CHAPTER 9:
Targeted Grazing to Manage Weedy Brush and Trees

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10 KEY POINTS

- Woody plants have encroached on many range and pasture lands.
- These plants use physical and chemical defenses to avoid being browsed.
- Control with grazing requires knowing plant structure and growth patterns.
- Goats work well on woody plants, but multi-species grazing evens out plant use.
- Selective breeding could create animals more useful for targeted grazing and browsing.
- Brush management may require short grazing periods with high stock densities.
- Some plants are best targeted in fall or winter when palatability is high and toxicity is low.
- To be effective, grazing treatments should begin while target plants are small.
- Providing supplements high in protein can increase woody plant consumption.
- A combination of treatments may offer the best chance for success.

Photo: Karen Launchbaugh, University of Idaho

INTRODUCTION

In North America, both native and exotic woody plants have encroached onto many rangeland and pastureland settings. Historically, frequent fires, healthy plant communities, and wildlife browsing kept woody plants at bay. An increase in woody plant abundance can limit or interfere with rangeland management objectives and overall habitat value. Plants like juniper, mesquite, pricklypear, oak, multiflora rose, and conifers may be unpalatable or even toxic to livestock or wildlife, interfere with livestock handling, reduce habitat values for wildlife, or compete with valuable forage plants for sunlight, nutrients, and water. Woody plants may also disrupt natural water flow patterns, allowing excess runoff and contributing to soil erosion. Properly managed grazing animals can provide an economical and environmentally friendly method of suppressing brush encroachment.

Vegetation Management Opportunities

Targeted livestock grazing to control brush has been applied in all regions of the United States. In Texas, goats have been used to slow juniper encroachment. Goats in Arizona and California have strategically browsed in the chaparral region to reduce fire risk created by volatile brush species. Sheep and goats have been applied in the Pacific Northwest to control invasive shrubs like blackberries and gorse. Sheep and goats have been used in the Intermountain region to manage sagebrush and oak brush. In the Eastern United States, sheep and goats have been used to control multiflora rose.

In their evolutionary struggle to survive, woody plants have developed defense mechanisms to reduce their probability of being grazed or browsed. To develop an effective browsing plan for shrub and tree management, these physical and chemical defenses need to be addressed. Some shrubs defend against herbivores with structural features like spines, thorns, and thatched branching patterns. Others contain chemicals that cause animals to avoid eating them. Among the most prevalent aversive phytochemicals, also called secondary chemicals, are terpenoids found in juniper and sagebrush, tannins found in oak and blackbrush, and alkaloids found in acacias and mesquite. Browsing animals generally avoid an otherwise nutritious plant that contains significant amounts of aversive chemicals.

Criteria for Animal Selection

Species Selection

Sheep, goats, and cattle vary in how readily they will consume woody plants *(see Chapter 2 on Animal Behavior)*. Goats are particularly well suited for managing woody plants. They consume more browse than either cattle or sheep. They consume fewer forbs than sheep and less grass than sheep or cattle. Their narrow muzzles and prehensile tongues allow them to efficiently remove leaves and young stems. Their digestive systems are well adapted for extracting nutrients from woody tissue and detoxifying secondary compounds like tannins and terpenes. Goats have larger livers (relative to body size) than sheep or cattle, and the detoxification capacity of their digestive organs is generally greater than in other livestock species. Research shows that detoxification in the liver is more active and effective in goats than in sheep or cattle.[32]

Multi-species grazing is also a compatible and beneficial way to increase net animal production while conserving resources *(see Chapter 6 on Multi-Species Grazing)*. The unique feeding strategies of grazers and browsers provide a more uniform use of vegetation than if one species were used alone. Cattle, sheep, and goats will be more evenly scattered across a grazing area as they seek out feeding patches most suited to their preferences.

