TARGETED GRAZING:

A natural approach to vegetation management and landscape enhancement

Photo: Resource Concepts, Inc.

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READER'S GUIDE:
To the Targeted Grazing Handbook

By Ron Daines

Ron Daines is an editorial consultant, freelance writer, and photographer based in Logan, UT.

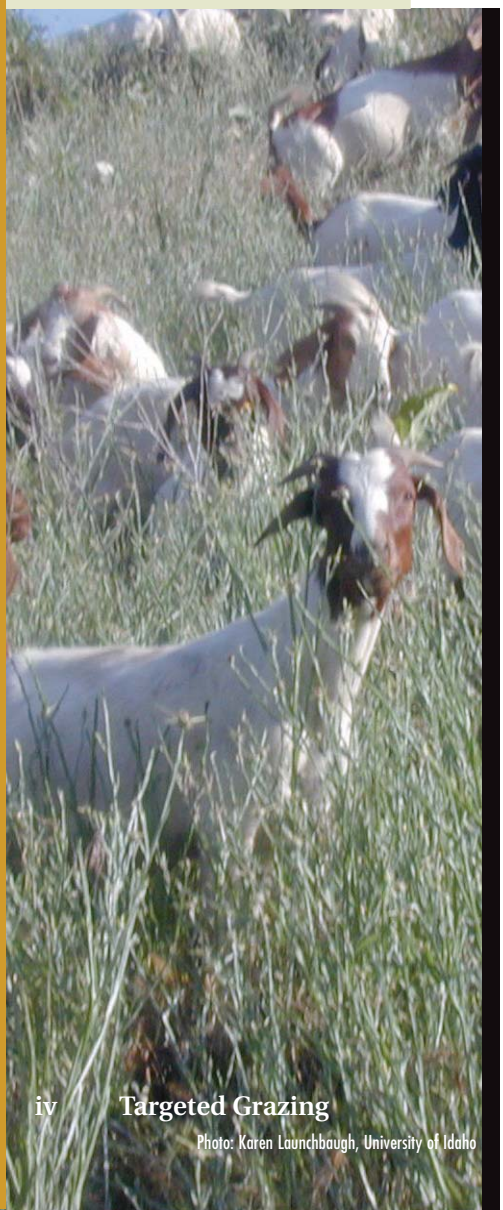

Photo: Karen Launchbaugh, University of Idaho

Photo: Jodie Mink, Idaho Rangeland Resources Commission

Employing livestock to manipulate vegetation is as old as grazing itself. Promoting grazing to manage vegetation as a paid service – typically called prescribed or targeted grazing – is a more recent phenomenon. As targeted grazing has gained a foothold in the land management arena, both research and experience have evolved to provide land managers and grazing service providers with more definitive tools for managing vegetation. This handbook represents a compilation of the latest research on harnessing livestock to graze targeted vegetation in ways that improve the function and appearance of a wide variety of landscapes.

The handbook is organized both as an introduction to targeted grazing for the novice and as a useful reference for those already familiar with the topic. The chapters can be studied collectively or individually, depending on a reader's needs, and they're written toward an audience that includes livestock producers, land managers, landowners, grazing enthusiasts, or simply interested observers.

Readers will note that the same topics appear more than once throughout the handbook, for example, discussions on animal diet selection, fencing, predators, and integration with other vegetation management tools. In each instance, the editors have tried to assure that the topics are in context and germane to that particular discussion.

Organization

The sequence of topics is designed so that the first section, chapters 1 through 6, provides readers with basic principles that underlie animal and plant behavior and response in the context of managed herbivory. Following the overview and introduction in Chapter 1, Chapter 2 discusses animal behavior and ways it can be applied to enhance grazing effectiveness. Chapter 3 describes basic approaches for working with animals to carry out grazing prescriptions, from herding, to fencing, to setting up management relationships. Chapter 4 provides information on how various plants – grasses, forbs, and shrubs – respond to grazing, including their defenses and their susceptibility. In Chapter 5, readers will learn about the rationale behind, and techniques for, monitoring to assess the results of grazing projects. Chapter 6 provides an important look at how using more than one species of livestock, in combination, can have more profound impacts on vegetation than using just one species.

The second section of this handbook on targeted grazing takes a detailed look at each of several management applications for the practice. First it looks at managing several types of plants in various geographic contexts, namely: herbaceous broad-leaved weeds (Chapter 7), annual invasive grasses (Chapter 8), and brush and woody plants (Chapter 9). Chapter 10 provides management considerations for silviculture, both natural and plantation; Chapter 11 discusses applications in orchards and vineyards; Chapter 12 shows various methods for applying grazing to alter or minimize fire risk; Chapter 13 looks at ways to improve wildlife habitat and points out cautions over wildlife-livestock interactions; and Chapter 14 shows different applications on cultivated cereal and alfalfa croplands, both for managing residue and suppressing insect pests.

Next, in Chapter 15, are prescriptions for 21 specific plants, including 14 forbs, five woody plants, and two grasses. These include a description and photograph of each target plant, followed by guidelines for the ideal livestock species, objectives to be achieved with grazing, the proper timing for treatment, and the potential for effectiveness in grazing that particular plant. References for additional information are listed on each of the 21 plant species.

To provide a sense of the experiences of successful targeted grazing managers, Chapter 16 looks at the practice from the vantage point of the service provider (the animal owner), and Chapter 17 offers the perspective of the land manager.

The editors and authors have sought to round up the latest and most pertinent information on targeted grazing. But no handbook can include the vast storehouse of knowledge on the subject. To that end, a list of additional resources is included as Chapter 18, followed by a glossary of terms and a list of plants discussed in this handbook.

Points to Ponder

Readers, whether owners or managers of land or livestock, who intend to engage livestock to manipulate landscapes should keep in mind a couple of crucial points:

1. Targeted grazing is not a one-time shot. Anyone who promises to solve vegetative problems in a single pass or in a single season has no place in the business. While research and experience have proved that targeted grazing can alter landscapes, it has also shown that it takes patience. A grazing prescription may call for three years of repeated grazing. It may take five years. Or it could require a continuing prescription to keep unwanted vegetation in check.
2. Before any grazing project begins, both the land manager and the grazing service provider need a shared vision of what they want the landscape to look like as the grazing prescriptions evolve. They should focus on plant succession from an unwanted state to a desirable community. What plants are wanted on the site? Will they emerge naturally or require some type of seeding? Will the grazed site become susceptible to invasion by plants that are worse than the ones removed? Just as cleared land is opened for rejuvenation with desirable plants, it is also susceptible to invasion by unwanted plants.
3. Targeted grazing is a business. Land owners and managers must recognize the value of targeted grazing to improve the appearance, function, and environmental quality of plant, land, and water resources – and be willing to compensate service providers for that value.

The goals of targeted grazing are simply this: to improve the country's vast natural and cultivated landscapes in the most effective manner and at the least cost, both economically and environmentally. It is hoped that the tools and information shared in this handbook will help achieve those goals. Indeed, this is a handbook whose time has come.

A Brief History

In a publication like this, with a long trail to completion, it's difficult to give sufficient credit where it is due. As is pointed out in the handbook, the idea of using grazing animals to manage vegetation has a long history. But the idea of bringing the body of knowledge to bear on targeted grazing as a service business for achieving environmental goals began taking shape in the 1960s and emerged into focus during the 1980s and 1990s.

In 1968, the U.S. sheep industry began gathering the existing knowledge and research on lamb and wool production into a format useful to producers. This yielded the Sheep Industry Development Program's Sheep Production Handbook and the Sheep and Goat Research Journal. However, by the early 1990s, it had become apparent that, while references were made to using sheep as natural resource management tools, there was no collection of information that producers and resource managers could practically apply. To address this gap, Tom McDonnell, director of the American Sheep Industry Association (ASI) Resource Management Council at the time, formed an ad hoc steering committee in September 1992, with members from across the country representing universities, government agencies, and producers. The committee crafted this statement of its beliefs:

"The United States sheep industry supports the need for healthy functioning ecosystems and realizes that proper management of sheep grazing is compatible with most of these systems. A viable sheep industry provides the opportunity for economic, social and cultural benefits from the use of natural resources. In addition, sheep can be effectively utilized as a biological tool by natural resource and land managers to benefit ecosystems. Unsustainable grazing by any herbivore is not condoned by the sheep industry."

With statement in hand, the committee launched a 10-year project to compile information on using sheep as natural resource management tools. The initial fruits of the effort appeared in a 1994 special issue of the Sheep Research Journal titled, "The Role of Sheep Grazing in Natural Resource Management." In 80 pages of the journal, nine articles discussed the value of sheep grazing to provide ecological benefits in a variety of venues, including weed control, riparian management, fire fuel management, range improvement, forest management, and wildlife habitat improvement. In 1995, ASI developed nine brochures and a display booth to promote the concept of prescribed grazing, at the same time encouraging research on various aspects of prescribed grazing at universities and government agencies.

In 2003, retired sheep specialist Dr. Hudson Glimp initiated a prescribed grazing conference in Sparks, Nev. The overflow audience of nearly 300, many of them sheep and goat producers, attested to the powerful interest in adopting prescribed, or targeted, grazing and confirmed the need for a handbook on the subject.

In short order, Karen Launchbaugh, a rangeland professor and department head with the University of Idaho, joined with John Walker, a rangeland professor

and research director at Texas A&M's Research and Extension Center in San Angelo, to pick up the baton, applying for and receiving a grant from the National Sheep Industry Improvement Center to develop this handbook.

The Future

This handbook is just a milestone along a continuum to incorporate targeted grazing into the mainstream of resource management. As this handbook reached the final stages in October 2006, agencies and universities had been briefed on the issues and made commitments to ratchet up research efforts into a variety of vegetation management arenas involving sheep, goats, and cattle. In addition, testimony had been developed and presented that would make targeted grazing a basic tenet of the next Farm Bill.

At the same time, ASI and other groups continued to solicit grant dollars to support the effort. A two-year grant from the Natural Resources Conservation Service (NRCS) on invasive species management, received in mid 2006, was to help establish a training program in targeted grazing, with the handbook at its core, for new and existing employees at NRCS, the Bureau of Land Management, and the U.S. Forest Service. Additional energy was to be expended to train employees with the Farm Service Agency, the U.S. Fish and Wildlife Service, and the National Park Service.

Further, efforts were being focused on developing a certification program for contract grazing with support from the Society for Range Management and through the American Sheep Industry Association.

Credits

As with any project of this nature, it takes a fully engaged team to bring the product to completion. Certainly, the handbook authors – more than 30 of them who volunteered their time, energy, and expertise – deserve praise and gratitude. The authors have been working with Karen Launchbaugh and John Walker, project editors, who sponsored an innovative meeting in January 2006, in Boise, to review and critique an early draft of the handbook. Several producers involved in targeted grazing along with university researchers, agency employees, and members of ASI committees – more than 40 in all – spent two days providing guidance, which has been crucial in bringing the handbook to completion. Indeed, several of the producers involved in the meeting said they wished the handbook had been available when they began their own targeted grazing projects.

This handbook and the accompanying brochure promoting its use were designed and laid out by Amy Trinidad, editor of Sheep Industry News with ASI. Ron Daines, an editorial consultant from Logan, Utah, provided editorial advice as the handbook evolved.

Special thanks for funding support go to the American Sheep Industry Association, the American Land and Resources Foundation, the National Sheep Industry Improvement Center, and the Joe Skeen Institute for Rangeland Restoration.

Photo: ASI

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CHAPTER 1:
Targeted Grazing – A New Paradigm for Livestock Management

By Karen Launchbaugh and John Walker

Karen Launchbaugh is a rangeland scientist and Chair of the Rangeland Ecology and Management Department at the University of Idaho, Moscow, ID. *John Walker* is a professor and Resident Director of the Texas A&M Research and Extension Center in San Angelo, TX.

Photo: Craig Madsen, Healing Hooves, Edwall, WA

INTRODUCTION

Grazing by wild and domestic animals is a powerful natural force working in all ecosystems. The kind and abundance of plants that characterize any plant community are a result of the climate, soils, and herbivores including insects, wildlife, and livestock that inhabit that place. The regenerative or destructive power of herbivory to shape plant communities has been demonstrated time and time again as humans have managed the grazing of domestic livestock. For better or worse, livestock grazing has been applied for thousands of years in ways that change plant communities. Along with fire, grazing is the oldest vegetation management tool.

Today, livestock grazing is being rediscovered and honed as a viable and effective tool to address contemporary vegetation management challenges, like controlling invasive exotic weeds, reducing fire risk in the wildland-urban interface, and finding chemical-free ways to control weeds in organic agriculture. The challenge of converting livestock grazing from a ubiquitous land

use into a powerful vegetation shaping tool requires a paradigm shift for both land managers and livestock producers. Generations of herders and scientists have focused their efforts on improving the production efficiency of sheep, goats, and cattle for meat, milk, and fiber and for strength as draught animals. Recognizing that left unchecked, livestock grazing often resulted in the deterioration of pastures, early grazing management focused on mitigating these adverse effects so that forage could be grazed in a sustainable manner. Today's paradigm will harness the powerful ability of livestock grazing to change the botanical composition of grazing lands and use it to manage and control undesirable plants. The natural power of herbivory and the knowledge of how grazing influences vegetation communities can be skillfully combined to convert livestock grazing into a powerful tool for vegetation management.

This creation of a new livestock-based ecological service will require careful understanding of animal behavior and plant response. In the last few decades, a cadre of livestock producers has emerged who employ livestock with the primary purpose of controlling unwanted vegetation. In these new enterprises the traditional products of livestock production (meat, milk, and fiber) are a byproduct of vegetation management. This new paradigm emphasizes managing livestock as a service for vegetation control and creating desirable landscapes.

Targeted Grazing Defined

Targeted grazing is the application of a specific kind of livestock at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals. This concept has been around for decades and has taken many names, including prescribed grazing and managed herbivory. The major difference between good grazing management and targeted grazing is that targeted grazing refocuses outputs of grazing from livestock production to vegetation and landscape enhancement. The concept of a target requires that one has a clear image on which to focus and then aims something (i.e., an arrow) at the target to accomplish the desired outcome. In the case of targeted grazing, the land manager must have a clear vision of the desired plant community and landscape, and the livestock manager must have the skill to aim livestock at the target to accomplish land management goals. The key to success is having a clear understanding of both the Target (landscape condition) and the Arrow (livestock). Targeted grazing therefore requires knowledge of vegetation and landscape dynamics as well as livestock husbandry and animal behavior.

Value of Targeted Grazing

Scientific studies and practical experiences reveal the substantial value of grazing to meet ecological objectives. Sheep and goats are effective tools for reducing noxious weeds such as leafy spurge, spotted knapweed, and kudzu. Managed grazing can also reduce the risk and extent of wildfire and improve wildlife habitat. Removing undesirable vegetation can be accomplished by controlled grazing along power line easements, irrigation canals, and roadsides and in forest plantations and orchards. Animal impact can also be harnessed to sow seeds for ecological restoration of degraded lands.

Targeted grazing should be considered as another tool in the kit for constructing desirable ecosystems. It can and should be used in combination with other technologies, such as burning, mechanical tree harvesting, hand-grubbing, chaining, applying herbicides, chiseling, and seeding. Most of these traditional management tools have significant economic, ecological, or social implications that limit their application. The vast roadless extent of many grazing lands makes it difficult to control noxious weeds with herbicides or to reestablish desirable forage plants after spraying. Weed and vegetation control is difficult on lands of low economic value, making chemical and mechanical treatments impractical. Insects and microbes for biocontrol can be quite effective for weed control but are difficult, expensive, and time consuming to develop. Prescribed burning is a useful tool, but its application is often hindered by concern over air pollution and the risk of unintended spread. Targeted livestock grazing is a readily available and under-exploited tool that is fast proving effective for vegetation management in many settings.

Research and on-the-ground experiences have clearly demonstrated that sheep and goats are a promising tool in the battle against weeds. Targeted sheep and goat grazing is an effective technique, rivaling traditional chemical and mechanical control methods for the management of deleterious invasive plants including leafy spurge, spotted knapweed, yellow starthistle, cheatgrass, saltcedar, and kudzu. Further, targeted grazing is viewed as an "environmentally friendly" alternative to traditional methods because it is often more effective and can be applied in vast roadless areas, leaves no chemical herbicide residue, can be removed whenever necessary, and often improves biodiversity. Plus, in the process of controlling undesirable plants, grazing animals convert them into saleable products – meat and fiber.

Livestock grazing, like any tool, can be misapplied and cause harm instead of repair. Overgrazing has often been implicated in encouraging the spread of noxious weeds. However, grazing can be honed into a highly effective weed management tool with precise application based on an understanding of plant-herbivore interactions. Converting grazing from a ubiquitous agricultural practice into a powerful tool for weed control and landscape enhancement will require information on the susceptibility and potential of the target plant or community for grazing the appropriate season and type of livestock necessary to achieve the desired objective.

Basic Principles of Targeted Grazing

The most important skill for all people applying targeted grazing for vegetation management is patience and commitment. The effects of correctly applied targeted grazing are generally slow and cumulative. A minimum of three years is usually required before noticeable differences in perennial herbaceous weeds are apparent. Browse may take much longer. Once management objectives are obtained, managers must be prepared to modify their grazing from the system in use when the problem occurred, or surely it will return.

Effective grazing programs for weed control require a clear statement of the kind of animal, timing, and rate of grazing necessary to suppress troublesome plants and maintain healthy landscapes. A successful grazing prescription should: 1) cause significant damage to the target plant; 2) limit damage to the surrounding vegetation; and 3) be integrated with other control methods as part of an overall landscape management strategy. Developing a successful grazing prescription requires a great deal of site-specific ecological information and animal management skill.

First, a targeted grazing prescription specifies the time grazing should be applied for maximum impact. This time is set when the target weeds are most susceptible to damage by grazing and when they are most palatable to livestock. How acceptable or palatable a plant is depends in part on the plant's nutritive characteristics. The nutritive value or potential toxicity of plants varies throughout the growing season. Most plants are highly digestible and nutritious when they are young, and they become less nutritious as the season advances. It is also critical to apply grazing at a time of year when the target plant is susceptible to damage from defoliation. Plants are generally most susceptible to grazing when they have started flowering until they begin to form seeds. Enticing livestock to eat and cause damage to specific target plants requires careful selection of the time of year to apply grazing.

Second, the palatability of the target plant also depends on the animal's inherited and developed plant preferences. Animals are born with a digestive architecture that makes some plants better forage than others. For example, cows have large, broad mouths and large rumens well suited for harvesting and digesting grass, but these same attributes make them less capable of eating shrubs. The narrow mouths of sheep and goats make them well suited for eating non-woody (herbaceous) broad-leaved weeds like leafy spurge, knapweeds, and kudzu. Goats are particularly well designed for eating shrubs with their dexterous tongues and lips and their relatively good capacity for detoxifying the tannins and terpenes often found in shrubs. Selecting the appropriate species for grazing forms the basis for an effective targeted grazing prescription. However, the life experiences and current nutritional state of an herbivore also influence the plants they will readily consume. A skilled livestock manager, or grazing service provider, knows how to prepare animals for specific vegetation management settings.

Finally, one must bear in mind that the plant targeted for control exists in a plant community of desirable plants. The basic goal of targeted grazing is to give the desired plants a competitive advantage over the target plant or plants. The challenge is to select the correct animal, grazing time, and grazing intensity to maximize damage to the target plant and minimize effects on the surrounding desirable vegetation. A clear understanding of the palatability and susceptibility of all plants in the community is needed to design a grazing strategy that will compromise the target plants and benefit the desirable plants.

Photo: Rob Rutherford, Cal Poly State University

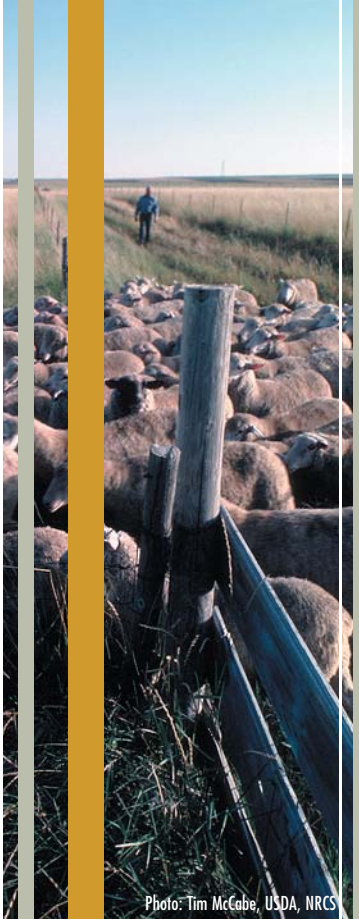
Photo: Tim McCabe, USDA, NRCS

Role of Grazing to Reach Land Management Goals

Targeted grazing can play many land management roles depending on the current state and abundance of troublesome plants or weeds. Targeted grazing alone will not eradicate a weed. The prescriptive application of livestock grazing in vegetation management cannot be viewed as a one-time-then-walk-away approach. It must be viewed as a long-term landscape maintenance tool and as part of an integrated strategy. Targeted grazing can play an important role depending on the weed abundance:

- **Problem Prevention** – When weeds are at low levels on the landscape, carefully managed livestock grazing can keep weeds at bay and restore the balance to desirable plants in the community. It is likely that grazing programs could be useful in early stages of plant invasion to reduce colonization and slow the rate of invasion. Targeted grazing could prevent establishment of new plants or maintain low levels of weeds in the community.
- **Weed Control and Management** – At levels where weeds are having noticeable impacts, targeted grazing could be applied to control weedy plants and promote desirable vegetation. The careful application of the appropriate grazing animal at the appropriate time and intensity can restore a balance in the ecosystem that allows the desirable plants to persist and thrive.
- **Converting Weeds to Feeds** – At high levels of weed dominance, livestock may be applied to harvest weeds as feed to gain a saleable product. Some weeds have significant nutritive value to grazing animals and can support livestock production. Many weed-dominated communities are stable and would be difficult to restore to a more desirable state. Viewing these communities for their potential forage value may be an important strategy with a focus on preventing the proliferation of other exotic plants that may be less palatable or more ecologically damaging. In some situations, such as crop aftermath or fallow, there is no concern for the so-called "desirable" plant community, and weeds can be viewed exclusively for their potential forage value.
- **Rehabilitation and Restoration** – When desirable plants have been pushed out of a plant community by the weedy species, opportunities to convert a landscape to a desirable state may require seeding and introducing new plants into the community. In these situations, livestock can be used to prepare a seedbed, trample seeds into the soil, and control weeds as new plants become established.

Photo: USDA, NRCS

Balancing Vegetation Management Goals with Animal Production Goals

There is a continuum of management intensities that can be used for targeted grazing, and it is important to match the management intensity with the economic constraints of the land manager and the livestock production goals of the grazer. Examples of factors that will increase cost and reduce animal performance include: 1) high grazing pressure to induce livestock to consume a target plant, and 2) proximity to urban areas with inherent problems related to pets and the need to ensure that animals do not escape areas targeted for landscape enhancement. Vegetation management in situations like these can be very expensive and is often accomplished with dry females or castrated males that are not expected to produce a livestock product. At the other end of the continuum are producers from Texas to Montana where control of plants such as juniper and leafy spurge is a byproduct of their normal operation. These grazers may be willing to provide targeted grazing for the reimbursement of out-of-pocket expenses and free pasture.

There is also a continuum of the difficulty of controlling invasive plants, from easy to difficult to impossible. The difficulty of control will directly affect the intensity of management necessary to gain success in a targeted grazing project. On the "easy" end are plants such as Johnsongrass. Johnsongrass is considered a noxious weed and is a big problem in crops, but it is rarely found in pastures because it is very palatable and is quickly grazed out by any species of livestock at any intensity of management. Leafy spurge might be considered a difficult plant to control because it is avoided by cattle. However, it is readily controlled with sheep or goat grazing, but that requires additional management intensity compared to cattle-only grazing. Examples of situations where targeted grazing is not appropriate include mature stands of juniper. While goat browsing is very effective for controlling small juniper, if the trees are allowed to get large, reclamation methods like mechanical control or warm season prescribed fire will be necessary before targeted grazing can be used.

Integrating Livestock Grazing into Weed Control Programs

Vegetation management and landscape enhancement strategies must be ecologically based with careful attention to positively directing community change, not just removing a weedy species. It is also important to develop integrated weed management systems using several techniques in well planned and coordinated strategies. Most landscape enhancement objectives are not easily accomplished with a single vegetation management tool. An approach that integrates several management techniques, including chemical, mechanical, and biological, is almost always the most effective and longest lasting strategy. For example, recent research indicates that grazing could increase the efficacy of herbicides. Livestock grazing may also be applied to reduce recruitment of weeds after herbicide or mechanical treatments. And, livestock grazing can be applied in concert with insect biocontrol agents to exact greater damage to a target plant population.

Incorporating grazing management into weed management plans has been recognized as one of the key components in successfully addressing weed problems. Using grazing animals to control noxious plants is a readily available approach because it is already the dominant use of Western rangelands and may be as simple as switching to the appropriate species of livestock for the current botanical composition of the land. However, making targeted grazing an active part of vegetation management programs will require greater dedication and commitment to grazing management techniques. Guidelines offered in this handbook are presented to promote targeted grazing as a technology to meet vegetation and landscape management goals. The intended uses of this handbook are to provide: 1) a reference for land managers to prepare targeted grazing management plans; and 2) a training and reference manual for people interested in initiating or expanding their livestock operation to include vegetation management.

Targeted Grazing Case Study – Leafy Spurge

Photo: Suzi Taylor, Montana State University

The effectiveness of prescription grazing by sheep and goats has been clearly demonstrated for the management of leafy spurge, which aggressively competes with native plants on over 3 million acres of rangeland in the Northern Great Plains. According to the Government Accounting Office, these invasions are estimated to cause about $100 million in damage each year (GAO 2001). Because cattle avoid grazing leafy spurge, the forage value of rangeland and pastureland can be decimated as leafy spurge invades and forms near monocultures. Fortunately, sheep and goats readily graze leafy spurge, finding it a nutritious and desirable forage and selecting it before resorting to eating grasses. Sheep and goats are highly effective tools for reducing the dominance of leafy spurge and are a readily applied technique in many areas of Montana and North Dakota (MSU 2002). Using sheep to control leafy spurge can cost as little as 60 cents per acre, compared to a cost of $35 per acre to spray herbicides from a helicopter. Currently, Montana weed trust fund dollars compensate sheep producers $1 a head per month for grazing services to control leafy spurge on over 28,000 acres.

Photo: Karen Launchbaugh, University of Idaho

Targeted Grazing Case Study – Spotted Knapweed

Spotted knapweed is considered one of the most troublesome rangeland weeds in the northern United States and Canada. It is an aggressively spreading weed currently occupying more than 7.5 million acres of Western rangelands and costing the livestock industry more than $42 million a year in lost forage and in additional weed control expenses. Herbicides, insects, pathogens, and fires have not effectively contained the spread of this noxious weed. Sheep readily graze spotted knapweed, consequently reducing its reproductive output and abundance.

Targeted Grazing Case Study – Kudzu

In the Southeastern United States, the aggressive climbing vine kudzu is rapidly spreading, overtaking everything in its path. Over 7 million acres are dominated by kudzu, and it is spreading at a rate of about 120,000 acres a year. This plant can easily creep up trees, fences, power poles, machinery, and buildings. Its aggressive growth costs the forest industry over $20 million every year in Mississippi alone. Sheep and goats readily browse the leaves and young stems of this massive plant, providing an alternative to costly traditional control strategies based on herbicides and mechanical removal. After several years of grazing, kudzu can be radically reduced in stature and basically kept in check.

Photo: Jean-Marie Luginbuhl, North Carolina State Univeristy

Targeted Grazing Case Study – Firebreaks

There is growing interest in livestock grazing to reduce fire fuel loads in response to continued urban development at wildland interfaces and to the extensive and destructive fires of 2000. Strategically applied sheep and goat grazing has reduced the risk and extent of wildfire in many settings. The most successful programs to reduce fuel loads are in California, where goats and sheep are commonly employed to graze the highly flammable shrubs of the chaparral region. Intensive grazing at the urban interface can create effective firebreaks as was accomplished near Carson City, Nevada, in a program named "Only Ewes Can Prevent Wildfire." A fenced corridor around the city was grazed by ewes resulting in removal of 71 to 83% of fine fuels. A survey of nearby homeowners revealed that over 90% supported the project and preferred the sheep to traditional chemical or mechanical methods of creating fuel breaks. In the Great Basin, extensive wildfires often burn through areas dominated by cheatgrass. Intense sheep grazing of cheatgrass-dominated sites, for as little as two years, can effectively suppress or even eliminate cheatgrass stands (Mosley 1996). Though targeted grazing is used minimally for fuel management on federal forest rangeland, success has been demonstrated by several trial projects, and opportunities for targeted grazing are expected to expand. Federal funds for hazardous fuel reduction, exceeding $350 million a year, could be used to secure the services of sheep and goat operators.

Photo: Resource Concepts, Inc.

CHAPTER 2:
Animal Behavior Principles and Practices

By Elizabeth Burritt and Rachel Frost

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10 KEY POINTS

- Understanding animal behavior is a powerful tool that can help managers modify diets to improve targeted grazing.
- The consequences of foraging experiences – positive and negative – shape animal behavior.
- Herbivores are not created equal in foraging, digestion, and toxin-coping skills.
- Herbivores are classified as grazers, browsers, or intermediate feeders.
- Foraging behaviors differ by species, age, body condition, gender, production cycle, and heritability.
- An animal's mother lays the foundation for the foods it will prefer later in life.
- Experiences in early life can influence animal behavior.
- Animals learn automatically from feedback after eating.
- Livestock must be taught to eat new foods.
- Animals are born with constraints that can be bent but not broken.

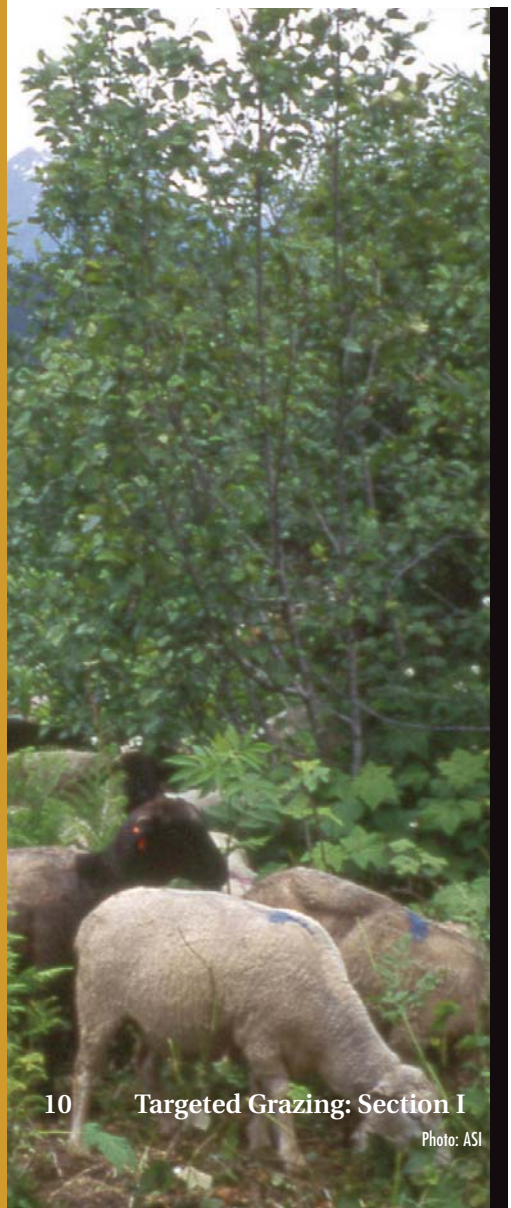

Photo: ASI

INTRODUCTION

Nature and nurture work in concert to influence animal behavior. Animals are born with certain physiological needs and inherited abilities. However, these needs and abilities vary greatly by species, breed, sex, age, physiological state, and experience. Understanding how these attributes influence diet selection can help in determining which species and class of animal will be effective for specific prescription grazing projects.

As animals gain foraging experience, the consequences of their actions shape future decisions. Positive consequences increase the likelihood of a behavior recurring. Negative consequences decrease it. Experiences that shape animal behaviors, including diet selection, continue throughout life. Managers who understand how animal behavior is shaped can harness and direct foraging of sheep, goats, and cattle to create powerful tools for vegetation management.

Animal Attributes that Influence Diet Selection

Selecting Species – Sheep, Goats, or Cattle?

Developing a grazing prescription begins by selecting the right animals for the job. The species of livestock best suited for vegetation manipulation depends on the plants of concern and the production setting. All herbivores are not created equal when it comes to digestion and the ability to cope with toxins. Animals consume foods that they are physiologically adapted to digest and that meet their nutritional requirements. Because of these inherent dietary differences, herbivores are often classified into three major groups: grazers, browsers, and intermediate feeders.[18, 41]

Grazers, including **cattle** and **horses**, primarily consume grass and have the digestive capabilities to handle large quantities of forages relatively low in quality. Cattle, because of their overall size and mouth design, are better adapted to grazing than browsing.[33] Cattle have a large muzzle and lips and a tongue that is used as a prehensile foraging tool.[48] The larger muzzle limits their ability to select among plants and plant parts. They forage using their tongue to sweep vegetation into their mouth where is it pinched between an upper dental pad and lower incisors and torn off. Cattle have large rumens, giving them the ability to digest lower quality roughage. That makes them superior to goats or sheep for managing fibrous and abundant herbaceous vegetation like dormant grasses. For example, cattle and horses are being employed to control Johnsongrass in Arizona in an attempt to restore native grasses.[47]

Sheep, classified as *intermediate feeders*, possess a narrow muzzle and a large rumen relative to body mass, allowing them to graze selectively and still tolerate substantial fiber content. Sheep, like all ruminants, have incisors only on the bottom with a hard dental pad in their upper jaw. Sheep also possess a relatively small mouth allowing them to graze relatively close to the ground and take small bites to select specific parts of a plant, such as small leaves or buds.[2] These anatomical differences give them an advantage over cattle to harvest prostrate plants or strip leaves or flowers from stems.[30] These features result in diets generally dominated by forbs. (Forbs are herbaceous plants that are not grasses, usually with broad leaves and showy flowers.) Indeed, sheep have been used successfully to control several weedy forbs including leafy spurge, spotted knapweed, yellow starthistle, thistles, tansy ragwort, and others.

Sheep will readily consume grass-dominated diets when grasses are succulent or when other forages are unavailable. Sheep tend to consume more forbs as forb availability increases. Plant parts that are tender, succulent, and readily visible are usually selected over those that are coarse, dry, and obscure.[2] Compared with cattle, it is more difficult for sheep to graze tall dense stands of forage than short dense stands.

Sheep are small, sure-footed, and well suited for travel in rough topography. Sheep will graze steeper terrain than most cattle and tend to avoid marshy wet areas.[15] These attributes, coupled with their gregarious nature, make them ideal for careful and strategic application of grazing in many weed-dominated lands.

Browsers, like **goats**, have a narrow, strong mouth with a dexterous tongue well designed for chewing branches and stripping individual leaves from woody stems. For this reason, goats are used extensively throughout the United States to manage invasive woody plants like juniper, saltcedar, and oak brush. Their smaller mouths give them the ability to selectively consume the highest quality leaves and stems, generally resulting in higher quality diets than cattle when grazing on the same range. A goat's adaptation for browse often results in diets with higher crude protein but lower digestibility compared to sheep.[29, 50]

Relative to body weight, goats also have larger livers than cattle or sheep, so they can more effectively process plants that contain secondary compounds like terpenes or tannins. This could explain why goats consume a higher percentage than sheep or cattle of leafy spurge, which contains a host of plant-defensive chemicals. Browsers are equipped with salivary glands that produce saliva, which binds tannins. They also possess specialized rumen microbes to break down alkaloids and other toxins in many situations.

Goats are physically agile animals that can stand on their hind legs to reach high-growing forage or use their forefeet to pull down branches to strip leaves. Smaller goats can even climb trees to gain access to higher forage. Their athletic nature enables goats to handle rougher and steeper terrain than sheep or cattle.

Multi-species Grazing

The best way to combat invasive plants is to select the livestock species that most readily consumes the plant targeted for control. Using more than one species – multi-species grazing – can enhance the benefits. Such grazing uses two or more species to graze the same piece of ground, not necessarily at the same time. It has the potential to restore balance to ecosystems by encouraging more even utilization of all forage species, preventing an ecological advantage for one plant species or class of plants. An example of multi-species grazing is adding sheep to cattle ranches to control leafy spurge. The sheep graze through a pasture quickly while the spurge is in the yellow bract stage. After the sheep remove the flower heads, effectively eliminating seed production, the cattle are turned out for the normal grazing season.

Choosing a Breed

Breeds of livestock differ in size and production characteristics, which dictate their nutrient requirements, dry matter intake, and digestive ability. These factors influence which plants, and in what proportion, an animal chooses to include in its diet.

Research on redberry juniper illustrates the differences in dietary preference among breeds. Spanish goats ate juniper more readily than Angora goats, while Ibex goats (a wild breed from Europe) ate more than both domestic breeds.[23] These differences may be explained by the degree of breeding selection. Ibex goats are largely feral and have experienced virtually no selective breeding by humans. Angoras have been highly selected for hair production, and Spanish goats are raised primarily for meat production. When selecting for these performance traits, managers may have inadvertently selected physiological traits that influence diet selection, such as the ability to handle various secondary plant compounds. Livestock selection and breeding may have also affected the kind of terrain animals can effectively forage. Breeds of cattle developed in mountainous terrain may graze rugged rangeland more uniformly than breeds developed in gentler terrain.[3] An animal's ability to navigate rough terrain is an advantage of using livestock to manage vegetation compared to conventional methods.

Animal Age

Animal age can also profoundly affect diet selection and tolerance to secondary compounds. Metabolic requirements change with age, so older animals need less food and spend less time foraging. Compared with adults, young, growing animals need diets higher in crude protein and energy and lower in fiber.[17] Their search for a more nutritious diet takes more energy. This, combined with limited foraging knowledge, may lead younger animals to try novel foods and retry foods that once made them sick.[39] For example, younger animals appear more willing than older animals to consume less desirable forages like juniper. Animals just weaned are expanding their diet choices, so they are also more willing to try novel foods.

As herbivores age, their incisor teeth wear, so they are less able to graze and achieve maintenance requirements, particularly on short forage. Incisor wear also influences forage selection. Goats with worn teeth tend to avoid grasses and choose a higher proportion of tender-leaved shrubs than goats with unworn incisors.[25]

Photo: Scott Bauer, USDA/ARS

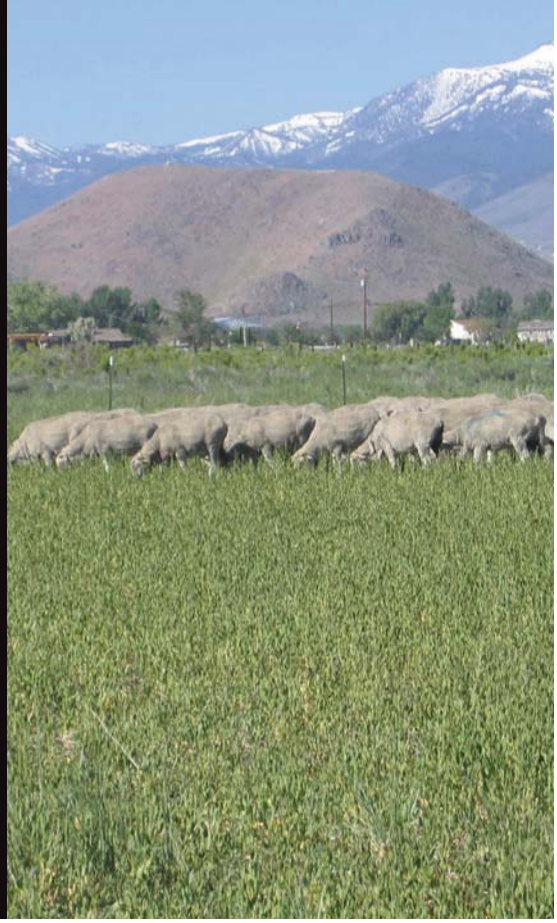

Photo: Leslie Haug, University of Nevada-Reno

Body Condition

How fat or thin an animal is influences its foraging behavior. Animals in low body condition or on a diet that fails to meet their maintenance requirements may have reduced tolerance for plant toxins. That's because there is a nutritional "cost" to metabolize a toxic or aversive plant compound.[12, 19] Detoxification most often occurs in the liver, so an animal that consumes chemically defended plants needs a large, healthy liver. Prolonged nutritional stress can reduce liver mass. Protein and mineral supplements can enhance rumen microbial function, liver enzymes, and compounds for conjugating toxins, all of which enhance an animal's detoxification abilities.

Malnourished and thin herbivores generally eat more than animals in good condition.[1, 42] When forage is limited, animals in low body condition may turn to poisonous or less desirable plants to maintain that higher intake. For example, cattle in low body condition began grazing the poisonous plant lupine sooner and in greater quantity than cattle in average body condition.[24] Goats in low body condition consumed nearly four times more redberry juniper than those in average body condition.[14] So, even though animals in low body condition are generally less able to metabolize plant toxins, they may be more likely to eat aversive or poisonous plants and in greater quantities.

Sex of Animal

Males and females select different diets, in part because of differences in size and overall nutrient requirements during reproduction. Morphological and physiological traits, such as growth rate and feed conversion efficiency, also contribute to differences in diets. Males generally have larger stature and muzzle size than females and may have greater energy needs.[17] Differences in foraging behavior between males and females are widely recognized but not well understood. Still, the sex of the grazing animal should be considered when selecting animals to achieve specific vegetation management goals.

Stage in Production Cycle

Animals choose their diets based on nutritional needs, which change dramatically during life stages. This knowledge can help with prescribed grazing. For example, some invasive plants with high nutrient content can meet the requirements of lactating females and growing offspring. Studies indicate that sheep grazing leafy spurge wean heavier lambs than their counterparts grazing spurge-free rangeland.[9] However, not all invasive plants are highly nutritious, and animals must have enough alternative forage to maintain body condition before breeding to meet nutrition needs during gestation and lactation.

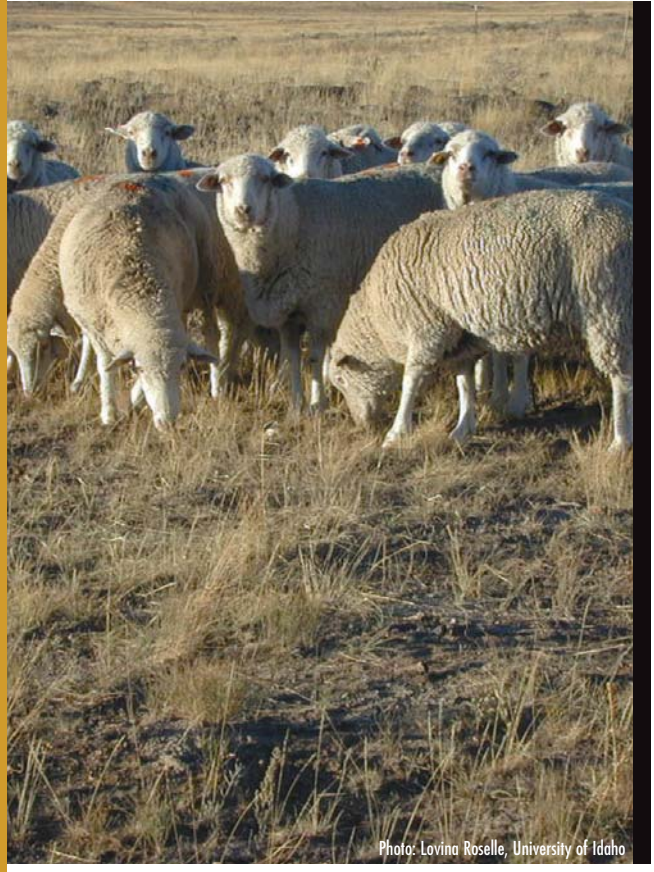
Photo: Lovina Roselle, University of Idaho

Castrated males can be useful for managing vegetation because they do not need to maintain body condition for breeding and can recover lost weight faster than females. Dry (non-lactating) females are also effective in managing low quality forages.

