UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

UC ANR Publication 8717 | October 2022
https://doi.org/10.3733/ucanr.8717
https://anrcatalog.ucanr.edu

UC PEER REVIEWED

Managing Small Ruminant Nutrition in Chaparral

Targeted Grazing to Reduce Fire Fuel Loads in California Chaparral Series, Part 2

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Chaparral is a fire-prone shrubland plant community that grows across roughly 7 million acres of coastal and inland California (Quinn and Keeley 2006). It ranges from the northern to the southern end of the state. Wildfires in chaparral can cause severe devastation in human communities, especially communities built on steep slopes above chaparral with heavy fuel loads. Chaparral wildfires can be particularly dangerous when they happen in late summer or autumn, a time of year when the shrubs are dry and highly flammable. In windy conditions, these wildfires can quickly spread (fig. 1).

Six of the seven largest wildfires in California within the last 90 years happened in 2020 and 2021 (CAL FIRE 2021). This trend highlights the urgent need to reduce the potential impacts of wildfire in populated areas of California. One option is to reduce fuel loads—the amount of burnable plant material within a given area.

Targeted grazing for fuel-load reduction in chaparral

Land managers can reduce fire fuels in multiple ways, including prescribed burning, mechanical removal of vegetation, manual removal of vegetation, herbicides, and targeted grazing. Though any of these treatments can be used alone, they are likely to be more effective as an integrated approach. Each treatment has its own challenges, making

Figure 1. Chaparral wildfire near urban landscape, 2010.

some more difficult to use. For example, some hurdles associated with prescribed burning are the year-round requirement for permits from the local air resources district, the need for permits from CAL FIRE during burn-ban season, lack of availability of insurance, and fear of liability in the unlikely event that a prescribed burn gets out its designated area. Herbicide challenges include the need for permits for some products and use restrictions that may apply near populated areas. Herbicides can also be costly when large areas are treated. In addition, land managers may not want to use herbicides due to liability issues associated with using a potentially hazardous chemical. Mechanical and manual removal can be time-consuming—or, if the work is hired out, expensive.

The challenges associated with many of these treatments have created an opportunity for small ruminants (sheep and goats) to play an important role in ongoing fuel reduction (fig. 2). While targeted grazing or browsing of chaparral plants cannot completely eliminate wildfire danger, it is a practical method for managing vegetation, particularly after another method has been used to remove large, woody stems. The following information can help guide managers through some of the nutritional challenges related to targeted grazing for fire-fuel reduction in California chaparral.

Figure 2. Goats grazing on ceanothus for fuel reduction. *Photo*: Roger Ingram.

Sidebar 1: **Prescribed burning**

In some areas of California, prescribed burning is becoming an increasingly viable option for fuel reduction due to leadership from newly formed prescribed burn associations (PBAs) and already established range improvement associations. Targeted grazing can enhance these efforts by reducing brush that regrows after a prescribed burn or mechanical removal. For more information about PBAs, visit calpba.org/. New PBAs continue to be established throughout the state.

Nutritional requirements of small ruminants

Much of the chaparral vegetation targeted for fuel-reduction grazing has low nutritive value and can be undesirable to livestock. Many of these plants also produce secondary chemical compounds that can further decrease nutrient availability and can even be toxic to livestock. However, with proper management, browsing can effectively control woody vegetation if the nutritional requirements of the animal are being met.

In general, animals require an energy source (carbohydrates or fats) and protein, as well as micronutrients for optimal performance. The amount of energy in a food source is typically measured as total digestible nutrients or metabolizable energy, depending on the class of livestock being evaluated. Higher values of total digestible nutrients and metabolizable energy mean more energy is available. Protein is measured as crude protein. (See glossary below for definitions.) If nutritional requirements are not met, animals lose body condition (muscle and fat) in order to meet the energy demands for maintenance of essential body functions, while reproductive performance, growth, and overall health may become compromised.