Breed Selection

Historically, small ruminants like sheep and goats have been developed for enhanced meat and fiber production. Breeds heavily selected for enhanced production of fiber or growth potential (e.g., Angora and Boer goats) have often been spared from coping with environmental extremes because of management interventions by livestock managers, so little selection pressure has been applied to enhance their ability to utilize low quality chemically defended woody plants. Spanish and Damascus goats, on the other hand, have experienced less management intervention and have been largely selected to survive in shrub-dominated ecosystems. This may explain why Spanish goats eat a larger diversity and amount of browse than other breeds.[23] Sheep breeds also exhibit differences in browse consumption. For example, Barbado blackbelly sheep were imported into the United States in 1904 from the Caribbean and crossed with rambouillet and mouflon breeds. Diet studies comparing rambouillet, Barbados, and Karukul sheep and Spanish and Angora goats reported that Barbados sheep consumed more browse than the other sheep breeds and occupy a food niche intermediate between goats and other sheep breeds.[31] While many differences may exist among breeds of livestock relative to their ability to consume woody plants, little foraging research has focused on breed differences.

Selective Breeding

Selective breeding may be a way to increase the consumption of undesirable plants. The heritability of preference for plant species that were generally avoided by goats averaged nearly 30%.[30] The preference for mountain big sagebrush in the diet of rambouillet sheep was about 29% heritable.[25] Recent research has shown that juniper consumption may be a genetically controlled trait that is passed to subsequent generations.[27] The research shows that a preference for juniper in the diet is about 40% heritable in Boer X Spanish goats and about 20% heritable in Angora goats (sire-model heritability estimate method).[27] Measuring juniper consumption in specific goats and breeding high-consuming females to high-consuming males could enhance juniper consumption of goats and increase their value for juniper control.

Grazing Strategies to Meet Ecological Objectives

Stocking rate and timing are grazing strategies that can be applied to enhance consumption of targeted woody plants to meet ecological objectives. In applying these strategies, grazing managers should take advantage of the natural defenses (i.e., structural or chemical) that invasive woody plants use to avoid defoliation. When they are browsed, these woody plants are generally at a competitive disadvantage to grasses, which cope with herbivores by rapidly replacing grazed leaves from numerous growing points. Compared with grasses, defoliation of woody plants to a similar degree is generally more detrimental to the shrub than it is to the grass.

Stocking Rate

Rangeland managers must be aware of the amount of forage available and anticipate current and future forage demand for livestock and wildlife. Monitoring use on key desirable and undesirable plants is a useful indicator of stocking rate or grazing pressure. Brush management often requires short grazing periods with high stock densities, which applies enough grazing pressure on the shrubs to have a detrimental effect. Appropriate rest periods allow the herbaceous or desirable plants time to recover.

Timing

It is important to browse the target plant when it is relatively palatable either because it is more nutritious than alternative forages or has a low level of secondary chemicals. Effective control of woody plants requires browsing when animals are likely to consume the target plant. Diet studies provide information on when the use of a target species is greatest during the year. For example, consumption of juniper trees is generally highest during the winter months (November to February) when other forage is dormant.[4] Winter is also the season when aversive phytochemicals in juniper foliage are at their lowest levels. Sagebrush consumption is greater in the fall and winter, perhaps because of the seasonally low concentration of monoterpenes.[12]

The age of a plant or branch may present another period of vulnerability to browsing. Some chemically defended plants, like juniper, have lower concentrations of aversive chemicals in early growth stages, such as the seedling stage and initial regrowth following a topkill. Palatability studies of juniper seedlings indicate that immature seedlings are a preferred forage.[4] In other plants, aversive chemicals are in greatest amounts in the new annual stems. For example, the stems of blackbrush that are older than one year have less tannins than the new year's branches.[21]