Individual Variation and Heritability

"Individuality" is a powerful force that influences dietary preference. Even animals of the same age, sex, breed, and experience will vary in their plant preferences. Some prefer plants high in energy while others prefer those with medium or low energy concentrations.[40] Just as with humans, animals have unique dental structure, physical abilities, organ size and function, and sensory abilities. Individual differences affect foraging abilities and how an animal metabolizes nutrients. Individuals also vary in responses to plant toxins. Almost every feeding trial with toxic plants has revealed individuals capable of consuming what would be a lethal dose to other animals without showing signs of toxicity. For example, some sheep fed a high dose of the alkaloid-containing plant goatsrue appeared unaffected, while others were killed by eating a small amount of this plant.[20] Physiological ability enables some animals to tolerate or metabolize plant toxins better than the average animal.

It would be helpful to identify these individuals and determine if their dietary traits can be perpetuated through breeding. There is evidence suggesting that diet selection may be somewhat heritable. For example, genetic factors significantly influenced dietary preferences of sheep browsing mountain big sagebrush[44] and goats eating juniper.[8]

Origins of Diet Selection

When selecting animals to manage plants, livestock species, breed, sex, and age are only part of the story. As an animal grows, experience shapes its body, physiology, and food preferences. Goats reared on shrub-dominated ranges of Texas perform better on blackbrush ranges in southern Utah than goats reared on grass. Sheep reared on foods containing toxins, such as tannins, terpenes and oxalates, eat these foods readily compared to sheep that have never seen the foods even when alternative foods without toxins are present.[49] Finally, some cattle eat plants they aren't expected to eat. For example, cattle on a ranch in Nebraska eat leafy spurge, cattle on another ranch in eastern Montana eat snowberry and silver sagebrush, and, recently, cattle have learned to incorporate knapweed, leafy spurge, and a variety of thistles into their diets (Kathy Voth, personal communication). Understanding that animal behavior, especially diet selection, can be shaped enables the training of animals to utilize and modify vegetation structure and abundance to meet management goals.

Social Models for Learning

When it comes to foraging, "mother knows best." An animal's mother is a good role model because she has foraged well enough to grow up and reproduce. Interacting with mother teaches young animals about the kinds and locations of both nutritious and toxic foods as well as locations of water, shade, cover, and predators.

Lambs and kids learn about foods before birth because they can taste the flavors of their mother's diet in the womb.[27] They do the same while nursing as food flavors are often transferred through milk.[28] As young ruminants begin to forage, they learn which foods to eat and which to avoid by foraging with their mother, and they remember those foods for years. Lambs fed wheat – a nutritious food – with their mothers for an hour a day for five days ate more wheat than lambs introduced to wheat without their mothers. Even three years later, with no additional exposure to wheat, lambs exposed to wheat with their mothers ate nearly 10 times more wheat than lambs exposed to wheat without their mothers.[16] Lambs of mothers trained to avoid one of

two palatable shrubs – mountain mahogany and serviceberry – avoided the shrub their mother avoided.[26] Thus, an animal's mother lays the foundation for the foods it will prefer later in life. Strong as a mother's influence can be, lambs won't eat foods that make them sick. Lambs made sick each time they eat a food, even if their mother strongly prefers it, soon refuse to eat it.[36]

While mother may be the best teacher, a young animal can learn about new foods from any member of the flock or herd. Lambs eating barley with their mothers ate 40% more barley than lambs eating barley with another adult. But lambs eating barley with any ewe ate dramatically more barley than lambs eating alone.[45] Peers also affect diet selection. In one study, mature nannies reared in different locations had distinctive dietary habits and maintained them when moved to a common pasture. Their kids preferred the diets they did, but the diets of successive generations became more alike as peers influenced each other's dietary preferences.[4]

Learning How to Eat

In addition to learning *what* to eat, animals need to learn *how* to eat. With just 30 hours experience browsing serviceberry, lambs had bite rates and intake rates 27% higher than lambs with no experience.[10] Young animals learn foraging skills more quickly than older ones. After 30 days exposure to blackbrush, six-month-old goats had faster bite rates than 18-month-old goats.[31] And the bite rates for the younger goats were still increasing after 30 days, while those for older goats had leveled off. Foraging skills acquired on one type of plant – grass or shrub – carry forward. Lambs experienced at browsing shrubs are more efficient at harvesting shrubs than lambs experienced at grazing grass, and vice versa.[11] Skills may transfer from one shrub species to another. Goats with experience browsing blackbrush were more efficient at harvesting oak leaves than goats with no experience.[32]

Experience Early in Life

Animal experiences, especially those early in life, are so influential that they can even change body structure and physiology. For example, the size of the rumen papillae, the structures that absorb nutrients from the rumen, increases in animals fed grain early in life. Later in life, young animals raised on poor quality forages have larger rumens, recycle urea nitrogen more efficiently, and eat more poor quality forages than those raised on high quality diets. Exposing animals to toxins early in life has variable results. In some cases, early exposure may increase the liver's ability to detoxify toxins.[7] But it can also cause liver damage, depending on the toxin and its dose.[34] Experiences early in life can even change connections within the brain and how well animals cope with changes in their environment.[13]

Learning from Feedback

Whether animals continue to eat or avoid a specific food depends on how they feel after they eat it. As a food is eaten, digestion releases nutrients and toxins, making the animal feel better or worse. Animals form preferences for the flavor of foods that are satisfying and aversions to foods that are not satisfying or that make them ill. Once the consequences of a particular food are learned, flavor helps animals identify which foods are good and nutritious and which are toxic or low in quality.

Animals determine which foods made them feel better or worse in a variety of ways. If the flavor suddenly changes, animals may eat less of a plant. In a diet of familiar and unfamiliar foods, animals associate changes in feedback, positive or negative, with new foods. They associate feedback with the plant they ate the most during a meal or the plant eaten last.

People often assume that animals lack the intelligence to learn about foods through feedback, but it's not a matter of intelligence. Learning from feedback happens automatically. Even when animals are anesthetized or tranquilized, post-ingestive feedback can change food preferences. When sheep eat a nutritious food and then receive a toxin dose during deep anesthesia, they become averted to the food because the negative feedback of the toxin still occurs even though they are deeply asleep.[37]

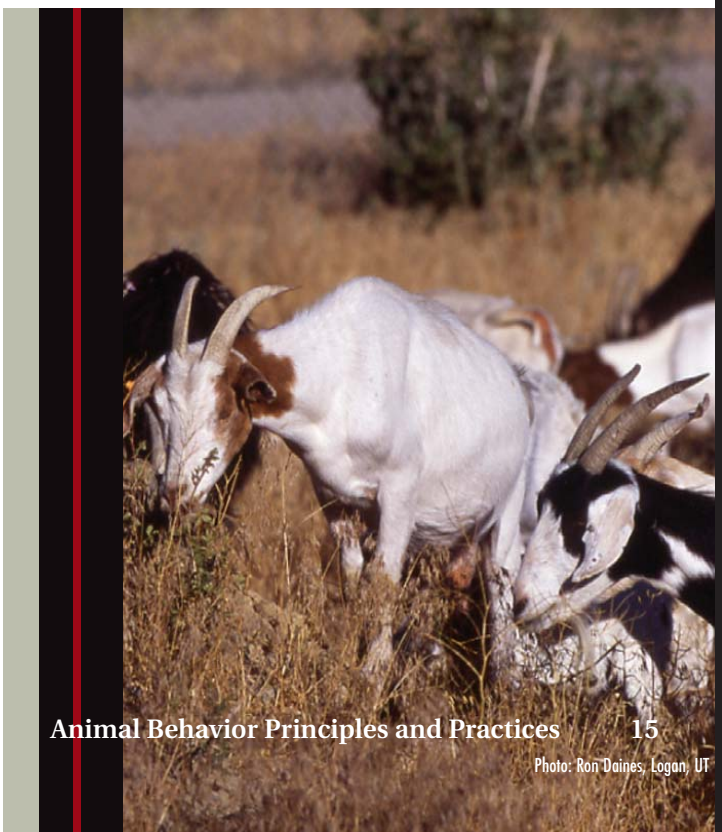

Photo: Ron Daines, Logan, UT

What Is Palatability and How Is It Created?

Most people assume that plant palatability depends on flavors that are inherently good or bad. That may be true in some cases, but an animal's response to a flavor depends primarily on feedback. Flavor only allows animals to distinguish among plants. Whether a flavor is preferred or disliked depends on the nutrient and toxin content of the plant, the nutritional needs of the animal, the animal's experiences with the food, and its ability to digest the plant. When nutrients are eaten in correct amounts, animals experience comfort or "satiety" and a liking for the flavor of the plant, so palatability increases. Conversely, when animals over-ingest nutritious or toxic plants, or plants containing inadequate nutrients, they experience discomfort and form a disliking for the flavor of the plant, so palatability decreases.

Many weedy species contain moderate to high levels of potentially toxic plant compounds. Over-ingesting toxins like terpenes, tannins, nitrates, alkaloids, and cyanogenic glycosides decreases palatability. However, ruminants rarely over-ingest toxins; rapid post-ingestive feedback causes nausea and limits the amount they can eat. If toxin concentrations decline, intake of the plant increases. Still, an animal's ability to distinguish between safe and harmful plants sometimes fails, leading to deaths from toxic plants.

Managing Diet Selection

What does all this mean for targeted grazing? Where possible, select animals that have experience eating the target plants. If such animals are not available, choosing animals with experience eating a wide variety of forages will increase the chances they will eat a new plant. Remember, animals are most likely to eat weeds that are high in nutrients and low in toxins. Plant nutrients are highest early in the growing season, but peak toxin levels can occur at any time and vary from plant to plant or species to species.

Encouraging Animals to Eat New Foods

Grazing animals are more likely to consume plant species with which they are familiar. Using animals unaccustomed to an area often results in diet selection patterns that differ from those of animals more familiar with the vegetation and terrain. Encouraging animals, especially older ones, to try new foods requires more effort than simply starving the animals until they eat the new plant. While animals are reluctant to try new foods, especially those with strong flavors, they will acquire preferences for new foods that contain needed nutrients. Several tactics can encourage animals to eat new foods:

- Introduce young animals with their mothers to the plants or feeds they will need to eat later in life. Young animals are more likely than older animals to eat new plants.
- Take it slow. Animals should not be forced to eat a diet consisting of a single new plant species for an extended time, especially if the new plant is high in nutrients or toxins. Immature plants high in nutrients can cause acidosis or ammonia toxicity, and the rumen needs time to adapt to them. Foods high in toxins can cause numerous health problems. The liver and the rumen need time to gear up to process and ameliorate toxins.
- First impressions matter. If animals get really sick the first few times they eat a plant, either from excessive nutrients or toxins, they will be unlikely to eat much of that plant again.
- Another tactic is gentle persuasion or encouragement, like offering new plants early in the morning for a short time followed by access to familiar plants or feeds.
- Peer pressure works. A few animals familiar with the plant targeted for consumption may nudge other animals unfamiliar with the plant to give it a try.
- Animals are more likely to eat a new plant if they are in a familiar location.
- Make new plants familiar. Spraying a familiar flavor, like molasses, on unfamiliar plants sometimes increases acceptance.

Diet Mixing

Livestock can be trained to eat foods considered unpalatable even when nutritious foods are available. The key is to provide a balance. To encourage animals to eat lower quality plants targeted for control, access to nutritious foods may need to be limited. As other plants become scarce, animals are more likely to eat plants high in toxins. At the same time, nutrients must be available to help detoxify any chemically defended plants the animals may consume. Consumption of forbs or browse containing toxins, for example, is usually greater after herbivores have been eating grass-dominated diets for two to three days. It is believed that grass may help buffer the toxins and enable livestock to consume more of these plants.

Consider Supplements

Supplementing ruminants with moderate amounts of protein and energy can increase intake of foods like juniper or oakbrush that contain toxins like terpenes or tannins. In a grazing study, sheep fed supplemental protein and energy for 15 minutes a day spent 12% more time feeding on sagebrush (which contains terpenes or essential oils) than sheep without supplements.[38] Supplemented sheep continued to increase intake of sagebrush throughout the study, while sheep without supplements decreased intake near the end of the study. In Montana, a rancher's hungry sheep balked at eating spotted knapweed but grazed it readily after eating nutritious forages low in toxins. In New Mexico, hungry goats that refused to browse sagebrush for several days ate it readily after grazing alfalfa-grass pasture. The consumption of tannin-containing shrubs can sometimes be increased by supplementing animals with polyethylene glycol, a compound that binds to tannins and disarms their protein-binding characteristics.[43, 46]

Why do supplements help? When animals eat plants low in nutrients or high in toxins, they need more nutrients. Most toxins are lipophilic or fat-soluble compounds. They must be converted into hydrophilic or water-soluble substances before they can be eliminated from the body. This conversion requires additional energy and protein. In short, as toxin ingestion increases, an animal's nutritional requirements also increase, and supplements can provide these necessary nutrients and energy.

Potential Plant Toxicity

Animals typically avoid plants that are novel, low in nutrients, or high in toxins. Not all plants targeted for control under grazing prescriptions are toxic. But, caution is required. While some toxins may simply cause aversions to a plant, others have the potential to cause production loss, illness, or even death. Animals can learn to avoid a plant only if the toxin causes nausea. They cannot easily learn to avoid plants that cause neurological problems, respiratory failure, birth defects, or chronic liver disease.[35]

It is a good idea to research the nutritional and toxic properties of plants that animals will graze, although information on the chemical content of many weed species is limited. Some excellent references are: 1) *Natural Toxicants in Feeds, Forages and Poisonous Plants*, by Peter Cheeke,[6] 2) *Toxic Plants of North America*, by George Burrows and Ronald Tyrl,[5] and 3) *A Guide to Plant Poisoning of Animals in North America,* by Anthony Knight and Richard Walter.[21]

Photo: ASI

CONCLUSION AND POINTS TO PONDER

Understanding animal behavior is a powerful tool that can help managers modify diet selection to increase the effectiveness of animals used to manage vegetation. Animals learn from feedback and social models like mother and peers. Their behavior, especially when it comes to diet selection, is incredibly flexible. For targeted grazing programs to be sustainable, managers should remember that animals are born with constraints that can be bent but not broken. A sound knowledge of how animal behavior, morphology, and physiology influence diet selection can greatly increase the effectiveness of grazing prescriptions while maintaining animal health and productivity. Keep these points in mind:

1) Even if animals are familiar with toxic or detrimental plants, if they are hungry, they may eat too much of the plant before feedback mechanisms signal them to stop.

2) Introduce animals to new foods slowly. Their rumen and liver often need time to gear up to effectively digest or detoxify compounds in plants.

3) Do not starve animals to get them to eat weeds or force them to eat a single species. They need other forages to balance nutrients and toxins.

4) Provide supplements when appropriate. Many plants targeted for control contain potentially toxic compounds that may be detoxified more quickly if animals have supplemental nutrients.

5) Get the timing right. Plant nutrients and toxin levels change over the growing season. Animal health and production depend on grazing at times of maximum nutritional benefit and minimum potential toxicity.

6) Provide adequate water. Thirsty animals may lose their appetite. High quality water can maximize plant intake.

7) Manage stress. Moving animals to an unfamiliar place can add stress and limit intake for a few days. A dose of plant toxins can be much more deadly if animals are stressed. However, animals routinely moved to new locations, such as occurs during contract grazing, may suffer less stress because they're used to being moved.

Literature Cited

[1]Arnold, G.W. and H.A. Birrell. 1977. Food intake and grazing behaviour of sheep varying in body condition. *Animal Production* 24:343-353.

[2]Arnold, G.W. and M.L. Dudzinski. 1978. Ethology of free-ranging domestic animals. New York, NY: Elsevier. 198p.

[3]Bailey, D.W., D.D. Kress, D.C. Anderson, D.L. Boss, and K.C. Davis. 2001. Evaluations of F1 crosses from Angus, Charolais, Salers, Piedmontese, Tarentaise and Hereford sires. V: Grazing distribution patterns. *Proceedings, Western Section, American Society of Animal Science* 52:110-113.

[4]Biquand, S. and V. Biquand-Guyot. 1992. The influence of peers, lineage and environment on food selection of the criollo goat *(Capra hircus). Applied Animal Behaviour Science* 34:231-245.

[5]Burrows, G.E. and R.J. Tyrl. 2001. Toxic plants of North America. Ames, IA: Blackwell Publishing. 1350 p.

[6]Cheeke, P.R. 1998. Natural toxicants in feeds, forages, and poisonous plants. Danville, IL: Interstate Publishers, Inc., 481 p.

[7]Distel, R.A. and F.D. Provenza. 1991. Experience early in life affects voluntary intake of blackbrush by goats. *Journal of Chemical Ecology* 17:431-450.

[8]Ellis, C.R., R.E. Jones, C.B. Scott, C.A. Taylor, Jr., J.W. Walker, and D.F. Waldron. 2005. Research note: Sire influence on juniper consumption by goats. *Rangeland Ecology and Management* 58:324-328.

[9]Fay, P.K. 1991. Controlling leafy spurge with grazing animals. In: L.F. James, J.O. Evans, M.H. Ralphs, and R.D. Childs [EDS.] Noxious range weeds. Boulder, CO:Westview Press. p. 193-199.

[10]Flores, E.R., F.D. Provenza, and D.F. Balph. 1989a. Role of experience in the development of foraging skills of lambs browsing the shrub serviceberry. *Applied Animal Behaviour Science* 23:271-278.

[11]Flores, E.R., F.D. Provenza, and D.F. Balph. 1989b. The effects of experience on the foraging skill of lambs: Importance of plant form. *Applied Animal Behaviour Science* 23:285-291.

[12]Foley, M.J., S. McLean, and S.J. Cork. 1995. Consequences of biotransformation of plant secondary metabolites on acid-base metabolism in mammals-a final common pathway? *Journal of Chemical Ecology* 21:721-743.

[13]Francis, D., J. Diorio, D. Lui, and M.J. Meaney. 1999. Nongenomic transmission across generations of maternal behavior and stress response in the rat. *Science* 286:1155-1158.

[14]Frost, R.A. 2005. Age and body condition influences consumption of redberry juniper *(Juniperus coahuilensis)* and disposition of four monoterpenes. [dissertation] Moscow, ID: University of Idaho. 150 p.

[15]Glimp, H.A. and S.R. Swanson. 1994. Sheep grazing and riparian and watershed management. *Sheep Research Journal* (Special Issue):65-71.

[16]Green, G.C., R.L. Elwin, B.E. Mottershead, R.G. Keogh, and J.J. Lynch. 1984. Long-term effects of early experience to supplementary feeding in sheep. *Proceedings of the Australian Society of Animal Production* 15:373-375.

[17]Grings, E.E., R.E. Short, M.R. Haferkamp, and R.K. Heitschmidt. 2001. Animal age and sex effects on diets of grazing cattle. *Journal of Range Management* 54:77-81.

[18]Hoffmann, R.R. 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: A comparative view of their digestive systems. *Oecologia* 78:443-457.

Literature Cited

[19]Illius, A.W. and N.S. Jessop. 1995. Modeling metabolic costs of allelochemical ingestion by foraging herbivores. *Journal of Chemical Ecology* 21:693-719.

[20]Keeler, R.F., D.C. Baker, and J.O. Evans. 1988. Individual animal susceptibility and its relationship to induced adoption of tolerance in sheep to Galega officinalis. *Journal Veterinary and Human Toxicology* 30:420-423.

[21]Knight, A.P. and R.G. Walter. 2001. A guide to plant poisoning of animals in North America. Teton New Media, Jackson, WY.

[22]Kothmann, M.M. 1966. Nutrient content of forage ingested in the morning compared to the evening. *Journal of Range Management* 19:95-96.

[23]Launchbaugh, K.L., C.A. Taylor, and S.D. Hohensee. 1997. Do different breeds of livestock have different dietary preferences? *Women in Natural Resources* 18:22-24.

[24]Lopez-Ortiz, S. 2002. Nutritional status, dietary preferences, and response to toxicosis of livestock exposed to lupine (*Lupinus* spp.). [dissertation]. Moscow, ID: University of Idaho. 124 p.

[25]Mellado, M., A. Rodriguez, J.A. Villarreal, R. Rodriguez, J. Salinas, and R. Lopez. 2005 Gender and tooth wear effects on diets of grazing goats. *Small Ruminant Research* 57:105-114.

[26]Mirza, S.N. and F.D. Provenza. 1990. Preference of the mother affects selection and avoidance of foods by lambs differing in age. *Applied Animal Behaviour Science* 28:255-263.

[27]Nolte, D.L., F.D. Provenza, R. Callan, and K.E. Panter. 1992. Garlic in the ovine fetal environment. *Physiology and Behavior* 52:1091-1093.

[28]Nolte, D.L. and F.D. Provenza. 1992. Food preferences in lambs after exposure to flavors in milk. *Applied Animal Behaviour Science* 32:381-389.

[29]Norton, B.W., P.J. Kennedy, and J.W. Hales. 1990. Grazing management studies with Australian cashmere goats 3. Effect of season on the selection of diet by cattle, sheep and goats from two tropical grass-legume pastures. *Australian Journal of Experimental Agriculture* 30:783-788.

[30]Olson, B.E. and J. R. Lacey. 1994. Sheep: A method for controlling rangeland weeds. *Sheep and Goat Research Journal* 10:105-112.

[31]Ortega-Reyes, L. and F.D. Provenza. 1993a. Amount of experience and age affect the development of foraging skills of goats browsing blackbrush (*Coleogyne ramosissima*). *Applied Animal Behaviour Science* 36:169-183.

[32]Ortega-Reyes, L. and F.D. Provenza. 1993b. Experience with blackbrush affects ingestion of shrub live oak by goats. J*ournal of Animal Science* 71:380-383.

[33]Owen-Smith, N. 1982. Factors influencing the consumption of plant products by large herbivores. *In:* B.J. Huntley and B.H. Walker [Eds.] Ecology of tropical savannas. Ecological Studies 42. Berlin: Springe-Verlag p. 259-404.

[34]Pritz, R.K., K.L. Launchbaugh, and C.A. Taylor Jr. 1997. Effects of breed and dietary experience on juniper consumption by goats. *Journal of Range Management* 50:600-606.

[35]Provenza, F.D., J.A. Pfister, and C.D. Cheney. 1992. Mechanisms of learning in diet selection with reference to phytotoxicosis in herbivores. *Journal of Range Management* 45:36-45.

Literature Cited

[36]Provenza, F.D., J.J. Lynch and J.V. Nolan. 1993. The relative importance of mother and toxicosis in the selection of foods by lambs. *Journal of Chemical Ecology* 19:313-323.

[37]Provenza, F.D., L. Ortega-Reyes, C.B. Scott, J.J. Lynch, and E.A. Burritt. 1994. Antiemetic drugs attenuate food aversions in sheep. *Journal of Animal Science* 72:1989-1994.

[38]Provenza F.D., J.J. Villalba, L.E. Dziba, S.B. Atwood, and R.E. Banner. 2003. Linking herbivore experience, varied diets, and plant biochemical diversity. *Small Ruminant Research* 49:257-274.

[39]Ralphs, M.H. and F.D. Provenza. 1999. Conditioned food aversions: principles and practices, with special reference to social facilitation. *Proceedings of the Nutrition Society* 58:813-820.

[40]Scott, L. and F.D. Provenza. 1999. Variation in food selection among lambs: Effects of basal diet and foods offered in a meal. *Journal of Animal Science* 77:2391-2397.

[41]Shipley, L.A. 1999. Grazers and browsers: How digestive morphology affects diet selection. *In:* K.L. Launchbaugh, K.D. Sanders, and J.C. Mosley. [EDS.] Grazing Behavior of Livestock and Wildlife. Moscow, ID: Idaho Forest, Wildlife & Range Exp. Sta. Bull. # 70. University of Idaho.

[42]Sibbald, A.M. and W.G. Kerr. 1994. The effect of body condition and previous nutrition on the herbage intakes of ewes grazing autumn pastures at two sward heights. *Animal Production* 58:231-235.

[43]Silanikove, N., Z. Nitsan, and A. Perevolotsky. 1994. Effect of a daily supplementation of polyethylene glycol on intake and digestion of tannin-containing leaves (*Ceratonia siliqua*) by sheep. *Journal of Agricultural Food Chemistry* 42:2844-2847.

[44]Snowder, G.D., J.W. Walker, K.L. Launchbaugh, and L.D. VanVleck. 2001. Genetic and phenotypic parameters for dietary selection of mountain big sagebrush (*Artemisia tridentata* Nutt. spp. *vasayana* [Rydb] Beetle) in Rambouillet sheep. *Journal of Animal Science* 79:486-492.

[45]Thorhallsdottir, A.G., F.D. Provenza, and D.F. Balph. 1990. Ability of lambs to learn about novel foods while observing or participating with social models. *Applied Animal Behaviour Science* 25:25-33.

[46]Titus, C.H., F.D. Provenza, A. Perevolotsky, N. Silanikove, and J. Rogosic. 2001. Supplemental polyethylene glycol influences preferences of goats browsing blackbrush. *Journal of Range Management* 54:161-165.

[47]Tu, M., C. Hurd, and J.M. Randall. 2001. Chapter 2: Grazing. *In:* Weed Control Methods Handbook. The Nature Conservancy. Available at: http://tncweeds.ucdavis.edu. *Accessed 14 July 2001*.

[48]Van Dyne, G.M., N.R. Brockington, Z. Szocs, J. Duek, and C.A. Ribic. 1980. Large herbivore subsystem. *In:* Breymeyer, A.I. and G.M. Van Dyne [EDS.]. Grasslands, systems analysis and man. New York: Cambridge University Press. p. 269-537.

[49]Villalba, J.J., F.D. Provenza, and H. Guo-dong. 2004. Experience influences diet mixing by herbivores: Implications for plant biochemical diversity. *Oikos* 107:100-109.

[50]Wilson, A.D., J.H. Leigh, N.L. Hindley, and W.E. Mulham. 1975. Comparison of the diets of goats and sheep on a *Casuarina cristata - Heterodendrum oleifolium* woodland community in western New South Wales. *Australian Journal of Experimental Agriculture and Animal Husbandry* 15:45-53.

CHAPTER 3:
Animal Husbandry of Sheep and Goats for Vegetative Management

By Rodney Kott, Tim Faller, Jim Knight, Dan Nudell, and Brent Roeder

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10 KEY POINTS

- Vegetation management projects can impose extra challenges on both animals and their managers.
- Many target plant species make good forage because of their high protein and energy content.
- Modifying breeding times can place mature animals on projects without their offspring.
- Early-season lambing, early weaning, and out-of-season lambing are options.
- Targeted grazing requires well trained herders who can remain with the animals.
- Predator attacks can be reduced with proper bedding grounds and trained guard animals.
- Using the right kind of fencing in the right situation is key to animal control.
- Managers should take steps to minimize transport of noxious weed seeds.
- Grazing arrangements can take several forms, including cooperatives, partnerships, and contracts with service providers.
- Land managers should be aware that managing unwanted vegetation is a long-term commitment.

Photo: Jim Moore, Montana State University

SETTING MANAGEMENT GOALS FOR PRODUCTION AND VEGETATION

When embarking on a targeted grazing program, both land and animal managers should consider the simultaneous needs of maintaining animal health and production and manipulating vegetation. While strategies for each can work in concert, the goals for managing vegetation may impose extra burdens on both animals and their managers. For example, a grazing prescription may limit the use of non-target vegetation like native grass, which could mean moving animals more frequently than might otherwise be the case. In addition to stress from frequent moves, managers and animals must find and adapt to new bedding grounds, campsites, and trails, all of which can disrupt normal production practices. This chapter addresses key considerations for successfully producing livestock while manipulating vegetation. Armed with such information, animal and land managers can more clearly identify mutually beneficial goals.

Recognizing Enterprise Expenses

The typical livestock operation incurs expenses for feed, medicine, veterinary services, and labor as well as non-cash costs for production losses resulting from weight loss, injury, or death from predators, toxic plants, and diseases. Vegetation management projects often accrue extra expenses beyond these normal costs of production, expenses that can vary widely depending on the project. For instance, veterinary expenses may be higher because of increased confinement and transportation. Moving animals to unfamiliar areas may reduce initial forage intake or increase risk from poisonous plants.

Several extra costs result directly from well managed targeted grazing projects. To ensure contract fulfillment, a higher level of monitoring is usually required to document how the vegetation is responding to grazing. The increased management and more frequent animal movement typical in such projects may mean hiring more people to control and herd the animals. If a management goal entails a higher density of animals confined to smaller grazing areas, additional fencing and movement of that fencing may be required. Also, because targeted grazing may be considered more environmentally safe than herbicides, many projects are conducted in areas with high human populations, like parks and the wildland-urban interface, resulting in problems with domestic dogs or requiring more attention to fencing or increasing the number of guardian dogs.

Nutritional Considerations

Efficiently producing lambs, kids, wool, and mohair requires knowing the animal's specific nutrient requirements – protein, energy, vitamins, minerals, and water. Proper nutrients are especially critical during breeding, late gestation, and early lactation, so it's important, when possible, to match livestock needs with the proper feed. Most plant species targeted in grazing projects make fairly good forage because of their high protein and energy content. For instance, leafy spurge, an invasive plant that infests vast tracts of land in the Intermountain West and Northern Great Plains, is nutritionally similar to high quality alfalfa. The nutrient composition of early-growth leafy spurge is 18-20% crude protein and 65% total digestible nutrients, making it ideal for lactating ewes or nannies. However, as plants mature their nutritive value decreases, so managers should try to use animals that have lower nutrient requirements, such as those not lactating, at times when the plant nutrients are low. Many plants targeted for management contain chemicals that are toxic or poisonous – tannins, terpenes, and alkaloids. However, just because a plant contains such compounds does not mean it will have dire consequences. Grazing animals

evolved with these compounds and have physiological and behavioral mechanisms that can ameliorate their negative effects. For example, microbes in the rumen of sheep, goats, and cattle can often detoxify a poisonous plant compound before it enters the animal's blood stream. Livestock managers must be aware of toxic plant compounds, but they must also realize that their danger to animal health or well-being may not be readily apparent.

Providing adequate water is critical in vegetation management programs. A lactating ewe or nanny requires 2 to 2.5 gallons of water a day during hot summer months when forage is relatively dry. Some target plants contain compounds that may increase an animal's water needs, or the plants may even become toxic if water is limited. For example, goats readily consume saltcedar. But, as the name implies, it contains high concentrations of salt. With adequate high quality water, animals can flush this salt from their bodies without ill effects. (For more information, see the American Sheep Industry's "Sheep Production Handbook" and its chapters on nutrition and range and pasture nutrients, available at www.sheepusa.org.)

Modifications to Traditional Breeding Schemes

Using mature animals without young in grazing projects can mitigate several management challenges, including predator problems, transportation difficulties, and the need for increased fencing when lambs or kids are present. Ewes or nannies that are dry or in early and mid pregnancy have lower nutritional requirements providing greater feeding flexibility. The challenge of managing lactating animals with their young has prompted many contract grazers to opt for adult females that are without lambs (dry ewes) or for castrated males (wethers).

Several management strategies such as early-season lambing followed by early weaning and fall lambing have been tried to manipulate breeding or lambing time so that only mature ewes or nannies are available for summer vegetation management programs. In a traditional sheep operation, ewes are bred in the fall, lamb in the spring, and lambs are weaned in late summer or early fall. Many breeds of sheep and goats are seasonally anestrous, meaning they don't cycle and can't be bred during certain times of the year. Shorter days and cooler temperatures signal breeding times, and most will enter breeding condition and be able to conceive between late summer and early winter.

Lambing and kidding typically occur in mid to late spring in the northern regions and in early spring in southern regions. Success in changing these times requires careful planning and management. Managers have two options, early-season and out-of-season lambing or kidding.

Early-Season Lambing and Kidding

This strategy involves lambing or kidding between January and mid March. Gestation lasts about five months (145-150 days), so animals must be in good breeding condition by late August or September to accomplish this strategy. Weaning lambs at two to three months of age makes ewes ready for vegetation management projects by April or May.

Advantages of early-season lambing or kidding include:

- Reduced predation risk and easier flock management because of the absence of lambs and kids.
- Fewer labor conflicts between lambing and other ranch activities.
- Reduced nutritional requirements for the herd or flock allowing for contracts on lower quality forages or where intense stocking rates are required.
- Potential for better prices by marketing lambs or kids when supplies are limited or to meet ethnic holiday demands.

Disadvantages include:

- Increased housing and facilities to protect young animals from winter weather.
- Increased need for winter feed or high quality shrublands for foraging when nutrient requirements are high for lactating animals.
- Increased labor for shed lambing or kidding compared to range-based approaches.

Early Weaning

Early weaning strategies in sheep are fairly well established. As a general rule, lambs can be early weaned at 60 days of age or 45 pounds with minimal problems. Some individuals wean lambs as early as three weeks of age. More information on early weaning is available in "The Sheep Production Handbook."

Advantages of early weaning:

- Dry ewes or nannies available for grazing projects earlier.
- Decreased predator risk by having dry ewes on the grazing project.

Disadvantages:

- Increased management skills by the livestock owner.

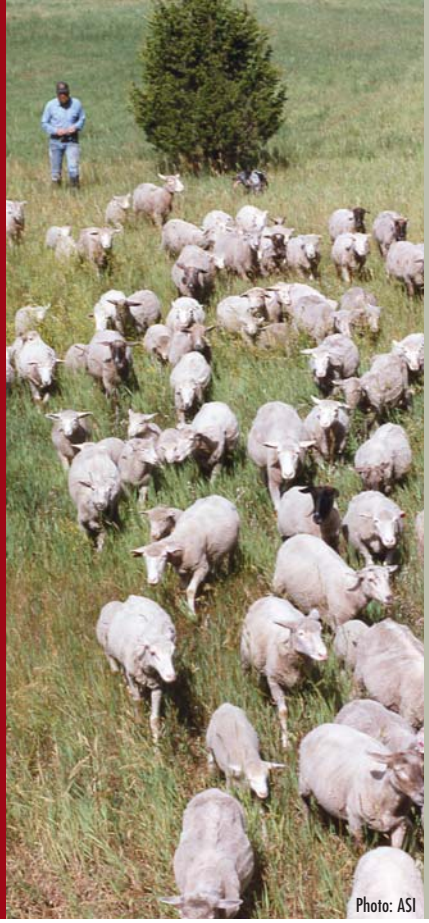
Photo: ASI

Photo: Karen Launchbaugh, University of Idaho

- Increased costs for harvested feed.
- Lambs not exposed to noxious weeds so training is not occurring.

Out-of-Season Lambing and Kidding

Considerations for employing out-of-season lambing are similar to those for early-season lambing. Out-of-season or fall lambing and kidding can require significant technical input to be successful, such as administering hormones or artificially controlling day length. Information on out-of-season breeding and lambing is available from local extension specialists or ASI's "Sheep Production Handbook." Breeding plans that deviate from the traditional lambing or kidding season need carefully developed business plans with economic justification. Plans should be sufficiently researched to assure they're biologically possible. The Hettinger Research Extension Center in North Dakota has developed a fall lambing management calendar that explains the requirements (for more information email HREC@ndsu.edu).

Animal Handling and Control

Using sheep or goats for targeted grazing requires careful and accurate control of grazing location and intensity. As the numbers of sheep operations have declined over the last 20 years, fewer people have experience raising and handling them. Even though many ranches in the Western United States once raised sheep or goats, few current owners and managers have experience with these livestock. Adding sheep or goats to an existing cattle ranch will require modification of fences, shelters, and working facilities.

Prescribed or targeted grazing projects require attentive, well trained herders who can remain with the sheep, living in a camp wagon or camping near the animals. Herders control where the animals graze, how much they consume in a given area, and where they drink or bed down. Where grazing is limited to smaller areas, and more precise control of animals is needed, some type of fencing (often in the form of temporary electric fence) may be required to contain the animals. In large unfenced areas, where precise and heavy utilization levels are not needed to achieve the vegetation management goal, herding can be used to control grazing. Several factors will determine the size of the herd or band. Steep, heavily timbered terrain with little water is best suited for yearlings or smaller bands (around 600 mature animals). Relatively open country with good water and an experienced herder can accommodate larger bands (up to 1,500 ewes or nannies).

Herding Strategies and Tips

The following tips on animal handling and control may be useful for both experienced and inexperienced managers. A herder's day typically begins at daylight

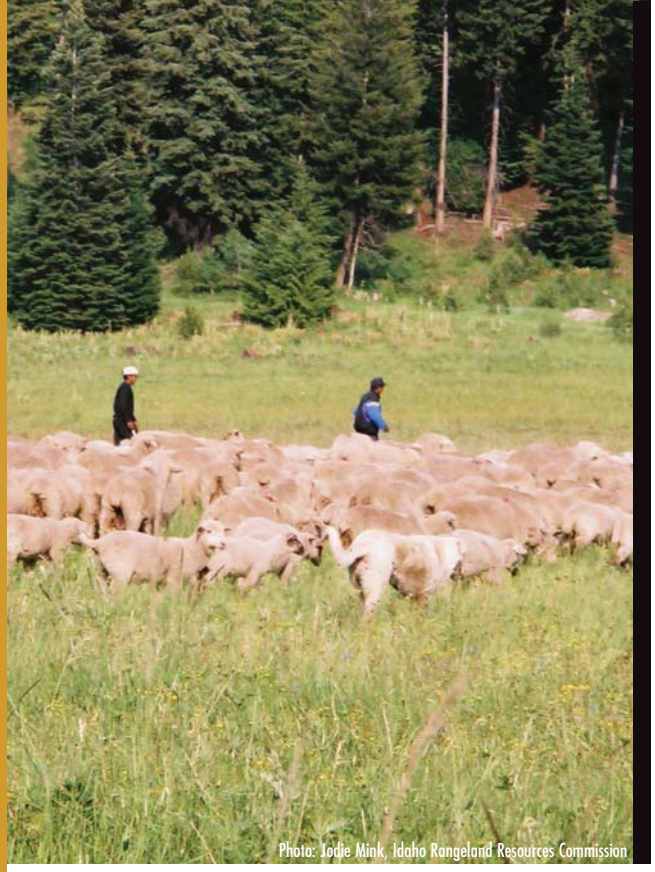

Photo: Jodie Mink, Idaho Rangeland Resources Commission

when he or she pushes the sheep off the bed ground and drifts them in mass toward the day's intended grazing area. The herder checks the band for sick animals or any missing from the previous night. After returning to camp for a quick meal, the herder then returns to check the location of the animals and to keep them from heading to water too early. Before lunch, the flock or herd is allowed to drift to water for the hottest part of the day. The herder can then return to camp for a noon meal and afternoon nap while the animals rest and ruminate. In early afternoon, the herder gets the sheep moving for afternoon grazing. Depending on the heat, this may last until late afternoon, when the herder will slowly drift the animals back to the night's chosen bed ground, bedding them around dusk. During mid summer, the workday can last from 4 a.m. to 11 p.m. As the summer gets hotter and drier, the band will awake and graze early, spend most of the day resting, and graze late into the evening. Many weed-infested areas are heavily timbered, complicating tracking and moving the animals. Herding dogs and horses are essential when moving animals and navigating rough terrain. This means that provisions must be made for guard and herding animals. It is important to store dog and horse food in bear- and sheep-proof containers.

Well-sited bed grounds can alleviate many problems. The herder should place camps in areas with good fields of view and above the bed ground so that sheep wandering at night will awaken the dogs. The camp can be placed away from the bedding ground if the herder has good guard dogs and the area has few predators and little timber. To minimize predator attacks, bed the sheep away from creeks on small open hills. Make sure they're full in the evening to reduce night wandering, and remember that yearlings tend to be restless at night, especially during a full moon. The herder may opt to pitch a small tent near bed grounds distant from the camp trailer to be nearer to the stock at night.

Bed grounds and camps should be moved at least every three days. Set the date for moving the camp several days in advance, then move on that day. Timely scheduling helps the herder effectively plan grazing paths. Provide the animals with salt and mineral mix on the bed grounds in troughs.

When starting a grazing project, several considerations must be addressed before the sheep arrive. Who will tend and move camp, and how often? When and from where will the sheep arrive and depart? Where is the available water? Does the land manager or herder prefer horses or four-wheelers to assist in moving stock? What will be the predator management program? Herders should be provided with cell phones and local contacts for emergencies. And they should have reliable maps of the ranch listing water holes, fences, and roads. In short, to encourage herders to perform well, give them respect and the resources to do the job.

In small areas, some grazers have combined extremely intensive herding with night penning to manage sheep or goats on a grazing project. Night pens are usually well constructed conventional or electric fence. It is not unusual to have additional herders managing fewer sheep or goats on small or marginally fenced acreages.

Fencing Options for Animal Control

Fencing requirements will depend on the species and breed of animal and type of project. The typical western whiteface ewes of predominantly rambouillet ancestry may be the easiest to confine, mainly because of their gregarious nature. Dr. Scott Kronberg, a TEAM Leafy Spurge scientist from North Dakota State University, documented that most sheep breeds are acceptable as vegetation control animals, but speckled-face and black-face breeds tend to be more aggressive grazers and less gregarious. Goats typically require more and better fencing because they are more aggressive and athletic grazers than sheep.

Tight woven (net) wire fence is standard for sheep and goats and the most desirable, although horned goats can cause some problems. These woven wire

fences also provide some protection against predators. They are, however, rather expensive. Many sheep producers have chosen to utilize single-strand fences. A minimum of four tight and properly spaced strands of barbed wire are needed to control sheep (four strands will only provide marginal control). Wire spacing, starting at the ground, should be 7, 7, 10, and 12 inches for four-wire fences and 6, 7, 9, 10, and 12 inches for five-wire fences. That makes the four-strand fence 36 inches tall, probably not high enough for cows. The five-strand fence at 46 inches should be adequate for most animals. With an existing four-wire fence designed to confine cows, it may be easier to add two new wires than to move existing wires to meet the spacing needs for controlling sheep in a five-wire application, especially when lambs are present. A secure six-wire fence, adequate for sheep, cattle, and some goats, can be spaced at 5, 6, 7, 9, 10, and 12 inches, giving a top wire height of 49 inches. A six-wire fence provides excellent control even when the pasture adjoins regularly traveled thoroughfares. In many more confined situations producers have gone to smooth wire because of the potential for injury to livestock from the barbs.

Land managers who use sheep or goats to control invasive plants on land previously grazed with cattle should consider re-fencing areas at the bottoms of washouts, draws, or thickets. Smaller species may find escape routes that were inaccessible to larger species.

In pastures where fencing already exists but is inadequate for sheep and goats, it may be more economical in the long run to build new fence to meet livestock enclosure needs. When a producer or land manager is willing to make this level of investment, such commitment should be documented and the grazing plan developed based on a longer-term approach.

In small pastures, electric fencing may provide some protection from predators, although that's usually minimal and should not be relied on as the primary protection. In some cases, it may be effective to add two electric wires to an existing barbed wire fence, one between the two bottom wires and the other between the second and third wires from the bottom.

Another application for small pastures is high-tensile electric fence, which can be erected quickly at low cost. While electric and high-tensile fencing work well in smaller pastures, they don't work as well for more extensive areas because of the challenges of retaining power over long distances and keeping the system functional. Adequate voltage must be maintained along the entire length of the fence, which requires a good charger and proper installation. A minimum charge of 3,000 volts is usually required to contain sheep. In many cases additional voltage will be required. If the charge is sufficient and consistent, sheep and goats can be trained to respect electric fences. Proper construction of electric fence is essential for satisfactory animal control. Those considering electric fencing should work with reputable companies experienced with sheep and goat fencing.