Ruminant livestock are unique in their ability to use fibrous plant material as a food source. The rumen is the largest forestomach in their digestive tract and contains a vast and diverse population of microbes that secrete enzymes necessary to digest fibers by fermentation. The ruminant can then absorb the fermentation products (also known as volatile fatty acids, or VFAs) and microbial proteins that flow down the digestive tract into the intestines. A plant's digestibility, or fermentation rate, greatly depends on its structural components (fiber) and composition (carbohydrates, protein, micronutrients, and secondary compounds), as well as the microbial environment within the rumen. Thus, the amount of forage a ruminant will consume in a day depends on the rate of digestion, rumen passage rate (influenced by multiple factors), and capacity of the rumen.

Table 1 shows the nutrient requirements for sheep and goats at different life stages: maintenance and early gestation (lowest demand), late gestation (medium demand), and lactation (highest demand). Total digestible nutrients, metabolizable energy, and crude protein are indicators of required energy and protein proportions of the daily diet on a dry-matter basis (not as fed or wet). The total nutrient demands of young animals increase with their body size. Because of their growth demands, yearling wethers (castrated males) have nutrient requirements similar to those of lactating sheep or goats. Adult goats and sheep without the additional nutritional demands of reproduction or lactation (older wethers and non-producing females) can maintain body functions on feed with less energy and protein for part of the year. This lower level of nutritional demand is considered "maintenance."

Table 1. Total digestible nutrients (TDN), metabolizable energy (ME), and crude protein (CP) requirements for sheep and goats. These numbers are presented as percentage of DM intake (DMI) or lbs of dry matter. DMI will vary by body weight, stage of production, energy concentration of the diet, and other factors. The calculations of intake and nutrient requirements were based on a hypothetical diet with an energy concentration of 0.87 kcal/lb DM. In some cases, diets having greater or lesser concentrations of energy would be appropriate.

Sheep (NRC 2007)			
	TDN %	*ME (Mcal/lb)*	*CP %*
Maintenance	53	0.87	8
Early gestation (single lamb or twins)	53	0.87	9
Late gestation (twins)	66	1.08	11
Lactation (single lamb)	53	0.87	12
Lactation (twin lambs)	66	1.08	15
Goats, non-dairy (NRC 2007)			
	TDN %	*ME (Mcal/lb)*	*CP %*
Maintenance	53	0.87	7
Early gestation (single kid or twins)	53	0.87	10
Late gestation (twins)	66	1.08	14
Lactation (single kid)	53	0.87	11
Lactation (twin kids)	53	0.87	13

Nutritional value of chaparral plants

Neutral detergent fiber (NDF) is a measure of fiber content in feed. It is determined by the cellulose, hemicellulose, lignin, cutin, silica, and other minor compounds that make up the cell walls of a plant. Fiber stimulates rumen motility and saliva production and is a critical component of the ruminant diet to maintain a healthy microbial environment within the rumen. The amount of fiber (NDF) and its quality (potentially digestible NDF) can affect forage intake. Typically, feeds with low NDF (7.5 to 35.5 percent) tend to enhance forage intake, while higher NDF values (22.2 to 45.8 percent) tend to decrease intake (Harper and McNeill 2015). Depending on the digestibility of the NDF, fermentation of the fiber may occur at a much slower rate, delaying rumen emptying and decreasing rumen capacity. Feeds with less-digestible forage often have a lower energy value.

Table 2 displays average total digestible nutrients, metabolizable energy, NDF, and crude protein data for eleven common chaparral plants in spring, summer, and fall (Narvaez 2007). These data come from plant samples collected at the Hopland Research and Extension Center (Hopland, California) and the Sierra Foothill Research and Extension Center (Browns Valley, California). Nutrient quality of the plants changed from season to season, generally with the highest nutrient values in spring and lowest values in fall. With a few exceptions, nutrient levels were relatively low in all seasons. The nutritional value of wedgeleaf ceanothus was different at the two collection sites, indicating that some site variance can exist, likely due to differences in the age of the plants, regional precipitation, or ambient temperature. Nevertheless, the table provides a good general sense of the nutrient quality of various chaparral plants. For comparison, the nutritional quality of mature alfalfa hay is as follows: Total digestible nutrients are 50 percent, metabolizable energy is 0.82 megacalories per pound, NDF is 59 percent, and crude protein is 13 percent (NRC 2007).