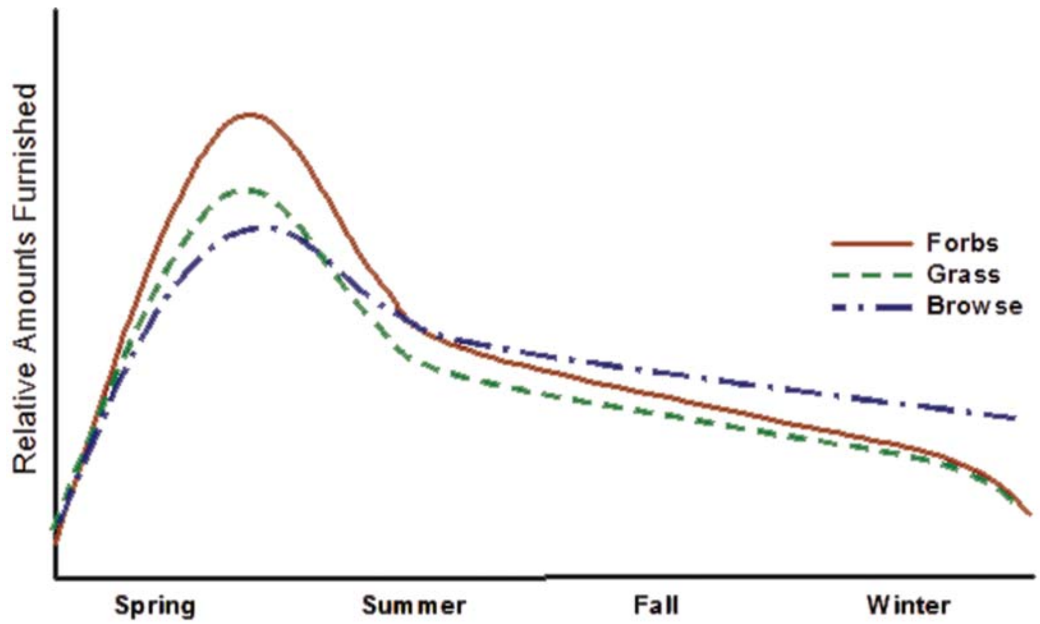

Figure 1. Seasonal trends in protein, minerals, and vitamins in forest and rangeland forages

Animal Production Considerations

Many undesirable shrubs and trees are sufficiently nutritious to meet livestock energy and protein demands. Woody plants are generally less digestible and nutritious than grasses and forbs during the growing season but are important forages in the fall and winter when their stems provide relatively high amounts of protein, minerals, and vitamins (Figure 1 and tables on next page). Evergreen shrubs can be particularly good sources of nutrients in the winter.

Although nutrient composition of browse is an important consideration, of equal or greater importance are the structures and compounds that reduce the utility and value of browse species. Some defend against herbivores with structural features like spines, thorns, and thatched branching patterns. These structural components reduce bite mass and slow stem and leaf removal, which reduces intake. Reduced intake has the greatest consequence in arid environments where annual production is low and where spines are more common.[14]

Many browse species also contain chemicals like monoterpenes, tannins, and alkaloids that are physiologically damaging or nutritionally undesirable to herbivores, creating a chemical barrier to foraging. Browsing animals will avoid an otherwise nutritious plant that contains aversive chemicals. These phytochemicals occur in varying concentrations within different parts of the same plant and may vary seasonally and among growth stages. Few browse plants produce enough to be deadly when eaten or to provide complete protection. The most prevalent aversive phytochemicals, also called secondary chemicals, include terpenoids found in juniper and sagebrush, tannins found in oak and blackbrush, and alkaloids found in acacias and mesquite.

Tannins are soluble polymers that readily combine with proteins, forming indigestible substances. By binding with digestive enzymes and dietary proteins, tannins depress digestion. Tannins also depress intake either by reducing digestibility of the diet components or by the astringency of condensed tannins and short-term post-ingestive malaise.[16] High protein supplements or high molecular weight substances like polyethylene glycol can be used to bind tannins and increase the consumption and digestibility of plants with high tannin content.

Terpenoids, consisting of a collection of five-carbon units, exhibit remarkable structural and functional diversity.[17] Although terpenoids in browse species have a variety of functions, the most relevant are toxicity and feeding deterrents. Terpenes and volatile oils in juniper reduce intake.[23] Those in sagebrush decrease diet digestibility for sheep.[20] Terpenoids are not water soluble (they are lipophilic or fat-soluble compounds) and must be transformed to be excreted.[6] Diets high in protein can enhance the rate of this transformation and detoxification.[9]

Nutritive Value of Selected Woody Plants

Blackbrush Acacia *(Acacia ridgidula)*		
	Spring	Winter
Protein (%)	14.9	13.9
Fiber (% NDF)	37.5	37.5
Ash (%)	7.1	11.8
Azim et al. 2002		

