree usually has very crooked branches with smooth purplish or reddish-brown bark that may become shredded with age. The small flowers are white or pinkish, bell-shaped, and in clusters. The fruit are round and berrylike.

Hoary manzanita (*Arctostaphylos canescens* ssp. *canescens*)

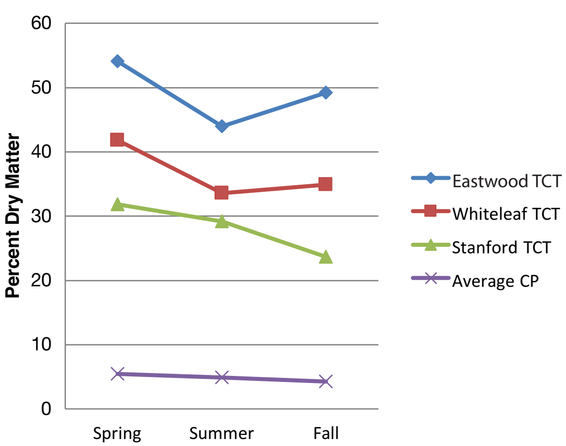
Hoary manzanita can be distinguished from other manzanita species by having no burl at the base of the stem, stems covered in fine hair, and pale gray-green leaves.

Eastwood manzanita (*Arctostaphylos glandulosa*)

Whiteleaf manzanita is found in the dry chaparral areas of lower elevations in the Coast Range south to the mountains of southern California. It can be identified as having a burl at the base of the stem, stems covered in coarse hair, and sticky fruit.

Stanford Manzanita (*Arctostaphylos stanfordiana*)

Stanford manzanita is found along the north coast of California. Its leaves are oblong and bright green to shiny.



Manzanita has a browse rating of poor to useless for goats and deer and useless for cattle and sheep. Experiments 100 years ago to eradicate manzanita in northern California using goats failed because the goats nearly starved to death after eating everything other than manzanita (Sampson and Jespersen 1963). While all species have similar CP levels, the concentration and timing of tannins is different, so grazing should occur in the summer or fall, when tannins are at their lowest level. ADF is similar for all species, ranging from 20 to 25%.

Hoary manzanita. *Photo:* Walter Knight © California Academy of Sciences.

Eastwood manzanita. *Photo:* Charles Webber © California Academy of Sciences

Stanford manzanita. *Photo:* Charles Webber © California Academy of Sciences

Wedgeleaf ceanothus (*Ceanothus cuneatus*)

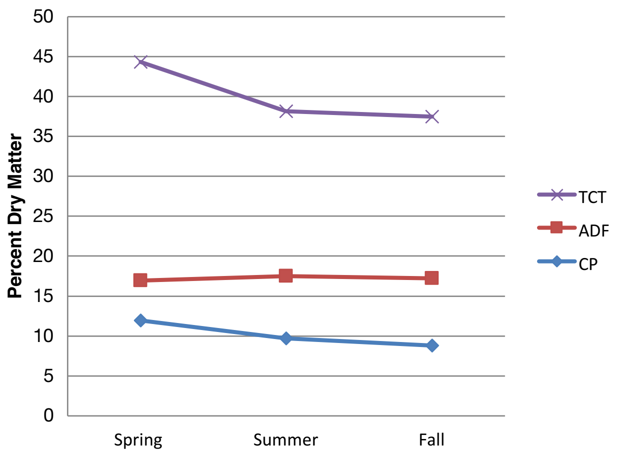
Plant family: Rhamnaceae, Buckthorn Family.
Toxic compound: Tannins.
Signs: Lower body condition due to weight loss.
Treatment: Protein supplement and possibly energy supplement if there is little other forage to consume.
Time to graze: Any. Winter is the preferred time of grazing for goats.
Management: Protein supplement.

Wedgeleaf ceanothus inflorescence. *Photo:* © 2002 Lynn Watson.

Wedgeleaf ceanothus, commonly referred to as buckbrush, is an erect shrub 3 to 8 feet tall that keeps its leaves year round. The leaves are ¼ to 1 inch long, dull green, and attached to spurlike stems. The flowers are white, lavender, or bluish, in short round clusters that bloom from March to April. Seeds, which are contained in a capsule with horns on the back, mature in September and October. Wedgeleaf ceanothus is fast growing and fixes nitrogen, so it establishes quickly in new areas.