Tables 1 and 2 may guide an animal manager's decisions about which class of livestock may be the best fit for a site, considering the livestock's nutritional requirements and the plant species present. Depending on available forage diversity and season, meeting the nutrient requirements for late-gestation and lactating animals in California chaparral may require supplementary feeding. It is likely that dry

Table 2. Total digestible nutrients (TDN), metabolizable energy (ME), neutral detergent fiber (NDF), and crude protein (CP) from leaves of eleven chaparral species in spring, summer, and fall (Narvaez 2007)

	TDN (%)[*]			ME (Mcal/lb)[†]			NDF (%)[‡]			CP (%)		
Plant species	**Spring**	**Summer**	**Fall**	**Spring**	**Summer**	**Fall**	**Spring**	**Summer**	**Fall**	**Spring**	**Summer**	**Fall**
Chamise[§] (*Adenostoma fasciculatum*)	47.67	45.73	44.62	0.78	0.75	0.73	30.60	31.00	29.20	7.86	6.25	5.57
Hoary manzanita[§] (*Arctostaphylos canascens*)	37.42	35.48	35.75	0.61	0.58	0.59	31.50	35.10	31.50	5.72	4.64	3.97
Eastwood manzanita[§] (*Arctostaphylos glandulosa*)	35.75	34.92	34.65	0.59	0.57	0.57	33.20	34.50	32.00	5.16	4.93	4.43
Stanford's manzanita[§] (*Arctostaphylos stanfordiana*)	35.20	33.54	35.75	0.58	0.55	0.59	34.50	36.90	33.30	5.48	5.23	4.37
Coyote bush[§] *(Baccharis pilularis)*	48.50	39.08	39.63	0.79	0.64	0.65	31.30	30.80	30.70	11.02	8.41	7.08
Wedgeleaf ceanothus[§][1] *(Ceanothus cuneatus)*	44.35	39.63	41.57	0.73	0.65	0.68	27.20	28.90	29.90	11.93	9.69	8.78
Yerba santa[§] *(Eriodictyon californicum)*	53.49	41.57	39.91	0.88	0.68	0.65	24.50	26.30	24.60	9.05	6.04	5.29
Leather Oak[§] *(Quercus durata)*	35.48	33.54	32.43	0.58	0.55	0.53	44.60	46.90	44.10	7.82	7.38	6.73
Toyon[#] *(Heteromeles arbutifolia)*	31.32	28.55	30.49	0.51	0.47	0.50	40.00	37.50	34.60	8.18	6.79	6.23
Blue oak[#] *(Quercus douglasii)*	34.37	36.03	35.48	0.56	0.59	0.58	34.00	30.80	27.40	11.24	9.16	8.32
Interior live oak[#] *(Quercus wislizeni)*	31.60	35.48	37.42	0.52	0.58	0.61	46.80	46.40	43.70	8.02	7.63	7.91
Wedgeleaf ceanothus[#][1] *(Ceanothus cuneatus)*	44.07	44.35	46.01	0.72	0.73	0.75	27.20	29.60	28.60	13.45	9.39	8.90

[*] TDN numbers were calculated by converting metabolizable energy in MJ/kg from Narvaez (2007) to Mcal/kg. The Mcal/kg values were then converted to TDN.

[†] ME (Mcal/lb) numbers were calculated by entering the TDN numbers into an energy conversion website.

[‡] NDF % on dry-matter basis.

[§] Plants present at Hopland.

[#] Plants present at Browns Valley.

[1] Wedgeleaf ceanothus is the only species that was present at both field sites. Thus, it is shown twice in the table and has different values for each site.

(nonlactating) animals could eat selectively to meet their energy and protein needs. The general consensus is that grazing/browsing animals consume a diet of better quality than forage analysis often shows, because even in confined areas they exhibit some ability to select the most nutritious forage. Other factors that may contribute to the difference between what is observed in grazing animals and what the texts predict (based on data gathered from feeding trials) are increased activities of walking, grazing, and chewing. These activities, among other things, stimulate rumen motility and thus the rate at which feed is digested.

Consuming a higher quantity of forage, even for lower-quality feeds, increases the amount of nutrients that are available to be absorbed in the intestines. That said, it is important to evaluate the body condition of your animals often to be sure you are meeting their nutrient requirements. If body condition is declining, then proper supplementation should be evaluated.