Blackbrush *(Coleogyne ramosissima)*						
	Spring		Summer		Fall	
	Leaves	Stems	Leaves	Stems	Leaves	Stems
Protein (%)	9	4	7	5	7	2
Crude Fat (%)	7	4	7	4	9	5
Fiber (% ADF)	23	45	25	53	24	52
Phosphorus (%)	0.14	0.13	0.10	0.11	0.11	0.10
Bowns and West 1976						

Big Sagebrush *(Artemisia tridentanta)*				
	Spring	Summer	Fall	Winter
Protein (%)	11-12	12-13	8-11	10-12
Crude Fat (%)	9-18	2-3	2-6	4-6
Kelsey et al. 1982				

Broom Snakeweed *(Gutierrezia sarothrea)*				
	Spring	Summer	Fall	Winter
Protein (%)	3.8	3.9	3.6	4.8
Fiber (% Crude)	16.0	14.6	14.7	14.8
Crude Fat (%)	1.3	0.7	1.2	1.1
Ash (%)	1.6	1.9	1.5	1.6
Phosphorus (%)	0.07	0.12	0.08	0.1
Gastler et al. 1951				

Catclaw Acacia *(Acacia greggii)*		
	Spring	Winter
Protein (%)	14.9	13.9
Fiber (% NDF)	37.5	37.5
Ash (%)	7.1	11.8
Azim et al. 2002		

Nutritive Value of Selected Woody Plants

Gambel Oak *(Quercus gambelii)*

	Spring	Winter
Protein (%)	14.9	13.9
Fiber (% NDF)	37.5	37.5
Ash (%)	7.1	11.8

Azim et al. 2002

Ceanothus

Deer Brush *(Ceanothus integerrimus)*

	Leaves	Twigs
Protein (%)	17-18	8
Fiber (% NDF)	25-34	53-64
Digestibility (% IVDMD)	54-64	34-35
Phosphorus (%)	0.18 - 0.19	0.12 - 0.16

Kilgore et al. 1971

Snowbrush Canothus *(Ceanothus velutinus)*

	Summer
Protein (%)	14.4-15.0
Digestibility (% IVDMD)	48.7-53.0
Phosphorus (%)	0.14-0.21

Canon et al. 1987

Gorse *(Ulex europaeus)*

	Leaf	Stem
Protein (%)	12	8
Fiber (% NDF)	64	72
Phosphorus (%)	0.11	0.08

Lambert et al. 1989

Juniper

Common Juniper *(Juniperus communis)*

	Spring	Summer	Fall	Winter
Protein (%)	2.9	3.5	4.2	3.3
Fiber (% Crude)	12.7	9.5	11.3	15.5
Crude Fat (%)	7.2	4.2	7.5	6.1
Ash (%)	2	1.4	1.4	1.7
Phosphorus (%)	0.12	0.07	0.09	0.08

Gastler et al. 1951

Ashe Juniper *(Juniperus ashei* / Redberry Juniper *(Juniperus pinchotii)*

	Ashe Juniper Summer/Fall	Redberry Juniper Summer/Fall
Protein (%)	5-8	6-9
Fiber (% NDF)	31-34	34-37
Digestibility (% IVOMD)	59-63	57-66
Crude Fat (%)	--	--
Ash (%)	4-6	4-6
Phosphorus (%)	0.10-0.12	0.08-0.17

Huston et al. 1981

Honey Mesquite *(Prosopis glandulosa)*

	Spring	Summer		
	Leaves	Leaves	Leaves & Stems	Seeds & Pods
Protein (%)	32	26	16	9
Fiber (% NDF)	25	35	47	7
Digestibility (% IVOMD)	68	58	44	--
Ash (%)	7	6	4	3
Phosphorus (%)	0.46	0.22	0.08	--

Huston et al. 1981[11] and Becker and Grosjean 1980

Nutritive Value of Selected Woody Plants

Live Oak *(Quercus virginiana)*

	Summer	Winter
Protein (%)		8-9
Crude Fat (%)	15-19	--
Ash (%)	--	8
Phosphorus (%)	0.09-0.11	0.3

Urness 1966 and Short et al. 1966

Oregon Grape *(Berberis repens)*

	Summer	Winter
Protein (%)		8-9
Crude Fat (%)	15-19	--
Ash (%)	--	8
Phosphorus (%)	0.09-0.11	0.3