Wedgeleaf ceanothus has a browse rating of good to fair for sheep and goats, fair for deer, and poor for cattle. In a digestion trial with deer, it was found that wedgeleaf ceanothus was similar to good hay in TDN. However, it was noted that protein digestibility was low, which is now known to be due to tannins (Hagerman et al. 1992).

Tannin levels do not change significantly by season but tend to be slightly higher in spring. Protein does not change, remaining above 7% year round. The best times to graze is in the summer or fall.



Wedgeleaf ceanothus plant. © 1995 Saint Mary's College of California.

Brush that Contains Cyanogenic Glycosides

Cyanogenic glycosides are not toxic themselves, but they break down into toxic cyanide gas when consumed. Several species of the Rosaceae (Rose) family contain cyanogenic glycosides. The clinical signs of cyanide poisoning include apprehension, distress, weakness, ataxia, labored breathing, collapse, seizures, and death within an hour. If caught quickly, recovery is likely with treatment of 30 to 40% sodium thiosulfate administered intravenously. The best prevention to poisoning is to avoid grazing during the mid to late summer (the period of highest risk) and supply alternative forage. Also avoid grazing plants with cyanogenic glycosides during droughts, for 2 weeks after non-killing frosts, or until the vegetation has dried after killing frosts (Arnold et al. 2014). Consumption of 200 ppm of cyanogenic glycosides is dangerous, and signs of poisoning will show in 15 minutes.

Chamise (*Adenostoma fasciculatum*)

Plant family: Rosaceae, Rose Family.

Toxic compound: Tannins and cyanogenic glycosides causing cyanide poisoning and poor digestibility.

Signs: See introductory paragraph.

Treatment: See introductory paragraph.

Time to graze: Fall, winter, or spring, not mid to late summer (Peischel 2003).

Management: Protein supplement and alternative forages.

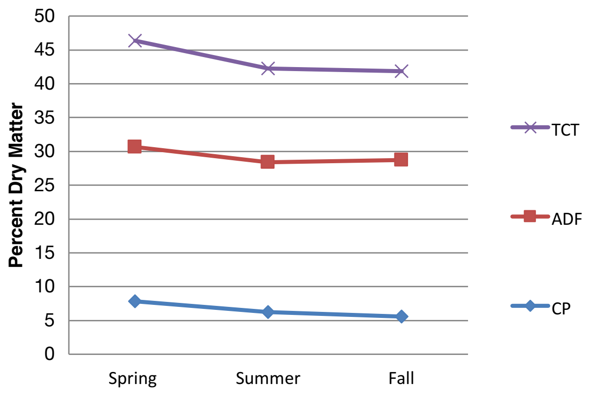
Chamise is a shrub that keeps its leaves year round. It is about 2 to 12 feet tall, with slender, dense branches that have gray or dark bark. The leaves are needlelike, ¼ to ½ inch long, in alternate clusters. Seeds mature from midsummer to fall. Chamise probably has the widest range and produces more volume of growth than any shrub in California (Sampson and Jespersen 1963).

Chamise inflorescence. *Photo:* © 2009 Keir Morse.

Chamise is not highly palatable to livestock or deer and has a browse rating of good to fair for deer, sheep, and goats and poor to useless for cattle. After a fire, chamise sprouts are palatable for about 3 years; therefore, previous management techniques included burning every 3 years. Chamise can be controlled by spraying 2, 4-D in the spring and burning that fall. However, application of 2, 4-D increases cyanide levels in chamise, so livestock should not have access after its application.

Levels of tannins and ADF change very little by season, but CP is slightly higher in the spring, reaching about 7%. Cyanide poisoning can occur in consuming the leaves, stems, and fruit.

Mature chamise plants. *Photo:* © 2010 John J. Kehoe.



Chamise stems. *Photo:* © 2009 Barry Breckling.

Toyon (*Heteromeles arbutifolia*)

Plant family: Rosaceae, Rose Family.

Toxic compounds: Tannin and cyanogenic glycosides.

Signs: Difficulty breathing, convulsions, bloody nose, bloating, and death (Fuller and McClintock 1986).

Treatment: See introductory paragraph.