Supplemental feeding

Supplemental feeds may come in the form of high-carbohydrate sources (cereal grains, cull fruits, molasses, and so on) or high-protein sources (legumes, pulses, oilseeds, urea, and so on). It is important for the producer to determine if the animals are energy- or protein-deficient. That way, producers can effectively design a supplement that best fits their situation and is most cost-effective. As discussed earlier, both carbohydrates and protein are necessary for maintaining microbial function, microbe numbers, fermentation rates, and the rate of passage from the rumen. High-carbohydrate supplements should be added to the diet gradually and fed regularly, as they will quickly change the pH of the rumen, which in turn changes the microbial population (Freer and Dove 2002). Often, the animal will continue to gain weight, but forage intake will decrease as fewer microbes are available to digest high-fiber forages. High-protein supplements may be a good alternative, as they tend not to disrupt the microbial population to the same degree (unless proteins are fed in excess of carbohydrate availability). Many plant protein sources have readily digestible carbohydrates. Ultimately, supplemental feeds should be based on the resources available to your operation and the nutrient requirements of the animal.

Lactating animals require a concentrate supplement to meet their needs. Even high-quality alfalfa hay fed alone lacks the energy required to sustain milk production, though it can be used in conjunction with a concentrate to help meet protein requirements. Cereal grain can be added to a protein source to provide energy based on the number of offspring a pregnant animal is carrying (diagnosed by ultrasound). With sheep, for example, farmers might want to feed heavy-bred ewes (those carrying multiple lambs) separately from ewes carrying single lambs, to avoid overfeeding the latter group.

Timing of the breeding and weaning seasons can help achieve both brush-control and reproduction goals. One strategy is to breed small ruminants in the spring, causing them to give birth in the fall. This allows lambs and kids to be weaned in late March or early April, when they can go out on grazing projects

Sidebar 2: **Strategies for feeding supplemental protein**

Ruminant animals can digest forage thanks to the microbes in their guts. To thrive, and to digest the cellulose in dry forage, these microbes need protein. On a maintenance diet, sheep and goats need a diet containing 9 to 10 percent crude protein. Based on the protein content of the brush species listed in table 2, managers likely need to provide supplemental protein to be sure livestock are getting sufficient nutrition. But how much supplemental protein is needed?

Using alfalfa hay as an example, we can calculate the amount of hay necessary to supplement the protein in the brush that livestock are browsing. First, we can calculate the total quantity (not percentage) of protein required for maintenance. A 120-pound doe, for example, should consume approximately 3 percent of her body weight daily (measured on a dry-matter basis), or 3.6 pounds of forage. For maintenance purposes, 10 percent of her diet—or 0.36 pounds daily—should be crude protein. Good alfalfa sheep hay is about 16 percent protein. A 110-pound bale of hay (at 90 percent dry matter) contains just under 16 pounds of total protein. If the doe is grazing brush with an average protein content of 6 percent (or 0.22 pounds per day of protein), we'll need to add another 0.14 pounds of protein to her diet. One pound of alfalfa hay would provide about 0.16 pounds of protein—enough to meet her dietary needs.

To calculate the cost of various protein sources (such as hay, molasses, loose protein, or other sources), we can calculate the cost of the protein directly. In our alfalfa hay example, let's assume a ton of hay costs $250. This ton of hay contains 288 pounds of crude protein, resulting in a protein cost of $0.87 per pound. We can compare this to other protein supplements to determine the most cost-effective supplementation strategy. Obviously, the cost of purchasing the feed is not the only cost we need to consider; storage costs and feeding labor should also be considered.

with nonlactating ewes and does that have lower nutrient demands than lactating animals.

If brush control is the sole goal of the operation, rather than meat production, adult wethers could be a good choice for grazing as a herd. Once past the yearling stage, wethers generally have lower nutritional requirements than females. Wethers can reach decent heights in 2 to 3 years, allowing them to access taller shrubs.

Consumption of chaparral plants by goats and sheep

Figures 3 and 4 compare the daily chaparral plant consumption in a study of six Kiko goats and six Targhee sheep wethers (Narvaez 2007). The goats generally ate more woody plants than the sheep. Consumption rates of these woody species varied by season for both sheep and goats, but the two types of livestock in the study did not always follow the same seasonal patterns. For example, goats ate more leather oak in summer, and sheep ate more leather oak in fall, but both sheep and goats ate more yerba santa in spring.