Another option is three- or four-strand polywire electric fence. It can be rolled up, transported, and erected on portable electric fence posts. Polywire fencing also comes in a net form that can be highly effective in small areas. The net wire can be gathered section by section and then expanded like an accordion to fence an area.

Minimizing Losses to Predators

Predators pose a major threat in many prescribed grazing projects. Coyotes are usually the biggest concern, but producers must beware of foxes, bobcats, wolves, bears, mountain lions, and domestic dogs. Several tools (lethal and non-lethal) can help producers mitigate predation. The degree to which such tools can be employed will often determine the economic cost or risk predators impose on an operation.

Among the non-lethal management tools are penning stock at night, predator-resistant fencing, guard animals, and modifying the production cycle so that only mature animals are used in vegetation management projects.

Because most predator attacks occur at night, corralling animals in a secure area can reduce predation.

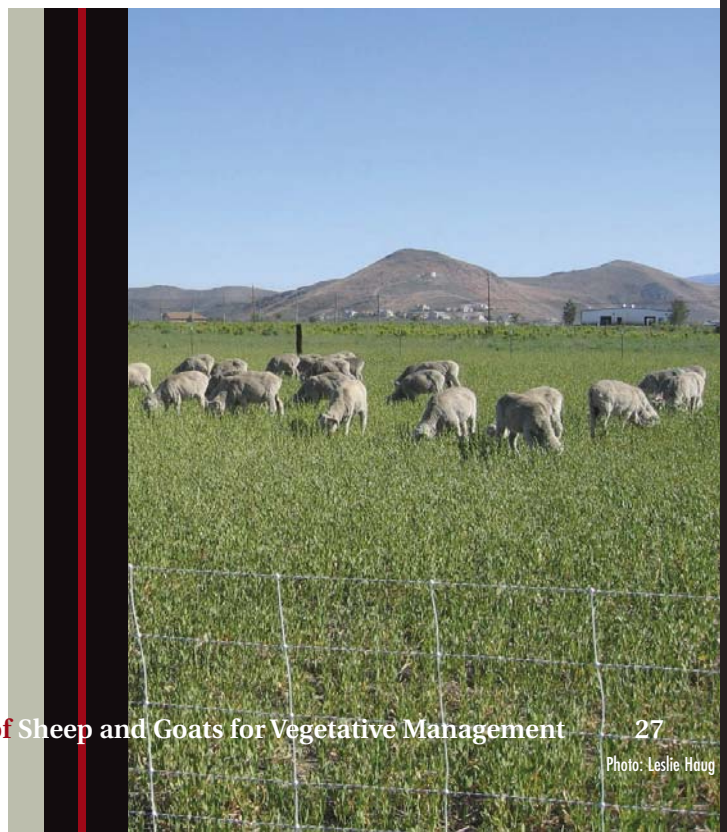

Photo: Leslie Haug

Locate corrals near buildings, lights, and human activities to discourage predators. If losses are high enough, fences designed to exclude predators may be needed. Exclusion fences can reduce livestock losses to coyotes, but no fence is coyote proof. Electric fences are the most economically feasible, either as new fences or electric strands added to the outside of existing fences. Keep in mind when building the fence that coyotes prefer to crawl under or through a fence than over it. Net wire fences can also keep predators out of corrals and pastures. It is important to remove or bury dead animals, covering carcasses with hydrated lime and then with soil. Most predators can smell carcasses from long distances. Leaving carcasses in pastures or open pits not only teaches predators to associate livestock with food, it encourages them to congregate near livestock.

Guardian animals – guard dogs, llamas, and donkeys – can also deter predators. Guard dogs work well in open range and larger pastures, while llamas and donkeys are often most effective in fenced pastures smaller than 300 acres. The appropriate species depends on the specific setting and the breed or individual animal. All three species can be trained or raised to "adopt" a flock of sheep or goats as their own and will go to great lengths to protect them. For the best results with dogs, they must be raised with sheep or goats from the time the dogs are eight weeks old. Treat them as working dogs, not as pets. Common breeds of guard dogs include Great Pyrenees, Komondor, Anatolian Shepherd, and Akbash. As with dogs, llamas and donkeys need a period to adjust to the flock or herd they will be protecting. Guarding skills will vary among individuals. For more information on selecting and managing guard animals, consult the "Sheep Production Handbook."

Address predation problems quickly. Once a problem develops, it will continue until actively resolved – it won't go away on its own. It may involve removing the offender, which can be a problem with attacking domestic dogs that are usually someone's pet. For assistance with predation problems, consult with local animal control officers or the U.S. Department of Agriculture's Wildlife Services.

Minimizing Seed Transport

Prescription grazers should be sensitive to the potential for spreading the seed of noxious weeds. The seeds are rarely dispersed in the wool. Grazing typically occurs during the summer when fleeces are short and unlikely to pick up many seeds. Seeds that are picked up will become embedded in the fleece and remain there through shearing. One study confirmed that there is little risk of spreading leafy spurge through fleece contamination.[3]

The rate of passage and viability of noxious weed seeds consumed by sheep or goats is very low. Still, some viable seeds may pass through the digestive system.[5] Chewing or partial digestion renders most seeds unviable. The longer the seeds remain in the sheep's digestive system the greater the possibility of digestion. Research at Montana State University showed that less than 20% of leafy spurge seeds ingested by sheep escaped digestion.[2] Most of the undigested seeds were passed in the first four days after ingestion, and all were passed by day nine. Seed viability deceased from 40% one day after ingestion to 0% after five days or more. One study[5] found that sheep no longer passed viable seed of spotted knapweed seven days after consumption.

Several strategies can retard the spread of viable weed seed. One is to graze the weeds before seed set. If stock consume seeds, place them in drylot or weed-free pasture for five to seven days after the animals have been removed from the seed source before moving them to non-infested areas. The animals could be moved to a small area where any new weeds from seed-contaminated feces can be managed with herbicides, remembering that the viability of any seed passed in the feces has been vastly reduced.

Spreading noxious weed seed to uninfested areas by ranch vehicles and four wheelers is as great a concern as spreading the seed by livestock. The undercarriages of vehicles should be cleaned after being driven through weed-infested areas after seed set.

Financial and Operational Considerations

Land managers exploring the addition of a targeted grazing enterprise must learn new skills for managing both livestock and capital investments. Adding such an enterprise requires equipment, facilities, and management expertise for day-to-day operation. With this increased responsibility, the land manager accrues the profits from the sale of lambs, kids, wool, or mohair. The land manager has other options. One is to form a cooperative to own and manage the enterprise. A second is a share rental agreement where a sheep or goat owner partners with a land manager needing vegetation management. A third option is to contract with a professional prescription grazing service provider who will meet grazing specifications for a contracted price. All three options have potential benefits and each requires the land manager to contribute a different set of resources.

In a cooperative, members typically hire a competent manager to provide day-to-day labor and management. Such an arrangement requires minimal involvement from the land manager, who can count on the cooperative staff to provide the husbandry needed for success. In a share agreement, the land manager leasing the sheep or goats would need to be more involved in animal management. At least one of the partners needs specific expertise with sheep and goats as would any partner handling day-to-day responsibilities. A land manager employing a contract grazer needs to negotiate the specific terms of the contract *(see chapters 16 and 17 in this handbook for more information)*. Contract grazers, for a pre-arranged service fee, typically will supply and manage the animals and provide the equipment needed to meet the agreed-upon vegetation standards.

Capital investment is handled differently under each grazing scenario. A land manager who buys animals and conducts the grazing assumes the capital investment. A cooperative allows several people to own the animals, facilities, and equipment, and it spreads the risks and rewards of the venture among all the owners. A shared agreement is typically between a livestock owner who provides the stock and a land manager who provides most other inputs. The investment is reduced for each partner, and risks and rewards are shared according to the percentage of their respective inputs. With contract grazing, the land manager assumes no capital investment. The grazing service provider, who is paid by the land manager, supplies the animals, equipment, and facilities and, ideally, is insured and bonded to assume the risks under the contract.

Cooperatives and share agreements can apply to both small and large targeted grazing operations. There is an important difference: the cost of establishing the agreement. By law, a cooperative has many requirements. A share agreement can be as simple as the two parties wish to make it. Two publications can help land managers assess the risks and rewards of each scenario. "Feasibility of a Sheep Cooperative for Grazing Leafy Spurge" addresses the feasibility of forming a large-scale cooperative to own sheep and related facilities for leafy spurge grazing.[4] "Sheep on Shares" details strategies for two parties to negotiate a share rental agreement for sheep production.[1]

Cooperatives, leasing agreements, and contracts all differ in investment costs, risk exposure, and tax implications. Evaluate each in the context of desired outcomes and each participant's financial situation and explore options with a financial advisor.

PUTTING IT ALL TOGETHER TO ADDRESS VEGETATION MANAGEMENT PRESCRIPTIONS

Land managers should be aware that using sheep or goats to manipulate vegetation is a long-term treatment that can achieve long-term effectiveness when prescriptions are properly applied. The first year will seldom run smoothly – the herder may be unfamiliar with the terrain and the sheep may be untrained on the target plant. But skill and patience can overcome these.

The key to success lies with a skilled herder who understands that the sheep are being used as a vegetation management tool. When the target vegetation is grazed to the prescribed level, animals should be moved to the next area. The herder should never attempt to remove 100% of the target plant. For example, it can be effective to "remove the yellow" from leafy spurge or to "hedge the top" off knapweed. The herder should pay close attention to the desirable forbs and grasses to keep them from being overgrazed. It may be more important to assure that desired species are not overused than to attain a certain degree of use on the target plant.

Targeted grazing with sheep and goats can be a powerful tool to manage vegetation. Success on the ground starts with a healthy, well managed herd or flock and effective planning to address key questions: When to breed? Herding or fencing? Guard dogs, donkeys, or llamas? How to minimize seed transport? Cooperative, share agreement, or contracted grazing service provider? A successful targeted grazing enterprise is built on maintaining a productive flock and making good decisions to manage grazing.

Proper management of all aspects of animal husbandry, including nutrition, supplements, breeding, health, and preventative maintenance, is essential for a successful grazing project. The "Sheep Production Handbook," the local county extension service, and large animal veterinary practitioner are important sources of additional information.

Literature Cited

[1]Brown, E., D. Nudell, H. Hughes, and T. Faller. 1999. Sheep on Shares. Report Number EC-1168. *Available at:* http://www.ext.nodak.edu/extpubs/agecon/farmmgt/ec1168w.htm. *Accessed 12 August 2006.*

[2]Lacey, J.R., R. Wallander, and K. Olson-Rutz. 1992. Recovery, germinability, and viability of leafy spurge (*Euphorbia esula*) seeds ingested by sheep and goats. *Weed Technology* 6:599-602.

[3]Olson, B.E., R.T. Wallander, and R.W. Kott. 1997. Recovery of leafy spurge seed from sheep. *Journal of Range Management* 50:10-15.

[4]Sell, R.S., D.J. Nudell, D.A. Bangsund, F.L. Leistritz, and Tim Faller. 2000. Feasibility of a sheep cooperative for grazing leafy spurge. Agricultural Economics Report Number 435. *Available at:* http://www.ag.ndsu.nodak.edu/hettinge/economics/Archive/sheepcooperativegrazingspurge.pdf. *Accessed 12 August 2006.*

[5]Wallander, R.T., B.E. Olsen, and J.R. Lacey. 1995. Spotted knapweed seed viability after passing through sheep and mule deer. *Journal Range Management* 48:145-149.

CHAPTER 4:
Understanding Plant Response to Grazing

By John Hendrickson and Bret Olson

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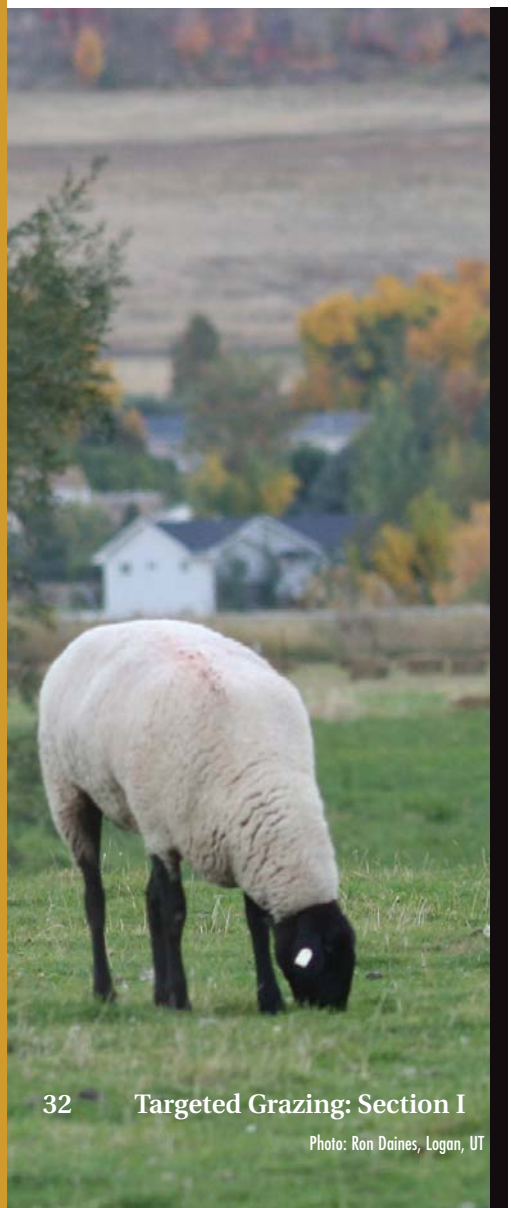

Photo: Ron Daines, Logan, UT

10 KEY POINTS

- The effects of targeted grazing on plants are difficult to predict because plants grow in complex ecosystems subject to change.
- Along with fire, grazing was the first tool humans used to manage vegetation.
- Plants have developed numerous defense mechanisms to protect them from grazing.
- A plant's ability to recover after grazing depends on its ability to reestablish leaves and renew photosynthesis.
- How plants interact with neighboring plants will influence their response to grazing.
- To determine a plant's response to grazing, it should be grazed during its growth stage.
- To be effective, targeted grazing must be applied with the right herbivore at the right time.
- Two or more grazing treatments may be needed during a growing season to suppress undesirable vegetation.
- Care must be taken to avoid overgrazing desirable species.
- The key to success is knowing the right herbivore, time, and amount of grazing for each vegetation situation.

INTRODUCTION

Natural and agricultural landscapes containing a wide diversity of plants. The effects of grazing on individual plants can be difficult to predict because plants grow in complex ecosystems that are subject to seasonal and yearly fluctuations in weather and natural disturbances. The degree of grazing on a plant is determined by its nutritive value, growth form, content of distasteful or harmful secondary compounds, and type of livestock that graze it. Plants also differ in their ability to tolerate or compensate for grazing. The ability of a plant to regrow after grazing depends on its age and physiological condition, stage of development, and carbohydrate allocation patterns. In addition, competition with other plants for space, soil nutrients, and water can influence how a plant responds to grazing.[2, 20]

Problems with vegetation composition are not quickly or easily solved. Understanding plant response to grazing is further complicated because these factors are constantly interacting. Still, some general principles that explain how plants respond to grazing can be used to select the right season and level of grazing to reduce weeds and, at the same time, favor or promote the growth of desirable plants. The key to a successful grazing prescription is for managers to have a good understanding of how plants respond to grazing and to know how to use and manipulate these responses to accomplish long-term vegetation management and landscape goals.

Plant Tolerance and Susceptibility

Grazing is a natural process that has influenced the evolution of plants for millennia. Along with fire, it was the first vegetation management tool ever applied by humans. Grazing, or herbivory, is a constant influence on all natural plant communities. Every plant species varies in its ability to survive and prosper in a grazed ecosystem. Most plants are not killed with a single grazing event that removes its foliage, flowers, and stems. Rather, plants have evolved mechanisms that reduce their likelihood of being grazed or promote their regrowth after grazing.[2]

Plant Defense Mechanisms

Plants low in forage value or containing potentially toxic compounds have lower palatability, and herbivores usually avoid them. Palatability is a collective term for the plant characteristics that influence whether an herbivore will prefer or avoid a plant. Many weeds have an acrid or bitter taste or "noxious" smell, at least to humans. Yet, sheep and goats readily consume the bitter-tasting spotted knapweed and leafy spurge. The high fiber and lignin in some weeds make it difficult for herbivores to tear full bites of foliage, reducing the plant's palatability. Still, most weeds are quite palatable and have good forage value during some point in the growing season. Many weeds are similar in structure and digestibility to native grasses and forbs. In fact, some weeds, like leafy spurge, remain greener, more succulent, and more nutritious longer into the summer than neighboring native plants.[12]

All plants possess a variety of compounds that can reduce forage value or deter grazing. Some are innocuous and some have the potential to harm livestock. These plant chemicals, called secondary compounds, include tannins, terpenes, alkaloids, oxalates, and glycosides. Levels of these compounds vary seasonally in plants and among plant parts. They can deter grazing by reducing plant digestibility, producing toxic effects, or causing illness. Animals reduce their intake of chemical-laden plants by selecting among different species or grazing specific plant parts like leaves or flowers that may have lower concentrations of these compounds.

Many shrubs and succulent plants possess thorns or spines that deter herbivores. Animals may also avoid young tender plant shoots mixed among the skeletons of dead stems. Some bunchgrasses accumulate and maintain upright dead stems that can deter grazing – a growth form commonly called a "wolf plant."[9, 21] Long-term grazing or mowing may cause plants to become decumbent – growing closer to the ground with a larger number of small shoots containing fewer, smaller leaves.[4] Plants that develop these characteristics, called grazing morphotypes, are less likely to be grazed or will lose less plant material if they are grazed.[1]

Plant Tolerance to Grazing

Plants have traits that increase their ability to regrow after grazing.[2] Some are simply better than others at replacing leaves or stems lost to grazing and producing new shoots to sustain growth and reproduction. A plant's ability to recover after grazing depends largely on its ability to reestablish leaves and renew photosynthesis. Plants do not maintain large stores of energy and nutrients, so they need carbohydrates gained from photosynthesis to survive, grow, and reproduce.

When plants are grazed, meristems at the base of the leaf blade, sheath, and stem internodes (called intercalary meristems) can be activated to provide regrowth. Plants can further regain plant material by lengthening stems and producing new leaves from apical meristems located at the tip of the shoots and branches. Plants can also grow new tillers or shoots from axillary buds at joints (nodes) along the branch or at the base of the plant. Plants tolerant of grazing generally have an abundant supply of viable meristems or buds that can be quickly activated to initiate regrowth[8] if water and nutrients are available.

Understanding the contribution of meristems to plant regrowth can show how plants regrow after they are defoliated and how to apply grazing to hasten the demise of target plants. Losing apical meristems is particularly damaging to a plant because regrowth must come from activation of axillary buds, a slow process that requires significant water and nutrients. While intercalary and apical meristems respond most rapidly after defoliation, most regrowth comes from new tillers or shoots produced by axillary or crown buds.[2]

Grasses are different from forbs and shrubs in how they respond to grazing because of where their growing points or meristems are located. Grasses maintain apical and axillary buds near the base of the plant until flowering is initiated.[2] This is why grasses are relatively tolerant of grazing before flowering and why they can regrow quickly when grazed in the young leafy stage. On the other hand, forbs and shrubs have axillary buds all along the stem and apical buds at the tips of branches. These meristems are readily available to herbivores and can be removed throughout the plant's life. Some forbs and shrubs have numerous growing points in the root crown at the base of the plant that can produce new shoots or underground runners called rhizomes.

Plant tolerance to grazing is also determined by physiological mechanisms like accelerated photosynthetic rates after grazing, an ability to quickly move energy and nutrients throughout the plant, and good root growth and function. It was once believed that carbohydrate reserves in roots determined whether a plant could recover from grazing. But plants also gain the energy needed for regrowth from existing leaves, not just from carbohydrates stored in the roots. So, depending on management goals, grazing activities should focus on either enhancing or suppressing the plants' ability to gather sunlight and photosynthesize. Heavy

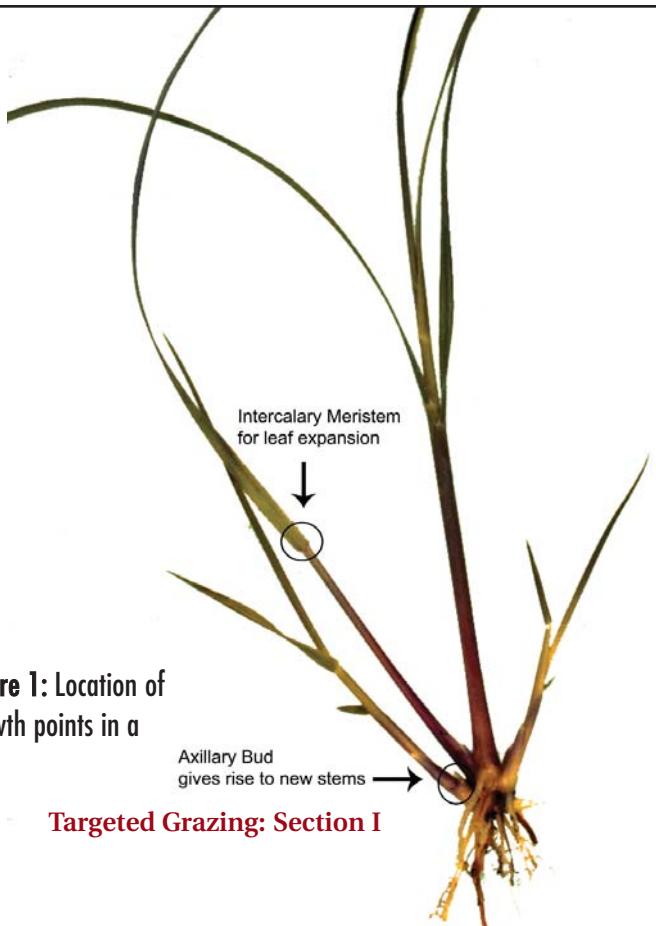

Figure 1: Location of growth points in a

defoliation also reduces root growth, and thus a plant's ability to compete for water and nutrients, placing it at considerable disadvantage with neighboring plants.

Healthy and vigorous roots also help plants tolerate grazing. Grazing an actively growing plant above a certain level (about 50-60% utilization) will immediately curtail root growth because the plant no longer has the leaves to photosynthesize and produce carbohydrates needed to fuel root growth. Under favorable growing conditions, plants well adapted to grazing will resume root growth within a few days. Maintaining a leafy canopy for photosynthesis is therefore important for root growth and functioning.[4]

A good example of differences in grazing tolerance is how crested wheatgrass and bluebunch wheatgrass respond to defoliation. After being defoliated, crested wheatgrass sends more nitrogen and carbon to shoots than to roots compared with bluebunch wheatgrass.[6] Because crested wheatgrass allocates more resources to leaves and stems, it can regrow faster after grazing and reestablish leaves necessary for photosynthesis. This regrowth pattern gives crested wheatgrass its well-known ability to withstand and recover from grazing.

Competition Among Plants and Selective Grazing

A plant's response to grazing does not occur in isolation but as a member of a complex plant community. How plants interact with neighboring plants will influence how they respond to grazing. How severely a plant is defoliated may therefore be less important than how much a plant must compete with its neighbors for limited soil water and nutrients.[13] However, defoliation may not affect competitive interactions in the short term (less than three years) as strongly in drier regions as in wetter regions.[3]

Understanding which plants are likely to be grazed, and anticipating competitive interactions, forms the basis for effective targeted grazing strategies. Plants grazed more heavily are at a competitive disadvantage compared with those grazed less severely.[7] In simplest terms, grazing should be applied when the target plant is most palatable to livestock and most susceptible to damage through defoliation. Likewise, grazing should be applied when associated or desired plants are more tolerant to grazing. Such efforts can be enhanced by selecting animals that favor the plants targeted for control. It may be difficult for livestock producers or land managers to concentrate grazing during specific short periods when undesirable plants are most susceptible to damage, especially on vast rangelands where intensive management is more difficult. Still, the need to precisely apply grazing at specific times creates opportunities for livestock enterprises dedicated to vegetation management.

Selecting the Right Season to Maximize Grazing Effects

Plant phenology, or how plants grow through the season, should be considered when using grazing to manage vegetation. A plant's growth stage will determine how it responds to grazing. For example, most grasses and forbs tolerate early-season grazing, a time when soil moisture and nutrients needed for regrowth are abundant. Apical meristems are close to the soil surface at this time and less likely to be removed by herbivores, so leaf growth from stems or shoots can continue unabated after grazing.

Early in the growing season, plants need fewer nutrients because they are smaller with fewer leaves and stems. Losing leaves and reducing the ability to capture sunlight early in the season is less damaging than later in the growing season when energy demands are higher. For these reasons, grazing early in the season may have little effect on the plant community. However, many perennial plants have large root systems to support. Spring may be a poor time for controlling invasive herbaceous plants unless they grow and mature early in spring. The effects of early-spring browsing on shrubs are less well researched than for grasses and forbs. As with herbaceous plants, shrubs often tolerate early-season grazing because water and nutrients needed for regrowth are readily available.

Plants are most likely to be damaged by grazing at specific stages of development. Generally, a plant has the most difficulty recovering if it is grazed or browsed between the time when the flowerhead is ready to emerge (boot or bud stage) and full bloom.[22] Grasses are most susceptible to grazing in the boot stage when the developing, elongating flowerhead is causing the stem to swell, often bulging where the flowerhead is forming. For example, wheatgrasses grazed after the stem starts elongating and the flowerhead begins to emerge produced fewer new shoots the following year than when grazed earlier in the season, although the exact time when grazing is most detrimental varies by species.[10, 15] Likewise, forbs are most susceptible to grazing when stems are elongating and exposing the developing flowerhead – called the bolting stage.

Annual grasses require seeds to develop new plants. Defoliating grasses to limit seedstalk production can help reduce the numbers of seeds in the soil (the seedbank) and may decrease their density in the vegetative

Photo: Ron Daines, Logan, UT

community. Biennial plants have a rosette stage in one year followed by a seed production stage the next year. As with annual plants, biennials need regular seed production to maintain populations. However, plants with a long-lived seedbank can be more difficult to control because the seeds can remain dormant in the soil until environmental conditions are favorable for emergence.

If the newly formed flowers and seeds are removed, the regrowth a plant needs to regain its ability to capture sunlight and synthesize carbohydrates must come from expansion of existing leaves or from new stems and leaves initiated by axillary buds. In many parts of the arid West, defoliation during the boot or bolting stage can damage plants because it coincides with a time in the growing season when water and nutrients required for regrowth are becoming limiting. This window of susceptibility for grazing target plants – generally in the boot stage for grasses and the bolting stage for forbs – typically occurs six to eight weeks before seed set.

Utilization levels during late summer or winter when a plant is dormant can be relatively high without impacting subsequent plant growth. Grazing dormant grasses and forbs generally has little effect on the plant because the leaves are not photosynthesizing and the plant will not attempt to replace lost plant material. However, browsing shrubs in the dormant season may hinder spring regrowth by removing axillary and apical buds. Shrub stems contain stored energy and nutrients a plant uses throughout dormancy, so losing stem material can harm the plant.

To be effective, grazing must be applied with the right species at the right time to suppress the target plant and leave the desired or native plants relatively intact. For example, Kentucky bluegrass is invading wetter sites in the Northern Great Plains. Because it starts growing relatively early in the season, Kentucky bluegrass may be suppressed by grazing early in spring when the native grasses are dormant. Annual grasses like cheatgrass are among the first plants to start growing in the spring. They begin flowering and elevating their seed-stalk when native grasses are still in the vegetative stage, for example, they have not started producing flowers. That opens an opportunity to graze such grasses early in the season to suppress them and favor growth of perennial grasses. In August 2005, sheep grazing a foothill bench in Montana avidly consumed flowerheads of spotted knapweed and avoided the native perennial grasses, most likely because the relatively green spotted knapweed had greater nutritive value than the dormant perennial grasses. Grasses were hardly used because they were dormant.

The Effects of Repeated Grazing

Two or more grazing treatments during a grazing season are often needed to suppress undesirable weedy plants simply because plants regrow. During the growing season, grazed areas should be rested for at least four weeks to allow desired plants to regrow leaf material and root mass. For example, weeds like spotted knapweed and yellow starthistle can be grazed as they begin bolting in the spring, which usually occurs before native grasses become vulnerable to defoliation. The weeds will generally respond by producing new shoots. Grazing can be reintroduced to the site when the native plants have completed seed production and the weeds are still bolting and flowering in response to the earlier grazing.

Weeds are susceptible to grazing at a certain stage of their development, but so are the desired species. The key in using repeated grazing is to avoid grazing desirable plants twice during the growing season, or at least ensure that enough time has elapsed for sufficient regrowth. Plant composition should be carefully monitored. The period of susceptibility of desirable species and weeds often coincide, but weeds often regrow more rapidly after grazing. For example, leafy spurge can be more tolerant of defoliation than the desired species.[18]

Repeated grazing can be very effective. In southwestern Montana, spotted knapweed-infested areas repeatedly grazed by sheep had lower densities of seedlings, rosettes, and mature spotted knapweed

plants than ungrazed areas.[17] Further, grazed areas had fewer young spotted knapweed plants and spotted knapweed seed in the seedbank than ungrazed areas. These changes were evident after three summers of repeated sheep grazing with minimal impact on the native grass community even though the grasses were grazed at rates similar to those for spotted knapweed.[19] The density of mature leafy spurge stems was relatively unchanged, but the leafy spurge stems were shorter.[16] Other studies indicate that sheep must graze leafy spurge at least four years before it is noticeably reduced.[5, 11]

Grazing Effects on Flowering and Seed Production

Most sheep and goats relish bolting stems with their nutritious developing flowerheads.[14] Removing the developing flowerhead of biennial or perennial plants will likely prevent seed production, one of the most observable effects of carefully timed grazing. Three years of repeated sheep grazing in southwestern Montana reduced leafy spurge seed in the seedbank and seedling densities. The plant may send up new shoots from the base, but seed from these new shoots will rarely mature before the end of the growing season. Annual weeds are more likely to resprout and produce viable seeds. For example, grazing cheatgrass or yellow starthistle at flowering may trigger a regrowth of flower stalks yielding more seeds than ungrazed plants. In this case, repeated grazed may be needed to prevent further seed production.

Grazing Clonally Spreading Plants

Some weeds like leafy spurge, Canada thistle, reed canarygrass, and kudzu reproduce asexually, spreading by extensive lateral root systems or rhizomes that give rise to new plants. These species respond differently to grazing. While grazing can reduce seed production and may hinder the long-distance spread of seed via wind, water, or animals, these species can still spread across the landscape by their underground network of roots or rhizomes. Because of this, they are often more difficult to suppress.

CONCLUSIONS

Landscapes are collages of complex plant communities and site conditions. Within a plant community, competition for shared and often limited resources can be fierce. Prescription grazing managers must consider how the forage needs of their livestock can provide vegetation management solutions. To be successful, using grazing or browsing to control weeds requires a clear understanding of how both target and non-target plants respond to grazing, how plant communities can be modified by grazing pressure, and how grazing integrates with other management activities. Vegetation can often be effectively managed by simply grazing the right herbivore at the right time and intensity. The key is knowing the right herbivore, time, and amount of grazing for each vegetation situation.

Literature Cited

[1]Berdahl, J.D., A.C. Wilton, and A.B. Frank. 1989. Survival and agronomic performance of 25 alfalfa cultivars and strains interseeded into rangeland. *Journal of Range Management* 42:312-316.

[2]Briske, D.D. 1991. Developmental morphology and physiology of grasses. *In:* R.K. Heitschmidt and J.W. Stuth [EDS.], Grazing management: An ecological perspective. Portland, OR: Timber Press. p.109-139.

[3]Briske, D.D. and J.R. Hendrickson. 1998. Does selective defoliation mediate competitive interactions in a semiarid savanna? A demographic evaluation. *Journal of Vegetation Science* 9:611-622.

[4]Briske, D.D. and J.H. Richards. 1995. Plant responses to defoliation: A physiological, morphological and demographic evaluation. *In*: D.J. Bedunah and R.E. Sosebee [EDS.], Wildland plants: Physiological ecology and developmental morphology. Denver, CO: Society for Range Management. p. 635-710.

[5]Bowes G.G. and A.G. Thomas. 1978. Longevity of leafy spurge seeds in the soil following various control programs. *Journal of Range Management* 31:137-140.

[6]Caldwell, M.M., J.H. Richards, D.A. Johnson, R.S. Nowak, and R.S. Dzurec. 1981. Coping with herbivory: Photosynthetic capacity and resource allocation in two semiarid *Agropyron* bunchgrasses. *Oecologia* 50:14-24.

[7]Caldwell, M.M., J.H. Richards, J.H. Manwaring, and D.M. Eissenstat. 1987. Rapid shifts in phosphate acquisition show direct competition between neighboring plants. *Nature* 327:615-616.

[8]Dahl, B.E. 1995. Developmental morphology of grasses. *In:* D.J. Bedunah and R.E. Sosebee [EDS.], Wildland plants: Physiological ecology and developmental morphology. Denver, CO: Society for Range Management. p. 22-58.

[9]Ganskopp, D, R. Angell, and J. Rose. 1992. Response of cattle to cured reproductive stems in a caespitose grass. *Journal of Range Management* 45:401-404.

[10]Hendrickson, J.R., J.D. Berdahl, M.A. Liebig, and J.F. Karn. 2005. Tiller persistence of eight intermediate wheatgrass entries grazed at three morphological stages. *Agronomy Journal* 97:1390-1397.

[11]Johnston A. and R.W. Peake. 1960. Effect of selective grazing by sheep on the control of leafy spurge (*Euphor bia esula* L.). *Journal of Range Management* 13:192-195.

[12]Landgraf, B.K., P.K. Fay, and K.M. Havstad. 1984. Utilization of leafy spurge (*Euphorbia esula*) by sheep. *Weed Science* 32:348-352.

[13]Mueggler, W.F. 1972. Influence of competition on the response of bluebunch wheatgrass to clipping. *Journal of Range Management* 25:88-92.

[14]Olson B.E. and R.G. Kelsey.1997. Effect of Centaurea maculosa on sheep rumen microbial activity and mass in vitro. *Journal of Chemical Ecology* 23:1131-1144.

[15]Olson, B.E. and J.H. Richards. 1988. Annual replacement of the tillers of Agropyron desertorum following grazing. *Oecologia* 76:1-6.

[16]Olson B.E., R.T. Wallander, and R.W. Kott. 1997a. Recovery of leafy spurge seed from sheep. *Journal of Range Management* 50:10-15.

Literature Cited

[17]Olson B.E., R.T. Wallander, and J.R. Lacey. 1997b. Effects of sheep grazing on a spotted knapweed-infested Idaho fescue community. *Journal of Range Management* 50:386-390.

[18]Olson B.E. and R.T. Wallander. 1999. Carbon allocation in *Euphorbia esula* and neighbors after defoliation. *Canadian Journal of Botany* 77:1641-1647.

[19]Olson B.E. and R.T. Wallander. 2001. Sheep grazing of spotted knapweed and Idaho fescue. *Journal of Range Management* 54:25-30.

[20]Trilica, M.J. and L.R. Rittenhouse. 1993. Grazing and plant performance. *Ecological Applications* 3:21-23.

[21]Truscott, D.R. and P.O. Currie. 1989. Cattle preferences for a hybrid grass: Chemical and morphological relationships. *Journal of Range Management* 42:22-27.

[22]Vogel, W.G. and A.J. Bjugstad. 1968. Effects of clipping on yield and tillering of little bluestem, big bluestem and indiangrass. *Journal of Range Management* 21:136-140.

CHAPTER 5:
Monitoring for Success

By Steven H. Sharrow and Steven S. Seefeldt

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Photo: Suzi Taylor, Montana State University

10 KEY POINTS

- Monitoring entails making observations – then gathering, organizing, and reporting information from those observations.
- An initial inventory provides an important benchmark for comparing progress.
- Management goals should be specific and stated in terms of things that can be measured.
- Who will monitor and what they'll monitor should be determined at the outset.
- The more precise the data, the more difficult and expensive they are to gather.
- When assessing grazing progress, consider outside influences like precipitation and wildlife impacts.
- Monitoring with photos is an easy and effective method for measuring long-term change.
- Consistent techniques, locations, and plot sizes make monitoring data more valid.
- Field notes and records should be logged systematically in a form that can be updated easily.
- Assessing vegetation change is essential to determine the economic viability of targeted grazing.

INTRODUCTION

To determine if a grazing prescription is altering vegetation, the vegetation must be measured and the data compared with subsequent measures. Likewise, to establish that livestock are effective vegetation management tools, data must be collected to show that they are achieving the contracted ecological benefits. Many grazing contracts require the service provider to log activities and record pertinent observations. These are the kinds of activities that fall under the scope of monitoring. Monitoring is the process of making observations and gathering, organizing, and reporting the information from those observations.

The first step in any vegetation management program is to inventory the current state of the target area. These initial data provide a benchmark against which subsequent conditions can be compared. Vegetation measurements should catalog what is present and its current condition relative to management objectives. This information is so fundamental to successful management that monitoring should be a part of decision-making rather than a separate and independent activity.

Monitoring assesses current conditions and compares those conditions to past measurements so that land managers and service providers can understand how the vegetation has changed and predict what might happen in the future. Management strategies must be changed if the current or predicted conditions are unsatisfactory or not trending in the desired direction. With this in mind, the objectives for monitoring are to:assist in making management decisions, detect changes in animal status or vegetation communities, and determine if contract requirements are being met.

Setting Management Goals and Monitoring

Monitoring protocols should be developed with management goals in mind. The best management goals are stated in such a way that progress toward meeting them can be easily understood and measured. A vegetation management goal should:

- Clearly describe the desired end point of the management activity – what the land should look like when the work is completed.
- Be written in terms of conditions and activities that can be measured.
- List a timeframe for expected results.

Most importantly, effective management plans contain specifically stated goals. For example, a goal that says "reduce pasture weeds" is difficult to evaluate. It fails to address what is considered a weed, how many weeds there are now, how many fewer there would have to be for weeds to be meaningfully "reduced," and when results are expected. A goal that captures these questions might say: "The Lazy Bar X ranch will reduce the canopy cover of spotted knapweed plants by 80% over the next four years."

Start with reasonable expectations. When setting goals for targeted grazing projects, it is important to understand the capability of the land and to set achievable goals. The land manager will base expectations on previous experience on that piece of land. Other sources of information about a site's potential are the county soil survey (http://websoilsurvey.nrcs.usda.gov), land capability class of farmland, site index for forest land, and ecological site descriptions for rangelands. The Ecological Site Information System (http://esis.sc.egov.usda.gov) can be accessed to determine expected production levels in favorable, normal, or unfavorable years for different sites. When a pasture or other land management unit contains more than one type of site, it is generally best to monitor each site separately.

Who Should Monitor

If the land manager or the grazing service provider wants to measure effectiveness of the targeted grazing practices, someone needs to measure and monitor land response. However, who should do the monitoring is less clear. All parties involved can benefit from monitoring. But a meaningful and effective monitoring program is often time-consuming and may require training and experience. The party responsible for monitoring and the expected monitoring activities should be clearly outlined in each contracted grazing endeavor. At a minimum, the land manager and service provider should regularly take photos and conduct joint site visits. Another alternative for monitoring is to hire a third-party consultant. People who are trained and hold credentials in natural resource management, such as a

Certified Range Management Consultant or a licensed consulting forester, can work with land managers and service providers to implement monitoring programs that assess progress toward project goals.

What to Measure

Gathering useful information requires asking the right questions. Monitoring data may be expressed as numbers or observations, such as photos. Numbers may be precise, as in 570 pounds per acre, or a range, such as between 500 and 1,000 pounds per acre. The more precise the data, the more difficult, expensive, and time consuming it will be to gather. So, how precise must data be? That depends on how the information will be used. A grazing contract may require specific target levels of animal impacts, so precise numbers may be required to evaluate contract compliance. Likewise, concern over legal liability may encourage managers to collect information more detailed than that required to make management decisions. The amount and refinement of information needed to support decisions is related to the fineness of the decision being made. *The best way to judge what information is required is to ask: "What would make me change my decision?"*

Measurements should be relevant to the goals of the project or enterprise. To place those measures into an interpretable context, general background information about the situation is needed. This may include wildlife use, insect activity on plants, growth stage of vegetation, or evidence of soil erosion, fires, or disturbance. Background information is simply a clear description of the current situation. Though much less detailed than the primary measurements, background information helps explain why changes are occurring. *Measurements only become information when their meaning is understood.*

Because vegetation responds strongly to moisture, *precipitation data are also important.* A warm, moist growing season can have a greater influence on plants and animals than all but the most drastic management actions. Precipitation data help distinguish between changes resulting from yearly or seasonal weather patterns and changes resulting from management actions. Inexpensive rain gauges are available in most hardware or garden stores. They should be read at least monthly. A few drops of oil added to the barrel will reduce evaporation between readings. Few rain gauges measure snow accurately, so areas with significant snow require larger-diameter gauges. The National Weather Service logs precipitation and temperature data accessible on the Internet at sites like the Regional Climate Center's www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html.

The most commonly measured aspects of grazing are:

- Livestock performance or weight gain
- Consumption of vegetation
- Changes in vegetation structure.

Livestock performance can profoundly affect revenue stream and profitability. It should be monitored and accounted for in setting the price or value of targeted grazing projects. Changes in livestock condition over time can be documented by periodic weighing or by assessing and recording body condition score. In the long run, animal body condition and weight reflect the type and amount of vegetation present. However, condition and weight are poor reflections of current vegetation structure because they rarely decline until substantial changes in vegetation are well under way.

Consumption of vegetation by livestock or native herbivores like deer and elk may be measured with utilization or residue techniques. Utilization is the proportion of current year's plant growth that is consumed or destroyed by grazing animals. It is often used to describe the degree of grazing that has occurred. Utilization is most frequently measured by comparing plant weight, number, or size before and after grazing, or by comparing grazed areas to ungrazed reference areas, such as grazing exclosures. Residue is the amount of vegetation remaining at the end of a grazing period. Comparing the kind and amount of plants before grazing or in ungrazed areas with that remaining after grazing indicates which plants animals chose or avoided. Monitoring the herbage utilized or residue from plants targeted for removal is important to meet vegetation management goals. It is also important to track use of desirable plants to be maintained in the community. Vegetation-reduction goals are often stated as either utilization or residue values. For instance, a goal in a timber stand may be to reduce ground vegetation present by 50% or to 500 pounds per acre. This goal could be monitored by clipping or visually estimating the weight of understory vegetation before and after grazing. If there are 1,500 pounds per acre before grazing and 1,000 pounds after, then residue is 1,000 pounds per acre and utilization is 33% [(1,500-1,000)/1,500 = 500/1,500 = 33%]. That means more grazing is needed.

Vegetation structure describes the type, size, and amount of plants present. It is used to describe the plant community and to determine whether the grazing has had a negative or positive impact on the vegetation. The most commonly measured characteristics for describing the impact of targeted grazing on vegetation are:

Using Biomass to Estimate Carrying Capacity

An Example

A flock of 250 ewes, each weighing 140 pounds, eats 3% of their body weight per day. This requires 250 × 140 × 0.03 = 1,050 pounds of dry forage each day for the flock.

If a 20-acre pasture currently has 2,500 pounds per acre of forage and the goal is to have 1,000 pounds per acre of residue left, then the usable forage is 20 acres × 1,500 pounds per acre = 30,000 pounds.

The pasture can be grazed for 28 days (30,000 pounds of forage supply @ 1,050 pounds of daily forage demand = 28 days).