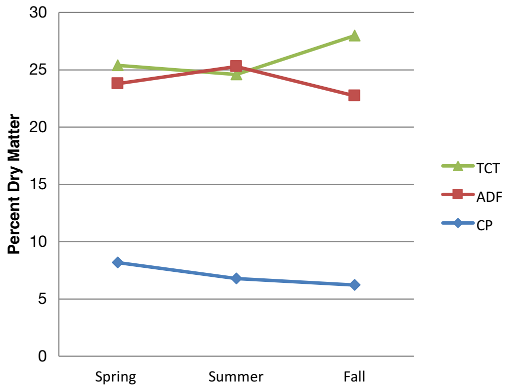
Time to graze: Before flowering and berry development (Peischel 2003); cyanide levels are higher in young growth in spring.

Management: Protein supplement, alternative feed; watch for cyanide poisoning.

Toyon is a large shrub, 6 to 10 feet tall, that keeps its leaves year round. It has thick, leathery leaves that are dark glossy green above and lighter beneath, with bristly, toothed edges. The flowers are small and white in clusters that bloom from June to July. The berrylike, red fruit is present from November to January.

Toyon has a browse rating of good to fair for goats and deer, poor to useless for sheep, and useless for cattle.

Cyanide levels are highest in new leaves during spring, drop in the fall, then rise again once it rains. In one case, goats fed trimmings died within 4 hours; however, the plant is not always a problem because feral goats have heavily grazed it near Baja California (Burrows and Tyrl 2013).



Toyon fruit. *Photo:* © 2003 Michael Charters.

Toyon inflorescence. *Photo:* © 2003 Christopher L. Christie.

The pulp of immature fruit contains cyanide; once mature, the seeds contain cyanide, but the pulp does not.

Tannin content is slightly higher in the fall. CP is highest in spring. The best time to graze toyon may be in summer prior to flowering; however, later in the fall, before it rains, the risk of cyanide poisoning from leaves diminishes.

Western chokecherry (*Prunus virginiana* var. *demissa*)

Plant family: Rosaceae, Rose Family.

Toxic compounds: Cyanogenic glycosides.

Signs: Difficulty breathing, convulsions, bloody nose, bloating, and death (Fuller and McClintock 1986).

Treatment: Use 20 cc of a 10% solution of sodium thiosulfate mixed with 10 cc of a 10% solution of sodium nitrate (Panter et al. 2011). Seek advice from a veterinarian.

Time to graze: Avoid grazing chokecherry in spring (Panter et al. 2011).

Management: Animals usually avoid chokecherry if there is plenty of forage available. Avoid grazing in areas with chokecherry during drought or other times when little other forage is available (Panter et al. 2011).

Chokecherry is a shrub 3 to 8 feet tall that loses its leaves in the winter. It has white flowers on stalks 2 to 5 inches long that bloom from April to May, producing red or dark purple fruit ¼ to ½ inch in diameter that mature in September and October.

Western chokecherry accounts for more sheep losses than any other species in the rose family. This plant is palatable to deer, sheep, and goats, with CP ranging from 15% in midsummer to 12% in the fall. It is very poisonous at certain growth stages; however, usually only a few animals become ill or die. Toxicity depends on the amount consumed, cyanide content variation by season, amount of moisture in the leaves, size of the animal, amount of forage in the stomach, and how quickly the foliage was consumed.

Western chokecherry fruit. *Photo:* © 2007 Mary Winter.

Bitter cherry (*Prunus emarginata*)

Plant family: Rosaceae, Rose Family.
Toxic compounds: Cyanogenic glycosides.
Signs: See introductory paragraph.
Treatment: See introductory paragraph.
Time to graze: Avoid grazing sheep in fall (Sampson and Jepperson 1963).
Management: See introductory paragraph.

Bitter cherry is similar to chokecherry, but it has flowers in short, rounded clusters and produces fruit that is oval, ½ inch long, and turns from red to black when ripe.

Bitter cherry has occasionally caused poisoning in sheep in the fall. Its CP levels are similar to those of desirable plants, and it has a browse rating of excellent for deer, fair for cattle and goats, and fair to poor for sheep.

Bitter cherry inflorescence. *Photo:* © 1995 Saint Mary's College of California.

Serviceberry (*Amelanchier alnifolia*)

Plant family: Rosaceae, Rose Family.
Toxic compound: Cyanogenic glycosides.
Signs: See introductory paragraph.
Treatment: None.
Time to graze: Also avoid grazing during droughts, for two weeks after non-killing frosts, or until the vegetation has dried after killing frosts.
Management: Avoid grazing during the early growing season when toxin levels are high.