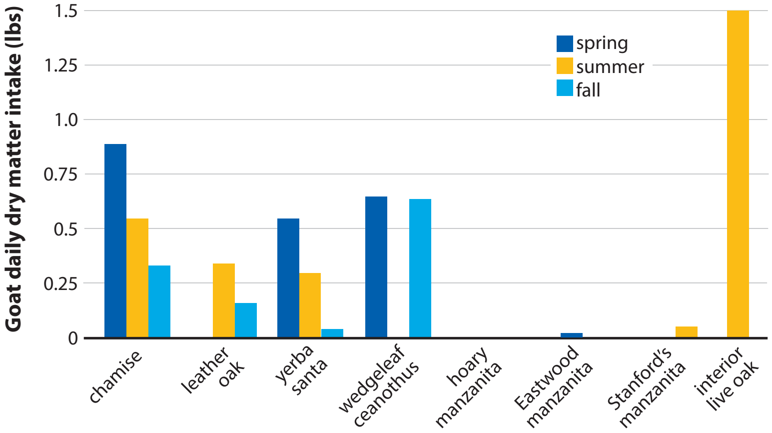

Figure 3. Daily dry matter intake by goats (Narvaez 2007).

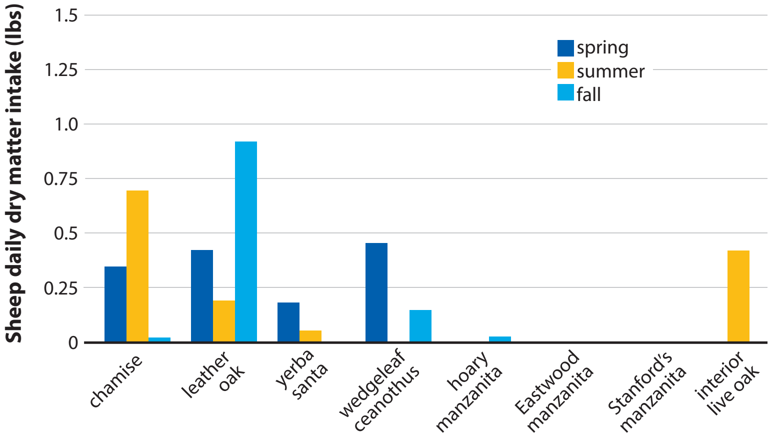

Figure 4. Daily dry matter intake by sheep (Narvaez 2007).

In the same study, goats met their maintenance requirements by eating a variety of woody species year-round, whereas sheep could not. In fact, sheep ate predominantly herbaceous plants in spring, although they did eat more chamise in summer and leather oak in spring and fall than did goats. Sheep may be better suited than goats for reducing grass fuel load and undesirable grasses (for example, cheatgrass and medusahead). It is important to note that domestic grazers tend to eat the plants their mothers taught them to eat (Burritt and Frost 2006), so they will eat more chaparral plants if they are raised learning to consume those plants. If domestic grazers are not familiar with a particular plant species, it will take time for them to become acclimated to eating it.

Sidebar 3: Note on supplementation

Some people think livestock should be able to meet their nutritional needs solely from the plants available at the site. However, the data presented here clearly show that chaparral species lack the energy and, in some cases, protein levels to sustain either sheep or goats. If chaparral species are the bulk of these animals' diets, supplementation will be necessary.

Sidebar 4: Minerals

The mineral concentrations in California chaparral plant species have not yet been studied. It is important to ensure that browsing livestock consume the appropriate balance and quantity of minerals. An imbalance of calcium and phosphorus may lead to urinary stones (especially in wethers); deficiencies in microminerals such as copper, selenium, and zinc can impact rumen function as well as overall health and productivity. The mineral status of the herd can be monitored by testing blood samples or sending the bodies of animals that die for any reason to a diagnostic laboratory for a necropsy.