For more information about setting stocking rates, see the National Range and Pasture Handbook www.glti.nrcs.usda.gov/technical/publications/nrph.html

Photo: Rodney Kott, Montana Sheep Institute

- Biomass
- Canopy cover or basal area
- Plant density

Biomass is the weight of vegetation. It may be measured by harvesting, drying, and weighing the vegetation within an area of known size, such as a small frame. This provides an estimate of the pounds per acre of material present. Most people can learn to estimate biomass from the general appearance of vegetation. Training involves estimating biomass and then clipping plots to check the accuracy of the estimates. A good estimator will consistently be within 10% of the actual clipped weight. Estimates are sensitive to season of year, climatic fluctuations, changes in soil fertility, changes in grazing patterns, or anything else that affects plant growth. Because so many things affect it, biomass is sometimes difficult to interpret, but it does respond rapidly to management changes. Biomass numbers can be used to estimate the number of animals or days of grazing necessary for specific vegetation management jobs (see example above).

Canopy cover is the proportion of land area covered by plants. It can be visualized as the percentage of area in shadow if the sun is directly overhead. Basal area is the area occupied by plant bases. Canopy cover and basal area are often estimated by the proportion of a plot of known size or the intercept along a 50- or 100-foot line (transect) that is covered by plants. Basal area is less affected by seasonal growth patterns than is canopy cover, so time of year has less effect on measures. Canopy cover is especially useful for monitoring shrubs and clumped vegetation like bunchgrasses. For example, a goal in rehabilitating a bunchgrass stand may be to increase perennial grass basal area to 10% within five years. This can be assessed each year by randomly establishing a group of 10 to 20 line transects in the management unit. The length of line that crosses grass bases is recorded and the percentage basal area calculated by dividing this intercepted distance by the line length (Figure 1). If 20 inches of a 1,200-inch-long line cross over plant bases, basal area for that transect would be 20/1,200 = 2%.

Figure 1. For more information on the line intercept method, consult the Sampling Vegetation Attributes manual available at: http://www.blm.gov/nstc/library/pdf/samplveg.pdf.

Density, the number of plants per square foot or per acre, is a useful measure for examining changes in plant populations over a period of years. It can be estimated by counting all of the plants within a plot of known size. Density is less sensitive to season, and responds to management actions less quickly, than biomass and cover. Monitoring density is especially important for annual or biennial weeds that reestablish each year from seed. Reducing the number and size of flowering stems is often a prescription goal for these plants. For example, tansy ragwort is a biennial or short-lived perennial pasture and range weed. Sheep grazing that consumes the flowering stems will control the tansy by denying seed production. A prescription goal might be to consume over 95% of the flowering stems. Success could be gauged by randomly establishing plots immediately before and after grazing and counting the first-year rosettes along with the flowering and stripped stems of older plants in each plot. If a 25-foot-square plot had 21 stripped stems and two flowering stems, then 21/23 = 91% of the stems were consumed, leaving 2/25 = 0.08 plants per square foot (3,484 plants per acre) to set seed. A similar sampling to count new plants (rosettes) the year after grazing would provide a reference to determine if the number of tansy plants is declining. However, long-lived perennial plants maintain a stable population without frequent reproduction. So, absence of young perennial plants does not necessarily indicate a declining population for them.

Table 1: Commonly measured plant characteristics.

Plant Type	Characteristic to Measure
Grasses	Canopy cover, basal area, plant height, biomass, or utilization
Forbs	Canopy cover, density, or plant height
Shrubs	Canopy cover, density, or plant height
Canada thistle	Rosette or stem density
Knapweeds	Rosette or flower density
Leafy spurge	Stem density, canopy cover, or biomass
Downy brome	Plant density or biomass

Photo Monitoring

For many years, the Bureau of Land Management and Forest Service have used sequential photos to study vegetation changes over time. This technique is becoming more popular with livestock producers because it offers a relatively simple way to document land condition and the effects of management over years or decades. Areas where vegetation is being measured make excellent sites to photograph. Photos typically include a general view of the area and several detailed views of the sampling plots in each area. To ensure that photos are of exactly the same place and the same scale, a lens with the same focal length should be used each year. Plot photos should be taken pointing straight down. A marker of known size, such as a profile board, should be placed in the center of each photo to provide a reference for scale (Figure 2, see next page). The location, date, and compass bearing of each photo should be recorded along with a photo number and associated field information. The information can be written on a piece of paper and included in each photo. Taking past photos into the field and taking photos from the same spot (a steel fence post or wooden stake) and on the previously recorded compass bearing helps assure a consistent view over time. A short guide to using photo monitoring is available at www.anrcatalog.ucdavis.edu/pdf/8067.pdf. A more detailed guide can be found at the U.S. Forest Service website, www.fs.fed.us/pnw/pubs/gtr503/.

How to Measure

Size and Shape of Sampling Plots

Vegetation measurements are best made using plot frames. The same set of frames should be used throughout the monitoring program. Most sheet metal shops can make them by bending 1/4 inch round stock or rebar, or they can be made from small-gauge PVC pipe and elbows.

Frame shape depends on the type of measurement and the vegetation to be sampled. *Rectangular plots* work well for rangeland and pastures because they tend to include more variation of the vegetation community within each plot. Rectangular plots are more likely to cut across plants or clumps of plants rather than being completely occupied by a single plant or all bare ground. A common rectangular plot frame has a short side half the length of its long side. Typical frame sizes are 12 x 24 or 24 x 48 inches. Square and rectangular plots are especially useful when estimating cover because envisioning proportions in these plots is easier than in circular plots. When estimating density, it is also

Figure 2. A profile board or person in a photo can create a reference to assess the height and amount of vegetation.

Photo: Karen Launchbaugh, University of Idaho

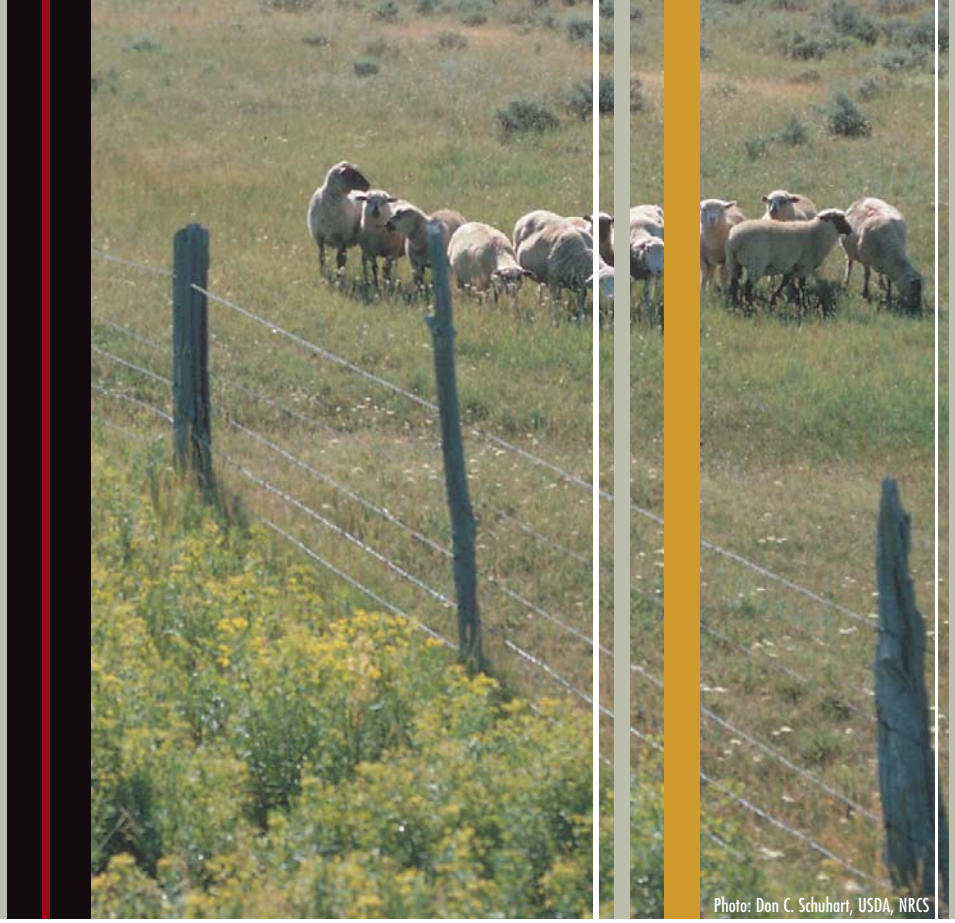

Photo: Don C. Schuhart, USDA, NRCS

easier to count individual plants from one end to the other of a square or rectangular plot than to count plants in circular plots. Rectangular frames are commonly constructed with one side open for easier placement in dense vegetation. Circular frames are often used for estimating biomass in dense uniform vegetation because a circle has a lower perimeter for a given area than a square or rectangle. Circular plot placement is easier with fewer perimeter decisions about whether a plant is "in" or "out."

Plot size depends on the variability of the plant community and the size and density of plants being measured. Any size plot should be able to accurately reflect vegetation. The issue is really efficiency – how much work is required to obtain the estimate. Here are a few guidelines for setting an appropriate plot size:

- Plots that are too small will be noticeably different from each other and will require a large number of such plots to be accurate. It is more efficient to sample fewer larger plots. Sampling plots that are too large will waste time examining more space than is really needed to represent that spot within the community.
- A plot should be larger than the average-size plant and larger than the average space between plants.
- If more than 5% of sampling units have values of 0 for the plants of interest, the plot size should be increased.

Once a plot size is selected, converting the density of plants per plot to plants per acre is relatively simple, as is converting grams of biomass per plot to pounds per acre. (Common conversion factors can be found in *Calculating Available Forage* www.extension.usu.edu/files/natrpubs/range3.pdf.)

Selecting sample locations randomly guards against inaccurate data caused by patterns in vegetation or observer bias. The location can be randomly selected by tossing the plot frame or some other object into the area to be measured. Long-term monitoring studies are more efficient if the same spots are marked and periodically re-measured. Markers for permanent plots, such as T-post, rebar, or PVC stakes, should be placed well away from the plots because curious animals often over-utilize the area around them. Inexpensive Global Position System (GPS) devices can be invaluable for relocating plots, particularly when continuity of personnel is not assured.

Number of Plots to Measure

Several observations should be made in each area to be measured. The vegetation will be denser in some parts of the area and less dense in others. Generally, the more diverse the vegetation, the more plots are needed. At least 10 to 12 plots is a good rule of thumb.

Where to Monitor

One of the most important decisions to make in establishing a monitoring system is *selecting the sites or plant species to be monitored*. Sites and species are generally selected because they meet one or more of these criteria:

- They represent a larger vegetation type or management unit.
- They are of special interest relative to management goals (i.e., contain exotic weeds).
- They are especially sensitive to change.

Key Areas

Monitoring sites should include several small key areas that represent a significant portion of the land, are major contributors to seasonal forage supplies, or are targets for vegetation management (i.e., contain weeds of interest). Key areas may also contain rare or endangered plant or animal species, be under public scrutiny, be included in contracts using livestock to provide ecological benefits, contain critical wildlife habitat, or have other special significance. Roadsides, fence lines, salting or bedding grounds, areas near corrals or water, and sites where livestock congregate or human activities are concentrated make poor monitoring sites because they do not represent the larger area surrounding them.

Land management units often vary in topography, plant communities, or other characteristics. Lumping together information from these distinctly different areas is a poor practice. Monitoring each separately is more likely to provide meaningful information. When uncertainty arises whether two areas are sufficiently different to warrant separate monitoring, it's probably a good idea to monitor them separately.

Key Species

A few key species within the plant community should be selected for measuring. Key species include the plants targeted for management and a few desirable species that the targeted grazing is meant to enhance. Species may also be selected because they are the first to show signs of change.

Proper Controls

Because areas monitored over years will show changes from both weather patterns and management practices, proper controls are needed to detect and understand vegetation changes. Climate impacts can be separated from management impacts by including untreated reference areas. Such ungrazed "control" areas are routinely used in research projects to separate management impacts from outside forces like weather, wildfires, invasion by new plants, or natural cycles in plant and animal populations. Excluding livestock by fencing off small areas (exclosures) has proved to be one of the best tools for demonstrating the long-term ecological impacts of managed livestock grazing. To be a useful reference, an exclosure should be as similar as possible to the rest of the area and large enough for the plant community it represents to fully develop within it. Exclosures generally range from 10 × 10 feet for grasslands to 25 × 50 feet for shrublands, to over one-tenth of an acre for forests and woodlands.

When to Measure

Under grazing contracts, it is best to measure vegetation just before and just after grazing. For short-term monitoring within a single year (grazing period less than two weeks), it is important to attach to the observations a description of the growth stage of plants, when the site was last grazed, and the date data were collected. Monitoring conducted over several years requires that information be collected at similar times of year. This is best done by setting collection dates based on plant growth stage rather than the calendar. For example, a perennial pepperweed infestation may be examined each year when the pepperweed is in full bloom. Grass stands are often sampled each year at the soft dough stage, a time when plants are in seed and seed is still soft. The time of targeted grazing should also be based on plant growth stage, not the calendar.

Keeping Field Notes and Records

All data should be recorded and stored systematically in a field book or on a computer in a form that can be easily updated. Computer-stored data should be backed up on a CD or DVD. Notes should include dates and the names of who collected the data.

Observations should be factual, not judgmental. For example, knowing that the density of Scotch thistle plants in 1995 was 670 plants per acre is much more useful today than knowing that “there were a lot" or that “there were more than last year." Accurate numerical measurements of vegetation are difficult to achieve, especially in wildland ecosystems. The natural variability in the landscape, the influence of climate, and the season of measurement can alter measurements considerably. Each plant being measured is growing or dying and constantly changing. Insects, microbes, viruses, and large wildlife could be preying on these plants. A contract grazer’s vegetation measure one day may bear little resemblance to a second measure by someone else two weeks later. Vegetation may have increased because of timely rains or declined because of elk or deer grazing or browsing.

Still, it is important to measure and note success or failure each year in meeting grazing prescriptions, contracts, or goals as a means of evaluating current vegetation conditions relative to important management objectives. Collecting data carefully and making observations of what is happening are keys to understanding cause and effect. The better the information gathered, the more knowledge is available about vegetation response to targeted grazing techniques.

PARTING THOUGHTS

In every business, costs and profits must be calculated. If profits outweigh costs, the business will have a chance for success. Targeted grazing for vegetation management is the business of intentionally altering plant communities and landscapes. If the ecological benefits of grazing outweigh the cost of grazing, then targeted grazing will be a good business venture. Assessing vegetation change is an essential part of determining the viability of targeted grazing practices. Monitoring will help livestock and land managers impartially assess these costs and benefits, learn from mistakes, and replicate successes.

References

Blossey, B. 1999. Before, during and after: the need for long-term monitoring in invasive plant species management. Biological Invasions 1:301–311. *Available at:* http://weedeco.msu.montana.edu/class/MSSE/Blossey1999.pdf. *Accessed 11 August 2006.*

Bonham, C.D. 1988. Measurements for terrestrial vegetation. John Wiley & Sons, New York, NY.

ForestandRange.org. 2006. Rangeland monitoring in western uplands. *Available at:* http://agweb.ag.utk.edu/forestandrange/modules/vegmonitor/index.html. *Accessed 11 August 2006.*

Haber. E. 1997. Guide to monitoring exotic and invasive plants. *Available at:* http://www.eman-rese.ca/eman/ecotools/protocols/terrestrial/exotics/intro.html. *Accessed 11 August 2006.*

Hall, F.C. 2002. Photo Point Monitoring Handbook. USDA Forest Service Gen. Tech, Report PNW-GTR-526. *Available at:* http://www.fs.fed.us/pnw/pubs/gtr526/. *Accessed 11 August 2006.*

Muir, S. and M.P. McClaran. 1997. Rangeland inventory, monitoring, and evaluation. *Available at:* http://cals.arizona.edu/agnic/az/inventorymonitoring/. *Accessed 11 August 2006.*

National Applied Resource Sciences Center, Bureau of Land Management. 1996. Sampling vegetation attributes, interagency technical reference. Denver, CO: BLM/RS/ST-96/002+1730. *Available at:* http://www.blm.gov/nstc/library/pdf/samplveg.pdf. *Accessed 11 August 2006.*

National Applied Resource Sciences Center, Bureau of Land Management. 1996. Utilization studies and residual measurements, interagency technical reference. Denver, CO: BLM/RS/ST-96/004+1730. *Available at:* http://www.blm.gov/nstc/library/pdf/utilstudies.pdf. *Accessed 11 August 2006.*

CHAPTER 6: Improving Grazing Lands with Multi-Species Grazing

By John W. Walker, Linda Coffey, and Tim Faller

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10 KEY POINTS

- Wildlife and livestock grazing preferences influence which plants dominate grazing lands.
- Single-species grazing can adversely affect botanical composition.
- Multi-species grazing is the norm for natural ecosystems.
- Tradition and easier management have made cattle the norm on grazing lands.
- The spread of invasive weeds on Western rangelands coincides with a reduction in sheep numbers.
- Multi-species grazing can increase grazing and carrying capacity.
- Two or more species grazed together can improve animal performance.
- Grazing cattle with sheep or goats can reduce sheep and goat parasites.
- Multi-species grazing can improve cash flow and reduce financial risk.
- Those committed to improving the land may find that multi-species grazing is the best way to fulfill that commitment.

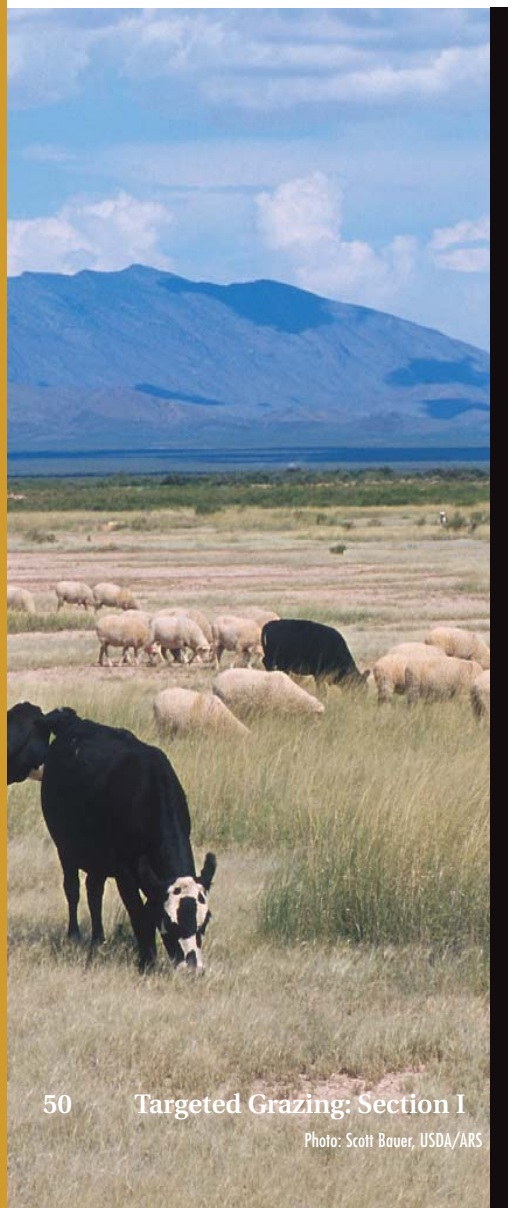


Photo: Scott Bauer, USDA/ARS

Grazing lands are covered by a variety of plant species that affect the land's productivity and suitability for different species of herbivores. Although environmental factors like soils, climate, and fire are the primary forces that determine the kind of plants growing on a pasture, grazing preferences of livestock and wildlife also have a strong influence on which plants dominate grazing lands. Even the feeding habits of insects can change vegetation composition. For example, some forms of biological control are based on introducing an insect that feeds exclusively on a weedy plant species. Insect feeding on the target plant places it at a competitive disadvantage relative to other plants, which ultimately reduces the plant below a threshold level that is acceptable to the land manager. All herbivores, four-legged and six-legged, have a similar effect on the botanical composition of plant communities.

Multi-species grazing is when more than one kind of livestock (i.e. sheep, goats, cattle, or horses) graze a unit of land. The grazing can occur at the same time or at different times and still be considered multi-species grazing. Multi-species grazing is the norm for naturally regulated ecosystems.[1] The grazers are a variety of wild animals like deer, elk, rabbits, rodents, and insects. On managed grazing lands, the norm is that grazing is dominated by a single species of livestock, usually cattle. The reasons for this include tradition, lower management requirements for beef cattle, and increased complexity of multi- vs. single-species management. However, few land managers appreciate the adverse impact that single-species grazing can have on the botanical composition of grazing lands. Simply including sheep and goats in an extensive management system could have highly beneficial results in terms of vegetation composition.

> *"Stock eat the valuable forage plants and leave the poor ones, thus giving the latter undue advantages in the struggle for existence."*
>
> Wooten 1908

It can be argued that the current problem with invasive weeds in the Western United States has resulted from declining sheep numbers during the past 20 years (Figure 1). Many of the worst weeds we currently battle, like leafy spurge, yellow starthistle, and spotted knapweed, are forbs that sheep and goats find palatable and nutritious.

The major challenges to multi-species grazing for producers currently grazing only cattle are:

- Increased fencing requirements.
- Lack of knowledge of small ruminant husbandry.
- Increased complexity because of enterprise diversity.

Advantages of multi-species livestock grazing over single-species grazing include:

- Increased carrying capacity.
- Improved botanical composition of pastures and suppression of undesirable species.
- Increased individual animal performance of one or more species in the mix.
- Reduced predation of sheep or goats grazing among or bonded to cattle.
- Improved animal health because parasite problems are often reduced.

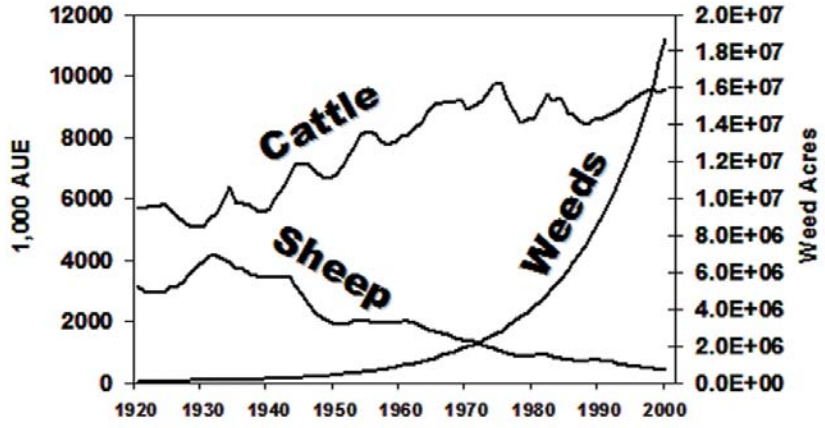


Figure 1. Trend in cattle, sheep, and weeds in the 11 Western states. The decline in sheep numbers accounts for almost 90% of the variation in weed acreage.

• Greater net return for the ranching enterprise.
• Improved cash flow from marketing different products at different times of the year.
• Reduced financial risk because of increased enterprise diversity.

These advantages result from different dietary and topographic preferences of different species of livestock (Figure 2). These differences include the plants the animals prefer to eat and where they graze. Cattle are primarily grazers, and their diets across a wide array of grazing land types are typically 70% grass. In contrast, goat diets average about 60% browse. Sheep diets are about 50% grass, 30% forbs, and the rest browse.[4] In addition to botanical differences in diet preference, cattle, sheep, and goats differ in the parts of the landscape on which they prefer to graze. Cattle prefer lower flatter areas, which can lead to degradation of riparian areas. Sheep and goats will utilize steep slopes, prefer to bed on open upland areas, and have a strong tendency to graze into the wind. This can result in overuse around bed grounds or on the side of a pasture from which prevailing winds blow. These are broad generalizations that vary seasonally and among different plant communities with different botanical compositions.

Grazing lands that contain a variety of grass, forb, and browse species are difficult to graze with a single species of livestock in a way that will avoid shifting the botanical composition to a less desirable condition than the original pasture. A classic example is grazing a mixed-composition range with only cattle. After several years of cattle-only grazing, preferred grass species decline while less preferred grass, forb, and browse plants increase (Figure 3, see next page). This change in composition, which rangeland ecologists call retrogression, resulted in the development of grazing systems to counteract the effect of selective grazing. Most grazing systems attempt to reduce selective grazing by increasing grazing pressure, then providing a period of deferment from grazing so grazed plants can recover. At proper stocking rates, such strategies can benefit the ecological condition of grazing lands, but they rarely benefit livestock production. In contrast, grazing with multiple species of livestock will spread grazing pressure across a wider variety of the plants in a pasture, which reduces the tendency of some lesser-grazed species to develop a competitive advantage over other species. Further, multi-species grazing increases total production as well as performance of at least one of the species.

This is not to infer that livestock grazing is the only cause of undesirable shifts in botanical composition of grazing lands. The introduction of exotic invasive plants, fire suppression, insect outbreaks, and other factors also contribute to vegetation changes, depending on the situation. Still, livestock grazing is the most ubiquitous factor that land managers can control that affects the composition and productivity of grazing lands. The ability to manage the number and kind of large domestic herbivores and the season they graze is a

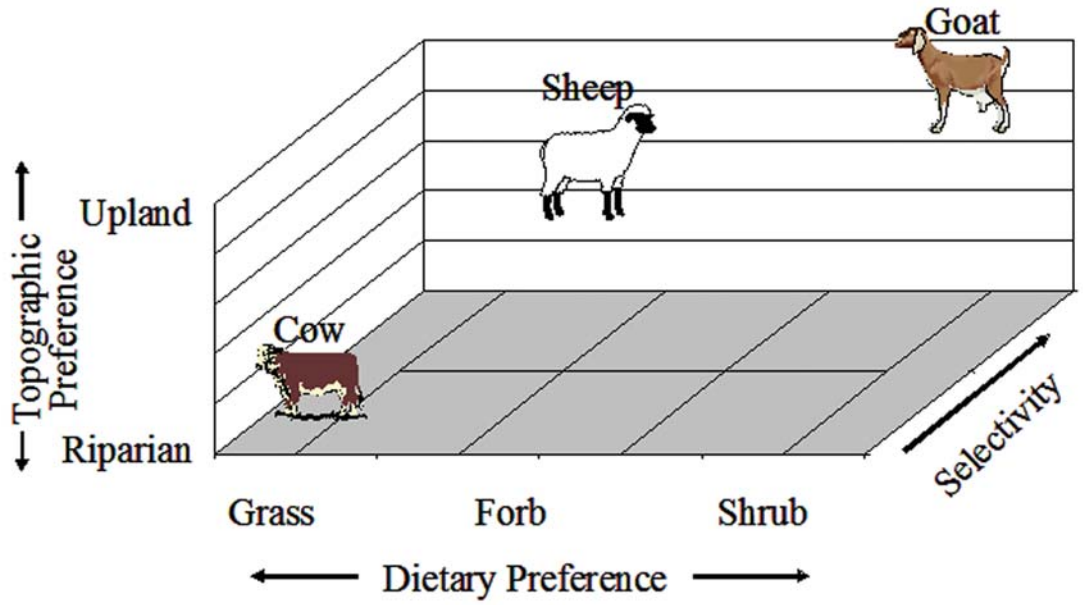


Figure 2. The X axis of this three-dimensional depiction of the relative dietary habits of cattle, sheep, and goats shows the relative preference for grass, forb, and shrub. The Y axis shows increasing ability to select higher quality components from diverse vegetation. The Z axis shows preference from low riparians to upland hilltops.

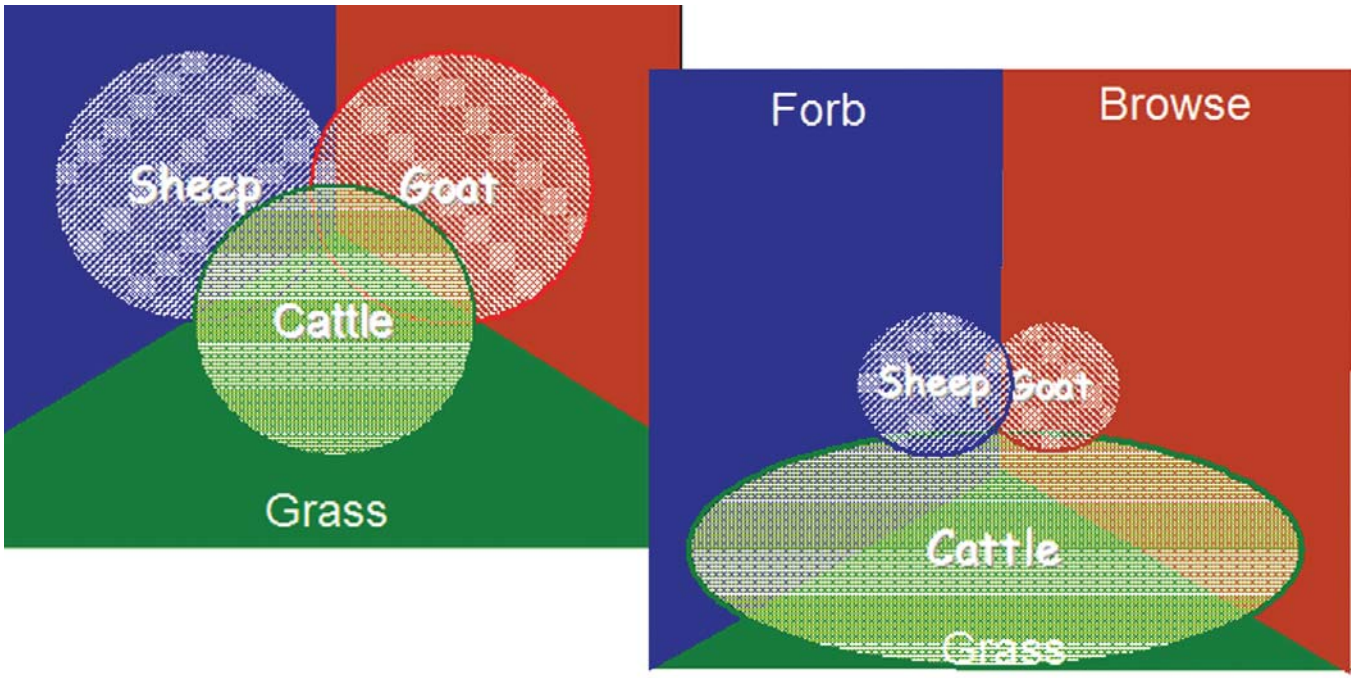


Figure 3. The diagram on the left shows how diet preferences should be balanced with available forage. The diagram on the right shows what is happening in many ecosystems where the major consumer is cattle and the grass component of the vegetation is declining while the forb and browse components are increasing.

critical consideration for using grazing animals to influence the succession of plant communities. For instance, in Texas goat browsing can slow the invasion of juniper even though white-tailed deer have a higher preference for juniper and are present in greater numbers.[6] This is possible because the land manager can control the goats' grazing pressure and season of grazing.

Multi-species grazing can increase grazing land carrying capacity. Compared with grazing only cattle, grazing sheep and cattle increased production per unit area an average of 24% (range: 10 to 53%). In contrast, adding cattle to sheep-only grazing increased production an average of only 9%. In some instances, there was no benefit because ewes typically wean more pounds of offspring than cows, and lambs have a higher relative growth rate than calves.[5] Competition for forage resources is always greater for two animals of the same species compared with two animals of different species. Because of this, grazing pressure is lower and individual animal performance higher at the same stocking rate under multi-species grazing compared to single-species grazing. Sheep grazed in combination with cattle gained an average of 30% more (range: 12 to 126%) than sheep grazed alone. The average gain was only 6% greater for cattle grazed with sheep than cattle alone. In some studies adding sheep to cattle-only grazing resulted in lower cattle gains. This indicates that when forage availability is low, sheep are more competitive for the limiting resource than cattle.

Benefits from multi-species grazing will be greatest when the different classes of livestock are balanced with the available forage resource and the total stocking rate does not exceed the carrying capacity of the land. A general rule of thumb is that on moderately stocked pastures one ewe can be added for each cow without affecting cattle performance or pasture condition. In areas with large amounts of undesirable brush that goats will consume (e.g., juniper or multiflora rose), the number of goats that can be added to a cattle- or sheep-grazed pasture can be much higher. However, not all brush is consumed by goats. For instance, mesquite, which infests millions of acres in the Southwest, receives only minor use by goats.

Replacement ratios of five sheep, six goats, or 1.2 horses per cow are commonly used and are based on relative differences in the amount of forage consumed per day. A more accurate approach for determining replacement ratios is to incorporate information about the dietary overlap of different species of livestock. Dietary overlap is the portion of diets from different species that is similar. So if dietary overlap with cattle is 25, 50, or 75%, the replacement ratio becomes 20, 10, or

seven ewes, respectively, that could replace each cow. However, animal unit equivalence is not symmetrical. Connolly and Nolan[3] found that one steer could be replaced with four lambs without affecting the performance of other lambs, but 10 lambs could be added without affecting the performance of other steers. The bottom line is that replacement ratios are situation specific and will reflect the skill and knowledge of land managers.

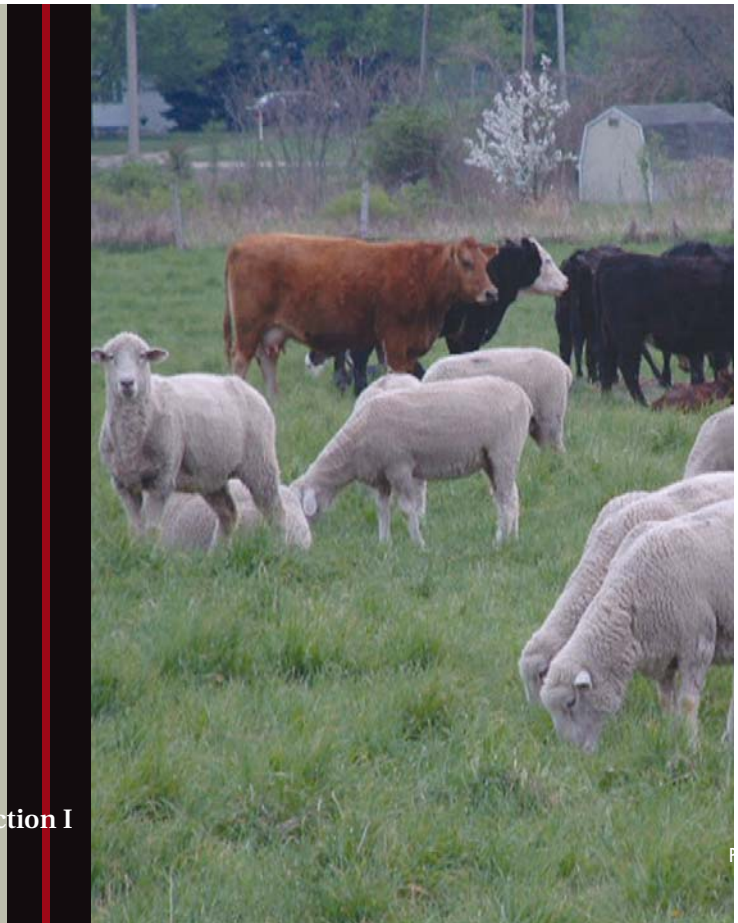
A major impediment to adopting multi-species livestock management is a lack of livestock growers with the skills and knowledge to raise small ruminants. This challenge can be met by developing cooperative arrangements with owners of other livestock species. Another problem is a lack of net wire or other fencing in place that will contain small ruminants. Barbed wire fences can be modified by adding offset electric wire or extra strands of barbed wire to contain sheep and goats *(see fencing in Chapter 3)*. In west Texas, where cattle, sheep, and goats are commonly run in the same pasture under extensive grazing conditions, interactions between different classes of livestock are seldom a problem. In intensive management systems and around water, interactions between cattle and small ruminants can present problems. These can be resolved by rotating one class in front of the other or installing fences or gates around portions of the water that allow sheep and goats to pass but prohibit cattle and horses (i.e., creep fencing).

Care must also be taken with trace minerals in multi-species grazing systems because sheep are more sensitive to copper than cattle. The levels of copper in supplements designed for cattle may exceed the safe level (25 ppm) for sheep but should not harm goats.

Multi-species grazing can also help manage internal parasites in sheep and goats.[2] Cattle do not have the same species of parasites as sheep and goats. Incorporating cattle into small-ruminant production systems can reduce parasite infection because the cattle reduce the density of small ruminants and consume parasite larvae, which move up the leaves and stems of herbaceous plants in part of their life cycle.

In many instances the most important decision in grazing management may be matching livestock dietary preferences to available forage, for example, using a class of livestock other than cattle to utilize the forage resource. This may also be the most difficult decision for land managers, especially livestock growers, because it can require a greater change in management, lifestyle, and self-image than any other decision relative to grazing management. However, for those committed to leaving the land in better condition than they received it, multi-species grazing may be the best way to fulfill that commitment.

Photo: Ron Daines, Logan, UT



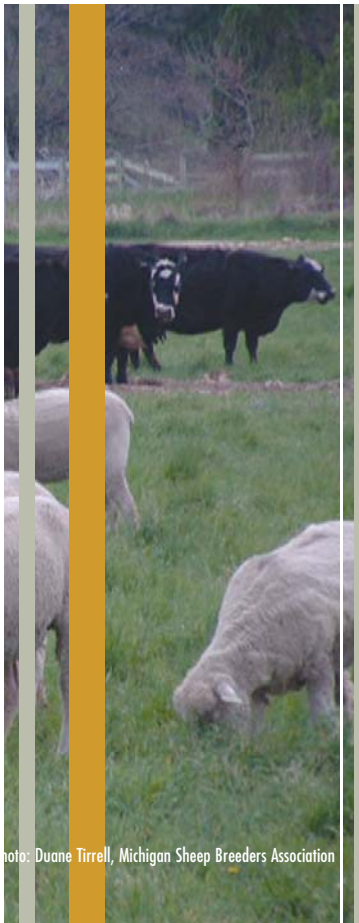


Photo: Duane Tirrell, Michigan Sheep Breeders Association

Literature Cited

[1]Bell, R.H.V. 1971. A grazing ecosystem in the Serengeti. *Scientific America* 225:86-93.

[2]Coffey, L. 2001. Multispecies Grazing. Published by Appropriate Technology Transfer for Rural Areas. *Available at:* http://attra.ncat.org/attra-pub/multispecies.html. *Accessed 11 August 2006.*

[3]Connolly, J. and T. Nolan. 1976. Design and analysis of mixed grazing experiments. *Animal Production* 23:63-71.

[4]Van Dyne, G.M., N.R. Brockington, Z. Sxocs, J. Duek, and CA. Ribic. 1980. Large herbivore sub-systems. *In:* A.I. Breymeyer and G.M. Van Dyne [EDS.]. Grasslands, systems analysis and man. Cambridge, England: Cambridge University Press. p. 269-537.

[5]Walker, J.W. 1994. Multispecies grazing: The ecological advantage. Sheep Research Journal (Special Issue):52-64. *Available at:* http://www.sheepusa.org/. *Accessed 11 August 2006.*

[6]Walker, J.W. 1999. Range war in West Texas. *Cashmirror* 10:13-14.

[7]Wooton, E.O. 1908. The range problem in New Mexico. Las Cruces, NM: New Mexico Agricultural Experiment Station Bulletin Number 66. p. 46.

Photo: Bob Nichols, USDA, NRCS

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CHAPTER 7:
Managing Herbaceous Broadleaf Weeds with Targeted Grazing

By Bret Olson and Karen Launchbaugh

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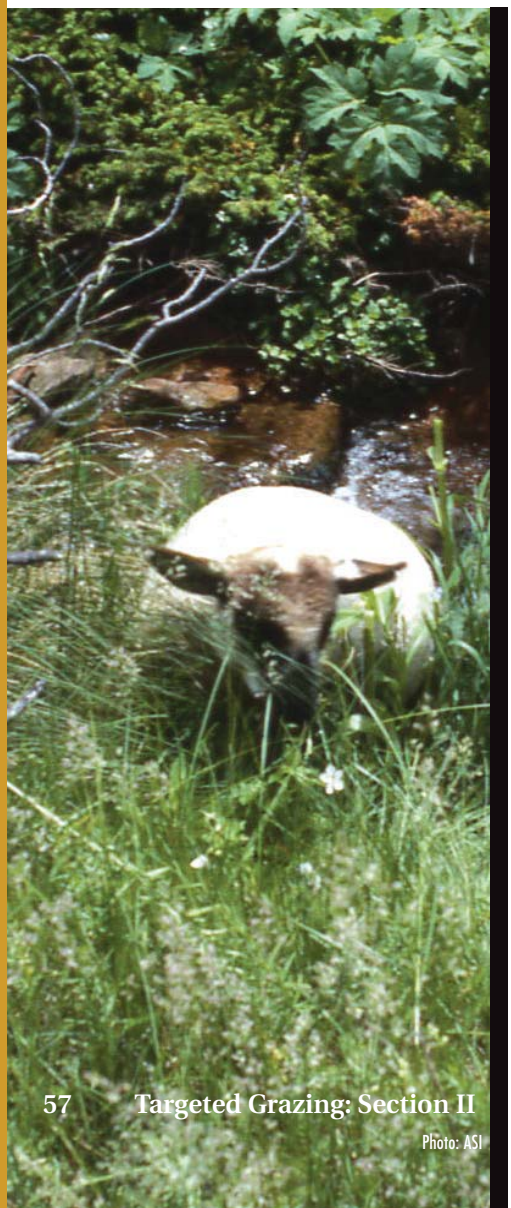

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10 KEY POINTS

- Most broadleaf weeds were brought from Eurasia to North America, where they are spreading rapidly across public and private land.
- Millions of dollars spent on herbicides and biological control address only the symptoms of the spread, not the cause.
- These weeds can be highly nutritious, and many are readily grazed by livestock during the growing seasons.
- The age and breed of livestock best used to tackle herbaceous weeds will depend on the grazing situation.
- Broadleaf weeds are most susceptible to grazing damage when they are initiating flower production and rapidly elevating flower stalks.
- The number of days to graze in a year depends on the target broadleaf weed and the surrounding vegetation.
- Broadleaf plants are generally most nutritious during their rapid growth phase when high water and nutrient uptake facilitates cell expansion.
- Secondary compounds in broadleaf weeds may reduce palatability by causing negative digestive consequences.
- The period of highest nutritional need for ewes and nannies generally coincides with the time of highest forage value in the weeds.
- Biological control and targeted grazing may be combined for an enhanced effect in controlling broadleaf weeds.

VEGETATION MANAGEMENT OPPORTUNITIES

The invasion of rangelands, forests, and pasturelands by herbaceous broadleaf plants is one of the greatest conservation and land management challenges of our modern era. Since the beginning of trans-oceanic travel, North America has been open to invasion from alien plants. Many of these invasive plants originated in regions that have been subjected to a long history of human habitation. Most co-evolved with agricultural practices, including intense livestock grazing by sheep and goats. This background has resulted in plants with enhanced invasive traits and an ability to thrive in disturbed systems. Problematic herbaceous (non-woody) broad-leaved weeds are forbs including leafy spurge, spotted knapweed, yellow starthistle, Canada thistle, houndstongue, whitetop, kudzu, and toadflax, among others. Exotic herbaceous weeds pose significant threats to livestock production and the integrity of native plant communities. Weed invasions most often result in reduced biodiversity, increased soil erosion, degradation of wildlife habitat, and reduced carrying capacity for livestock.[17]

Most of these invasive weeds were brought to North America from Eurasia and continue to spread across the continent despite millions of public and private dollars spent on herbicides and biocontrol. These control methods address the symptom, not the cause, of the weed problem. The cause of their spread stems from an imbalance between the plant community composition and the selective grazing patterns of the dominant livestock species grazing these communities – cattle. By avoiding these plants and selectively grazing native forbs and grasses, the native plants are put at a disadvantage when competing with weeds for limited soil water and nutrients. Consequently, composition of many plant communities has shifted from native species toward a preponderance of undesirable, weedy species, often creating solid stands of weeds. Grazing broadleaf weeds with sheep or goats has the potential to reduce their spread and control current infestations. Increasing the use of targeted grazing with sheep and goats could address a fundamental cause of weed invasions and restore balance to native communities

Criteria for Animal Selection

By nature, cattle are not prolific weed eaters, partly because their large mouths and tongues make it difficult to strip leaves and consume small flowerheads of many weeds. Plus, cattle have less effective digestive and metabolic systems to detoxify the deleterious plant compounds often found in weedy forbs. A few practitioners have been able to overcome the apparent physical limitations of using cattle to manage broadleaf weeds with proper diet training.[19] In contrast, sheep naturally prefer forbs over grasses and grasses over shrubs, so they make good candidates for consuming weedy forbs in a weed-control context. However, sheep also graze grasses, which some cattle producers dislike, limiting opportunities to use sheep for weed control in cattle pastures. Goats generally prefer shrubs over forbs or grasses. So they compete less with cattle for grasses, but they also readily consume shrubs and small trees, which may be undesirable in some places, like wooded riparian areas.