Urness 1966 and Short et al. 1966

Pricklypear Cactus *(Opuntia engelmannii)*

	Spring	Summer		Fall		Winter
	Pads	Pads	Fruits	Pads	Fruits	Pads
Protein (%)	12	7	6	9	8	5
Digestibility (% IVDMD)	75	69	--	71	63	68
Phosphorus (%)	0.13	0.10	0.13	0.11	0.18	0.08

Richardson 2000

Russian Olive *(Elaeagnus angustifolia)*

	Spring	Winter
Protein (%)	14.9	13.9
Fiber (% NDF)	37.5	37.5
Ash (%)	7.1	11.8

Azim et al. 2002

Rubber Rabbitbrush *(Chrysothamnus nauseosus)*

	Summer	Winter
Protein (%)		8-9
Crude Fat (%)	15-19	--
Ash (%)	--	8
Phosphorus (%)	0.09-0.11	0.3

Urness 1966 and Short et al. 1966

Soapwood Yucca *(Yucca glauca)*

	Spring	Summer	Fall	Winter
Protein (%)	3.8	3.9	3.6	4.8
Fiber (% Crude)	16.0	14.6	14.7	14.8
Crude Fat (%)	1.3	0.7	1.2	1.1
Ash (%)	1.6	1.9	1.5	1.6
Phosphorus (%)	0.07	0.12	0.08	0.1

Gastler et al. 1951

Providing a protein supplement can increase woody plant consumption, especially of terpene-containing plants like sagebrush and juniper. [26, 29] Goats fed either cottonseed meal or alfalfa as a supplement consumed 40% more juniper than did goats fed a corn supplement.[26]

Alkaloids are cyclic nitrogen-containing compounds that usually have a bitter taste and are characterized by powerful physiological effects. They can affect the central nervous system creating disorders like muscular weakness, respiratory failure, and incoordination. Most alkaloid-containing range plants in North America are in the legume family (Fabaceae). The kinds and amounts of alkaloids in most woody plants are generally not deadly, although they may lead to low palatability in plants like mesquite. Supplementation and other intervention strategies to increase the use of plants containing alkaloids have not been discovered.

Effectiveness and Integrated Management

Many brush-dominated plant communities in North America were once grasslands, maintained by constant, low grazing pressure and high fire frequency. With natural and human-induced ecosystem changes, these communities have crossed the threshold from grasslands to woodlands. Once brush has encroached, it is difficult to return to a grassland state without a major reclamation effort. Treatment programs, including mechanical, chemical, prescribed fire, and targeted grazing, can all reduce brush density. The expertise and management skills required to implement these different practices vary considerably (Figure 2). Mechanical control, such as chaining or shredding, requires the least management expertise but has the highest cost because of high inputs for energy, labor, and equipment. Chemical control with herbicides requires more management expertise than mechanical, but it too is relatively expensive and sometimes perceived as having harmful environmental side effects. Prescribed fire has low levels of external inputs and is potentially cost effective. However, it requires high levels of expertise and a commitment to long-term management planning. Livestock grazing and browsing also has low external inputs. It offers the most cost-efficient method of managing many plant species but requires significant management expertise.

In most instances a combination of treatments is required before the vegetation composition can be shifted in the desired direction. Targeted grazing can effectively reduce shrub regrowth after a mechanical or prescribed fire treatment, increasing the longevity of these traditional treatments. If the target plant is too tall for goats to reach, a fire or mechanical treatment can reduce the stand height, helping to control the plant and providing valuable forage for the goats. [10, 18] Grazing can also slow the invasion of woody plants after herbicide applications.[10]

After applying a vegetation treatment, continued management and regular monitoring are essential to maintain the desired plant composition and structure. Effective browsing to control woody species always requires repeated treatments, usually with multiple treatments in a year and for several continuous years. Even in the extreme case of all trees being top-killed with a control measure like fire, seedling germination will continue. Targeted grazing can reduce seedling establishment, which is a critical component of brush control: once woody plants become established they are more expensive and difficult to kill.