Serviceberry is a rigid shrub, 3 to 10 feet tall, with gray or reddish brown bark. The flowers are in roundish white clusters 1 to 2 inches long that bloom from April to June and produce a bluish or purple berrylike edible fruit that is ¼ inch wide. It has a browse rating of good for goats and good to fair for cattle, sheep, and deer. In samples collected in Northern California, the CP content of leaves and stems ranged from 13% in June to 4% in November.

Birch leaf mountain mahogany (*Cercocarpus betuloides*); Curl-leaf mountain mahogany (*Cercocarpus ledifolius*)

Plant family: Rosaceae, Rose Family.

Toxic compound: Cyanogenic glycosides.

Signs: Toxicity of plants from this genus can cause difficulty breathing, convulsions, bloody nose, bloating, and death (Fuller and McClintock 1986).

Treatment: See introductory paragraph.

Time to graze: Avoid grazing after early-autumn frosts (Burrows and Tyrl 2013).

Management: See introductory paragraph.

Plants in the *Cercocarpus* genus contain cyanogenic glycosides. While Western mountain mahogany and curl-leaf mountain mahogany are not specifically listed as toxic to livestock, other species in this genus can cause harm, particularly *C. montanus* (alder-leaf mountain mahogany) (Burrows and Tyrl 2013). Signs, treatment, time to graze, and management for toxic species within this genus are listed. Found along the mountain ranges of California, western mountain mahogany inhabits elevations of 400 to 5,000 feet; curl-leaf mountain mahogany inhabits 4,000 to 8,500 feet. Western mountain mahogany can be identified as having wedge-shaped leaves with smooth edges below the middle and sharply toothed above. Curl-leaf mountain mahogany has leaves that are leathery, sticky, smooth above, and white-hairy beneath, with smooth edges.

Mahogany is a valued browse species, with a browse rating of excellent for deer, excellent to good for sheep and goats, and good for cattle. In a nutritional study in California, mountain mahogany contained CP levels averaging 7% in January and February; 14 to 15% in April, May, and June; 12% in July, August, and September; and 9% in October, November, and December. Cyanide is potentially present in the leaves, especially in the fall after the first frost.

Birch leaf mountain mahogany stem. *Photo:* Charles Webber © California Academy of Sciences.

Curl-leaf mountain mahogany stem. *Photo:* ©2007 Dr. Mark S. Brunell.

Browse with Higher Toxicity

Ponderosa pine (*Pinus ponderosa*)

Plant family: Pinaceae, Pine Family.

Toxic compounds: Terpenes.

Signs: Early vulvar swelling and mammary development; blood-tinged discharge from the vulva, delivery of dead or weak calves; placental retention, metritis, flaccid uterus (Burrows and Tyrl 2013).

Treatment: Remove retained placenta; treat metritis; provide good feed (Burrows and Tyrl 2013).

Time to graze: Avoid grazing in winter when little other forage is available (Panter et al. 2011).

Management: Avoid grazing pregnant animals.

Ponderosa pine is found throughout California in dry, mountainous sites. It can be identified by its orangeish bark with large grains and needles 5 to 10 inches long in clusters. Consumption of more than 2.5 pounds of dry or green needles in the last 2 months of pregnancy can cause abortion in cattle (Pfister 2008). Deer, sheep, and goats are not as susceptible as are cattle.

Ponderosa pine. *Photo:* Charles Webber © California Academy of Sciences.

California buckeye (*Aesculus californica*)

Plant family: Sapindaceae, Soapberry Family.

Toxic compounds: Aesculin, saponins; in all, more than thirty compounds.

Signs: Sawhorse stance, trembling, reluctance to move; lasts 12 to 48 hours.

Treatment: Rarely fatal, usually not necessary.

Time to graze: Goats prefer buckeye in fall, when leaves are dry (Peischel 2003), although CP is very high in spring. Seasonal content of toxin is unknown.

Management: Supplementing diet with cholesterol may help but has not been studied. Supply alternative forage.

California buckeye is a 15- to 40-foot-tall tree that loses its leaves in fall. It has smooth gray bark and leaves that have 5 to 7 oblong, toothed leaflets that are 3 to 6 inches long. The flowers are large, pinkish, and fragrant in erect cylindrical clusters 6 to 10 inches long that bloom from May to July.

Palatability varies by season; deer feed on new leaves in the winter and fallen leaves in August. Its browse rating is excellent to good for deer, fair to poor for sheep and goats, and poor for cattle. Sheep and goats browse buckeye, but cattle rarely do. Goats graze once the leaves dry and will also remove bark from the tree.