Grazing animals seek variety just as humans do. Livestock may graze in *cyclic* patterns, consuming considerable amounts of a weed during one feeding grazing period, followed by low weed consumption in the following period. For example, sheep have been observed grazing substantial amounts of weeds one evening with little consumption of that weed the following morning. This could simply result from a desire for variety, or it could reflect the time needed for the rumen microorganisms of the host animal to process secondary compounds they have consumed.

Breed Considerations

Few studies have compared whether certain breeds of sheep or goats are better weed eaters than others. In North Dakota, consumption of leafy spurge by Columbia, polypay, rambouillet, and Suffolk sheep was assessed in 1999 and 2000 (Kronberg, unpublished data). Although differences among breeds were apparent during some weeks, overall differences were not consistent across the seven-week trial. The researchers concluded that any of these common breeds of sheep will graze leafy spurge effectively.

White-face breeds may be more appropriate for a herded situation as they are more gregarious and form a tighter flock. Black-face sheep work well under permanent fence, which may limit their utility for large-scale weed control. Goat breeds also vary in their tendency for forming tight herds, a behavior that can be influenced by training and the production setting. For example, goats that are penned at night and graze under the direction of a herder tend to graze more closely as a herd than free-ranging goats of the same breed. A breed may also be selected based on the desired level of winter or summer hardiness. Meat or fiber characteristics must also be considered, unless the producer runs wethers or dry open females (that is non-lactating females without kids or lambs) with the primary goal of weed control.

Animal Age and Experience

Are young animals more likely to graze weeds than older animals? It depends. Young animals are curious and seek novelty. On the other hand, young animals also rely on their mother and other adult females as role models for learning what to graze or avoid. This can be beneficial if the role model readily consumes weeds. A tendency to eat or avoid a plant can be passed from generation to generation, for better or for worse.

In southwestern Montana, research assessed whether yearling sheep exposed to leafy spurge as lambs grazed it more readily than yearlings that had not been exposed to it as lambs.[14] Also assessed was whether this difference, if present, persists through the grazing season. Experienced yearlings spent more than twice as much time grazing leafy spurge in early summer compared with naive yearlings, but neither group actively selected the plant (it was less than 5% of their diet). This may reflect that the associated cool-season grasses were highly palatable and nutritious in early summer. In addition, these yearlings did not have mature role models to influence their diet selection, positively or negatively. By mid summer, both groups were grazing leafy spurge, up to 45% of their diets. These findings indicated that: 1) there may be an advantage to using experienced sheep on leafy spurge, but perhaps only in early summer, and 2) inherent dietary preferences for forbs, such as leafy spurge, are strong in sheep.

The importance of social models was exemplified on a ranch along the Yellowstone River in eastern Montana, where a band of sheep was purchased to graze leafy spurge (personal communication). The sheep did not consume spurge for two years, until they were accidentally mixed with a band of sheep that readily consumed leafy spurge. The inexperienced band then learned that spurge was a nutritious and acceptable forage.

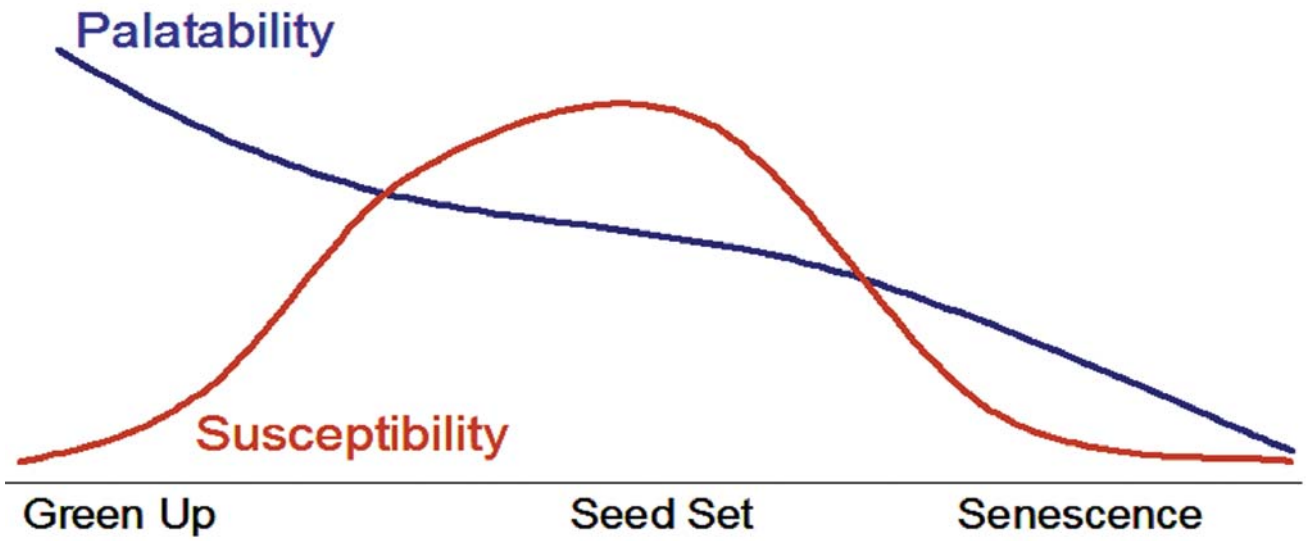

Figure 1. General curve depicting the time during the growing season when herbaceous broadleaf plants are susceptible to damage from grazing or browsing and when they are generally most palatable to herbivores.

Grazing Strategies to Meet Ecological Objectives

When to Graze

The loss of plant material to grazing herbivores, including insects, wildlife, and livestock, is a natural condition with which all plants evolved. Some plants have developed natural survival tactics. The ability of a plant to survive and recover from grazing varies depending on how much material is lost and when plants are defoliated. Shortly after herbaceous plants begin growing in the spring they tend to have low susceptibility to damage from grazing. However, as they grow, the potentially damaging effects of grazing increase until after the plant has set seed and started shutting down growth for the season during senescence (Figure 1). The plant's risk of being grazed is partly determined by how palatable it is to grazing animals. Generally, plants are palatable when they are young and nutritious. Plants tend to become less palatable as they grow and mature. How palatable a plant is depends on the herbivore doing the selecting. For example, goats find yellow starthistle palatable throughout the season, even when it has spines around the seedhead. Cattle, on the other hand, will select yellow starthistle when it is young and bolting, but will avoid it when it starts producing spines and flowering.

Ideally, weeds should be grazed when they are most susceptible and relatively palatable. Generally, forbs are most susceptible to grazing when they are initiating flower production and rapidly elevating their flowering stalks – a phase called "bolting." Grazing weeds when they are bolting may be most detrimental to them and the best time for their control. There is just one potential problem with this strategy. Native desirable forbs and grasses may also bolt or begin flowering at the same time as weeds, making them equally susceptible. If the grazing animal prefers these native plants over the weed, they could be placed at a competitive disadvantage, allowing, the weed to invade the site more rapidly. Selecting the most effective time for grazing to control weeds requires careful attention to when the weed is palatable relative to associated plants and when desirable plants in the community are most susceptible to grazing.

An alternative is to alter season of use so that desired species are not grazed year after year when they are most susceptible. This may lessen the impact on the associated weeds, but at least it will reduce seed production by the weeds and reduce long-term harm to desired species.

How Long to Graze

The number of days to graze in a year depends on the characteristics of the target weed and the surrounding vegetation. The general goal is to graze at a frequency and intensity that will be most detrimental to the weed and most beneficial to the surrounding desirable vegetation. Exactly how this goal is accomplished will depend on the situation and the skill and knowledge of the person making grazing management decisions. The most common grazing strategies involve concentrating animals in relatively small areas for a few days and then moving them onto another area when defoliation objectives are met. In many cases, grazing prescriptions will involve returning to an area that was grazed earlier in the season to graze the regrowth of the target plant, preferably when desired species are dormant.

The number of years of grazing required for weed control varies, but will nearly always involve several consecutive years. The initial two to five years will focus on weed suppression based on the response of the target weed and surrounding plant community. After the target plant has been reduced to an acceptable level, grazing may be applied at a lower rate (fewer animals) and/or less frequent level for landscape maintenance. Targeted grazing is not a one-time and then walk-away tool – it is a long-term landscape enhancement commitment.

Animal Production Considerations

The animal production consequences of using grazing to manage weeds must be considered and monitored. Despite the potential biological efficacy of using sheep and goats to manage weeds, targeted grazing may not be used widely until it is shown to be compatible with production goals.[11, 12] Sheep grazing some weeds, like leafy spurge, may outperform their counterparts on non-infested rangelands.[4] However, using animals to control weeds with low nutritional value, like mature whitetop, could cause weight loss and hinder production. Such situations may require short-term contract grazing or grazing by animals that can tolerate low nutrients, such as whethers or dry open females.

Forage Quality of Weeds

Broadleaf weeds can be highly nutritious and many are readily grazed during the growing season (Table 1). Plants are generally most nutritious during their rapid growth phase, when high water and nutrient uptake facilitate cell expansion. For cool-season plants, this period is usually in spring to early summer. Nutrient concentrations then begin to decline. The plants become more fibrous as stems elongate, leaves age and become less digestible, and soluble nutrients and carbohydrates are diverted to developing seeds and to roots for storage. Cool-season plants usually go dormant in mid summer. For warm-season plants, peak nutrient concentrations and growth occur later than for cool-season species, in mid to late summer, but trends in nutritional value are the same. If precipitation is abundant in early fall, cool-season plants may initiate new leaves and stems, regrowth that is as nutritious as spring growth and readily consumed by grazing animals.

Table 1. Nutritive value of several common broadleaf weeds expressed in terms of fiber (Neutral Detergent Fiber) and protein (Crude Protein) through the growing season (Frost et al., in prep).

Weed Species	Growth Stage: Rosette	Bolting	Flowering	Seedset
	% Fiber			
Dalmatian Toadflax	29-32	41-47	47-51	47-54
Hawkweed	36-39	32-36	47-52	45-48
Houndstongue	31-32	32-37	47-51	47-55
Rush Skeletonweed	25-29	38-44	57-62	56-58
Spotted Knapweed	30-35	35-38	42-46	58-62
Sulfur Cinquefoil	46-48	42-49	47-51	47-55
Tansy Ragwort	35-40	28-34	48-51	—
Whitetop	20-21	23-26	34-35*	—
Yellow Starthistle	32-37	34-37	41-48	50-57
*sample collected very early flower				
	% Protein			
Dalmatian Toadflax	12-18	9-12	5-7	5-7
Hawkweed	13-14	9-10	4-7	4-6
Houndstongue	26-29	13-16	8-10	6-9
Rush Skeletonweed	22-25	13-16	8-9	7-8
Spotted Knapweed	10-16	10-14	7-8	3-5
Sulfur Cinquefoil	14-16	9-11	6-7	4-5
Tansy Ragwort	15-16	12-14	8-9	—
Whitetop	27-30	27-30	18-20*	—
Yellow Starthistle	14-17	11-14	4-6	4-6
*sample collected very early flower				

Although some weeds are high in fiber, imparting greater resistance to tearing and presumably reducing palatability, many are similar to native grasses and forbs in fiber, nutrient value, and digestibility. Further, weeds as a group have similar moisture content as native species. In fact, many weeds, such as leafy spurge and spotted knapweed, remain greener, more succulent, and more nutritious longer into summer than associated native plants.[5]

Quality Considerations

Many broadleaf weeds have an acrid (e.g., oxeye daisy, burdock) or bitter taste (spotted knapweed) or a noxious smell, at least to humans. Bitter tastes and noxious smells are often associated with significant amounts of secondary compounds. Grazing animals rarely avoid plants simply because they have a strong or bitter flavor. If the plant tastes bad, causes nausea, or is toxic to the animal, it will be avoided when the animal encounters it in the future. Alternatively, if a plant does not taste bad, does not cause nausea, or is not toxic, it will be subsequently ingested *(for more information see Chapter 2)*.

Once eaten, a plant's first line of defense has failed. It may contain secondary compounds that affect a second line of defense focused at the rumen microbial population. The compounds can alter the composition of rumen bacteria, fungi, and protozoa and/or the level of rumen microbial activity. Digestion may be slowed or reduced if secondary compounds kill rumen microbes or shift the composition of rumen microbial populations. This will result in negative post-ingestive consequences, reducing the preference for and the subsequent intake of the plant. A change in diet is probably the most important factor influencing numbers and relative proportions of different microbial species in the rumen,[21] partly because ruminal bacteria vary widely in nutrient requirements, and partly because they have different tolerances or abilities to metabolize plant secondary compounds. Negative effects on microbial activity, resulting in negative post-ingestive feedback, may explain why some ruminants limit their consumption of certain weeds.

Secondary compounds may reduce plant palatability by causing negative digestive consequences when eaten. For example, leaves and flowers of spotted knapweed contain high concentrations of cnicin, a secondary compound.[9,13] Although levels of crude protein and digestibility of leaves and flowerheads of spotted knapweed are higher than those for stems, rumen microbial activity for those plant parts is lower than for stems,

presumably because of the presence of cnicin.[13] In contrast to spotted knapweed, the high nutritive value of leafy spurge in early summer appears to counteract, to a certain extent, negative effects associated with its secondary compounds.[16]

The Role of Supplements

Supplementing grazing animals with energy and nutrients may enhance the ability of rumen microbes to digest a weed and process associated secondary compounds. Improving the animal's nutritional state could also enhance detoxification capabilities and reduce toxic effects, which could lead to increased intake of foods that contain toxins. Though supplements may be useful in some situations to encourage the consumption of weedy herbaceous plants, few studies have revealed consistent benefits. Still, it is generally recommended that animals be supplemented with salt and other minerals to keep them healthy and in good condition.

Production Cycle Considerations

Most sheep-lamb operations breed their ewes in November or December and lamb in April or May. The nutritional demands of adult ewes and nannies are highest shortly after they give birth and start producing milk. This time of high nutritional demand generally coincides with the time of highest forage value in weeds. Targeted grazing strategies may complement production goals as long as the weeds targeted for control have nutritional value and do not have high levels of secondary compounds. Further, young animals are highly influenced by their dams and, later, their peers, which may enhance their consumption of certain plants and reinforce their avoidance of other plants. The key to using mother-young combinations is to ensure that adult females of the flock or herd readily consume the desired weed, a behavior that can be passed on to subsequent generations.

Mature wethers and dry ewes or nannies have low nutrient requirements, making them useful for managing weeds in settings where forage quality is low, such as grazing fibrous weeds in late fall or winter. These animals may also be effective when the grazing prescription calls for heavy stocking rates designed to encourage intake of low quality forages.

Effectiveness and Integrated Management

Grazing is seldom combined with other weed control methods to create integrated weed management strategies, but there is ample opportunity for integration.[15] Grazing has occasionally been applied with mowing, herbicides, or biocontrol agents to increase the effectiveness or longevity of these strategies.

Photo: ASI

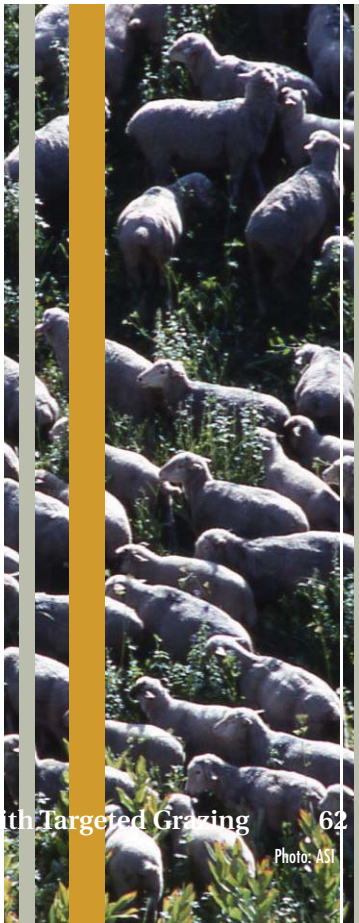
Photo: ASI

Targeted Grazing in Combination with Herbicides

Applying herbicides to control weeds on rangelands and pastures should be followed by proper grazing management. Integrating grazing and herbicides can be restricted by how long grazing must be withheld after herbicide application. There are many situations where grazing and herbicides can be used in tandem to increase weed mortality. For example, sheep and goat grazing has been combined with herbicide applications to provide leafy spurge control better than either herbicides or grazing alone.[8,10] This synergistic effect can be achieved by using herbicides to weaken the plant followed by strategic grazing to serve as a *multiple stressor* to hasten weed demise or slow recovery from the herbicide. Another approach is to apply heavy grazing to reduce and weaken the weeds' root system. The weeds are then allowed to regrow, followed by an application of herbicides. This strategy may increase weed mortality and enhance herbicide effectiveness.

Integrating Targeted Grazing and Insect Biocontrol

Biological control and targeted grazing, both effective weed management tools, may also be combined for enhanced effect. Targeted sheep grazing has been combined with introduced flea beetles to control leafy spurge.[2,6] However, beyond leafy spurge, little is known about how these techniques might be integrated into an effective weed management strategy.[15] Grazing can create conditions that make plants more susceptible to damage from biocontrol agents. For example, grazing above 50% use reduces root biomass.[3] This effect, combined with the added stress of herbivory from host-specific biocontrol insects, could additively or synergistically weaken the plant. Grazing might also enhance the effectiveness of biocontrol by reducing seed output, which is often observed among defoliated plants.[7,18] By reducing seed production with grazing, seed-feeding biocontrol insects would have fewer available seedheads from which to select, increasing success of attack on remaining seedheads. Further, removing dense canopies of shade will create warmer conditions for the feeding and reproduction of biocontrol insects, which are cold-blooded and have higher activity rates with warmer temperatures.

On the other hand, ill-timed and poorly managed grazing can be detrimental to biocontrol insects. Grazing, especially late in the season, can directly remove beneficial insects inhabiting stems or seedheads. Sufficient plant material must be maintained when biocontrol insects are first introduced into a landscape. Maintaining plant material in nursery sites can be essential to getting these insects established in the year of their release.

Potential Cost of Targeted Grazing

The cost of targeted grazing to control broadleaf herbaceous weeds varies with each situation. One must consider how effective targeted grazing is likely to be in a particular setting, how long the grazing will be required to have the desired effect, the cost of transporting animals to the site and applying the required grazing treatment, and the value of forage or other resources that will be gained from reduced weed dominance.

There is more information about using sheep for leafy spurge control than for any other livestock-weed interaction. Using sheep as a leafy spurge control method is economically feasible and effective across many management settings.[1] For example, in south-central Montana, a band or two of sheep have been rotated rapidly across leafy spurge-infested private lands for the last 15 years. The instructions for the herders are to "take the yellow out," or remove seedheads, before the sheep consume considerable amounts of grass. The ewes and lambs thrive, the sheep producer is provided an incentive for the extra management involved, and the willing landowners receive weed control, which has enhanced grass production for their cattle. In 2004, the actual costs for controlling leafy spurge with sheep in Montana were less than $1 per acre. In one situation, a county had to spray some ridge areas infested with leafy spurge with a helicopter because the sheep were not in the area and could not travel to that site in a timely manner. Those costs were $45 per acre. Obviously, sheep grazing provides an economically viable alternative for leafy spurge control. Because leafy spurge is clonal with a deep, extensive root system, it is still present in the project area. Sheep grazing may not eradicate leafy spurge, but its density and vigor are much lower than at the beginning of this project.

FINAL THOUGHTS

Herbaceous weeds can invade and threaten healthy rangelands, forests, and pasturelands. Recent success in the use of sheep and goats to control some herbaceous weeds, such as leafy spurge, has fueled interest in grazing for weed control.[12, 20] If these herbaceous weeds were palatable and preferred by herbivores they would not be considered weeds and would be only a minor part of plant communities as they are in their countries of origin. These plants are usually not *invasive* in their home countries because they are kept in check by natural insect enemies, pathogens, and grazing herbivores. Sheep and goats show particular promise in management of broadleaf weeds because they naturally select these forb-type plants. Carefully managed grazing holds potential for weed control in situations where traditional methods, including mechanical, cultural, biological, and chemical, are restricted by environmental or economic constraints.[12] As our understanding of targeted grazing grows, this tool will gain an important role in integrated systems aimed at managing broadleaf herbaceous weeds.

Literature Cited

[1]Bangsund, D.A., D.J.Nudell, R.S. Snell, and F.L. Leistritz. 2001. Economic analysis of using sheep to control leafy spurge. *Journal of Range Management* 54:322-329.

[2]Beck, K.G. and L.R. Rittenhouse. 2000. Leafy spurge management with sheep and flea beetles. *Proceedings Western Society of Weed Science* 53:48-49.

[3]Briske, D.D. 1991. Developmental morphology and physiology of grasses. In. Heitschmidt, R.K. and J.W. Stuth [EDS.] Grazing management: An ecological perspective. Portland, OR: Timber Press. p. 85-108

[4]Fay, P.K. 1991. Controlling leafy spurge with grazing animals. *In:* L.F. James, J.O. Evans, M.H. Raphs, and R.D. Childs. [EDS] Noxious range weeds. Boulder, CO: Westview Press. p. 193-199.

[5]Fox, D., D. Kirby, J. Caton, and R. Lym. 1991. Chemical composition of leafy spurge and alfalfa at four phenological stages of growth. *Proceeding North Dakota Academy of Science* 45:46.

[6]Hansen, R. 1993. Effects of *Aphthona* flea beetles and sheep grazing in leafy spurge. Proceedings 1993 Great Plains Agricultural Council Leafy Spurge Task Force Symposium: July 26-28, Silvercreek, CO.

[7]Kennett, G.A., J.R. Lacey. C.A. Butt, K.M. Olson-Rutz, and M.R. Haferkamp. 1992. Effects of defoliation, shading and competition on spotted knapweed and competition on spotted knapweed and bluebunch wheatgrass. *Journal of Range Management* 45:363-369.

[8]Lacey, J.R. and R.L. Sheley. 1996. Leafy spurge and grass response to picloram and intensive grazing. *Journal of Range Management* 49:311-314.

[9]Locken, L.J. and R.G. Kelsey 1987. Cnicin concentrations in *Centaurea maculosa*, spotted knapweed. *Biochemical Systematics and Ecology* 15:313-320.

[10]Lym, R.G., K.K. Sedivec, and D.R. Kirby. 1997. Leafy spurge control with angora goats and herbicides. *Journal of Range Management* 50:123-128.

[11]Mosley, J.C. 1996. Prescribed sheep grazing to suppress cheatgrass: A review. *Sheep and Goat Research Journal* 12:74-80.

[12]Olson, B.E. and J.R. Lacey. 1994. Sheep: A method for controlling rangeland weeds. *Sheep and Goat Research Journal* 10:105-112.

[13]Olson B.E. and R.G. Kelsey. 1997. Effect of *Centaurea maculosa* on sheep rumen microbial activity and mass in vitro. *Journal of Chemical Ecology* 23:1131-1144.

[14]Olson, B.E., R.T. Wallander, V.M. Thomas, and R.W. Kott. 1996. Effect of previous experience on sheep grazing leafy spurge. *Applied Animal Behavior Science* 50:161-176.

[15]Popay, I. and R. Field. 1996. Grazing animals as weed control. *Weed Technology* 10:217-231.

[16]Roberts, J. and B.E. Olson. 1999. Effect of *Euphorbia esula* on sheep rumen microbial activity and mass in vitro. *Journal of Chemical Ecology* 25:297-314.

[17]Sheley, R.L. and J.S. Jacobs. 1997. Response of spotted knapweed and grass to picloram and fertilizer combinations. *Journal of Range Management* 50:263-267.

Literature Cited

[18]Thomsen, C.E., W.A. Williams, M. Vayssiéres, F.L. Ball and R. George. 1993. Managing yellow starthistle on rangeland. *California Agriculture* 47:36-40.

[19]Voth, K. 2005. Seven steps for turning your cows into weed eaters! *Available at:* http://www.livestockforlandscapes.com/cowsweeds.htm. *Accessed 27 September 2006.*

[20]Walker, J.W., S.L. Kronberg, S.L. Al-Rawaily, and N.E. West. 1994. Managing noxious weeds with livestock: Studies on leafy spurge. *In:* Sheep Research Progress Report. Number 3, USDA-ARS 1994-4 p.125-135.

[21]Yokoyama, M.T. and K.A. Johnson. 1988. Microbiology of the rumen and intestine, *In:* D.C. Church [ED.], The ruminant animal: Digestive physiology and nutrition. Englewood Cliffs, NJ: Prentice Hall. p. 125-144.

CHAPTER 8:
Targeted Livestock Grazing to Suppress Invasive Annual Grasses

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Photo: Lovina Roselle, University of Idaho

10 KEY POINTS

- Targeted livestock grazing can suppress annual grasses where these grasses are considered weedy invaders.
- Invasive annual grasses have a self-perpetuating relationship with fire.
- Targeted grazing can be used to disrupt fine fuel continuity and reduce fuel loads.
- Annual invasive grasses can be suppressed when livestock grazing reduces the production of viable seeds.
- Seedheads of invasive grasses must be removed while the grasses are still green.
- It may be necessary to graze annual grasses two or three times in the spring.
- In mixed stands of annual grasses and perennial plants, livestock should be observed closely to avoid heavy grazing of any desirable perennial plants.
- Livestock perform well on annual grasses in the spring, producing weight gains similar to those from uninfested ranges.
- Targeted grazing can be integrated with prescribed fire, herbicides, and mechanical treatments to improve efficacy.
- Applying targeted grazing before artificial seeding can help in restoration efforts.

INTRODUCTION

Invasive annual grasses are a serious problem on North American rangelands. These undesirable species, such as cheatgrass (or downy brome), Japanese brome, and medusahead, often out-compete desirable perennial species.[14,29,50] Invasive annual grasses can form nearly pure stands that exclude most other plants, decrease biological diversity and forage production, and increase soil erosion. In some areas, invasive annual grasses also create continuous fine fuel loads that promote wildfires more frequent than native shrubs and perennial grasses can tolerate.[35, 36]

The range livestock industry has adapted to the presence of invasive annual grasses, especially where infestations are extensive. For example, on California annual grasslands dominated by soft chess, wild oat, and other species, livestock grazing is typically managed to retain sufficient residual dry matter of annual grasses. Light to moderate livestock grazing provides enough standing grass at the end of the grazing season to limit soil erosion and conserve soil moisture and nutrients.[2, 18] Elsewhere, however, where infestations of invasive annual grasses are less extensive or less advanced, opportunities exist for using targeted, or prescribed, livestock grazing to suppress annual grass plants.[19, 28, 44] This chapter focuses on using prescribed livestock grazing to suppress invasive annual grasses on sites where these grasses are considered weedy invaders.

Vegetation Management Opportunities

Invasive annual grasses, especially cheatgrass, have a self-perpetuating relationship with fire.[36] Fire creates conditions that favor their growth, which, in turn, creates fine fuel loads that favor subsequent wildfire. Targeted livestock grazing can help diminish this fire hazard by disrupting fine fuel continuity and reducing fuel loads. Extending fire-free intervals enhances the competitiveness of perennial plants. Protecting existing stands of shrubs or perennial grasses from frequent fire should be a high priority as it is easier and less expensive to prevent annual grasses from dominating than to restore or rehabilitate depleted plant communities.[46] Grazed fire lines should be at least 250 feet wide.[47, 48]

Using livestock grazing to suppress invasive annual grasses and enhance desirable perennials assumes that desirable perennials will fill the temporary void left by the annual grasses. In many areas, however, desirable perennials may be out-competed by species considered even more undesirable than annual grasses, such as yellow starthistle or spotted knapweed. Sites should be thoroughly inspected before initiating any form of plant control.[49]

Disking and plowing, prescribed burning, and herbicides are commonly used to manage invasive annual grasses. These treatments can temporarily reduce the abundance of annual grasses on specific sites, but they seldom provide long-term control unless followed by artificial seeding and revegetation.[27, 29] As discussed near the end of this chapter, targeted livestock grazing can be integrated with these treatments to help prepare sites for seeding with desirable herbs and shrubs.

Criteria for Animal Selection

Sheep, goats, cattle, and horses readily consume grass-dominated diets, provided grasses are plentiful.[43] All four of these livestock species can be used to suppress invasive annual grasses. Sheep and goats can be particularly effective because their grazing can be closely controlled by herding or confined with portable electric fence. The heavy grazing intensities required to suppress many annual grasses are easier to manage when livestock can be confined in small grazing areas. Effective management also requires applying grazing at the appropriate time, a precision more easily achieved when a herder can manage the animals. With their larger mouths, cattle and horses may not select annual grasses as readily as sheep or goats because livestock prefer plants they can eat quickly and efficiently.[3] Sheep or goats can get a full bite of annual grasses more easily than cattle or horses, especially when annual grass plants are small. In winter, goats will favor shrubs over annual grasses.

Some annual grasses are relatively palatable and readily eaten by grazing livestock. Others are rather unpalatable and may require grazing strategies that

reduce selectivity and encourage consumption. The degree of diet selectivity by livestock can be influenced, for example, by controlling their hunger level and the time of day when they begin grazing. Hungry livestock are usually less selective,[1] which may help explain why livestock tend to be less selective when grazing in the morning than in the evening.[8, 23, 45] The type of forage that livestock have grazed recently before they arrive in an annual grass infestation also affects their diet selectivity. Livestock that have been eating palatable vegetation may be more selective when foraging, whereas livestock that have been eating less attractive vegetation are usually less selective.[38] The breed of livestock used for targeted grazing can also affect diet selectivity. For example, intra-specific relationships within bands or flocks of highly gregarious breeds like Rambouillet or Merino may cause these sheep to graze less selectively than sheep within less cohesive breeds like Suffolk or Dorset.[28] Close herding or high stock densities also decrease grazing selectivity as does relatively rapid rotation among small areas or paddocks.[8, 39]

Grazing Strategies to Meet Ecological Objectives

Whether targeted livestock grazing achieves its desired effect depends on a manager's ability to apply the appropriate levels of defoliation at the proper times. Identifying the best time to graze is by far the most important decision determining success or failure in suppressing annual grasses. Repeat grazing will likely be needed when grazing occurs during spring, and grazing intensity and selectivity need careful consideration to limit negative impacts to associated plants.

Timing of Grazing

Annual grasses reproduce by seed; therefore, invasive annual grasses can be suppressed when targeted livestock grazing limits their production of viable seeds. Seedheads of invasive grasses must be removed while they are still green, before seeds reach the dough stage. In Michigan alfalfa fields, for example, cheatgrass was controlled by livestock grazing in late April and early May, but control failed when grazing was delayed until after May 15.[26] In Nebraska, mowing cheatgrass shortly after young seeds emerged controlled cheatgrass in native grass pastures.[11] Likewise, in southern Idaho, cheatgrass densities and seed reserves were reduced when disked in the spring before cheatgrass seeds ripened.[35] To prevent cheatgrass from producing viable seeds, cheatgrass plants should be grazed in the spring before cheatgrass begins to turn purple.[20]

Targeted grazing managers can encourage livestock to preferentially select invasive annual grasses by applying grazing at the appropriate time. Livestock readily graze most annual grasses in the spring before annual grasses set seeds. Seed set coincides with decreased forage nutritive value and lower digestibility of annual grass forage.[6]

Although medusahead is less palatable than cheatgrass and has a narrower window of acceptability for grazing animals (J. DiTamaso, personal communication), sheep and cattle will graze it when it is green for a few weeks in early spring before seed set.[13, 25] When medusahead seeds mature, they become armed with stiff barbs and awns that reduce palatability and repel grazing.

Defoliation of annual grasses generally suppresses their plant yield on a site, but it may not reduce the total number of annual grass plants. For example, in Nevada clipping in early spring (end of March to end of April) reduced cheatgrass biomass compared with an ungrazed control but did not reduce cheatgrass density.[40]

Frequency of Grazing

Grazing annual grasses several times during spring growth is an important and often essential element of an effective management strategy. Cheatgrass, for example, usually requires a second or third grazing in spring because it can regrow and produce new seedheads about three to four weeks after the first defoliation.[20] Cheatgrass populations crash when cheatgrass plants do not produce viable seed for two or more successive years, leaving only scattered, thin populations.[7,11] Seed maturity must be prevented by prescribed grazing every year or every other year to prevent cheatgrass from reinvading. Cheatgrass plant yield and plant density also will be reduced if cheatgrass plants can be heavily defoliated twice in late spring when cheatgrass plants are in the early boot stage.[40] Repeated defoliation will also suppress Japanese brome, an annual grass similar to cheatgrass. Clipping to either a 3- or 6-inch stubble height every week or every other week for two months reduces root growth and yield of Japanese brome.[15]

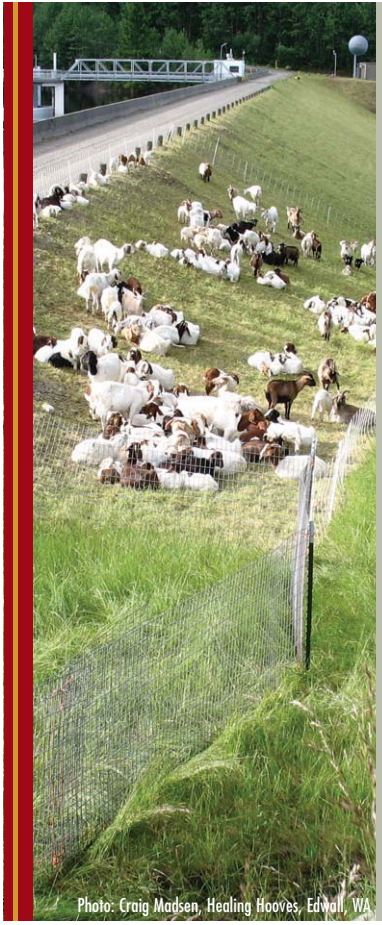


Photo: Craig Madsen, Healing Hooves, Edwall, WA

Photo: Karen Launchbaugh, University of Idaho

Grazing Monocultures vs. Mixed Stands

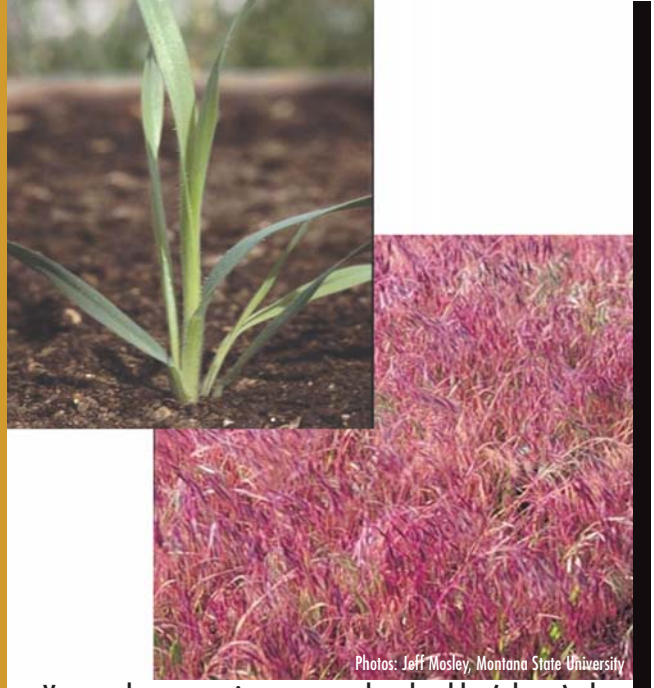
It is relatively easy to suppress invasive annual grasses where they form nearly pure stands (i.e., monocultures) that exclude most other plants. On these sites, prescribed livestock grazing can be applied to achieve maximum damage to annual grasses with little concern for non-target plants. Grazing intensity can be high (residual stubble height less than 3 inches) and grazing relatively uniform if a site is largely dominated by invasive annual grasses. The specific stubble height or utilization level is less important than selecting a grazing intensity heavy enough to prevent annual grasses from developing viable seeds. Clipping in spring to a height of 2 to 3 inches should be effective.[11]

When livestock grazing in late spring or early summer is applied to mixed stands of annual grasses and perennial plants, livestock should be observed closely to ensure they are selecting annual grasses and not heavily grazing desirable perennials. Desirable cool-season perennial grasses such as bluebunch wheatgrass, Idaho fescue, and rough fescue can sustain defoliation in spring to a 3-inch stubble height, provided it does not occur more than two years in a row.[4, 41] Perennial bunchgrasses also benefit when livestock in early spring are not allowed to graze an area for longer than three weeks before being moved to a new unit, a strategy that helps perennial bunchgrasses to recover in the weeks that follow.[34]

Timing is critical when trying to control annual grasses in mixed stands. For example, cheatgrass often grows adjacent to perennial grasses such as Sandberg bluegrass and bottlebrush squirreltail. Both of these perennials can initiate spring growth and become green and accessible to grazing animals before the winter rosettes of cheatgrass.[42] Livestock allowed access to such sites too early in the spring may graze almost exclusively on the perennials instead of the cheatgrass.[31]

Fall and Winter Grazing Opportunities

Grazing dormant cheatgrass or other annual grasses in late fall or winter reduces mulch accumulations and enhances seedling establishment of perennials.[21] Also, late fall grazing can target the fall germinating crop of annual grasses, prior to winter dormancy, thereby reducing the vigor of annual grasses the following spring. Grazing during winter dormancy has minor effects on perennial grasses as long as enough residue remains to insulate plant crowns from severe cold. Two-inch residual stubble heights are usually adequate after winter grazing. Browsing shrubs during winter will have minimal impact on shrub vigor as long as utilization does not exceed 50 to 60%.[12, 17, 22] In some areas, sagebrush or



Photos: Jeff Mosley, Montana State University

Young cheatgrass is green and palatable (above), but when the seedheads turn purple (below), the plant is less palatable and the seeds are viable. To prevent the seeds from becoming viable, cheatgrass needs to be grazed before the seedheads turn purple.

other shrub densities may need to be reduced to help perennial grasses and forbs compete with annual grasses. Shrub densities can be reduced with heavy sheep or goat grazing in late autumn (November and December) at stocking rates between 30 to 60 sheep or goat days per acre.[24, 30]

Animal Production Considerations

Although livestock performance is often a secondary objective in a targeted livestock grazing program, few livestock producers will agree to graze their animals to suppress annual grasses if meat or fiber production suffers greatly or variable production costs rise significantly. Grazing in the spring, before seed set and when annual grasses are relatively nutritious, should not materially hinder animal performance. Further, few annual grasses contain alkaloids, terpenes, or other aversive secondary chemicals sufficient to cause toxic effects or low palatability. One exception with cheatgrass is the susceptibility of its seed heads to ergot, a fungus that is poisonous to livestock.

Livestock perform well on annual grass diets in spring, producing weight gains similar to those from uninfested rangeland. For example, yearling ewes gained an average of 0.3 pounds a day from early April to mid May in southern Idaho.[31] Wethers grazing cheatgrass in northwestern Utah also gained 0.3 pounds a day during early May, but gained only 0.01 pounds per day during mid June.[6] Predictably, these weight gains followed the decline in nutritive content of cheatgrass as it matured. Crude protein content declined from 15.4% in early May to 8.2% at the end of May. During the same period, daily dry matter intake decreased from 3.3 to 2.3 pounds per head.[6] Yearling steers in spring gained 1.7 to 2.0 pounds per day on cheatgrass diets in southern Idaho.[32] Animals grazing dormant annual grasses will likely need energy and protein supplements to meet nutrient requirements.

Animals grazing mature or dormant stands of cheatgrass, Japanese brome, medusahead, ripgut brome, or several other annual grasses risk flesh or fleece damage from seeds with long, sharp awns. The awns can become embedded in an animal's nose or mouth, causing cysts and inflammation. In severe cases, these grass awns can penetrate the gums and jaw, causing irritation and infection in a condition called lump jaw. When embedded in fleeces, seeds and awns of annual grasses can reduce the commercial value of wool or hair clips.

Integrated Management

Targeted livestock grazing can be effectively integrated with prescribed fire, herbicides, or mechanical treatments to improve their efficacy. For example, fire removes excess mulch and reduces the number of annual grass seeds in the soil. This in turn greatly reduces the density of annual grass plants the next growing season. However, plants that do establish may produce so many more seeds per plant that total seed production for the site may actually increase by a factor as high as 100.[49] Targeted livestock grazing can be applied in the spring following a fall burn, reducing the vigor of the few annual grass plants that establish and preventing them from producing viable seeds.

Targeted livestock grazing also can be applied before artificial seeding in restoration efforts. Artificial seeding of depleted sites seldom succeeds unless invasive annual grasses are first suppressed. For example, cheatgrass at densities of 64 and 256 plants per square foot competes strongly with crested wheatgrass seedlings, but competes only moderately at cheatgrass densities of four and 16 plants per square foot.[9] Unless the seeded species becomes established and out-competes invasive annual grasses, the annual grass density may exceed pre-treatment levels within one to five years.[48] Prescribed livestock grazing can suppress invasive annual grasses before artificial seeding, especially on steep or rocky terrain or where predicted economic returns are low, and livestock can be used following broadcast seeding to help trample desired seed into the

ground.[16] A high stock density for a brief period on moist ground usually works best. If soils are too wet, excessive trampling damage and soil compaction will occur.

Prescribed fire often is used before artificial seeding to lessen competition between annual grasses and the new seedlings.[5, 37, 49] Targeted livestock grazing can be applied to remove annual grass seedlings that germinate after the fire, preparing the site for artificial seeding with desirable perennials. Drilling the site can be delayed until after the grazing treatment, or the site can be broadcast-seeded immediately before the grazing treatment so livestock can trample in the seeds. Ideally, the site should be re-grazed soon after new seedheads develop on annual grass plants that were grazed earlier in the spring. Similarly, targeted livestock grazing can suppress annual grasses before artificial seeding on sites that have been pre-treated with herbicides[10, 33] or disking.[35]

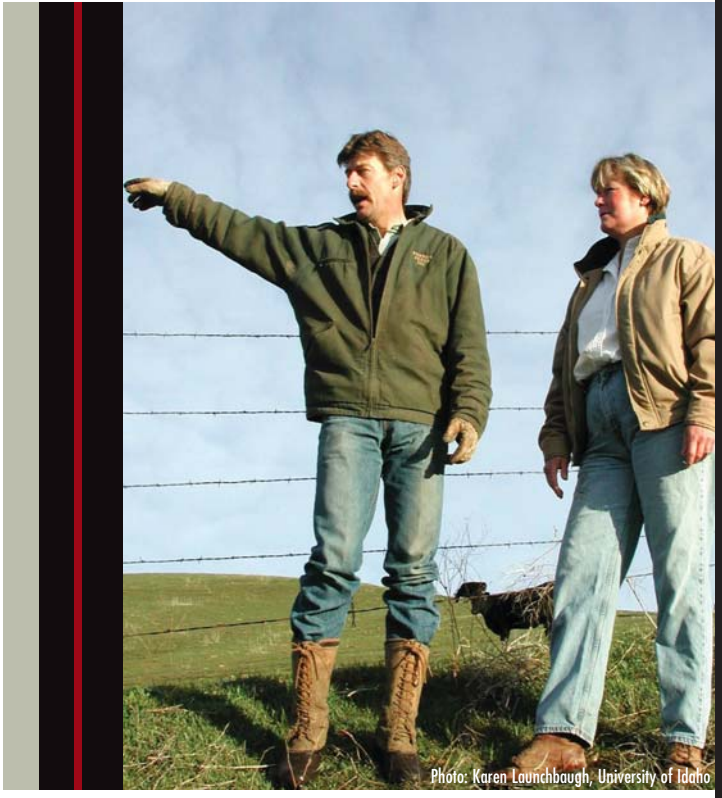


Photo: Karen Launchbaugh, University of Idaho

SUMMARY

Targeted livestock grazing can be used to suppress cheatgrass, medusahead, and other invasive annual grasses where these plants are considered weedy invaders. Yield, density, seed production, and mulch accumulations can be reduced, thereby favoring perennial plant species and improving biological diversity. Targeted livestock grazing also can favor perennial plants by disrupting fine fuel continuity, reducing fine fuel loads, and lengthening fire-free intervals. To limit seed production and yield of invasive annual grasses, livestock grazing should defoliate target plants twice in spring, separated by one to three weeks. Targeted livestock grazing should be repeated in spring for at least two consecutive years. Desirable perennials, if present, will likely suffer if spring grazing occurs for more than two years in a row. Also, targeted livestock grazing applied in winter can reduce the buildup of annual grass mulch to enhance seedling establishment of perennial plants. Livestock grazing to suppress invasive annual grasses is best suited to localized areas, either for protecting existing stands of perennial plants from fire or for aiding the artificial seeding of severely depleted sites. Targeted livestock grazing may work best when integrated with other rangeland restoration tools including prescribed fire, herbicides, disking, and seeding.