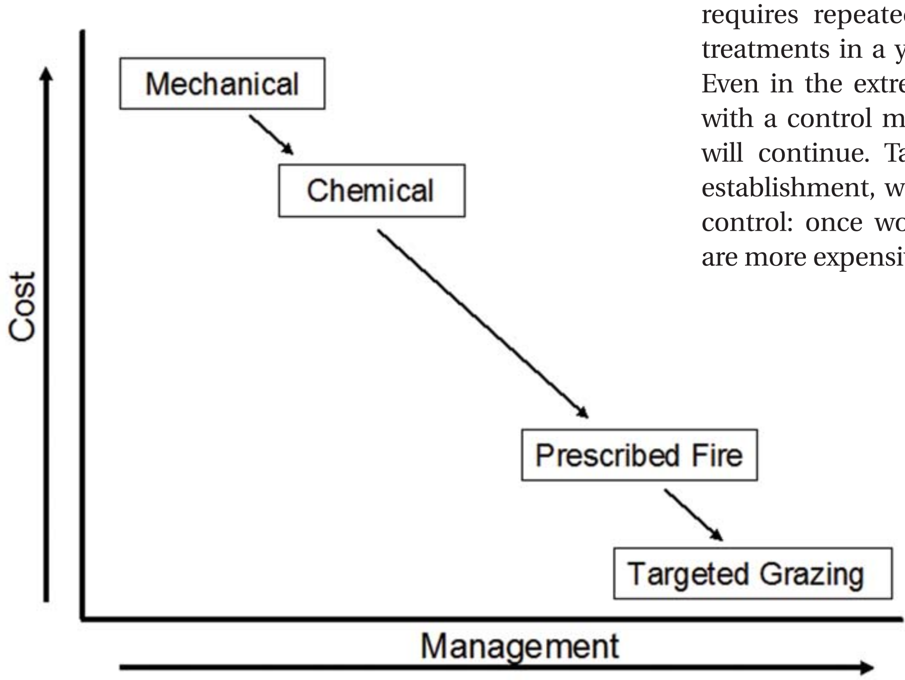

Figure 2. Relative inputs of management expertise and costs to accomplish brush management by various approaches.

CASE STUDY: LONG-TERM STOCKING EFFECTS ON SONORA EXPERIMENT STATION

On the TAMU Research Station near Sonora, juniper has increased from less than 1% canopy cover in 1948, when all existing juniper was removed by hand clearing, to the current level of greater than 50% in some pastures. The effects of different grazing treatments on establishment of new juniper plants and plant size are summarized in Table 1. The pasture in which all livestock and goats had been excluded (1949-present) had the greatest canopy cover of juniper and other woody plants (75%). The 1977 pasture, from which goats and other livestock had been excluded for 25 years from 1977 to the present, had moderate woody plant cover. There were two pastures in which goats and other livestock had been excluded for 16 years each (1986-present). These two pastures had the greatest density of juniper plants of all treatments, but most of these plants were less than 1 meter high. Canopy cover in these pastures was less than 15%. The two pastures that had light goat grazing pressure had significantly less juniper than the non-goat pastures, especially in the juniper size category of less than 1 meter tall and a canopy cover of less than 10%. The heavily goated pasture had the smallest juniper density of all treatments and a juniper canopy cover of less than 5%. Previous research at the TAMU Research Station has shown that as juniper canopy increases, carrying capacity, species diversity, and water yield decrease. It is important to manage juniper so that it doesn't grow taller than 3 feet. Once juniper exceeds 3 feet it starts to have a negative effect on herbaceous plant production and is more expensive and difficult to kill.

Table 1. Density of juniper (plants per acre) by size classes (height in meters).

First Year of Current Treatment	Treatment	0 to <½ meters	½ to 1 meters	1 to 2 meters	>2 meters	Total
		plants/acre				
1949	52 yrs no goats	207	47	82	330	666
1977*	25 yrs no goats	145	91	79	197	512
1986**	16 yrs no goats	631	367	18	18	1034
1986**	16 yrs no goats	571	333	36	70	1010
1949-present	Light goats	137	14	58	145	354
1949-present	Light goats	112	9	40	72	233
1949-present	Heavy goats	67	14	8	34	123

*Pasture was heavily grazed by goats until 1977.

**Pasture was heavily grazed by goats until 1986.

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