The CP of young leaves can be exceptionally high, sometimes 39%, dropping to 24% before flowering, 17% in late bloom, and 13% when leaves change color and drop.

The fruit and leaves are poisonous to domestic livestock if large amounts are ingested. Buckeye plants are poisonous to all livestock; the nectar and pollen are poisonous to honey bees. In 1960, after a late-April snowstorm in Tehama County, a number of cattle died from eating California buckeye leaves.

California buckeye fruit. *Photo:* © 2011 Neal Kramer.

Scotch broom (*Cytisus scoparius*)

Plant family: Fabaceae, Legume Family.

Toxic compound: Alkaloids.

Signs: Clinical signs have not been confirmed but are most likely to consist of abrupt onset of diarrhea, ataxia, tremors, and possible fetal deformities.

Treatment: Unknown.

Time to graze: Before flowering and in fall dieback (Peischel 2003). Leaves and stems have higher CP in spring.

Management: Remove adult females from areas with Scotch broom 3 weeks prior to blooming and do not return until after kidding. Remove doelings at least 6 months before breeding.

Several species of *Cytisus* grow in California, two of which have become invasive weeds: French broom and Scotch broom. Scotch broom is a 3- to 10-foot-tall shrub with sharply angled branches and bright yellow flowers that bloom from March to June, before leaves emerge. Young branches have five ridges, are green and hairy, and become smooth and brown as they age. Leaves are small and oblong, with three leaflets. The flowers are single or paired along the branches and resemble pea flowers.

The leaves contain several alkaloids, including lupanine, anagyrine, sparteine, and cystisine. These alkaloids bind to receptors and affect the nervous system and the digestive tract. Alkaloids cause the plant to taste bitter and therefore may affect palatability to animals, limiting intake. The plants also contain flavonoids, which may cause reproductive problems in livestock. Scotch broom has a browse rating little to no value.

Scotch broom plants. *Photo:* © 2005 Louis-M. Landry.

Scotch broom stem. *Photo:* © 2008 Neal Kramer.

Scotch broom inflorescence. *Photo:* © 2008 Neal Kramer.

California azalea (*Rhododendron occidentale*)

Plant Family: Ericaceae, Heath Family.

Toxic compounds: Diterpenoids, grayanotoxins.

Signs: Anorexia, profuse salivation, swallowing, vomiting, retching, colic, irregular respiration, and bellowing that lasts up to 24 hours.

Treatment: No specific antidote; 10 to 20 mg atropine sulfate and 15 to 20 mL 10% camphorsulfate given subcutaneously. Oral administration of charcoal limits absorption of toxins after ingestion.

Time to graze: Never.

Management: Plant is unpalatable but may be eaten in high amounts when no other green forage is available.

California azalea can be found in the north Coast Ranges, Sierra Nevada, and the mountains of southern California along streams and wet places. California azalea is a shrub that loses its leaves, is 3 to 16 feet tall, with bright yellow-green leaves 1½ to 3½ inches long. Flowers form in clusters of 5 to 20 and are very fragrant, tube shaped, and white to pink with a yellow stripe.

Sheep have been lost when pastured in an area with a large amount of azalea for a long period of time. In 1979, 15 to 20 goats became ill in Shasta County from eating California azalea. They were vomiting and showed diarrhea, and two goats died. All parts of the plant, including the nectar, is toxic. The toxins bind sodium channels, which has effects on many cells, especially neurological, cardiac, and muscular.

California azalea inflorescence. *Photo:* © 2011 Neal Kramer.

California azalea plant. *Photo:* © 2013 Aaron Arthur.

Tree tobacco (*Nicotiana glauca*)

Plant Family: Solanaceae, Nightshade Family.

Toxic compound: Alkaloids.

Signs: Excitement, salivation, and tremors of short duration; later, depression, ataxia, labored breathing, and birth defects.

Treatment: Induced vomiting and activated charcoal.

Time to graze: Never. All plant parts are toxic year-round.

Management: Unpalatable. As with other alkaloids, supply alternative feed. In cows, ingestion of 0.07% of body weight of dried leaves caused intoxication, while in sheep, ingestion of 0.13% of body weight produced clinical signs and higher dosage caused birth defects.

Tree tobacco is a shrub or small tree that can reach 25 feet tall. The leaves are 1 to 4 inches long and are bluish-gray or appear to be covered in a waxy white substance. The yellow, tubular flowers are 1¼ to 2 inches long at the end of branches. The plant blooms from April to November.