Literature Cited

[1]Arnold, G.W., W.R. McManus, I.G. Bush, and J. Ball. 1964. The use of sheep fitted with oesphageal fistulas to measure diet quality. *Australian Journal of Experimental Animal Husbandry* 4:71-79.

[2]Bartolome J.W., W.E. Frost, N.K. McDougald, and M. Connor. 2002. California guidelines for residual dry matter (rdm) management on coastal and foothill annual rangelands. Rangeland Monitoring Series Publication 8092, Oakland, CA: University of California, Division of Agriculture and Natural Resources. 8 p.

[3]Black, J.L. and P.A. Kenney. 1984. Factors affecting diet selection by sheep. 2. Height and density of pasture. *Australian Journal of Agricultural Research* 35:565-578.

[4]Brewer, T.K. 2002. Effects of spring clipping on bluebunch wheatgrass in summer [thesis]. Bozeman, MT: Montana State University. 62 p.

[5]Bunting, S.C., B.M. Kilgore, and C.L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the Northern Great Basin. General Technical Report INT-231, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 33 p.

[6]Cook, C.W. and L.E. Harris. 1952. Nutritive value of cheatgrass and crested wheatgrass on spring ranges of Utah. *Journal of Range Management* 5:331-337.

[7]Daubenmire, R.F. 1940. Plant succession due to overgrazing in the *Agropyron* bunchgrass prairie of southeastern Washington. *Ecology* 21:55-64.

[8]Doran, C.W. 1943. Activities and grazing habits of sheep on summer ranges. *Journal of Forestry* 41:253-258.

[9]Evans, R.A. 1961. Effects of different densities of downy brome (*Bromus tectorum*) on growth and survival of crested wheatgrass *(Agropyron desertorum)* in the greenhouse. *Weeds* 9:216-223.

[10]Evans, R.A., J.A. Young, and R.E. Eckert, Jr. 1983. The application and use of herbicides for brush and weed control. *In:* S.B. Monsen and N. Shaw [EDS.], Managing intermountain rangelands–Improvement of range and wildlife habitats. General Technical Report INT-157, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. p. 32-38.

[11]Finnerty, D.W. and D.L. Klingman. 1962. Life cycles and control studies of some weed brome grasses. *Weeds* 10:40-47.

[12]Garrison, G.A. 1953. Effects of clipping on some range shrubs. *Journal of Range Management* 6:309-317.

[13]George, M.R., R.S. Knight, P.B. Sands, and M.W. Demment. 1989. Intensive grazing management on annual range. *California Agriculture* 43:16-19.

[14]Haferkamp, M.R., R.K. Heitschmidt, and M.G. Karl. 1997. Influence of Japanese brome on western wheatgrass yield. *Journal of Range Management* 50:44-50.

[15]Haferkamp, M.R., J.A. Young, E.E. Grings, M.G. Karl, R.K. Heitschmidt, and M.D. MacNeil. 1994. Japanese brome in the Northern Great Plains. *In*: S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 396-401.

[16]Havstad, K.M. 1994. Sheep grazing as a range improvement tool. *Sheep Research Journal* (Special Issue):72-78.

Literature Cited

[17]Hormay, A.L. 1943. Bitterbrush in California. Research Note 34, Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station. 13 p.

[18]Hormay, A.L. 1944. Moderate grazing pays on California annual-type ranges. Leaflet 239, Washington, DC: U.S. Department of Agriculture, Forest Service. 8 p.

[19]Horton, W.H. 1991. Medusahead: Importance, distribution, and control. *In:* L.F. James, J.O. Evans, M.H. Ralphs, and R.D. Child [EDS.], Noxious range weeds. San Francisco, CA: Westview Press. p. 394-398.

[20]Hulbert, L.C. 1955. Ecological studies of *Bromus tectorum* and other annual brome grasses. *Ecological Monographs* 25:181-213.

[21]Hull, A.C. and J.F. Pechanec. 1947. Cheatgrass – a challenge to range research. *Journal of Forestry* 45:555-564.

[22]Julander, O. 1937. Utilization of browse by wildlife. *Transactions of the North American Wildlife Conference* 2:276-287.

[23]Kothmann, M.M. 1966. Nutrient content of forage ingested in the morning compared to the evening. *Journal of Range Management* 19:95-96.

[24]Laycock, W.A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. *Journal of Range Management* 20:206-213.

[25]Lusk, W.C., M.B. Jones, D.T. Torell, and C.M. McKell. 1961. Medusahead palatability. *Journal of Range Management* 14:248-251.

[26]Megee, C.R. 1938. Wild oats or downy brome. Michigan Agricultural Experiment Station Occasional Bulletin 20:153-156.

[27]Miller, H., D. Clausnitzer, and M.M. Borman. 1999. Medusahead. *In:* R.L. Sheley and J.K. Petroff [EDS.], Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. p. 271-281.

[28]Mosley, J.C. 1996. Prescribed sheep grazing to suppress cheatgrass: A review. *Sheep and Goat Research Journal* 12:74-80.

[29]Mosley, J.C., S.C. Bunting, and M.E. Manoukian. 1999. Cheatgrass. *In:* R.L. Sheley and J.K. Petroff [EDS.], Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. p. 175-188.

[30]Mueggler, W.F. 1950. Effects of spring and fall grazing by sheep on vegetation of the Upper Snake River Plains. *Journal of Range Management* 3:308-315.

[31]Murray, R.B. 1971. Grazing capacity, sheep gains: Cheatgrass, bunchgrass ranges in southern Idaho. *Journal of Range Management* 24:407-409.

[32]Murray, R.B., H.F. Mayland, and P.J. Van Soest. 1978. Growth and nutritional value to cattle of grasses on cheatgrass range in southern Idaho. Research Paper INT-199, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 57 p.

[33]Ogg, A.G, Jr. 1994. A review of the chemical control of downy brome. *In:* S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 194-196.

Literature Cited

[34]Pechanec, J.F. and G. Stewart. 1949. Grazing spring-fall sheep ranges of southern Idaho. Circular 808, Washington, DC: U.S. Department of Agriculture. 34 p.

[35]Pellant, M. 1990. The cheatgrass-wildfire cycle–Are there any solutions? *In:* E.D. McArthur, E.M. Romney, S.D. Smith and P.T. Tueller [EDS.], Proceedings–Symposium on cheatgrass invasion, shrub die-off and other aspects of shrub biology and management. General Technical Report INT-276, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 11-18.

[36]Peters, E.F. and S.C. Bunting. 1994. Fire conditions pre- and post-occurrence of annual grasses on the Snake River Plain. *In:* S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual range lands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 31-36.

[37]Rasmussen, G.A. 1994. Prescribed burning considerations in sagebrush annual grassland communities. *In:* S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 69-70.

[38]Senft, R.L., M.B. Coughenour, D.W. Bailey, L.R. Rittenhouse, O.E. Sala, and D.M. Swift. 1987. Large herbivore foraging and ecological hierarchies. *BioScience* 37:789-799.

[39]Senock, R.S., D.M. Anderson, L.W. Murray, and G.B. Donart. 1993. Tobosa tiller defoliation patterns under rotational and continuous stocking. *Journal of Range Management* 46:500-505.

[40]Tausch, R.J., R.S. Nowak, A.D. Bruner, and J. Smithson. 1994. Effects of simulated fall and early spring grazing on cheatgrass and perennial grass in western Nevada. *In:* S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 113-119.

[41]Thrift, T.M. 2006. Effects of long-term winter-spring grazing on foothill rangeland [thesis]. Bozeman, MT: Montana State University. 59 p.

[42]Tipton, F.H. 1994. Cheatgrass, livestock and rangeland. *In:* S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 414-416.

[43]Vallentine, J.F. 2001. Grazing management. San Diego, CA: Academic Press. 659 p.

[44]Vallentine, J.F. and A.R. Stevens. 1994. Use of livestock to control cheatgrass–A review. In: S.B. Monsen and S.G. Kitchen [EDS.], Proceedings–Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 202-206.

[45]Van Dyne, G.M. and H.F. Heady. 1965. Botanical composition of sheep and cattle diets on a mature annual range. *Hilgardia* 36:465-470.

[46]Whisenant, S.G. 1990. Changing fire frequencies on Idaho's Snake River Plains: Ecological and management implications. *In:* E.D. McArthur, E.M. Romney, S.D. Smith and P.T. Tueller [EDS.], Proceedings–Symposium on cheatgrass invasion, shrub die-off and other aspects of shrub biology and management. General Technical Report INT-276, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. p. 4-10.

Literature Cited

[47]Wright, H.A. and A.W. Bailey. 1982. Fire ecology: United States and southern Canada. New York, NY: John Wiley and Sons. 501 p.

[48]Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state-of-the-art review. General Technical Report INT-58, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 48 p.

[49]Young, J.A. 1983. Principles of weed control and plant manipulation. *In*: S.B. Monsen and N. Shaw [EDS.], Managing intermountain rangelands–Improvement of range and wildlife habitats. General Technical Report INT-157, Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. p. 6-10.

[50]Young, J.A. 1992. Ecology and management of medusahead *(Taeniatherum caput-medusae* ssp. *asperum* [SIMK.] Melderis). *Great Basin Naturalist* 52:245-252.

CHAPTER 9:
Targeted Grazing to Manage Weedy Brush and Trees

By Erika Campbell and Charles A. Taylor, Jr.

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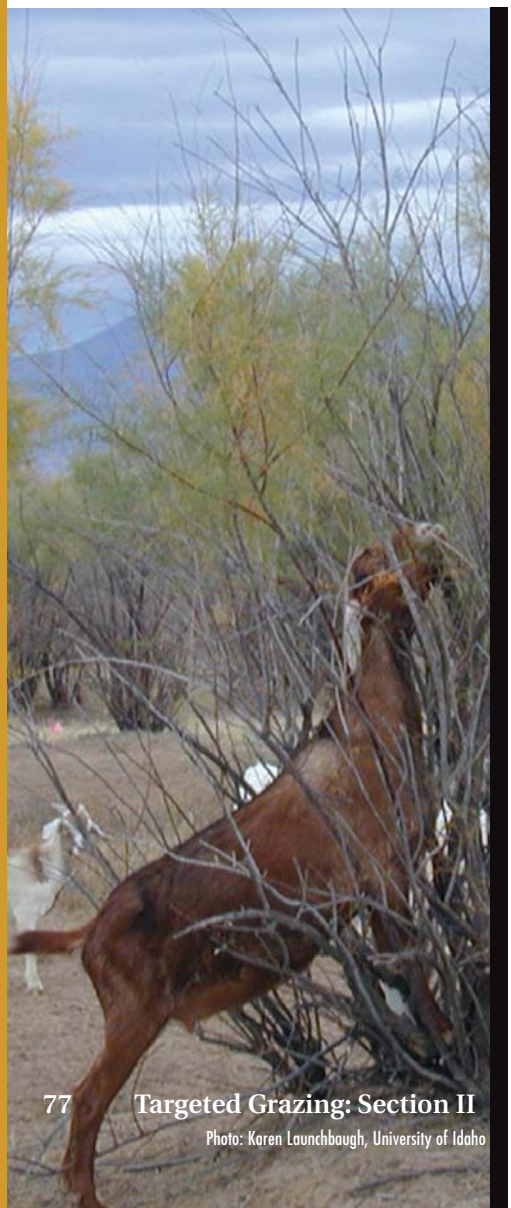

Photo: Karen Launchbaugh, University of Idaho

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.

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]

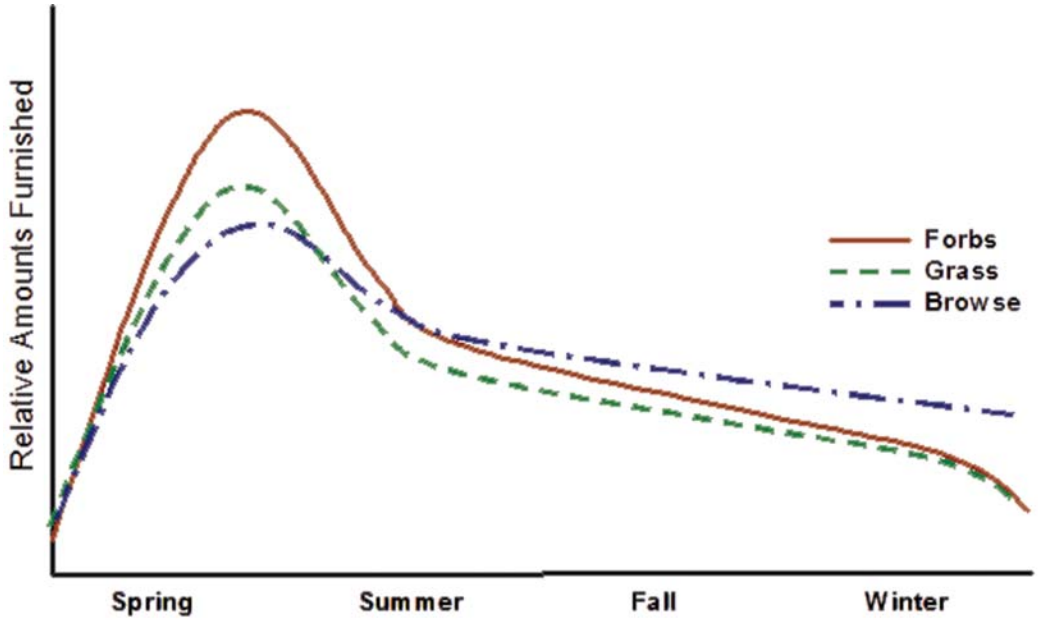

Figure 1. Seasonal trends in protein, minerals, and vitamins in forest and rangeland forages

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

Gorse *(Ulex europaeus)*

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

Lambert et al. 1989

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

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.

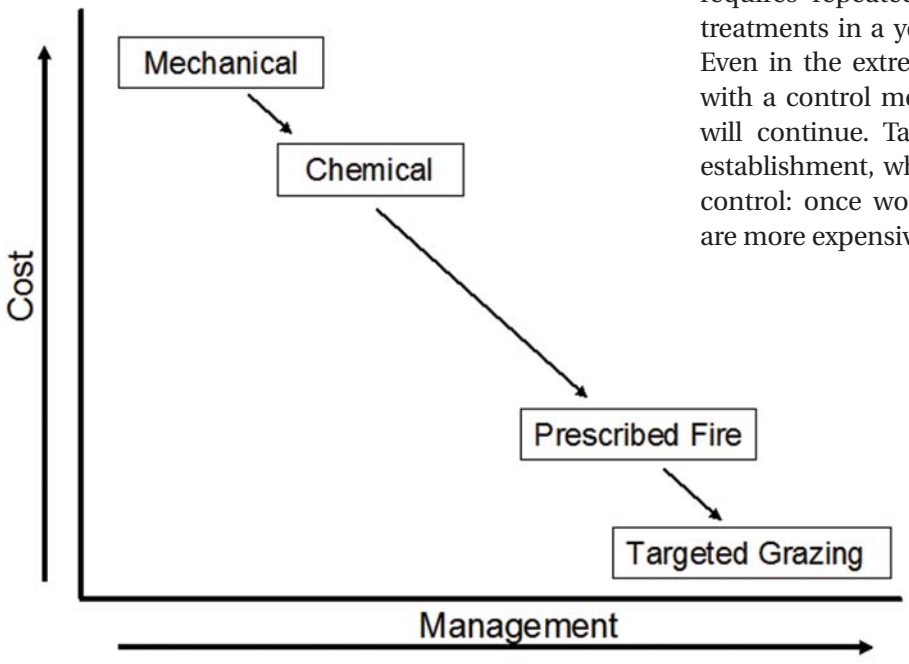

Figure 2. Relative inputs of management expertise and costs to accomplish brush management by various approaches.

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.

Literature Cited

[1]Azim, A., A.G. Khan, J. Ahmad, M. Ayaz, and I.H. Mirza. 2002. Nutritional evaluation of fodder tree leaves with goats. *Asian-Australian Journal of Animal Science* 15:34-37.

[2]Becker, R. and O.K. Grosjean. 1980. A compositional study of pods of two varieties of mesquite (*Prosopis glandulosa*, P. velutina). *Journal of Agricultural Food Chemistry* 28:22-25.

[3]Bowns, J.E. and N.E. West. 1976. Blackbrush (*Coleogyne ramosissima* Torr.) on southwestern Utah rangelands. Logan, UT: Research Report 27 Utah Agricultural Experiment Station.

[4]Campbell, E. and C.A. Taylor, JR. In Press. Monotperpene production in redberry juniper foliage following fire. *Rangeland Ecology and Managment* (In Press).

[5]Canon, S.K., P.J. Urness, N.V. DeByle. 1987. Habitat selection, foraging behavior, and dietary nutrition of elk in burned aspen forest. *Journal of Range Management* 40:443-438.

[6]Cheeke, P.R. and L.R. Shull. 1985. Natural toxicants in feeds and poisonous plants. AVI Pub. Co., Westport, Conn.

[7]Dick, B.L. and P.J. Urness. 1991. Nutritional value of fresh Gambel oak browse for Spanish goats. *Journal of Range Management* 44:361-364.

[8]Gastler, G.F., A.L. Moxon and W.T. McKean. 1951. Composition of some plants eaten by deer in the Black Hills of South Dakota. *Journal of Wildlife Management* 15:352-357.

[9]Guengerich, F.P. 1995. Influence of nutrients and other dietary materials on cytochrome p-450 enzymes. *American Journal of Clinical Nutrition* 61:651S-658S.

[10]Hart, S.P. 2001. Recent perspectives in using goats for vegetation management in the USA. *Journal of Dairy Science* 84:E170-E176.

[11]Huston, J.E., B.S. Rector, L.B. Merrill and B.S. Engdahl. 1981. Nutritional value of range plants in the Edwards Plateau region of Texas. College Station, TX: Texas Agricultural Experiment Station Bulletin B-1357.

[12]Kelsey, R.G., J.E. Stephens and F. Sharizadeh. 1982. The chemical constituents of sagebrush foliage and their isolation. *Journal of Range Management* 35:617-622.

[13]Kilgore, B.M. and H.H. Biswell. 1971. Seedling germination following fire in a giant Sequoia forest. *California Agriculture* 25:8-10.

[14]Laca, E.A., L.A. Shipley and E.D. Reid. 2001. Structural anti-quality characteristics of range and pasture plants. *Journal of Range Management* 54:413-419.

[15]Lambert, M. G., G.A. Jung, H.W. Harpster, and J. Lee. 1989. Forage shrubs in North Island hill country. 4. Chemical composition and conclusions. *New Zealand Journal of Agricultural Research* 32:499-506.

[16]Landau, S., N. Silanikove, Z. Nitsan, D. Barkai, H. Baram, F.D. Provenza and A. Perevolotsky. 2000. Short-term changes in eating patterns explain the effects of condensed tannins on feed intake in heifers. *Applied Animal Behaviour Science* 69:199-213.

[17]Mabry, T.J. and J.E. Gill. 1979. Sesquiterpene lactones and other terpenoids. *In:* G.A. Rosenthal and D.H Janzen [EDS.] Herbivores: Their interaction with secondary plant metabolites. New York, NY: Academic Press. p. 501-537.

Literature Cited

[18]Merril, L.B. and C.A. Taylor. 1981. Diet selection, grazing habits, and the place of goats in range management. *In:* C. Gall [EDS.] Goat Production. New York, NY: Academic Press. p.233-249.

[19]Nelson, A.B., C.H. Herbel, and H.M. Jackson. 1970. Chemical composition of forage species grazed by cattle on an arid New Mexico range. Bulletin 561. Las Cruces, NM: New Mexico State University, Agricultural Experiment Station.

[20]Ngugi, R.K., F.C. Hinds and J. Powell. 1995. Mountain big sagebrush browse decreases dry matter intake, digestibility, and nutritive quality of sheep diets. *Journal of Range Management* 48:487-492.

[21]Provenza, F.D., J.J. Lynch, E.A.Burritt, and C.B. Scott. 1994. How goats learn to distinguish between novel foods that differ in postingestive consequences. *Journal of Chemical Ecology* 20:609-624.

[22]Richardson, C.L. 2000. Factors affecting deer diets and nutrition. Texas Agricultural Experiment Station Publication E-40. *Available online:* http://tcebookstore.org/getfile.cfm?pubid=1251. *Accessed 27 August 2006.*

[23]Riddle, R.R., C.A. Taylor, Jr., M.M. Kothmann and J.E. Huston. 1996. Volatile oil contents of ashe and redberry juniper and its relationship to preference by Angora and Spanish goats. *Journal of Range Management* 49:35-41.

[24]Short, H.L. D.R. Dietz, and E.E. Remmenga. 1966. Selected nutrients in mule deer browse plants. *Ecology* 47:222-229.

[25]Snowder G.D., J.W. Walker, K.L. Launchbaugh and L.D. Van Vleck. 2001. Genetic and phenotypic parameters for dietary selection of Mountain Big Sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb) Beetle) in Rambouillet sheep. *Journal of Animal Science* 79:486-492.

[26]Taylor, C.A., Jr., and S.D. Fuhlendorf. 2003. Contribution of goats to the sustainability of Edwards plateau rangelands. Texas Agricultural Experiment Station Technical Report 03-1, College Station, TX.

[27]Taylor, C.A., Jr., E.S. Campbell, C.J. Lupton, D.F. Waldron, and J.W. Walker. 2005. Improving the use of goats to manage Juniper. Texas Agricultural Experiment Station. Ann. Prog. Rep. *Texas Food and Fibers Communications*: 9-17.

[28]Urness, P.J. 1966. Influence of range improvement practices on composition, production, and utilization of *Artemisia* deer winter range in central Oregon. [dissertation]. Corvallis, OR: Oregon State University.

[29]Villalba, J.J., F.D. Provenza, and R.E. Banner. 2002. Influence of macronutrients and activated charcoal on intake of sagebrush by sheep and goats. *Journal of Animal Science* 80:2099-2109.

[30]Warren, L., J.M. Shelton, D.N. Ueckert and G.D. Snowder, 1983. Influence of heredity on the selection of various forage species by goats. Texas Agric. Exp. Sta. CPR 4171, Texas A&M Univ., College Station. pp 72-81.

[31]Warren, L.E., L.E. Warren, D.N. Ueckert and J.M. Shelton. 1984. Comparative diets of rambouillet, barbado, and karakul sheep and Spanish and angora goats. *Journal of Range Management* 37:172-180.

[32]Wisnewski, J.A., D.E. Moody, B.D Hammock and L.R. Shull. 1987. Interlobular distribution of hepatic xenobiotic-metabolizing enzyme activities in cattle, goats and sheep. *Journal of Animal Science* 64:210-215.

Photo: Craig Madsen, Healing Hooves, Edwall, WA

CHAPTER 10:
Applying Targeted Grazing to Coniferous Forest Management in Western North America

By Steven Sharrow

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Photo: ASI

10 KEY POINTS

- Concern over mechanical and chemical treatments is prompting forest managers to opt for grazing to manage vegetation.
- Grazing in open-canopy forests can manage vegetation that competes with trees for water and nutrients.
- Several factors determine animal selection, especially the type of plants growing under and between the trees.
- Livestock accustomed to being managed as a herd will likely remain together when moved in a forest.
- Sheep grazing young plantations need adequate palatable forage.
- Flock tightness may need to be adjusted to meet specific prescription needs.
- The palatability of conifer foliage declines rapidly as it matures.
- Lower quality forage in silvicultural prescriptions may cause seasonal weight changes.
- Increased conifer growth is a main benefit from targeted livestock grazing.
- Browsing seldom kills planted conifers unless the trees are totally defoliated.

INTRODUCTION

Forestlands in North America have long served as important forage sources for both wildlife and livestock. In the West, forest management has progressed from an emphasis on livestock grazing as the primary land use up to around 1910, then through a period emphasizing tree production until the 1960s, and now to a period emphasizing multiple use management and environmental values. Intensive forest management that focused on commercial tree production since the 1950s is being reevaluated in light of new interest in forest ecosystem health and environmental concerns about clear cutting, slash burning, and chemical weed control.

Traditionally, understory vegetation in established forests and plantations was managed by mechanical and chemical removal. Mechanical methods are expensive, often several times more costly than using livestock or herbicides. Public concern about using chemicals to suppress unwanted vegetation in plantations of young trees is prompting many forest managers to take a closer look at livestock grazing as a more environmentally acceptable and cost-effective management tool.[14, 32]

Livestock grazing has long been recognized as having an impact – either negative or positive – on forest vegetation. Colville commented in 1898 about browsing damage to young conifers from heavy sheep grazing that had been under way in the Oregon Cascades for about 11 years prior to his report. On the other hand, Sparhawk noted in 1918 the usefulness of sheep grazing to reduce fire hazard in central Idaho.

Vegetation Management Opportunities

Targeted livestock grazing offers many opportunities for managing coniferous forests including pines, firs, spruce, hemlock, and larch. Grazing applications include removing biomass from grasses, forbs, and shrubs to prepare a site for planting tree seedlings; to reduce competition with young trees; to reduce snow press from tall grasses and forbs; as a pre-thinning treatment to remove shrubs and make thinning easier; as a post-thinning treatment to reduce slash; and to remove forest floor and ladder fuels to reduce fire risk or to create firebreaks.

In open-canopy forests such as ponderosa pine, lodgepole pine, or pinyon pine, grazing can be used to manage ground vegetation that competes with trees for soil water and nutrients. Decades of fire suppression in these historically open forests has resulted in expansive closed-canopy forests today. The accumulation of combustible fuels in these forests has rendered them highly vulnerable to wildfire. Targeted grazing can reduce vegetation fuel loads and ladder fuels to help minimize the risk of destructive wildfires and protect fences, houses, and other rural infrastructure.

Successes in using targeted grazing on forestlands are widely reported. In young conifer plantations, livestock grazing has controlled both brush[21, 38, 43, 44] and herbaceous vegetation.[8, 39] Thomas (1985) reported that sheep grazing in newly established conifer stands in the Tahoe National Forest reduced deerbrush canopy cover from 35-45% before grazing to 10-20% after grazing with only 1-2% of conifers damaged. In Oregon's coastal forest, sheep grazing substantially reduced vine maple, salmonberry, thimbleberry, and red alder with little accompanying damage to Douglas fir trees.[38, 40] Sheep graze agroforests (trees grown in improved pastures) in New Zealand,[20, 29] Australia,[4] and Chile[36] as a means of harvesting the understory grass crop without harming young Radiata pine being grown for saw timber. In western Oregon, up to 50% of the grass-clover forage produced in young Douglas fir agroforests can be harvested by sheep without significant damage to trees.[39] Kabzems (1992) mentioned the successful use of sheep grazing in British Columbia boreal forests to reduce the height of Canada reedgrass and fireweed in young conifer stands, which reduces the danger of young trees being crushed by snow press. Sheep also have grazed brush from sites in preparation for tree planting.[44]

Criteria for Animal Selection

When selecting animals for grazing in forests and plantations, one must consider the type, breed, and class of livestock and the size and topography of the area to be managed with targeted grazing. Of particular importance is whether the plant community between and under coniferous trees is predominantly herbaceous grasses and forbs or woody shrubs. Cattle have

been used in some open forest plantations to reduce biomass of grasses and forbs between plants. However, cattle generally cause greater trampling damage than sheep or goats.[1] Sheep tend to avoid browsing coniferous trees in favor of forbs and grasses. Sheep also travel frequently while grazing, so tree browsing is generally spread fairly evenly among trees in grazed areas.[39] Goats are more likely than sheep to strip bark from woody plants. While this can damage trees, it also provides an opportunity to use goats to girdle and kill target brush and hardwood tree species, even after the vegetation has grown quite large. Although cattle can damage young conifers by browsing and trampling, sheep and goats impact trees predominantly by browsing[15, 39] and, to a lesser extent, by stripping bark.[3, 39]

Dry ewes or nannies, because of their lower nutrient requirements and greater ease of herding, generally are preferred over those with lambs or kids. Little has been published about grazing rams or wethers in timbered pasture, but practitioners have noted that they can be used quite effectively.

Yearlings have been used to manage forest understory, but they browse both shrubs and young conifers more readily than do older ewes or lambs.[14, 31] Gillingham et al. (1976) observed that on agroforests grazed in the spring, yearling Romney ewes browsed at least twice as many Radiata pine trees as mature Romney ewes. Thomas (1985) preferred using ewes older than four years over younger sheep because the older sheep appeared to more selectively avoid browsing conifers.

The breed of sheep appears to make little difference in the risk of grazing damage to young trees.[31] However, breed selection may be important because breeds differ in their herding tendencies. Merino or Rambouillet crossbreeds like Columbia are easier to herd because of their greater tendency to form a tight flock. Farm sheep breeds like Suffolk, Romney, and Hampshire have been used successfully for fenced agroforest grazing[39] and for open-herded forest grazing.[26] However, their tendency to form numerous small groups makes controlling large numbers of them a challenge in steep, brushy country.

Learning is an important part of animal behavior. Livestock that are accustomed to being managed as a herd are more likely to remain together when moved to the forest. Likewise, animals that are wintered under trees or otherwise accustomed to eating conifer needles are more likely to continue this habit. Because livestock can learn from observing each other, it is advisable to quickly identify and remove individuals that are causing problems.

Livestock used in targeted forest grazing are entering habitat that most often supports other native grazing and predatory animals. It is important that health protocols be adequate to ensure that parasite or disease transfer does not occur between livestock and deer, elk, big horn sheep, or other native herbivores. It is equally important that bears, cougars, wolverines, or other local predators do not become aware of livestock as possible prey by consuming carcasses of livestock that have died in the forest. Bringing healthy livestock onto the forest and properly disposing of any dead animals are crucial in avoiding problems with local wildlife.

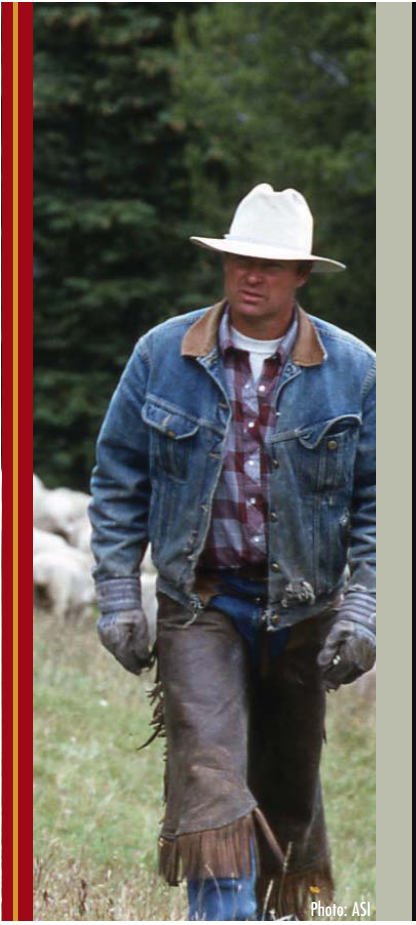
Grazing Strategies in Coniferous Forests

Using livestock to control weeds in young conifer stands depends on 1) the willingness of animal to consume target weed species, 2) the ability to minimize conifer damage, and 3) slow regeneration of the target species. Given the opportunity, sheep often eat a small amount of browse even when young herbaceous forage is plentiful. This may explain the observation that conifer browsing by sheep is a greater problem when timber plantations lack alternative browse plants.[14, 39] When sheep are grazed in young tree plantations, adequate palatable forage should always be available. When grass is mature and other browse is unavailable, sheep will eat conifer foliage.[31]

Small areas without stumps, steep slopes, stream channels, or other impediments may be fenced for livestock control. Areas where fencing is impractical because of size or terrain are best grazed using open-herded techniques with a shepherd and herding dogs. Generally, the economic minimum for open-herded forest grazing is 600 to 1,000 sheep, with flocks of 1,500 animals being common.

The herd impact includes both foraging and physical effects. Tight flocks actively moved through a site tend to trample and walk down more plants than they eat. This impact can be especially useful in northern forests for reducing snow press, where tall herbaceous vegetation collapses under the weight of snow, crushing and deforming the trees. Trees with weakly attached buds, like spruce, may be damaged by rubbing as animals pass by. Managing loose flocks that are allowed to move slowly through an area can reduce damage from trampling. To meet specific prescription needs, flock tightness may be adjusted by altering herding practices and herd composition.

Tree species vary in palatability. Generally, sheep and goats prefer to browse hardwoods over conifers.[22, 24] Phelps (1979) reported little browsing on trees in a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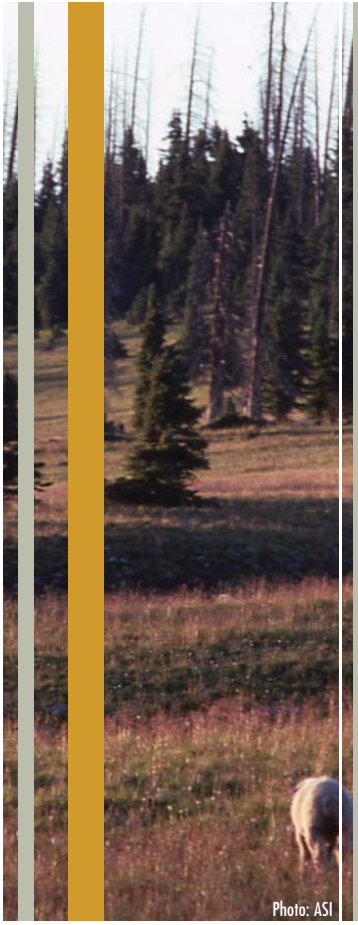
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mixed stand of Pacific silver fir, Douglas fir, and western hemlock in which herded sheep consumed about 47% of the understory vegetation. Among conifers, spruce is unlikely to be browsed even under high grazing pressure[2, 29] while Douglas fir, ponderosa pine, western hemlock, western white pine, and western larch are frequently grazed.[13] Ellen (1990) listed pine, Douglas fir, and spruce in order of decreasing susceptibility to sheep browsing. White fir has been reported to be more readily browsed than Douglas fir, ponderosa pine, or sugar pine.[35] Western red cedar is more palatable to browsing than Douglas fir.[17]

Season strongly affects the levels of browsing on conifers. The palatability of conifer foliage declines rapidly as it matures.[24] Sheep and goats are more likely to browse trees shortly after bud break in the spring when new light-green needles are present.[12, 25] Mature needles (fully expanded and dark green) are much less attractive to browsing animals than immature needles, and old needles from previous years' growth are seldom consumed. Spring bud burst in conifers often coincides with initiation of spring growth of associated grasses and forbs, both of which are more palatable than young conifers. By the time grasses and forbs have matured, conifer foliage has also matured. During the summer, forest shrubs and young hardwood trees generally are more palatable to sheep and goats than conifers. So, while palatability of conifer foliage varies substantially throughout the season, sheep seldom seek it over other available forage.[24]

The seasonal pattern of forage value and palatability suggests a two-pass grazing strategy where both grasses and shrubs compete with young trees. A flock or herd can be moved quickly from plantation to plantation during the spring to harvest the fresh green forage, then returned for a longer stay after grasses and forbs have matured in early summer to consume brush, walk down tall vegetation, reduce fire fuel loads, and achieve other silvicultural prescription goals.

Sheep rarely chew or strip bark from conifer trees in forest plantations. Debarking in open-forest grazing has generally been negligible except in areas where livestock are concentrated, as on bedding grounds. Research has reported that in intensively grazed pastures sheep debarked 2-7% of trees to some extent.[3, 39] Debarking was concentrated on smaller trees in the stand,[3] especially near bedding areas.[39] Debarking rarely kills the tree. However, trees stripped of bark are more susceptible to attack by insects or pathogens. Tree growth is unaffected by debarking unless more than 50% girdling occurs.[28, 39]

Animal Production Considerations

Sheep or goats applied in silvicultural prescriptions to manage woody plants in timber plantations often consume lower quality forage than if allowed to graze freely, resulting in lower diet quality and seasonal weight gains. Most woody species targeted for grazing, including woody vines, shrubs, and young hardwood trees, are green in the summer when grasses and forbs have matured, so sheep and goats will readily eat them. Several studies have compared weight gains of sheep browsing in forest clear cuts and local pastures. Phelps (1979) reported that ewes lost an average of 23 pounds per ewe during a summer of grazing Douglas fir/western hemlock forest in the Cascade Mountains of Washington. Producers grazing sheep in clear-cut spruce forest in British Columbia reported that while sheep gained weight on the forest, it was 68% less than sheep grazing local irrigated pasture.[41] During a four-year study, ewes grazing young Douglas fir forest in the spring lost weight, while ewes and lambs grazing local improved pasture gained weight.[26] In the summer, however, weight losses were similar for dry ewes on both forest and local pasture. Poor summer weight gains were probably caused by forcing sheep to eat brush that was relatively high in tannin, which reduces protein availability in the animal's stomach. Few studies have been done to examine goat production in the management of coniferous forests. However, goats are better able to tolerate plant chemical defenses such as tannins, and their performance grazing shrubs would be expected to be better than that of sheep or cattle. Goats, like sheep, are very selective grazers that are trying to obtain a highly nutritious diet. Although more likely to consume shrubs than are cattle or sheep, they often select young green grasses and forbs before making shrubs a large part of their diet.

Effectiveness and Integrated Management

Increased growth of conifers in grazed plantations is often reported as a main benefit of livestock grazing (Table 1). Silvicultural management, including grazing treatments, generally affects conifer diameter growth more than height growth.[40] While diameter grows any time resources and climate are adequate, height and branch length increase only from bud break until the cells contained in the bud are all fully extended. Reduction of competing vegetation will have its greatest impact on tree growth during the resource-limited portion of the growing season when trees have completed height growth but are still increasing in diameter. As a result of livestock grazing, ponderosa pine height increased 13-15% more than without grazing while the diameter increased 9-27%. The increases were 38% in height and 61% in diameter for western larch and 44% in height and 56% in diameter for western white pine.[9, 21] Conifers in these grazed pastures increased their growth because they have less competition,[9, 40] more retained soil moisture,[9, 15, 23] and more rapid nutrient cycling.[23]

Table 1. The increased diameter and height of Douglas firs in a targeted grazing situation compared to ungrazed sites. Values are expressed as a percent greater than trees on an ungrazed site.

Livestock	Diameter	Height	Age *	Source of Data
	----- % increase ----			
Sheep	8	10	33	Jaindl and Sharrow 1988
Sheep	--	27	12	Hedrick and Keniston 1966
Cattle	31	7	3	Doescher et al. 1989
Sheep	7	5	6-8	Sharrow et al. 1989
Cattle	26	18	18	Krueger and Vavra 1984
Sheep	22	6	11	Sharrow et al. 1992b
Sheep	--	20	10	Cleary 1978

* Years since planting at time of measurement

Another long-term benefit of grazing results from a process called competitive exclusion, in which one species benefits when a potentially troublesome competitor is excluded. An example can be found in Oregon where growth of Douglas fir trees was initially reduced by sheep browsing trees in a grass-seeded, clear-cut coastal forest. The combination of grass competition and grazing slowed establishment of red alder (the potentially troublesome competitor) such that 10 years later, Douglas fir timber basal area was 50% greater in grazed portions of the clear cut.[40] Total tree basal area was similar for grazed and ungrazed units, but the ungrazed areas were half Douglas fir and half alder, while almost all of the tree basal area where sheep grazed was Douglas fir. Short-term studies of tree response may be misleading about the true benefits of grazing.

Conifer regeneration can be damaged by browsing, particularly when sheep are poorly controlled or plantations are overgrazed.[30] In his review of the impacts of mammal damage in temperate forests, Gill (1992) noted that the potential of tree seedlings to survive after browsing is directly related to tree size. Younger trees are generally less likely to survive a browsing event than older ones. Tree mortality is greatly reduced after trees reach a critical age and size. The time needed to reach this stage varies with tree species and appears to be about one year for Douglas fir[7] and slash pine.[27] Two-year-old trees are planted most commonly in commercial forests, so browsing seldom kills planted conifers unless the trees are totally defoliated.[7, 27] For example, Sharrow et al. (1992b) reported no mortality of trees in a three- to four-year-old Douglas fir plantation heavily grazed by both deer and sheep even though some trees lost 90% of their new needles each of two consecutive years. Pearson (1931) observed that ponderosa pine seedlings completely defoliated by livestock generally died, while those with even a single fascicle of needles remaining after grazing often survived. Reduced tree growth rather than mortality is the most likely result of browsing damage.

When conifers are browsed, the associated understory plants are generally also defoliated. The benefit to the conifer trees from reducing competition of grasses and shrubs often makes up for the damaging effect of losing tree foliage to browsing.[15] Conifers tolerate high levels of lateral branch defoliation without appreciable loss of growth. More than 50% of a tree's foliage must by defoliated before growth is measurably reduced.[27] Even then, growth reductions may not be dramatic. Loss of the terminal leader (the uppermost stem that is the extension of the main trunk) is more detrimental to future tree growth than is the removal of lateral foliage[33, 40] perhaps because of the role the terminal buds play in hormonal regulation (apical dominance) or the potential for future growth that their buds represent.[40] When the terminal leader on young Douglas fir trees remained intact after 75% defoliation of current year's lateral branch foliage, the height was not reduced and the diameter growth was reduced by only 1.5%.[33] This is why tree producers are more concerned about protecting terminal leaders than lateral branches.

Photo: ASI

Literature Cited

[1]Adams, S. 1975. Sheep and cattle grazing in forests: A review. *Journal of Applied Ecology* 12:143-152.

[2]Adams, S.N. 1976. Sheep grazing in a young sitka spruce plantation. *Journal of Applied Ecology* 13:507-511.

[3]Anderson, G.W., M. Hawke, and R.W. Moore. 1985. Pine needle consumption and bark stripping by sheep grazing annual pastures in young stands of widely spaced *Pinus radiata* and *Pinus pinaster. Agroforestry Systems* 3:37-45.

[4]Anderson, G.W., R.W. Moore, and P.J. Jenkins. 1988. The integration of pasture, livestock, and widely spaced pine in South West Australia. *Agroforestry Systems* 6:195-211.

[5]Cleary, B.D. 1978. Vegetation management and its importance in reforestation. Oregon State University, Forest Resources Lab., Corvallis. Res. Note 60. 4.

[6]Colville, F.V. 1898. Forest growth and sheep grazing. USDA Division of Forestry Bulletin. Number16. 54 p.