Plant secondary compounds

Not only do chaparral plants offer low forage quality, but some also contain secondary chemical compounds, also known as secondary metabolites. Tannins, terpenes, alkaloids, glycosides, and oxalates are some of the secondary compounds in chaparral plants. Many secondary compounds act as chemical defenses and have negative impacts on insects and other animals that eat plants. Impacts can range in severity from creating undesirable flavors to reducing digestibility to significant toxicity.

Tannins are among the most common compounds present in chaparral plants. The term *tannins* may sound familiar because they are used to "tan" animal hides into leather by binding to hide proteins. Though tannins can bind to carbohydrates, microbes, and enzymes in the rumen, they primarily bind to proteins and make them less digestible. Small amounts can be beneficial to livestock because they can suppress bloat and help control internal parasites (Min and Hart 2003). However, high levels (more than 4%) cause animals to eat less and lead to toxicity. This happens when tannins limit protein in the diet and the action of enzymes and microbes in digestion (rumen microbes need protein). Ultimately livestock eat less because the rumen empties more slowly, protein consumption drops even lower, animals experience negative postingestive feedback (see sidebar 5), and tannins cause plants to be unpalatable. Figure 5 depicts how condensed tannin levels vary in spring, summer, and fall for nine California chaparral species (Narvaez 2007). Two of the 11 species studied (yerba santa and coyote bush) did not contain tannins and are omitted from the graph.

It is important to note that tannin levels in plants are not the sole predictor of nutritional impact. For example, while wedgeleaf ceanothus and blue oak both contain high levels of tannins, Narvaez et al. (2010) found that the tannins in blue oak are seven times better at binding to proteins. Also, the higher levels of tannins in Eastwood manzanitia bind less protein than the lower levels of tannins in chamise. While toyon has relatively low levels of tannins and the weakest ability to bind proteins, this species has the potential to cause cyanide poisoning. The two species that did not contain tannins (coyote bush and yerba santa) were also the most digestible. Goats, as well as deer, have tannin-binding proteins in their saliva (Robbins et al. 1991; Schmitt et al. 2020). In goats, these proteins can bind as much as 92 percent of the tannins consumed. In addition, goats have