Tree tobacco has caused human poisoning in California. The species is unpalatable to livestock, yet poisonings have been reported from tree tobacco as well as coyote tobacco and desert tobacco. Cleft palates occurred in goats exposed to tree tobacco at 35 to 40 days of gestation.

Tree tobacco inflorescence. *Photo:* © 2009 Thomas Stoughton.

Tree tobacco stem. *Photo:* © 2005 Steven Perkins.

References

Arnold, M., C. Gaskill, R. Smith, and G. Lacefield. 2014. Cyanide Poisoning in puminants. Publication ID-220. Lexington: University of Kentucky Cooperative Extension.

Burrows, G. E., and R. J. Tyrl. 2013. Toxic plants of North America. New York: John Wiley & Sons.

Cornell University Department of Animal Sciences. 2015. Plants poisonous to livestock website. http://poisonousplants.ansci.cornell.edu/toxicagents/tannin.html.

Fuller, T. 1988. Poisonous plants of California. Berkeley: University of California Press.

Fuller, T., and E. McClintock. 1986. Poisonous plants of California. California Natural History Guides 53. Berkeley: University of California Press.

Gordon, A., and A. Sampson. 1939. Composition of common California foothill plants as a factor in range management. Berkeley: University of California Agricultural Experiment Station Bulletin 627.

Gudej, J., and M. Tomczyk. 2004. Determination of flavonoids, tannins, and ellagic acid in leaves from *Rubus* species. Archives of Pharmacal Research 27(11): 1114–1119.

Hagerman, A., C. Robbins, Y. Weerasuriya, T. Wilson, and C. McArthur, 1992. Tannin chemistry in relation to digestion. Journal of Range Management 45:57–62.

Hart, G. H., H. R. Guilbert, and H. Goss. 1932. Seasonal changes in the chemical composition of range forage and their relation to the nutrition of animals. Berkeley: University of California Experiment Station Bulletin 543.

Launchbaugh, K., et al. 2006. Targeted grazing handbook. Englewood, CO: American Sheep Industry Association. University of Idaho Rangeland Center website, http://www.webpages.uidaho.edu/rx-grazing/Handbook.htm.

Narvaez, N. 2007. Prescribed herbivory to reduce fuel load in California chaparral. PhD diss., University of California, Davis.

Panter, K., M. Ralphs, J. Pfister, D. Gardner, B. Stegelmeier, S. Lee, K. Welch, B. Green, T. Davis, and D. Cook. 2011. Plants poisonous to livestock in the western states. USDA Agriculture Bulletin 415:13–5.

Peischel, A. 2003. Selection and utilization of various species by goats. California Multi-Species Academy, University of California Cooperative Extension.

Pfister, J. A., K. E. Panter, D. R. Gardner, D. Cook, and K. D. Welch. 2008. Effect of body condition on consumption of pine needles (*Pinus ponderosa*) by beef cows. Journal of Animal Science 86:3608–3616.

Peters, A., S. Filley, and A. Hulting. 2010. Forage value of pasture weeds in Southwestern Oregon. Oregon State University Beef Research Report 2010 Edition. Corvallis: Oregon State University.

Sampson, A., and B. Jespersen. 1963. California range brushlands and browse plants. Berkeley: University of California Division of Agricultural Sciences.

Acknowledgments

The work to develop this publication was funded by Renewable Resources Extension Act. The authors wish to thank the photographers identified in the captions for permission to reprint their work.

For Further Information

To order or obtain ANR publications and other products, visit the ANR Communication Services online catalog at http://anrcatalog.ucanr.edu/ or phone 1-800-994-8849. You can also place orders by mail or FAX, or request a printed catalog of our products from

University of California
Agriculture and Natural Resources
Communication Services
1301 S. 46th Street
Building 478 - MC 3580
Richmond, CA 94804-4600

Telephone 1-800-994-8849
510-665-2195
FAX 510-665-3427
E-mail: anrcatalog@ucanr.edu

Publication 8527

ISBN-13: 978-1-60107-921-3

An electronic copy of this publication can be found at the ANR Communication Services catalog website, http://anrcatalog.ucanr.edu/.

UC PEER REVIEWED

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by ANR Associate Editor for Natural, Marine, and Freshwater Resources William Stewart.

web-5/18-SB/CR