[7]Dimock, E.J. II. 1970. Ten-year height growth of Douglas-fir damaged by hare and deer. *Journal of Forestry* 68:285-288.

[8]Doescher, P.S., S.D. Tesch, and M. Alejandro-Castro. 1987. Livestock grazing: a silvicultural tool for plantation establishment. *Journal of Forestry* 85:29-37.

[9]Doescher, P.S., S.D. Tesch, and W.E. Drewien. 1989. Water relations and growth of conifer seedlings during three years of cattle grazing on a southwestern Oregon plantation. *Northwest Science* 63:232-240.

[10]Ellen, G. 1990. An examination of the cost benefit of sheep grazing to significantly reduce competing vegetation on conifer plantations in the Clearwater Forest District. *In:* P. Dewar and R. Greene [EDS.]. Sheep browsing in silviculture. Symposium Proceedings, Courtenay, B.C. p. 5-17.

[11]Gill, R.M.A. 1992. A review of damage by mammals in north temperate forests. 3. Impact on trees and forests. *Forestry* 65:363-388.

[12]Gillingham, A.G., B.L. Klomp, and S.E. Peterson. 1976. Stock and pasture management for establishment of Radiata pine in farmland. Proc. *New Zealand Grasslands Associasion* 37:38-51.

[13]Graham, R.T., J.L. Kingery, and L.A. Volland. 1992. Livestock and forest management interactions. *In:* H.C. Black [ED.. Silvicultural approaches to animal damage management in Pacific Northwest forests. USDA Forest Service General Technical Report. PNW GTR-287. p. 351-364

[14]Greiman, H.L. 1988. Sheep grazing in conifer plantations. *Rangelands* 10:99-101.

[15]Hall, F.C., D.W. Hedrick, and R.F. Keniston. 1959. Grazing and Douglas-fir establishment in the Oregon white oak type. *Journal of Forestry* 57:98-103.

[16]Hedrick, D.W. and R.F. Keniston. 1966. Grazing and Douglas-fir growth in the Oregon white-oak type. *Journal of Forestry* 64:735-738.

[17]Howell, H.B. 1948. The use of logged off land. USDA Yearbook of Agriculture. p. 594-599.

[18]Jaindl, R.G. and S.H. Sharrow. 1988. Oak/Douglas-fir/sheep: A three-crop silvopastoral system. *Agroforestry Systems* 6:147-152.

Literature Cited

[19]Kabzems, R. 1992. Sheep grazing as a silvicultural tool for *Calamagrostis* control in the BWBS. Internal Report, Fort St. John Forest District. Ministry of Forests, British Columbia. 7p.

[20]Knowles, R.L. 1991. New Zealand experience with silvopastoral systems : A review. *Forest Ecology and Management* 45:251-267.

[21]Krueger, W.C. and M. Vavra. 1984. Twentieth year results from a plantation grazing study. 20-24. IN: Research in rangeland management. Oregon Agriculture Experimental Station Special Report 715. p. 20-24

[22]Lavender, D.P., R. Parish, C.M. Johnson, G. Montgomery, A. Vyse, R.A. Willis, and D. Winston. 1990. Regenerating British Columbia's forests. University of British Columbia Press, Vancouver. 372.

[23]Leininger, W.C. 1984. Silvicultural impacts of sheep grazing in Oregon's coast range. Ph.D. Dissertation, Oregon State University, Corvallis, OR. 203.

[24]Leininger, W.C. and S.H. Sharrow. 1987. Seasonal diets of herded sheep grazing Douglas-fir plantations. *Journal of Range Management* 40:551-555.

[25]Leininger, W.C. and S.H. Sharrow. 1989. Seasonal browsing of Douglas-fir seedlings by sheep. *Western Journal of Applied Forestry* 4:73-76.

[26]Leininger, W.C., S.H. Sharrow, and B. Rhodes. 1989. Sheep production in coastal Oregon Douglas-fir plantations. *Northwest Science* 63:195-200.

[27]Lewis, C.E. 1980a. Simulated cattle injury to planted slash pine: Defoliation. *Journal of Range Management* 33:345-348.

[28]Lewis, C.E. 1980b. Simulated cattle injury to planted slash pine: Girdling. *Journal of Range Management* 33:337-340.

[29]MacBrayne, C.G. 1981. Forest-grazing: What can Britain learn from New Zealand? *Scottish Forestry* 35:22-31.

[30]Maki, T.E. and W.F. Mann Jr. 1951. Some effects of sheep grazing on longleaf pine. *Journal of Forestry* 49:278-281.

[31]McKinnell, F.H. 1975. Control of weeds in Radiata pine plantations by sheep grazing. *Journal of Austrailian Forest Resources* 6:1-4.

[32]Newsome, T., B. Wikeem, and C. Sutherlan. 1995. Sheep grazing guidelines for managing vegetation on forest plantations in British Columbia. British Columbia Ministry of Forests Research Program. Land Management Handbook 34. *Available at:* http://www.for.gov.bc.ca/hfd/pubs/docs/lmh/Lmh34.pdf. *Accessed 23 August 2006.*

[33]Osman, K.A. and S.H. Sharrow. 1993. Growth responses of Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) to defoliation. *Forest Ecology and Management* 60:105-117.

[34]Pearson, G.A. 1931. Recovery of western yellow pine seedlings from injury by grazing animals. *Journal of Forestry* 29:876-894.

[35]Pearson, G.A. 1950. Management of ponderosa pine in the Southwest. USDA Agriculture Monogram Number 6. p. 218.

Literature Cited

[36]Penaloza, R., M. Herve, and L. Sobarzo. 1985. Applied research on multiple land use through silvopastoral system in Southern Chile. *Agroforestry Systems* 3:59-77.

[37]Phelps, N.L. 1979. Sheep grazing on certain clearcut harvest units of the Beckler River drainage of western Washington. [thesis], Pullman, WA: Washington State University

[38]Sharrow, S.H., W.C. Leininger, and B. Rhodes. 1989. Sheep grazing as a silvicultural tool to suppress brush. *Journal of Range Management* 42:2-4.

[39]Sharrow, S.H., D.H. Carlson, W.H. Emmingham, and D.P. Lavender. 1992a. Direct impacts of sheep upon Douglas-fir trees in two agrosilvopastoral systems. *Agroforestry Systems* 19:223-232.

[40]Sharrow, S.H., W.C. Leininger, and K.A. Osman. 1992b. Sheep grazing effects on coastal Douglas-fir forest growth: a ten-year perspective. *Forest Ecology and Management* 50:75-84.

[41]Smith, A.V. 1990. Sheep grazing on spruce plantations to aid in forestry renewal. Report Number 2 to the British Columbia Sheep Grazing Association.

[42]Sparhawk, W.N. 1918. Effect of grazing upon western yellow pine reproduction in central Idaho. USDA Bulletin Number 738. 31p.

[43]Thomas, D.F. 1985. The use of sheep to control competing vegetation in conifer plantations of the Downieville Ranger District, Tahoe National Forest: 1981-1984. *In:* D.M. Baumgartner, R.J. Boyd, D.W. Breuer, and D.L. Miller [Eds.]. Weed control for forest productivity in the interior west. Pullman, WA: Symposium Proc. Washington State University Extension Service. p. 88-91.

[44]Wood, G.M. 1987. Animals for biological brush control. *Agronomy Journal* 79:319-321.

CHAPTER 11:
Targeted Grazing with Sheep and Goats in Orchard Settings

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Photo: Ron Daines, Logan, UT

10 KEY POINTS

- Orchard trees planted in traditional wide-spaced patterns are well suited to targeted grazing.
- Ground cover must be managed in orchards for orchard health and productivity.
- Excess ground cover competes with trees for water and nutrients.
- Sheep and goats have been used for centuries to graze orchard understory vegetation.
- Livestock must be monitored carefully to avoid overgrazing or browsing.
- The number of animals needed for targeted grazing fluctuates during the growing season.
- Orchard and vineyard grazing requires fencing, access to water, and a secure holding area.
- Livestock should be removed when the orchard is wet.
- Actively growing grass and weeds can have high forage value for livestock.
- Collaboration with other orchard and vineyard growers could facilitate targeted grazing.

VEGETATION MANAGEMENT OPPORTUNITIES

About 3 million acres of non-citrus tree fruit and nut orchards are grown in the United States,[19] much with the potential to use sheep and goats to manage orchard floor vegetation. Deciduous, non-citrus trees are grown on 2 million acres, producing apples, apricots, avocados, cherries, dates, figs, grapes, guavas, kiwifruit, nectarines, olives, papayas, peaches, and pears. Another million acres produce nuts, including almonds, hazelnuts, macadamias, pecans, pistachios, and walnuts. Vineyard acreage is dramatically expanding in many regions, and small ruminants are being used to prune the lower grape vines as well as to manage the understory vegetation.

Most nut trees and some fruit trees, like cherry, are cultured in the traditional fashion where large, widely spaced trees provide greater opportunities for grazing. For example, in Georgia, Texas, Alabama, and New Mexico, livestock routinely graze mature commercial pecan orchards.[13, 20] Mature nut trees are large and grown at wider spacing than fruit trees, opening substantial pasture for grazing and understory management.[4]

The arrangement and care of fruit trees in many production systems have changed across much of the United States in the past few decades. Commercial orchards increasingly grow dwarf and semi-dwarf trees (using size-controlling rootstock) and high-density plantings along trellised hedgerows about 10 feet high when mature. This trend toward semi-dwarf varieties of apples, pears, plums, and citrus facilitates harvesting and pruning but reduces the potential for targeted grazing in orchard management. The browsing animals may harm lower tree growth and can damage things like sprinklers or drip emitters in irrigated orchards.

Regardless of crop, most orchards comprise a network of systematically arranged trees with some type of ground cover, which is an important component of orchards. This orchard floor includes a vegetation-free strip in the tree rows with grass alleys between the rows. In the vegetation-free zone, roots can grow without competition from weeds or grass sod. Grass alleyways serve as a cover crop and provide a firm surface for machinery. The cover crop also conserves water, protects against erosion, increases infiltration, and maintains soil structure and organic matter.

Orchard ground cover is generally a combination of perennial, sod-forming grasses and occasionally a legume like white clover, subterranean clover, vetch, or birdsfoot trefoil. Depending on location, common grasses used in orchards include orchardgrass, perennial ryegrass, bentgrass, red fescue, Kentucky bluegrass, and timothy. There are specifically designed orchard mixes that provide the ideal growth form, biology, and phenology. Forage production, however, has not been a criterion in their development.

The orchard floor actively grows during spring, summer, and fall because of regular irrigation and fertilization. In many regions it grows year round. To assure orchard health and maximize productivity, ground cover must be managed. Vigorously growing ground cover can quickly build up excessive biomass that competes with trees for water and nutrients, especially nitrogen. Fruit trees compete poorly with other plants. The bulk of tree roots form in the top 3 feet of soil, where competition for water and nutrients is greatest. Tall vegetation can harbor pathogens, insect pests, and harmful rodents (mice and voles) that may girdle young trees and expose vulnerable surface roots. Managing ground cover is the most effective method of controlling mouse activity.[5]

In addition to the grass cover crop, herbaceous weeds compete with trees for water and nutrients. Weed growth and water uptake are greatest during the summer, a time when careful water management is important to maintain fruit quality,[18] making weed control an important component of orchard management. Abundant weeds disrupt water management and threaten fruit quality when it's hot. What's more, large weeds block sprinkler heads and disrupt water delivery.

Conventional management of orchard floor vegetation involves repeated mowing (seven times a season is typical) with specialized low-profile equipment and application of systemic and pre-emergent herbicides. Mowing keeps competitive grasses and weeds in check, ensures access to trees, and inhibits rodents and diseases. In many orchards, herbicides are regularly sprayed to control weeds and to maintain a vegetation-free zone at the base of the trees. However, growers have limited herbicide options and must apply them carefully to avoid damaging trees. Cultivation is generally avoided in orchards because it can degrade soil, damage roots, and cause erosion.

Small livestock like sheep and goats have grazed orchard understory vegetation for centuries.[15] In warm regions of the world, year-round or season-long grazing provides meat, milk, and fiber in addition to fruits and nuts. Orchard grazing was a common practice in North America until the 1950s. In contemporary commercial orchards, the primary purpose of grazing is to manage understory vegetation, which keeps grass from building up and competing with trees, minimizes pest and disease outbreaks, and maintains uniform water distribution. Orchard grazing provides several advantages, including greater economic returns,[18] more diversified farm operations,[8] and extended timing of cash flows.[17] Orchard grazing can reduce fuel and chemical inputs[9] and may enhance erosion control, water quality, water use efficiency, soil fertility, and nutrient cycling.[9, 10]

Orchard grazing is not widely practiced for several reasons, but primarily for concern over browsing and bark damage.[9] Growers also cite lack of research and technical assistance and difficulty obtaining and managing suitable animals. Orchardists without experience working with livestock may see that as a barrier. Contamination from livestock waste is also a concern.[6] Unpasturized apple cider, often made from apples collected from the orchard floor, can be contaminated with *E. coli* and other pathogens from animal waste.[16] Similarly, nuts collected from the orchard floor can also be contaminated from animal waste and pose public health risks.[1]

Despite these issues, orchard grazing is becoming more common today than in recent decades and is practiced in nearly every state where fruits or nuts are commercially produced. The widest acceptance appears to be in organic orchards.

Criteria for Animal Selection

Selecting the type and class of animal to graze depends mainly on orchard structure and the reasons for including livestock grazing in the orchard management system. A goal to diversify farm revenues by producing meat, milk, brood stock, or fiber will have different criteria for selecting animals than a goal to strictly manage vegetation.

Animal size is also important. Cattle, and even horses, have been used, but their weight and contact with fruit-bearing branches make them less desirable than smaller ruminants like sheep and goats. Sheep are preferred to goats in most fruit production systems because they do not climb into trees to browse and are more easily contained. However, goats are commonly used in certain situations, for example in mature nut orchards.[12, 14]

Breed and age correlate with size but may also determine some behaviors. In Washington, Hardesty and Howell (1991) began their work with a mixed-breed flock of sheep. Then, to control for browsing experience, they replaced it with a flock of Suffolks with no browsing experience. In spite of aversion training, the sheep quickly took to browsing. Because Suffolks are relatively tall sheep and have a reputation as browsers, the researchers added some short, stocky Hampshires. These animals could not access as many branches, but they compensated with determination, even feeding occasionally with their front feet on stems. Lambs and yearlings cannot browse as high and may benefit from the shelter offered by the trees. Much work remains to determine the best breeds for orchard grazing.

Animal selection may depend on their availability. Lawrence and Hardesty (1992) found that cattle were used more commonly than sheep in Washington orchards because cattle were more readily available than sheep or goats. Today, small ruminants are offered in irregular sales at local livestock auctions and through direct contact with producers, and the number of flocks and herds intended solely for vegetation management is growing.

Grazing Strategies to Meet Ecological Objectives

Proper animal husbandry is crucial for successful orchard grazing. Livestock must be carefully monitored and managed to avoid overgrazing or browsing.[9] The degree of browsing depends on type of orchard and animal, season, and how animals are managed. Many trees can tolerate some browsing without reduced fruit production or quality,[9] but orchardists generally find any level of browsing unacceptable. Browsing can be limited by continuously rotating livestock through the orchard and by grazing only mature orchards or

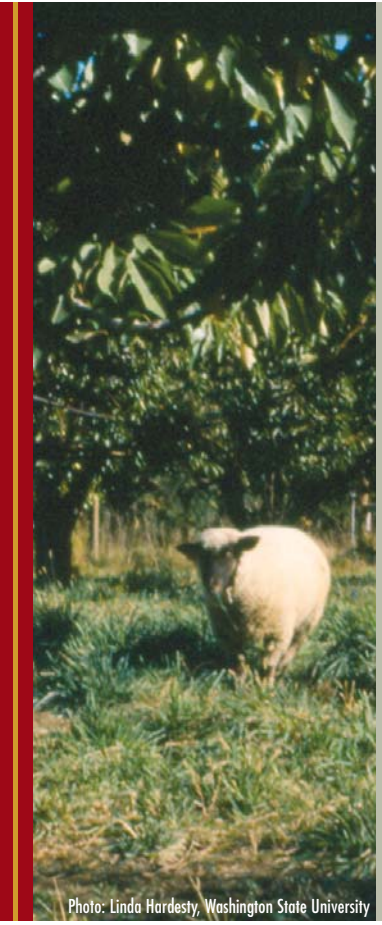
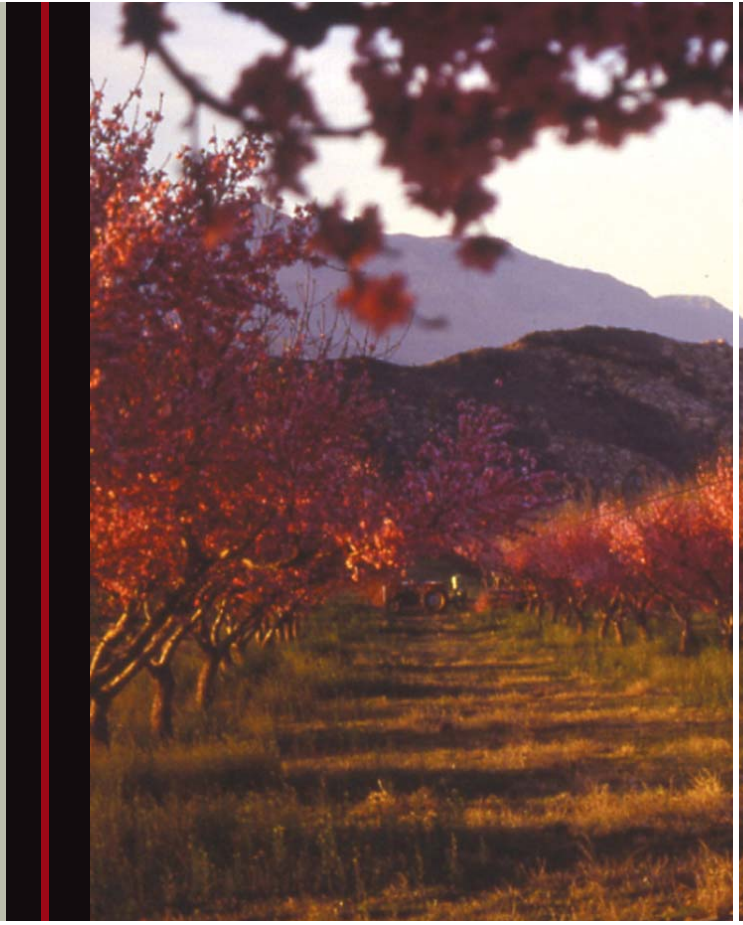


Photo: Linda Hardesty, Washington State University



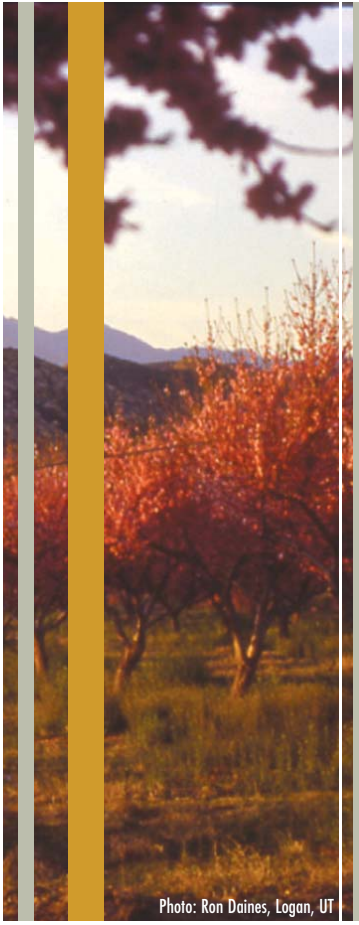


Photo: Ron Daines, Logan, UT

protecting trees in young orchards with temporary row fencing. Aversion training (when animals are dosed with a nausea-inducing compound after eating leaves or branches) can produce an aversion and reduce browsing on trees for about 10 days. (Lithium chloride has been used for research in aversive conditioning, but is not cleared for use in meat-producing animals.) For short periods, this may be enough if the herd or flock is small. Likewise, repellants have limited application against the high palatability of orchard browse.

Many fruit- and nut-producing regions have long growing seasons with the potential for season- or year-long grazing. In these situations, livestock can graze on a rotational basis and be removed from the orchard during spraying, pruning, irrigation, and harvest. An alternative is short-term, high-intensity grazing accomplished with a perimeter fence and a herder, often accompanied by a herding dog, moving higher numbers of animals quickly through the orchard.

Controlling the intensity of grazing is also important. Overgrazing ground vegetation can, cause soil and feeder root problems. Growers need to develop a rotational grazing system to provide appropriate rest cycles, which will vary according to seasonal growing conditions and the orchard production calendar. Proper pasture rotation provides fresh feed for the livestock and allows rest for the grazed plants to recover. Without a controlled rotation grazing program, the livestock will tend to feed only on the highly palatable forage and weeds within the larger area, leading to patchy grazing and a proliferation of ungrazed plants.

The production of understory biomass varies dramatically during the growing season. The number of animals needed to control vegetation in the spring and fall will be insufficient to achieve control during the peak growing period in the summer when plants are stimulated by irrigation, fertilization, and a humid canopy. Without flexibility in stocking rate, some mowing may still be needed during the peak growth period. A potential solution may be to select ground cover species that have low forage production, are reasonably palatable, and reach peak biomass at a time that fits the orchard management schedule. Some of these production traits might better balance year-long forage supplies, although no research was found in this area.

Orchard grazing requires a secure perimeter fence, access to water, and a non-orchard holding area.[9] Electric fencing is effective to facilitate rotating animals among paddocks if it is properly installed and livestock have been trained to it. Animals may need training to familiarize them with humans and paddock rotation. Wire panels offer high containment security that may be useful in some settings. Some types of net or electric fence also offer protection from predators, particularly roaming domestic dogs.

Photo: Linda Hardesty, Washington State University

Livestock should be removed during irrigation or naturally wet periods when soil is saturated. They should also be removed during the prescribed reentry period for agricultural chemicals.[9] In addition to fertilizers, pesticides, and herbicides, these chemicals include growth regulators, thinning agents, and oil sprays. Some tree species (e.g., apples) use considerably more fertilizers than others (cherries). Likewise some species take only weeks to bear (cherries) while others mature over several months (apples). These characteristics may affect chemical exposure and other management variables. Few chemicals used in orchards have been evaluated for grazing reentry, posing a particular concern for meat animals. Fruit intended for export may be more heavily treated with pesticides than fruit for local or domestic consumption. Organic orchard production does not preclude the use of chemicals, just synthetic chemicals. The impacts on animals of products used in organic orchards are likewise unknown. Many tree fruit leaves and seeds contain cyanide. Toxicity risk to grazing animals is probably low, but the question has not been examined in detail. Using animals not destined for consumption avoids most of these problems as long as synthetic or natural chemicals are not toxic to the animal themselves.

Animal Production Considerations

Orchard grazing must also fit into the animal owner's production cycle. Animals may be produced on rangeland, irrigated pasture, and crop aftermath, areas that may be distant from each other and perhaps from the orchard.

Actively growing grass and weeds in orchard ground cover can have considerable forage value. The residue of leaves and unharvested fruit that falls to the ground can also provide important nutrients late in the season. Grazing fruit orchards after the leaves fall reduces cover for rodents and clears the debris that harbors pests and pathogens. Leaves cut from fruit trees comprise nutritious and palatable forage that animals readily consume.[9] One range sheep producer in Washington routinely prepares his ewes for breeding (i.e., "flushing") in pear orchards because of abundant high energy forage. Properly grazed, orchard understory will likely provide animal gains similar to those from irrigated pasture.

An extensive economic analysis of sheep grazing in a Washington cherry orchard determined that the most important considerations were the availability and age class of livestock, sheep handling, transportation, and market.[2] Alezi (1997) analyzed two alternative livestock management systems: 1) grower-owned livestock, either as a permanent flock or weaned lambs purchased in the spring, grazed through the season, and sold in the fall, and 2) contract grazing, where grazing rights are leased to a livestock owner/operator. In the first case, where the orchardist owned the sheep, the production of meat and wool was the primary goal of grazing. Depending on the availability of additional pasture or rangeland, the sheep were grazed in the orchard year-round, being removed only during critical periods of fruit production. Alezi (1997) found that raising sheep year-round required high lamb prices to yield more net revenue than traditional orchard management. Under the livestock lease scenario, vegetation management is the primary goal. Grazing takes place only during the growing season when the orchard floor vegetation is actively growing and requires regular maintenance. However, Alezi (1997) found that leasing orchard forage was less profitable than traditional orchard management.

Labor availability and the cost of the manager's time are critical to profitability, necessitating efficient routines.[2, 9] Each product and production system has one or more periods of peak labor demand. These periods should be evaluated when formulating orchard grazing plans and selecting animal species to minimize overlap.

EFFECTIVENESS AND INTEGRATED MANAGEMENT

Livestock grazing provides a useful and important alternative for managing orchard ground cover. Depending on the type, age, and production system of the orchard and the grower's willingness to participate, orchard grazing programs can be developed to fit the needs of the orchard.

Several studies have shown sheep and goats to be as effective as conventional practices in meeting growers' vegetation management objectives. Hardesty and Howell (1991) conducted a study of sheep grazing in a mature sweet cherry orchard in Washington. Traditional orchard understory management (mowing and herbicide use) was compared with a variety of orchard grazing strategies using sheep. Over the five years of the study, they determined that sheep (and probably other grazers) can be successfully grazed in a mature orchard, reducing the need to mow and spray in the orchard and providing an additional revenue source. Alezi's (1997) economic analysis of this same project showed that grazing can be an effective and economic way to manage orchard floor vegetation, depending on animal market conditions. Overall, sheep grazing yielded substantial income, generating net returns of about $3,900 per acre. Orchard grazing also reduced labor, machinery, fuel, and herbicide costs for vegetation management.[9]

The trend toward integrated pest management, reduced chemical inputs, and enterprise diversity creates additional opportunities for integrating tree crop and livestock production. While the practice of livestock grazing in orchards can be effective, environmentally sound, and economically feasible, the extent to which it is adopted will depend on its acceptance by growers. Orchardists unfamiliar with handling and using livestock may resist any perceived risk to their highly capitalized orchard. Grower education is needed to increase the acceptance of orchard grazing. To modify a traditional orchard production system, the grower should have specific objectives identifying the intended role of livestock, acquire knowledge and understanding of livestock husbandry, understand basic grazing management principles,[7] and create realistic time and financial budgets. The large number of variables in successful orchard grazing presents both challenges and opportunities. But it also requires experimentation to optimize its use for each operation. Collaborative efforts with other local producers may facilitate implementation of grazing into orchard management and produce other efficiencies.

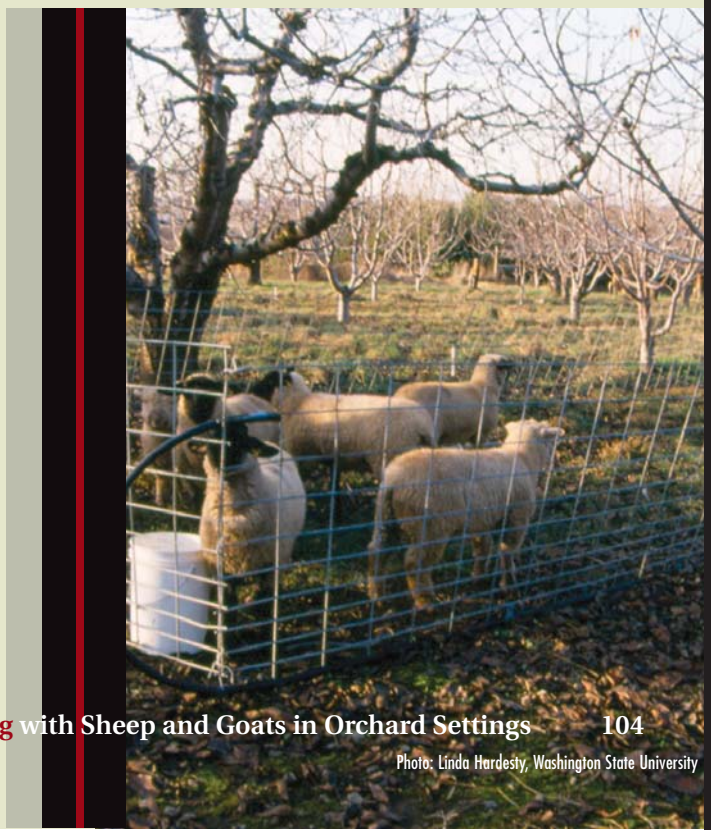


Photo: Linda Hardesty, Washington State University

Literature Cited

[1]Almond Board of California. 2005. Food Safety Program. www.almondboard.com.

[2]Alezi, H.L. 1997. An economic analysis of orchard grazing: The case of sheep grazing in a mature sweet cherry orchard. [thesis] Pullman, WA: Washington State University.

[3]Canadian Food Inspection Agency. 2005. Code of practice for the production and distribution of unpasteurized apple and other fruit juice/cider in Canada. *Available at:* www.inspection.gc.ca/english/plaveg/protra/codee.shtml. *Accessed 23 August 2006.*

[4]Carroll, B., M.W. Smith, and B.D. McGraw. 2005. Establishing a pecan orchard. Oklahoma State University Cooperative Extension. Bulletin F-6247. *Available at:* http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1047/F-6247web.pdf. *Accessed 23 August 2006.*

[5]Eaton, A.T. 1985 Management of orchard mice. Univ. New Hampshire Cooperative Extension Pest Management Fact
Sheet 8. *Available at:* http://extension.unh.edu/agric/AGPMP/Pubs/Apft5901.pdf. *Accessed 23 August 2006.*

[6]Gast, K. 1997. Food safety for farmer's markets. Kansas State University Agricultural Experiment Station and Cooperative Extension Service MF-2260. *Available at:* www.oznet.k-state.edu/library/hort2/mf2260.pdf. *Accessed 23 August 2006.*

[7]Fukumoto, G. 2003. Grazing livestock under orchards. University of Hawaii. College of Tropical Agriculture and Human Resources. *Available at:* http://www.ctahr.hawaii.edu/ctahr2001/InfoCenter/Forages/extensionResearch/GrazingUnderOrchards.doc. *Accessed 23 August 2006.*

[8]Hardesty, L.H. and J.A. Tiedeman. 1996. Integrating crop and livestock production in Inland Northwest farming systems. *American Journal of Alternative Agriculture* 11:21-26.

[9]Hardesty, L. and W. Howell. 1991. Silvopastoral orchard management options. *In:* Second Conference on Agroforestry in North America, Springfield, MO.

[10]Lawrence, J.H., L.H. Hardesty, R.C. Chapman, and S.J. Gill. 1992. Agroforestry practices of non-industrial private forest landowners in Washington State. *Agroforestry Systems* 19:37-55.

[11]Lawrence, J.H. and L.H. Hardesty. 1992. Mapping the territory: agroforestry awareness among Washington State land managers. *Agroforestry Systems* 19:27-36.

[12]Leuty, T. 2003. Tree nut orchards and food safety. Ontario Ministry of Agriculture. *Available at:* http://www.omafra.gov.on.ca/english/crops/facts/nutorchard.htm. *Accessed 23 August 2006.*

[13]Mitchem, W.E. and M.L. Parker. 2005. Orchard floor management in pecans. N. Carolina St. Univ. Cooperative Extension Service. *Available at:* www.ces.ncsu.edu/depts/hort/hil/hil-380.html. *Accessed 23 August 2006.*

[14]Muir, J.P. 2002. Cultivated cool-season pastures for meat goats in north-central Texas. Sheep and Goat, Wool and Mohair CPR:60-69. *Available at:* http://stephenville.tamu.edu/~jmuir/goatr/pdf/goawinCPR_01.pdf. *Accessed 23 August 2006.*

[15]Nair, P.K.R. 1985. Classification of agroforestry systems. *Agroforestry Systems* 3:97-128.

[16]Riordan, D., G. Sapers, T. Hankinson, M. Magee, A. Burke, and B. Annous. 2001. A study of U.S. orchards to identify potential sources of *Escherichia coli* 0157:H7. *Journal of Food Protection* 64:1320-1327.

Literature Cited

[17]Roper, T.R. 2004. Orchard floor management for fruit trees. University of Wisconsin Extension Publication A3562. *Available at:* http://s142412519.onlinehome.us/uw/pdfs/A3562.PDF. *Accessed 23 August 2006.*

[18]Smith, T.J. 2003. Orchard weed control – a quick overview. Washington State University Extension. *Available at:* http://www.ncw.wsu.edu/treefruit/weeds2.htm. *Accessed 23 August 2006.*

[19]USDA–National Agricultural Statistics Service. 2005. Noncitrus fruits and nuts 2004 summary. Fr Nt 1-3 (05). July 2005. *Available at:* http://usda.mannlib.cornell.edu/reports/nassr/fruit/pnf-bb/ncit0705.pdf. *Accessed 23 August 2006.*

[20]Weiss, S. and J.P. Muir. 2000. Winter annual pastures for finishing goats under pecan groves. *Agronomy Abstracts*, Minneapolis. p. 173.

CHAPTER 12:
Targeted Grazing to Manage Fire Risk

By Charles A. Taylor, Jr.

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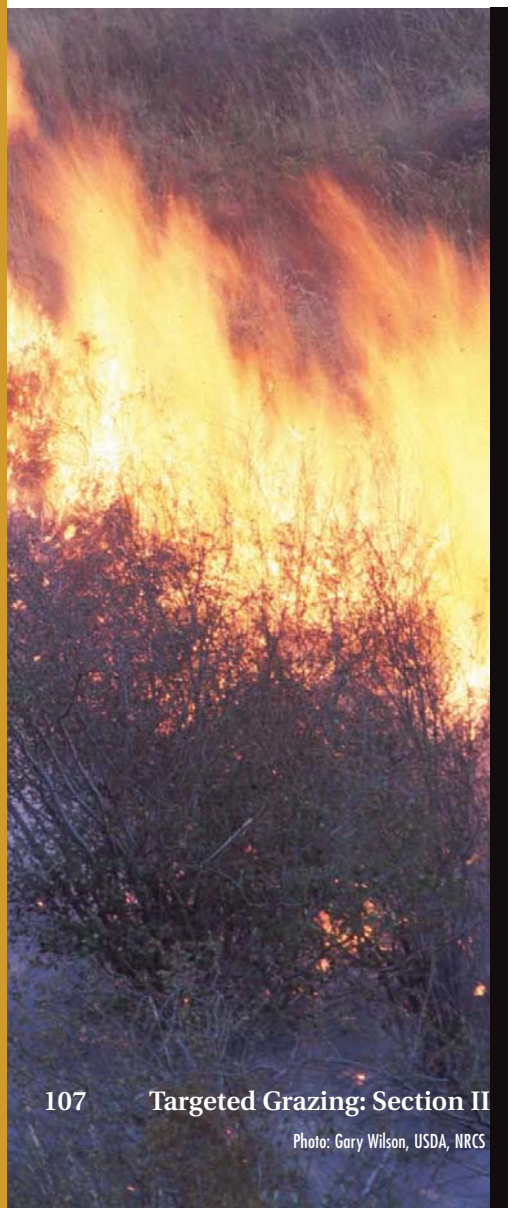

Photo: Gary Wilson, USDA, NRCS

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.

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

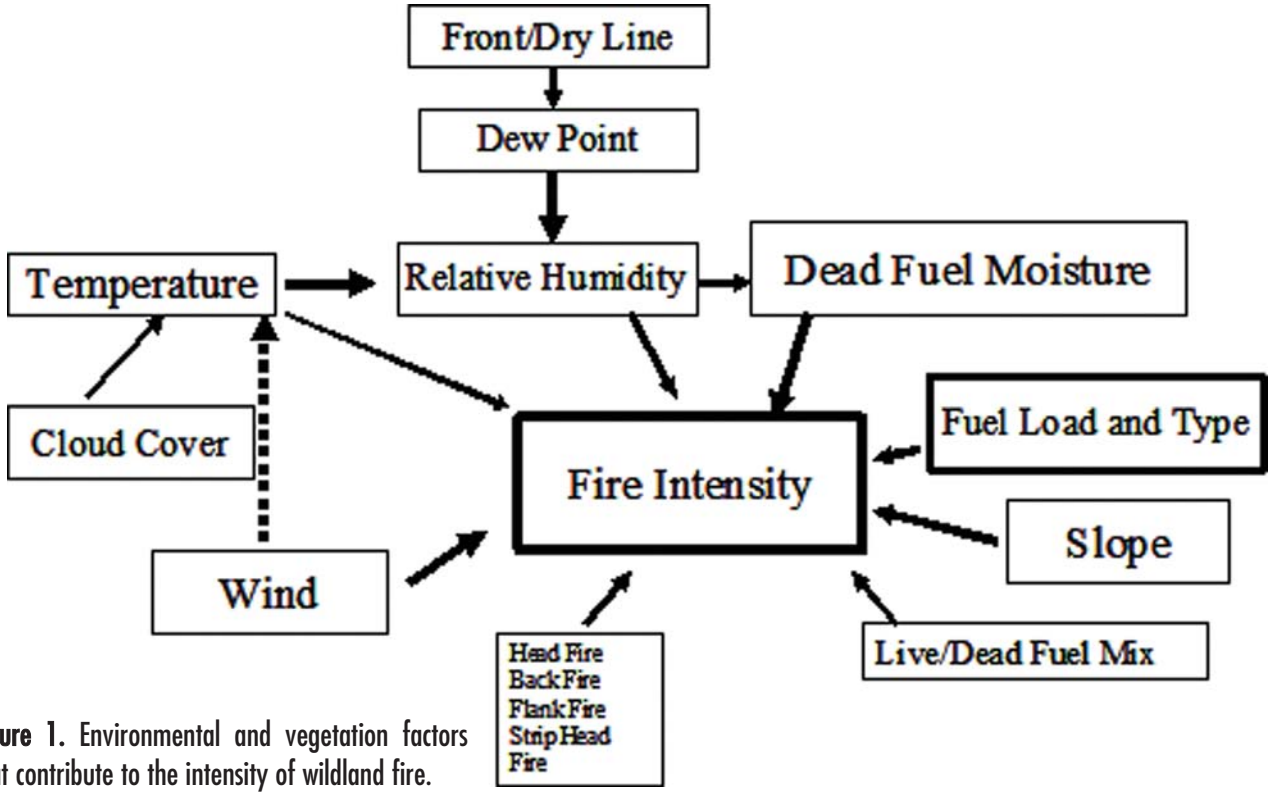

Figure 1. Environmental and vegetation factors that contribute to the intensity of wildland fire.

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.

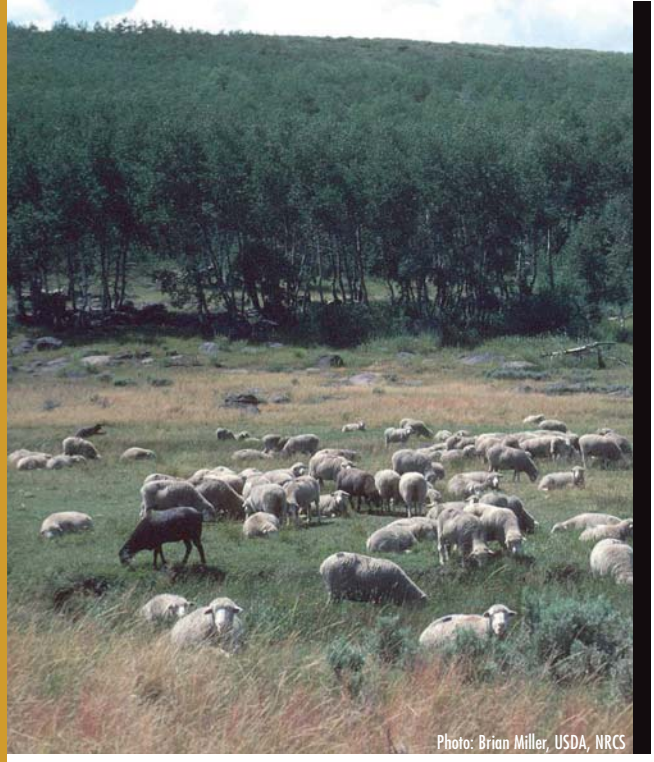

Photo: Brian Miller, USDA, NRCS

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.

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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.

CHAPTER 13:
Targeted Livestock Grazing for Wildlife Habitat Improvement

By Jeffrey C. Mosley and Tracy K. Brewer

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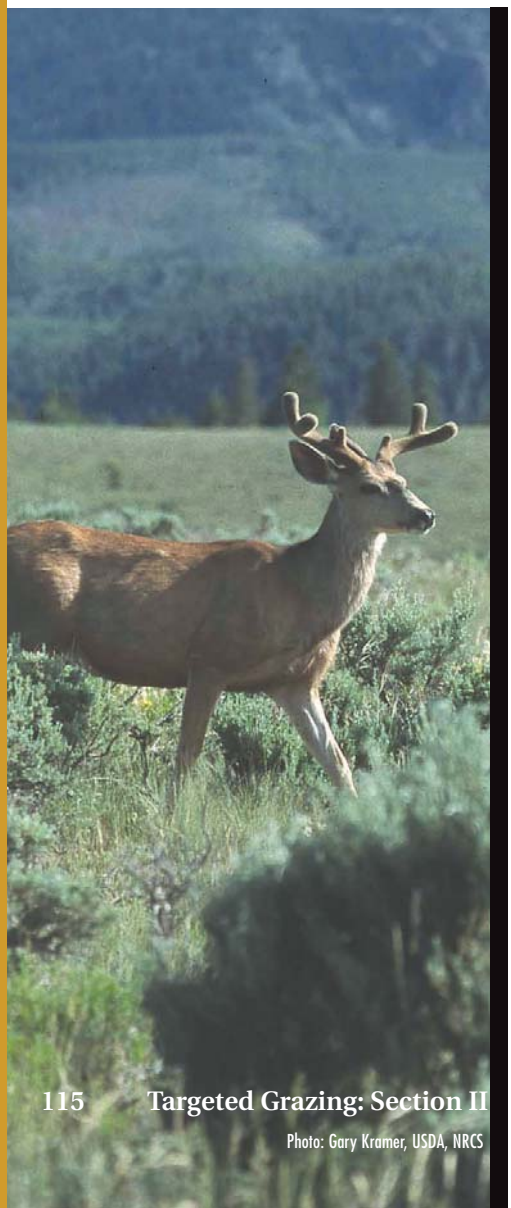

Photo: Gary Kramer, USDA, NRCS

10 KEY POINTS

- Some land managers have successfully used livestock grazing for many years to improve wildlife habitat, but this tool has not been widely applied.
- When wildlife habitat is altered, it is improved for some species and degraded for others.
- The maximum size of a wildlife species' population is limited by its poorest habitat essential (food, water, cover, or space).
- Unless the limiting habitat factor is improved, efforts to enhance targeted wildlife populations will fail.
- Success or failure depends on the land manager's ability to predict and control diet selection and grazing distribution of the livestock.
- Targeted livestock grazing can be used to enhance yield, accessibility, and nutritive quality of wildlife forage and alter cover, structure, and diversity of vegetation.
- Heavy grazing pressure in plant communities dominated by grazing-tolerant species can increase plant diversity.
- Grazing prescriptions must include strategies to mitigate impacts on wildlife from trampling and other disturbances.
- Livestock should be treated for parasites to avoid transfers to wildlife.
- Fencing used to manage livestock should be built with the needs of wildlife in mind.

INTRODUCTION

Food, water, cover, and space are the habitat essentials for wildlife. The quality of habitat is defined by how well the land provides these essentials. That quality, in turn, determines the vitality, numbers, and species of wildlife present on the land.

Many tools are available to improve wildlife habitat, including tree harvest, root plowing, chaining, seeding, and applying fertilizer and herbicides. Some of these traditional tools, however, are expensive and less socially and environmentally accepted than in years past. Prescribed fire is a useful tool, but increasing concerns about air pollution and risk of escape may limit its future use. Prescribed, or targeted, livestock grazing or browsing is another tool that can be used to purposely manipulate the environment to improve habitat for wildlife.