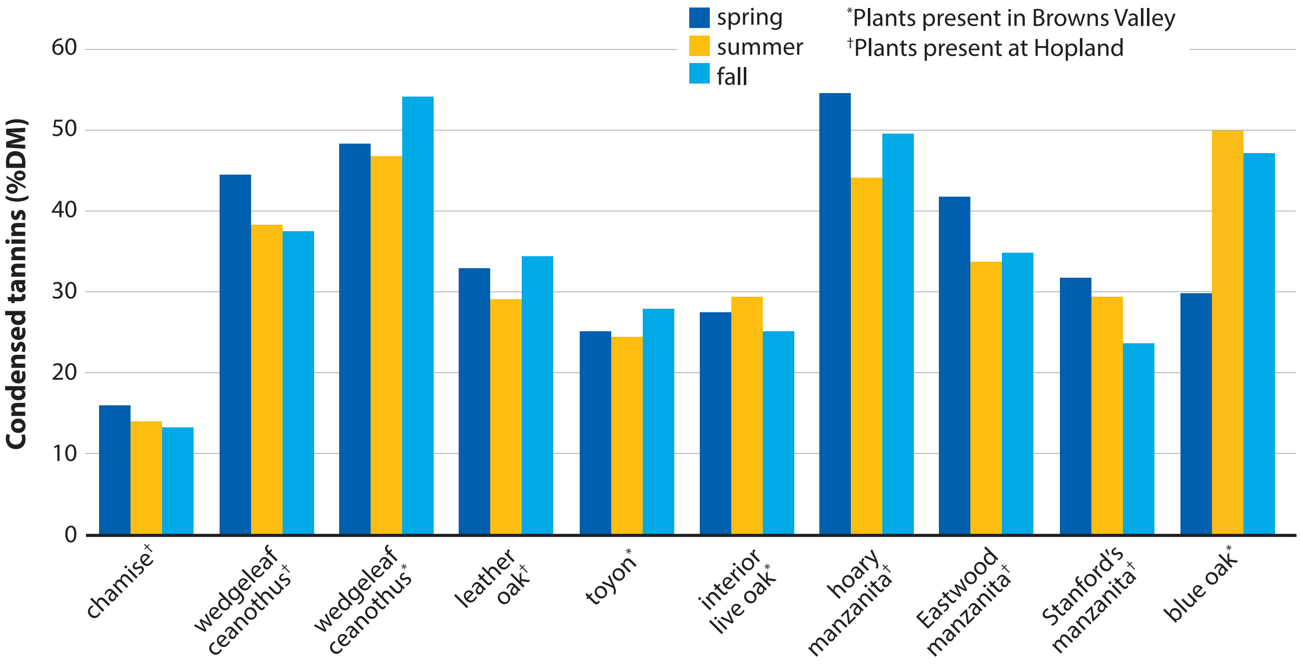

Figure 5. Seasonal tannin levels for common chaparral plants. Condensed tannin content for chamise, wedgeleaf ceanothus (Hopland), interior live oak, and Stanford's manzanita is lowest in fall (Narvaez 2007). For wedgeleaf ceanothus (Browns Valley), leather oak, toyon, hoary manzanita, and Eastwood manzanita, concentrations are lowest in summer. Blue oak is the only species whose lowest concentrations of condensed tannins were in spring.

microbial enzymes in the rumen that allow them to consume approximately double the tannin levels of cattle. However, animals can adapt to increasing levels of tannins. For example, over 20 days of slowly increasing tannin level in one study, sheep came to tolerate 50 percent acorn powder in their diet (Burrows and Tyrl 2013).

Managing plant secondary compounds

Livestock managers have options for minimizing the negative impacts of tannins and other secondary compounds. Eating activated charcoal can help livestock digest tannins (Burrows and Tyrl 2013). Polyethylene glycol (PEG) is a non-nutritive supplement that has been used in studies but is not approved by the U.S. Food and Drug Administration for use in livestock; it is important to be aware of research on the topic in case it is approved in the future. By binding to tannins, PEG increases intake and digestibility (Villalba et al. 2002; Narvaez 2007; Burrows and Tyrl 2013). In one study, supplying 10 to 25 grams per day of PEG in water or feed prevented oak poisoning (Burrows and Tyrl 2013).

Other options can help livestock consume more chaparral forage when secondary compounds limit intake. Dilution through mixing of forage types can work. Sheep can learn to consume a mixed diet of desirable feed (alfalfa and an alfalfa-barley mixture) and less-desirable feed containing secondary compounds such as terpenes, tannins, and oxalates even when given free access to the alfalfa and barley (Papachristou et al. 2007). Providing protein and energy supplements may help sheep and goats eat more tannin-containing foods and attain better protein and energy levels (Villalba et al. 2002). Observations suggest that if animals have a variety of grasses and forbs in their diet, they will eat more brush, without the need for supplementation with alfalfa.

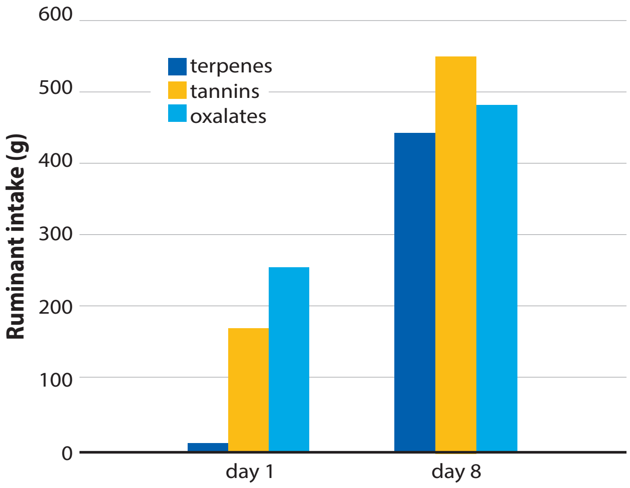

Figure 6. While supplemented with 600 g/day of alfalfa/barley, lambs increased consumption of terpenes, tannins, and oxalates over 8 days (Papachristou et al. 2007).

With adequate protein and energy, ruminants can detoxify compounds in their diets. Also, when protein and energy are adequate, animals can slowly acclimate to secondary compounds (fig. 6). In addition, livestock can select feeds that ameliorate the effects of toxins. In one study, when lambs learned which supplement ameliorated each of three different toxins, they selected the correct supplement for each toxin (Villalba et al. 2006).

Certain plants that contain secondary compounds can be poisonous to livestock. Some will cause livestock to become sick after eating only a small amount, while others have noticeable effects only when consumed in large amounts over long periods of time (Forero et al. 2011). But animals are not necessarily poisoned when they graze in a field with poisonous plants. Livestock can learn to minimize or eliminate a plant from their diet if they become nauseous within 12 hours of eating it (Burritt and Provenza 1991; Kronberg et al. 1993; Burritt 2012). However, not all plant toxins will cause a nauseous reaction within that time frame (Burritt 2012). Some poisonous plants—for example, locoweed (*Astragalus lentiginosus*) and broom snakeweed (*Gutierrezia sarothrae*)—may not cause nausea at all (Pfister et al. 2010). Therefore, managers must learn to identify these plants and manage livestock so that livestock are not poisoned. For information about toxicity and management for specific chaparral plants, review Dykier et al. (2018). For useful information about common poisonous plants, see the two publications listed in the resources section below.

Conclusion

Targeted grazing can be a viable option to reduce woody and fine wildfire fuels given the right circumstances and good management. Grazing will be most effective in combination with other fuel-management strategies such as mowing, prescribed burning, and chemical control.

To maintain appropriate livestock nutrition when implementing a targeted grazing program for fuel reduction in California chaparral, consider the following strategies:

1. Identify the chaparral plants your animals will be grazing.
2. Determine nutrient levels of the plants in different seasons (see table 2).
3. Use the species and class of grazing animals whose nutritional needs can be met with the plant species available (see table 1).
4. Graze during the season when the plants have highest nutritional quality (see table 2). Balance this strategy with grazing during the season when control of targeted plants will be most effective.
5. If it is not possible to meet your animals' nutritional requirements with the plants present, feed supplemental protein and/or energy to your animals.
6. Determine whether the plants have tannins (see fig. 5) or other secondary compounds. If they do, graze when concentrations of these secondary compounds are lowest, if possible.
7. If grazing plants with high tannin levels, consider supplementing with protein and energy to increase plant consumption and aid in digestion of tannins. Supplementing with activated charcoal may be another option, if practical.
8. Learn which chaparral plants are poisonous (see Dykier et al. 2018). If poisonous plants are present, minimize livestock access to them.

Targeted grazing will continue to increase in importance as a recommended treatment for reducing fuel loads. A better understanding of the nutrients and secondary compounds in chaparral will help determine optimal supplementation strategies for increasing the effectiveness of small ruminants in fuel-load reduction.

Glossary

Total digestible nutrients (TDN): A crude measure of the digestibility or energy available within a feedstuff. This measure is often calculated based on the digestible portions of the crude fiber, crude protein, crude fat, and nitrogen-free extract fractions of a feed. TDN is typically widely available for different feedstuffs; in practice, it tends to underestimate the amount of indigestible fiber in feeds.

Metabolizable energy: Total digestible nutrients, minus the amount of forage energy left after waste in the form of feces and urine. The remainder is the energy left for the animal's further function. This measure can be calculated directly from total digestible nutrients.

Crude protein: The amount of protein in a forage, which is calculated by multiplying the total nitrogen (all forms) within the plant by 6.25.

Resources

For more information on how planned herbivory reduces fuel load, visit https://www.intechopen.com/chapters/43235.

For a new interactive website that connects landowners with targeted grazing operators, visit matchgraze.com/.

For useful information about common poisonous plants—including toxic compounds contained in the plants, signs of poisoning, and treatment options—see UC ANR Publication 8398, Livestock-Poisoning Plants of California, anrcatalog.ucanr.edu/pdf/8398.pdf; and Agriculture Information Bulletin 415 from the Agricultural Research Service, Plants Poisonous to Livestock in the Western States, ars.usda.gov/is/np/PoisonousPlants/PoisonousPlants.pdf.

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Publication 8717

ISBN-13: 978-1-62711-207-9

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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 UC ANR Associate Editor for Animal, Avian, and Veterinary Sciences Julie Finzel.

web-10/22-LC/CA/SO/BC