Using livestock grazing to improve wildlife habitat is not a new idea. The concept was introduced into the scientific literature in 1933 by Aldo Leopold, the father of wildlife management in North America.[39] Others have followed Leopold and promoted this tool,[43, 62, 71, 72] but few managers have applied targeted livestock grazing to improve wildlife habitat. Most who have successfully implemented the practice have been forced to develop their own strategies through trial and error. While trial and error can be a good teacher, it is not the most efficient. The goal in this chapter is to synthesize the existing knowledge about how to use grazing or browsing by livestock, particularly sheep or goats, to enhance wildlife habitat in North America.

Vegetation Management Opportunities

Enhancing wildlife habitat is a noble goal. A difficult reality, however, is that it is impossible to maximize the habitat quality of all wildlife at the same time. Trade-offs must be considered. This is because the particular combination of food, water, cover, and space required by a specific wildlife species (i.e., its niche) is unique. Any time the habitat is altered, it is improved for some species, yet simultaneously and inevitably degraded for others.

Habitat Essentials and the Limiting Factor

The enhancement or degradation of habitat does not always affect a wildlife species' ability to survive, thrive, and reproduce. Improvement or degradation only affects a wildlife species when the habitat essential that is improved or degraded is the limiting factor for that species. Consider a wooden barrel with four slats (Figure 1, see next page). The maximum volume of liquid the barrel can contain is determined by the height of the lowest slat. In similar fashion, the maximum size of a species' population that can exist on the land is limited by the poorest habitat essential. If the limiting habitat essential is food, as in Figure 1, improvements to the water, cover, or space essentials will not affect the species' population. Similarly, degradation to water, cover, or space will not affect the population unless the degradations are so severe that one of these habitat essentials replaces food as the limiting factor. Habitat manipulations only affect a population when the species' limiting factor is enhanced or degraded.

It is also important to know which specific characteristic of the habitat essential is limiting the population. For example, if food is the limiting factor, what is it about the food that is limiting? Is it the quantity, accessibility, or nutritive quality of the available food that is limiting the population, and does this limitation occur in one or more seasons of the year? Consider a situation where the protein content of winter food is limiting (Figure 2, see next page). In this case, habitat improvement practices that improve the quantity, accessibility, or energy content of available food might be well-intended, but these habitat alterations would have no effect on the targeted wildlife species. Positive effects will occur in this example only if a habitat improvement project enhances the protein content of the food available in winter.

The examples in Figures 1 and 2 illustrate the importance of correctly identifying the limiting factor before initiating a project to improve wildlife habitat. Unless the limiting factor has been correctly identified, efforts to enhance targeted wildlife populations will fail. A knowledgeable wildlife biologist or wildlife habitat specialist can help identify the habitat's limiting factor (i.e., the weakest link) for a particular wildlife species in a specific place and time. Once the limiting habitat

Figure 1. Wildlife poplulation size is limited by the poorest habitat essential. For the four-slatted wooden barrel depicted to the left, food is the limiting factor.

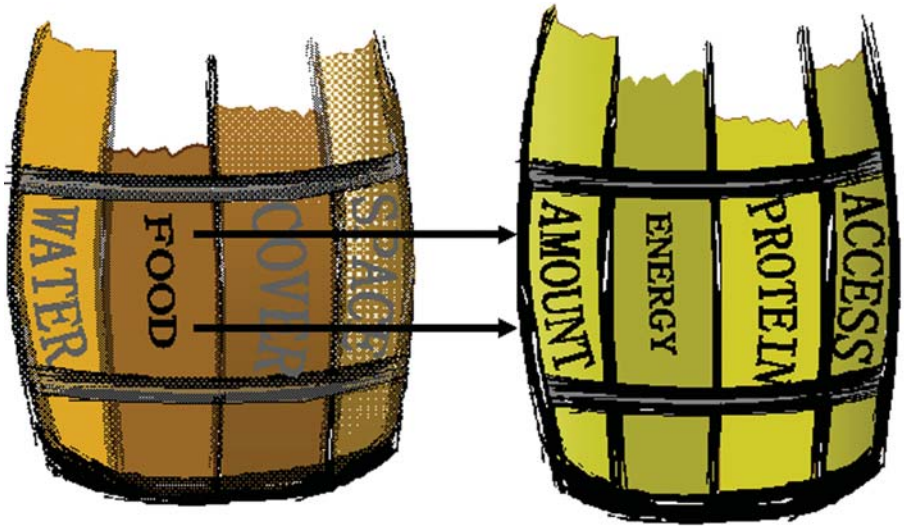

Figure 2. In the four-slatted wooden barrel depicted to the right, protein content is more precisely identified as the characteristic that is causing food to be the limiting factor, rather than food quantity, energy content, or accessibility.

factor is identified, targeted livestock grazing potentially can be used to address the limitation.

Biological Diversity

One possible objective for improving wildlife habitat is to promote biological diversity. This approach reduces the importance of knowing the limiting factor for one or more species and the need to make value judgments about which species of wildlife to favor at the expense of others. Rather than focusing on improving the habitat for a particular species, the goal becomes promoting habitat diversity to improve wildlife habitat overall. Biological diversity is maximized by providing a diverse array of habitat features, in varied patterns, across the landscape. Biological diversity is favored by mixtures of plant communities composed of varied plant species, vegetative cover and structure, plant ages, and plant densities. Targeted livestock grazing is a viable tool for creating or maintaining such diversity because: 1) various species of livestock can consume many different plant species and plant parts, 2) livestock can traverse many topographic landforms, 3) livestock grazing requires low fossil fuel inputs, and 4) the grazing locations of livestock, especially sheep and goats, can be controlled on the landscape without fences, if desired.

Criteria for Animal Selection

What, when, where, and how livestock graze or browse will determine whether the targeted wildlife habitat approaches the desired condition. The success or failure of using livestock grazing to enhance wildlife habitat depends on the land manager's ability to predict and control the animals' diet selection and grazing distribution. *(Additional information about using animal behavior principles to achieve targeted grazing goals is presented in Chapter 2 – "Animal Behavior Principles and Practices.")*

Lambs, wethers, and yearling ewes may be more likely to ingest woody plants than ewes,[18] but goats typically consume more browse than sheep.[9, 41] Both sheep and goats will readily consume grass-dominated diets when grasses are succulent or when other forages are unavailable.[41] Forb consumption by sheep and goats tends to increase as forb availability increases.[9, 10] Cattle and horses usually eat grass-dominated diets when grasses are available.[73]

Livestock usually select foods that limit unpleasant sensations to the animal. Plant parts that are tender, succulent, readily visible, and pleasant smelling and/or tasting are usually selected over those that are coarse, dry, obscure, and obnoxious smelling and/or tasting.[2]

Armed with this knowledge, a resource manager can survey the vegetation on a site at a specific point in time and reasonably predict which plants livestock will readily consume.

Livestock graze more selectively within plant communities and across landscapes that have diverse vegetation[77] and topography.[2, 73] Dense stands of vegetation of similar palatability will be grazed more uniformly.[2] Close herding or high stock densities also decrease grazing selectivity.[18, 60] However, vegetation with large relative differences in palatability must be watched carefully when grazed at high stock densities. In these situations, the most palatable plants and preferred foraging sites are often grazed heavily before the livestock select less desirable options.

Fast herding also decreases selectivity of grazing by livestock,[18] but may not promote uniform grazing pressure across plant species. For example, fast herding through sites with showy, readily accessible flowerheads may force animals to primarily consume the flowers because that is largely what they are able to select when traveling rapidly through a site.

Grazing selectivity can be altered by controlling the hunger level of livestock before they enter a site to be grazed and by controlling the time of day when livestock are allowed to graze an area. Hungry animals are usually less selective, which may help explain why livestock that graze in the morning tend to be less selective than animals grazing in the evening.[18, 36, 74]

The types of forage that livestock have been grazing immediately before they enter a site can also affect their diet selectivity. If livestock have been grazing highly palatable vegetation, they will be more selective when foraging, whereas livestock that have been grazing less attractive vegetation are usually less selective when entering a new site.[59] The type of forage they have been recently grazing may affect diet selection in other ways. Consumption of forbs or browse containing toxins, for example, is usually greater after livestock have been eating grass-dominated diets for two to three days prior. It is believed that grass may help buffer the toxins and enable livestock to consume them in higher concentrations.[75] Finally, livestock are also more likely to consume plant species with which they are familiar. Using animals unaccustomed to an area often results in diet selection patterns that differ from those of animals more familiar with the vegetation and terrain.[52]

Grazing Strategies to Meet Ecological Objectives

Targeted livestock grazing can be used to change the plant species composition, yield, accessibility, nutritive quality, cover, structure, or diversity of the vegetation. The effects depend largely on the timing, frequency, intensity, and selectivity of grazing.

Plant Species Composition

Targeted livestock grazing can change the plant species composition by altering the competitive interactions among plants. For example, summer sheep grazing in mountain meadows can increase the relative abundance of grasses and sedges,[5, 6] which are important elk forages in these habitats.[68] In sagebrush steppe, heavy sheep grazing in spring and early summer can reduce grasses and forbs and increase sagebrush,[37] which enhances the winter food supply for mule deer, pronghorns, pygmy rabbits, and sage-grouse.[16, 26, 27, 31, 61] If heavy spring sheep grazing continues for several years, weedy forbs, which are an important food source for juvenile sage-grouse,[16] can increase.[45] Heavy periodic goat browsing of Gambel oak in summer also can be used to increase the abundance of sagebrush for sage-grouse, wintering mule deer, and other species.[55, 56] Grazing and browsing guidelines to alter plant species composition to meet desired habitat conditions are summarized in Table 1. These guidelines can be used to select and implement the appropriate grazing strategy to favor the desired plant life form (e.g., bunchgrasses, rhizomatous grasses, shrubs, weedy forbs, or non-weedy forbs).

Table 1. Targeted grazing and browsing strategies used to favor different life forms and alter species composition of a plant community.

Desired Life Form	Grazing Strategies
Bunchgrasses	Late season grass and forb use or late season shrub use
Rhizomatous Grasses	Early season grass and forb use or late season shrub use
Shrubs	Growing season grass and forb use or dormant season grass and shrub use
Weedy Forbs	Extended early season grass and forb use
Non-weedy Forbs	Late season grass and shrub use

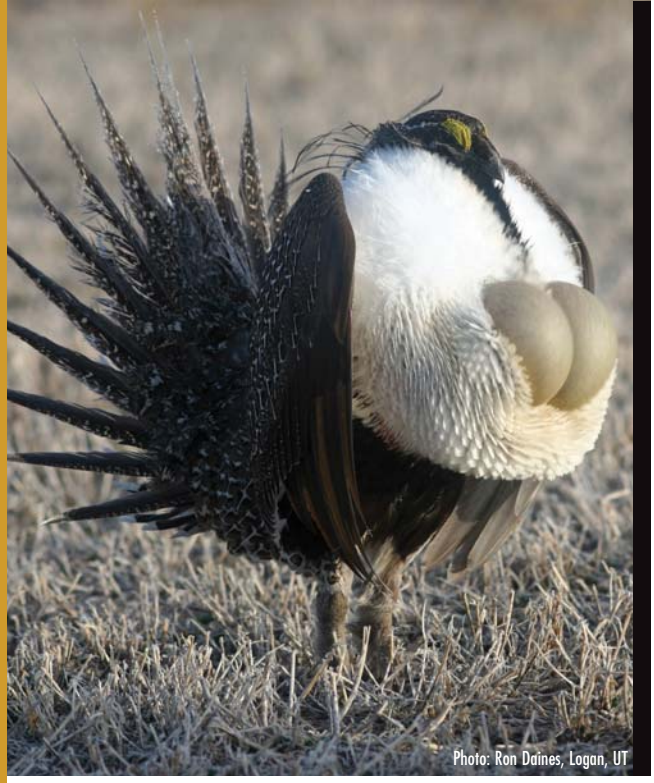

Photo: Ron Daines, Logan, UT

Forage Yield, Accessibility, and Nutritive Quality

Targeted livestock grazing can be used to enhance the yield and accessibility of wildlife forage. Bitterbrush, for example, is important forage for mule deer on many winter ranges, but it often grows too tall to be accessible to mule deer.[38] Also, if not browsed sufficiently, bitterbrush production declines.[69] Targeted livestock browsing can keep bitterbrush forage within reach of deer and can increase the production of nutritious twigs. Livestock should browse bitterbrush in spring until it sets seed, and bitterbrush should receive a season of rest every four or five years.[29]

Wildlife access to nutritious forage can be improved by targeted livestock grazing. For example, grazing livestock in spring can remove excessive standing dead material from grasses and enhance the nutritive quality of available forage. Removing this dead material allows plants to green up earlier the following spring, which enables deer and elk to shift their diets to succulent, more nutritious grass growth earlier in spring.[54, 66] This is important for wild herbivores because their winter mortality and reproductive failure is often caused by limited forage quality rather than forage quantity.[78] Removing dead grass in spring also makes forbs, low-growing shrubs, and grasses more accessible to deer and elk in autumn and early winter, which enables wild herbivores to delay consumption of key winter browse species until more critical periods later in winter.[24]

Forage nutritive quality is often enhanced in subsequent seasons when forage plants are preconditioned by light to moderate grazing in spring or early summer. In the northern Rocky Mountains, for example, moderate sheep grazing in spring has been used to improve the winter nutritive quality of bluebunch wheatgrass and Idaho fescue, important forage resources for elk and mule deer.[11] Additionally, moderate sheep browsing in early summer has been used to improve winter browse quality for elk and white-tailed deer,[1] and elk in winter-early spring prefer to forage in foothill and mountain grasslands where cattle have grazed moderately during the previous summer.[15]

Plant Cover and Structure

Some wildlife species expend more energy and become more stressed if vegetative cover is too sparse, forcing them to maintain greater vigilance for predators. Targeted livestock grazing can be used in these situations to promote plant growth, especially of shrubs. Other species of wildlife, however, rely on their ability to *"see and flee"* as their primary mode of predator defense. These species are best served if plant cover does not restrict their vision. Targeted livestock grazing can be used to increase visibility. For example, the long-billed curlew, a ground-nesting bird, prefers areas where vegetation is 4 inches high or less and curlews often confine their nesting activities to sites that have been grazed recently by livestock.[4] Other bird species that prefer very short vegetation and can benefit from heavy prescribed grazing include the mountain plover[25] and the horned lark.[13]

Many wildlife species require relatively dense hiding cover for rearing offspring. Where precipitation is scant and vegetation is sparse, these wildlife (e.g., desert tortoise) need some areas on the landscape to remain ungrazed year after year. In landscapes that receive plentiful moisture for plant growth, such as tallgrass prairie, coastal grasslands, or riparian meadows, habitat for rearing young may benefit from rotational grazing systems where only some of the habitat is ungrazed for a year or less at a time. Prairie chickens, wild turkeys, and sage-grouse are examples of species that can benefit from this strategy.[8, 16, 33] Many small mammals, such as ground squirrels, jackrabbits, cottontail rabbits, deer mice, and pocket mice, also benefit from opening dense plant canopies.[51, 64] Increased populations of small mammals, in turn, improve the prey base for eagles, hawks, and other raptors. In brood-rearing habitat, sage-grouse prefer lower vegetation (i.e., 2-6 inches vs. 12-20 inches) created by moderate cattle grazing on meadows.[38, 46] Dense, ungrazed vegetation is avoided by sage-grouse[34] as are heavily grazed meadows,[22, 34, 46, 47] but sage-grouse are attracted to succulent forb growth stimulated by moderate cattle grazing.[22, 46]

Height and patchiness of plant cover combine to partially define the different types of plant structure favored by wildlife species. For example, among grassland birds, Leconte's sparrows favor plant cover that is tall and uniform, horned larks favor plant cover that is uniformly short, western meadowlarks favor cover that has mixed heights, and lark buntings favor plant cover that has tall patches and short patches intermixed.[13] Grazing and browsing strategies for creating these plant structures are summarized in Table 2.

Table 2. Targeted grazing and browsing strategies used to alter vegetative structure of a plant community.

Desired Structure	Grazing Strategies
Tall / Uniform	No grazing or light use
Short / Uniform	Moderate to heavy use with low selectivity among plants
Mixed Tall & Short / Uniform	Moderate use with moderate selectivity among plants
Tall & Short / Patchy	Light to moderate use with high selectivity among plants

Plant Species Diversity

As mentioned earlier, one habitat management goal might be to increase plant species diversity, a goal that can be achieved with targeted livestock grazing. In plant communities dominated by grazing-tolerant species, plant species diversity is often increased by moderate to heavy grazing intensities, an effect that is more pronounced in moist climates. In communities dominated by plants that are more sensitive to grazing, plant species diversity is often increased by low grazing intensities.[42] These effects, however, also depend on how selectively the animals graze and whether they ingest plant species that are competitively dominant or inferior. If livestock selectively consume competitively dominant plants and the grazing intensity is sufficiently high, plant species diversity will likely increase.[27, 28] For example, when livestock grazing suppresses a noxious weed such as leafy spurge, grasses flourish and diversity increases.[49] However, if livestock selectively consume competitively inferior plants, plant species diversity may decline even with moderate grazing intensity.[3, 28] For example, bluebunch wheatgrass plant vigor is reduced by moderate early summer sheep grazing when it occurs for three or four successive years.[11, 76] Effects of grazing on competitive relationships between plants will be lessened when grazing occurs during plant dormancy. Grazing and browsing guidelines to increase plant species diversity are summarized in Table 3.

Table 3. Targeted grazing and browsing strategies used to increase species diversity of a plant community.

If Dominant Plant Species Are:	Grazing Strategies
Grazing Tolerant	Moderate to heavy use
Less Tolerant to Grazing	Light use
If Livestock Preferentially Select:	**Grazing Strategies**
Competitively Dominant Plants	Moderate to heavy use
Competitively Inferior Plants	Exclusion or light use

Other Management Considerations

All techniques used to improve wildlife habitat have disadvantages, and targeted livestock grazing is no exception. The principal negative impacts to wildlife from livestock grazing are trampling, social intolerance, parasite/disease transmission, and fences. Strategies to mitigate potential negative impacts should be included in livestock grazing prescriptions for enhancing wildlife habitat.

Trampling

Livestock trampling rarely kills small mammals, reptiles, or birds, and nest destruction by trampling is also rare.[50, 53] However, the presence of livestock can cause ground-nesting birds to abandon their nests, and this is more likely to happen when livestock are congregated.[50, 53] It is best to exclude livestock from prime nesting areas during egg-laying through incubation, but if livestock are not crowded excessively they are very careful where they place their feet and will avoid stepping on nests, young birds, and other wildlife. Livestock should be herded as loosely as possible, and herders should ensure that livestock avoid prime nesting areas when trailing livestock in spring. Sheep and goat bed grounds, water troughs, salt, or supplemental feed should be located away from prime nesting areas in spring. Herd dogs should be used sparingly because nest destruction and desertion will be more likely when livestock are startled and step without caution.

Photo: Tracy Brewer, Montana State University

Social Intolerance

Livestock presence sometimes temporarily displaces wildlife into less favorable habitat. For example, elk may leave mountain meadows and forage in adjacent forests due to the arrival of sheep,[67] or elk may simply remain nearby and graze the meadow whenever the sheep are away from the meadow.[57] White-tailed deer, mule deer, and elk usually ignore cattle, but deer and elk avoid large concentrations of cattle.[14, 63, 80] Domestic sheep, cattle, and horses are socially dominant over elk, mule deer, bighorn sheep, pronghorns, and white-tailed deer.[44] The relative social rank of goats and wildlife has not been studied extensively in North America.

Prescriptive grazing programs to enhance wildlife habitat should minimize noise and potential disturbances caused by herding dogs, herders, camp tenders, and vehicles, and many of the same husbandry practices that limit trampling impacts also minimize social intolerance conflicts. Loosely herded livestock, for example, are less likely to displace wildlife. Pronghorns are one species that often associates with loosely herded livestock, and the mere presence of livestock does not cause pronghorns to leave an area.[12, 21] At fawning time, however, a closely herded band of sheep can sometimes cause pronghorn does and their fawns to become separated and fawns to be abandoned.[21] Livestock grazing should be timed to minimize disturbance to desired wildlife during fawning and calving. Sites where livestock congregate, such as bed grounds, water troughs, salt, or supplemental feed, should not be situated in prime fawning or calving habitat. When wildlife habitat objectives require livestock to be concentrated at high densities, a rotational grazing system will decrease social intolerance conflicts by always providing areas without livestock. Many species of wildlife, including bighorns, deer, elk, and pronghorns, often adapt and habituate to the presence of livestock as long as the wildlife's needs for food, water, and cover are met.

Parasites and Diseases

Parasite transfers between livestock and wildlife are not a serious threat or problem, except when livestock have high levels of internal parasites. Internal parasite transfers can be avoided by routinely treating livestock with a broad spectrum anthelmintic.

Disease transmission from livestock to wildlife is not usually a concern except between domestic sheep and bighorns. This concern is not surprising because the two species are very closely related and are susceptible to many of the same diseases. However, many bighorn herds have coexisted with domestic sheep for decades without the loss of bighorns, and bighorns commonly fraternize with many mammals, including sheep, horses, cattle, elk, mountain goats, and especially mule deer.[65] Some declines and die-offs of bighorns have occurred in populations that had no association with domestic sheep.[40, 81]

The most common pathogens associated with bighorn die-offs have been pneumophilic (pneumonia-causing) bacteria such as *Pasteurella* spp. or *Mannheimia* sp. This has been true regardless of whether bighorns have had contact with domestic sheep. Pneumophilic bacteria are frequently isolated from healthy bighorns[20, 48] and may, in at least some cases, genetically differ from strains carried by nearby domestic sheep.[79] High bighorn density, poor nutrition, adverse weather, and human harassment can stress bighorns, lower their resistance to bacterial pneumonia, and initiate die-offs.[17, 23] Prescriptive grazing programs should minimize disturbance of bighorns. Much remains unknown about disease transmission by sheep and its effects on bighorns, and research is continuing to address these questions. Current knowledge suggests that "nose-to-nose" contact between sheep and bighorns is required for transmission of pneumophilic bacteria. Sheep husbandry practices that minimize the risk of transmission include night penning and keeping close account of all domestic sheep.

Fences

When herding is not used, targeted livestock grazing will require fences. Fences should be constructed in ways that limit their impacts on wildlife. If possible,

avoid using permanent fences with net or woven wire that can restrict the movements of some wildlife. Permanent fences should be as short as possible (< 48 inches total height) to make it easier for wildlife to jump or fly over, and the space between the two top wires on a wire fence or between a top wire stretched above woven wire should be 8-10 inches. This gap reduces the likelihood that wildlife hitting the top wire when jumping will become entangled in the fence. With wire fences, the bottom wire should be at least 16 inches above the ground, and a smooth bottom wire is preferred for wildlife species that crawl under, rather than jump over, fences. Electric fences charged at 0.5-4.5 joules will not harm pronghorns, elk, or mule deer.[32]

Wildlife conflicts with fences will be reduced when fences are visible. Wire fences can be made more visible by using white-topped steel fence posts, and newly constructed wire fences can be made more visible by temporarily tying white cloth or flagging to the top wire. Wooden fences, such as log-worm, log-rail, and log-block,[19, 58] reduce conflicts because they are more visible and usually easier for wildlife to cross. At traditional crossing points along wire fences, the top wire can be lowered or the top wire can be replaced with a wooden pole set slightly lower than the top wire.[35] Gates also can be left open when not needed to control livestock.

Lay-down or let-down fences can be used where wildlife commonly cross a fence. In one type of lay-down fence, wires are attached to stub posts or stays that stand upright on the ground next to permanent posts.[19, 58, 70] Wire loops attached to the permanent posts hold the stubs in place. Whenever the fence is not needed to control livestock movements, the fence can be laid flat on the ground by removing the stubs from the wire loops. Two other styles of let-down fence do not use stub posts. Instead, wires attach to permanent posts with removable staples[19] or specialized Davison fence clips[30] that enable each wire to be lowered separately.

Photo: Tracy Brewer, Montana State University

Photo: Gary Kramer, USDA, NRCS

SUMMARY

Targeted livestock grazing is a low-cost, low-energy input tool for manipulating and improving the species composition, yield, accessibility, nutritive quality, cover, structure, or diversity of vegetation in ways that favor wildlife. It is important to recognize that altering vegetation will only enhance a wildlife population if the species' limiting habitat factor is improved. Trade-offs must be considered because it is impossible to maximize the habitat of all wildlife at once. Any habitat alteration improves the habitat for some species but at the same time degrades the habitat for others. For these reasons, targeted livestock grazing practices that promote habitat diversity generally improve wildlife habitat overall. Significant improvements to plant standing crop, plant accessibility, and nutritive quality can occur with one year of targeted grazing. Changes to plant species composition usually require at least three to five years in riparian areas and five to 20 years in upland sites. Areas of low precipitation or land in poor condition may require 20-50 years or more for significant improvement in plant species composition.

The timing, intensity, frequency, selectivity, and species of livestock can be adjusted and managed to purposely create habitat features that favor targeted wildlife species. These grazing strategies include:

Grazing Intensity

- Light to moderate grazing intensities (≤ 60% utilization) at low stock densities generally create or maintain vegetation patchiness, increase forage palatability, and promote greater plant diversity than heavy grazing or no grazing.

Timing and Frequency of Grazing

- Rotational grazing can be used to apply infrequent heavy grazing (once every three or four years) in late spring-early summer for brief periods (≤ three to four weeks) to 20-30% of the area each year.
- Rotational grazing can decrease the potential for conflicts by always providing areas without livestock.
- Targeted livestock grazing in prime calving and fawning areas for wild ungulates (e.g., elk, deer, pronghorns), or in prime nesting areas for waterfowl or upland birds, should be deferred until early summer.
- If deferment of targeted grazing in calving, fawning, and nesting areas is not possible, openly and calmly herded livestock will likely have minimal impacts.
- Palatability and nutritive quality of forage in autumn, winter, and spring will be best after a site is prescriptively grazed during the first half of the previous year's growing season.

Other Guidelines

- Bunchgrasses are favored by late season grazing, by selective grazing of forbs, or by selective browsing of shrubs.
- Rhizomatous grasses are favored by grazing early in the growing season, by selective grazing of forbs, or by selective browsing of shrubs.
- Most forbs and shrubs are favored by heavy grazing of grasses in spring or early summer.

Literature Cited

[1]Alpe, M.J., J.L. Kingery, and J.C. Mosley. 1999. Effects of summer sheep grazing on browse nutritive quality in autumn and winter. *Journal of Wildlife Management* 63:346-354.

[2]Arnold, G.W., and M.L. Dudzinski. 1978. Ethology of free-ranging domestic animals. New York, NY: Elsevier. 198 p.

[3]Augustine, D.J., and S.J. McNaughton. 1998. Ungulate effects on the functional species composition of plant communities: Herbivore selectivity and plant tolerance. *Journal of Wildlife Management* 62:1165-1183.

[4]Bicak, T.K., R.L. Redmond, and D.A. Jenni. 1982. Effects of grazing on long-billed curlew *(Numenius americanus)* breeding behavior and ecology in southwestern Idaho. *In:* J.M. Peek and P.D. Dalke [EDS.], Proceedings of the Wildlife-Livestock Relationships Symposium. 20-22 April 1981, Coeur d'Alene, ID. Moscow, ID: University of Idaho Forest, Wildlife, and Range Experiment Station. p. 74-85.

[5]Bowns, J.E., and C.F. Bagley. 1986. Vegetation responses to long-term sheep grazing on mountain ranges. *Journal of Range Management* 39:67-71.

[6]Branson, F.A., and T. Lommasson. 1958. Quantitative effects of 23 years of controlled use on mountain range. *Journal of Range Management* 11:67-70.

[7]Branson, F.A., and G.F. Payne. 1958. Effects of sheep and gophers on meadows of the Bridger Mountains of Montana. *Journal of Range Management* 11:165-169.

[8]Bryant, F.C., F.S. Guthery, and W.M. Webb. 1982. Grazing management in Texas and its impact on selected wildlife. *In:* J.M. Peek and P.D. Dalke [EDS.], Proceedings of the Wildlife-Livestock Relationships Symposium. 20-22 April 1981; Coeur d'Alene, ID. Moscow, ID: University of Idaho Forest, Wildlife, and Range Experiment Station. p. 94-112.

[9]Bryant, F.C., M.M. Kothmann, and L.B. Merrill. 1979. Diets of sheep, Angora goats, Spanish goats and white-tailed deer under excellent range conditions. *Journal of Range Management* 32:412-417.

[10]Buchanan, H., W.A. Laycock, and D.A. Price. 1972. Botanical and nutritive content of the summer diet of sheep on a tall forb range in southwestern Montana. *Journal of Animal Science* 35:423-430.

[11]Clark, P.E., W.C. Krueger, L.D. Bryant, and D.R. Thomas. 2000. Livestock grazing effects on forage quality of elk winter range. *Journal of Range Management* 53:97-105.

[12]Clary, W.P., and D.M. Beale. 1983. Pronghorn reactions to winter sheep grazing, plant communities and topography in the Great Basin. *Journal of Range Management* 36:749-752.

[13]Cody, M.L. 1968. On the methods of resource division in grassland bird communities. *American Naturalist* 102:107-147.

[14]Cohen, W.E., D.L. Drawe, F.C. Bryant, and L.C. Bradley. 1989. Observations on white-tailed deer and habitat response to livestock grazing in south Texas. *Journal of Range Management* 42:361-365.

[15]Crane, K.K., J.C. Mosley, T.K. Brewer, W.L.F. Torstenson, and M.W. Tess. 2001. Influence of cattle grazing on elk habitat selection. *Proceedings of the Western Section of the American Society of Animal Science* 52:160-164.

[16]Crawford, J.A., R.A. Olson, N.E. West, J.C. Mosley, M.A. Schroeder, T.D. Whitson, R.F. Miller, M.A. Gregg, and C.S. Boyd. 2004. Ecology and management of sage-grouse and sage-grouse habitat. *Journal of Range Management* 57:2-10.

Literature Cited

[17]DeForge, J.R., D.A. Jessup, C.W. Jenner, and J.E. Scott. 1982. Disease investigations into high lamb mortality of desert bighorn in the Santa Rosa Mountains, California. *Desert Bighorn Council Transactions* 26:76-81.

[18]Doran, C.W. 1943. Activities and grazing habits of sheep on summer ranges. *Journal of Forestry* 41:253-258.

[19]Duffy, B., B. McBratney, B. Holland, and D. Colvert. 1999. Fences. Denver, CO: U.S. Department of Interior, Bureau of Land Management, U.S. Department of Agriculture, Forest Service, and Society for Range Management. 210 p.

[20]Dunbar, M.A., A.C.S. Ward, and G. Power. 1990. Isolation of *Pasteurella haemolytica* from tonsillar biopsies of Rocky Mountain bighorn sheep. *Journal of Wildlife Diseases* 26:210-213.

[21]Einarsen, A.D. 1948. The pronghorn antelope and its management. Wildlife Management Institute, Washington, DC. 238 p.

[22]Evans, C.C. 1986. The relationship of cattle grazing to sage grouse use of meadow habitat on the Sheldon National Wildlife Refuge [thesis]. Reno, NV: University of Nevada. 199 p.

[23]Fauerstein, V., R.L. Schmidt, C.P. Hibler, and W.H. Rutherford. 1980. Bighorn sheep mortality in the Taylor River-Almont Triangle area. 1978-1979: A case study. Colorado Division of Wildlife Special Report No. 48. 19 p.

[24]Fulgham, K.O., M.A. Smith, and J.C. Malechek. 1982. A compatible grazing relationship can exist between domestic sheep and mule deer. *In:* J.M. Peek and P.D. Dalke [EDS.], Proceedings of the Wildlife-Livestock Relationships Symposium. 20-22 April 1981; Coeur d'Alene, ID. Moscow, ID: University of Idaho Forest, Wildlife, and Range Experiment Station. p. 458-478.

[25]Graul, W.D. 1975. Breeding biology of the mountain plover. *Wilson Bulletin* 87:6-31.

[26]Green, J.S., and J.T. Flinders. 1980. Habitat and dietary relationships of the pygmy rabbit. *Journal of Range Management* 33:136-142.

[27]Hanley, T.A., and K.A. Hanley. 1982. Food resource partitioning by sympatric ungulates on Great Basin rangeland. *Journal of Range Management* 35:152-158.

[28]Hulme, P.E. 1996. Herbivory, plant regeneration, and species coexistence. *Journal of Ecology* 84:609-615.

[29]Jensen, C.H., A.D. Smith, and G.W. Scotter. 1972. Guidelines for grazing sheep on rangeland used by big game in winter. *Journal of Range Management* 25:346-352.

[30]Jepson, R., R.G. Taylor, and D.W. McKenzie. 1983. Rangeland fencing systems state-of-the-art review. Project Record 8322 1201, San Dimas, CA: U.S. Department of Agriculture, Forest Service, Equipment Development Center. 23 p.

[31]Johnson, M.K. 1979. Foods of primary consumers on cold desert shrub-steppe of south central Idaho. *Journal of Range Management* 32:365-368.

[32]Karhu, R.R., and S.H. Anderson. 2006. The effect of high-tensile electric fence designs on big-game and livestock. *Wildlife Society Bulletin* 34:293-299.

[33]Kirsch, L.M. 1974. Habitat management considerations for prairie chickens. *Wildlife Society Bulletin* 2:124-129.

Literature Cited

[34]Klebenow, D.A. 1982. Livestock grazing interactions with sage grouse. *In:* J.M. Peek and P.D. Dalke [EDS.], Proceedings of the Wildlife-Livestock Relationships Symposium. 20-22 April 1981; Coeur d'Alene, ID. Moscow, ID: University of Idaho Forest, Wildlife, and Range Experiment Station. p. 113-123.

[35]Knight, J.E., E.J. Swensson, and H. Sherwood. 1997. Elk use of modified fence-crossing designs. *Wildlife Society Bulletin* 25:819-822.

[36]Kothmann, M.M. 1966. Nutrient content of forage ingested in the morning compared to the evening. *Journal of Range Management* 19:95-96.

[37]Laycock, W.A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. *Journal of Range Management* 20:206-213.

[38]Leckenby, D.A., D.P. Sheehy, C.H. Nellis, R.J. Scherzinger, I.D. Luman, W. Elmore, J.C. Lemos, L. Doughty, and C.E. Trainer. 1982. Wildlife habitats in managed rangelands: The Great Basin of southeastern Oregon: Mule deer. General Technical Report PNW-139. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 40 p.

[39]Leopold, A. 1933. Game management. New York, NY: Charles Scribner's and Sons. 481 p.

[40]Marsh, H. 1938. Pneumonia in Rocky Mountain bighorn sheep. J*ournal of Mammalogy* 19:214-219.

[41]McMahan, C.A. 1964. Comparative food habits of deer and three classes of livestock. *Journal of Wildlife Management* 28:798-808.

[42]Milchunas, D.G., O.E. Sala, and W.K. Laurenroth. 1988. A generalized model of the effects of grazing by large herbivores on grassland community structure. *American Naturalist* 32:87-106.

[43]Mosley, J.C. 1994. Prescribed sheep grazing to enhance wildlife habitat on North American rangelands. *Sheep Research Journal* (Special Issue):79-91.

[44]Mosley, J.C. 1999. Influence of social dominance on habitat selection by free-ranging ungulates. *In:* K.L. Launchbaugh, K.D. Sanders, and J.C. Mosley [EDS.], Grazing behavior of livestock and wildlife. Moscow, ID: University of Idaho. Idaho Forest, Wildlife and Range Experiment Station Bulletin Number 70. p. 109-118.

[45]Mueggler, W.F. 1950. Effects of spring and fall grazing by sheep on vegetation of the Upper Snake River Plains. *Journal of Range Management* 3:308-315.

[46]Neel, L.A. 1980. Sage grouse response to grazing management in Nevada [thesis]. Reno, NV: University of Nevada. 47 p.

[47]Oakleaf, R.J. 1971. The relationship of sage grouse to upland meadows in Nevada [thesis]. Reno, NV: University of Nevada. 64 p.

[48]Onderka, D.K., S.A. Rawluk, and W.D. Wishart. 1988. Susceptibility of Rocky Mountain bighorn sheep and domestic sheep to pneumonia induced by bighorn and domestic livestock strains of *Pasteurella haemolytica. Canadian Journal of Veterinary Research* 52:439-444.

[49]Olson, B.E, and R.T. Wallander. 1998. Effect of sheep grazing on a leafy spurge-infested Idaho fescue community. *Journal of Range Management* 51:247-252.

Literature Cited

[50]Patterson, R.L. 1952. The sage grouse in Wyoming. Sage Books, Inc. Denver, Colo. 341 p.

[51]Phillips, P. 1936. The distribution of rodents in overgrazed and normal grasslands of central Oklahoma. *Ecology* 17:673-679.

[52]Provenza, F.D., and D.F. Balph. 1988. Development and dietary choice in livestock on rangelands and its implications for management. *Journal of Animal Science* 66:2356-2368.

[53]Rasmussen, D.I., and L.A. Griner. 1938. Life history and management studies of the sage grouse in Utah, with special reference to nesting and feeding habits. *Transactions of the North American Wildlife Conference* 3:852-864.

[54]Rhodes, B.D., and S.H. Sharrow. 1990. Effect of grazing by sheep on the quantity and quality of forage available to big game in Oregon's Coast Range. *Journal of Range Management* 43:235-237.

[55]Riggs, R.A., and P.J. Urness. 1989. Effects of goat browsing on Gambel oak communities in northern Utah. *Journal of Range Management* 42:354-360.

[56]Riggs, R.A., P.J. Urness, and K.A. Gonzalez. 1990. Effects of domestic goats on deer wintering in Utah oakbrush. *Journal of Range Management* 43:229-234.

[57]Rouse, R.A. 1957. Elk food habits, range use and movements, Gravelly Mountains, Montana [thesis]. Bozeman, MT: Montana State College. 29 p.

[58]Sanderson, H.R., T.M. Quigley, E.E. Swan, and L.R. Spink. 1990. Specifications for structural range improvements. General Technical Report PNW-GTR-250, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 120 p.

[59]Senft, R.L., M.B. Coughenour, D.W. Bailey, L.R. Rittenhouse, O.E. Sala, and D.M. Swift. 1987. Large herbivore foraging and ecological hierarchies. *BioScience* 37:789-799.

[60]Senock, R.S., D.M. Anderson, L.W. Murray, and G.B. Donart. 1993. Tobosa tiller defoliation patterns under rotational and continuous stocking. *Journal of Range Management* 46:500-505.

[61]Severson, K.E., and M. May. 1967. Food preferences of antelope and domestic sheep in Wyoming's Red Desert. *Journal of Range Management* 20:21-25.

[62]Severson, K.E., and P.J. Urness. 1994. Livestock grazing: A tool to improve wildlife habitat. *In:* M. Vavra, W.A. Laycock, and R.D. Pieper [EDS.], Ecological implications of livestock herbivory in the West. Denver, CO: Society for Range Management. p. 232-249.

[63]Skovlin, J.M., P.J. Edgerton, and R.W. Harris. 1968. The influence of cattle management on deer and elk. *Transactions of the North American Wildlife and Natural Resources Conference* 33:169-181.

[64]Smith, C.C. 1940. The effect of overgrazing and erosion upon the biota of the mixed-grass prairie of Oklahoma. *Ecology* 21:381-397.

[65]Smith, D.R. 1954. The bighorn sheep in Idaho: Its status, life history and management. Boise, ID: Idaho Department of Fish and Game Wildlife Bulletin Number 1. 154 p.

Literature Cited

[66]Smith, M.A., J.C. Malechek, and K.O. Fulgham. 1979. Forage selection by mule deer on winter range grazed by sheep in spring. *Journal of Range Management* 32:40-45.

[67]Stevens, D.R. 1966. Range relationships of elk and livestock, Crow Creek drainage, Montana. *Journal of Wildlife Management* 30:349-363.

[68]Torstenson, W.L.F., J.C. Mosley, T.K. Brewer, M.W. Tess, and J.E. Knight. 2006. Elk, mule deer, and cattle foraging relationships on foothill and mountain rangeland. *Rangeland Ecology and Management* 59:80–87.

[69]Tueller, P.T., and J.D. Tower. 1979. Vegetation stagnation in three-phase big game exclosures. *Journal of Range Management* 32:258-263.

[70]Turner, G.T. 1960. A lay-down fence for snow country. *Journal of Range Management* 13:43-44.

[71]Urness, P.J. 1982. Livestock as tools for managing big game winter range in the Intermountain West. *In:* J.M. Peek and P.D. Dalke [EDS.], Proceedings of the Wildlife-Livestock Relationships Symposium. 20-22 April 1981; Coeur d'Alene, ID. Moscow, ID: University of Idaho Forest, Wildlife, and Range Experiment Station. p. 20-31.

[72]Urness, P.J. 1990. Livestock as manipulators of mule deer winter habitats in northern Utah. *In:* K. Severson [ED.], Can livestock be used as a tool to enhance wildlife habitit? General Technical Report RM-194, Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. p. 25-40.

[73]Vallentine, J.F. 2001. Grazing management. San Diego, CA: Academic Press. 659 p.

[74]Van Dyne, G.M., and H.F. Heady. 1965. Botanical composition of sheep and cattle diets on a mature annual range. *Hilgardia* 36:465-470.

[75]Villalba, J. J., F.D. Provenza, and B. Han. 2004. Experience influences diet mixing by herbivores: Implications for plant biochemical diversity. *Oikos* 107:100–109.

[76]Vogel, W.G., and G.M. Van Dyne. 1966. Vegetation responses to grazing management of foothill sheep range. *Journal of Range Management* 19:80-85.

[77]WallisDeVries, M.F., E.A. Laca, and M.W. Demment. 1999. The importance of scale of patchiness for selectivity in grazing herbivores. *Oecologia* 121:355-363.

[78]Wallmo, O.C., L.H. Carpenter, W.L. Regelin, R.B. Gill, and D.L. Baker. 1977. Evaluation of deer habitat on a nutritional basis. *Journal of Range Management* 30:122-127.

[79]Ward, A.C.S., M.R. Dunbar, D.L. Hunter, R.H. Hillman, M.S. Bulgin, W.J. Delong, and E.R. Silva. 1990. Pasteurellaceae from bighorn and domestic sheep. *Proceedings of the Northern Wild Sheep and Goat Council* 7:109-117.

[80]Ward, A.L., J.J. Cupal, A.L. Lea, C.A. Oakley, and R.W. Weeks. 1973. Elk behavior in relation to cattle grazing, forest recreation, and traffic. *Transactions of the North American Wildlife and Natural Resources Conference* 38:327-337.

[81]Wishart, W.D., J. Jorgenson, and M. Hitton. 1980. A minor die-off of bighorns from pneumonia in southern Alberta (1978). *Proceedings of the Northern Wild Sheep and Goat Council* 2:229-245.

CHAPTER 14: Incorporating Targeted Grazing into Farming Systems

By Patrick Hatfield, Hayes Goosey, Andrew Lenssen, and Sue Blodgett

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10 KEY POINTS

- Cropping systems historically were wholly integrated with livestock production.
- Incorporating grazing into cropping systems could reverse the decline in organic carbon levels.
- Many summer fallow weeds are palatable making them susceptible to grazing.
- Grazing can remove excess crop residue that hinders crop production.
- Sheep grazing grain residue can reduce wheat stem sawfly populations.
- Grazing may inhibit cereal leaf beetle, Hessian fly, wheat stem maggot, and certain aphids and mites.
- Alfalfa weevil is susceptible to grazing with sheep.
- Volunteer weeds and crop residues can provide nutritious livestock forages.
- Grazing cropland may cause some soil compaction but not enough to hinder crop production.
- Integrating livestock into farming operations can provide low-capital business opportunities.

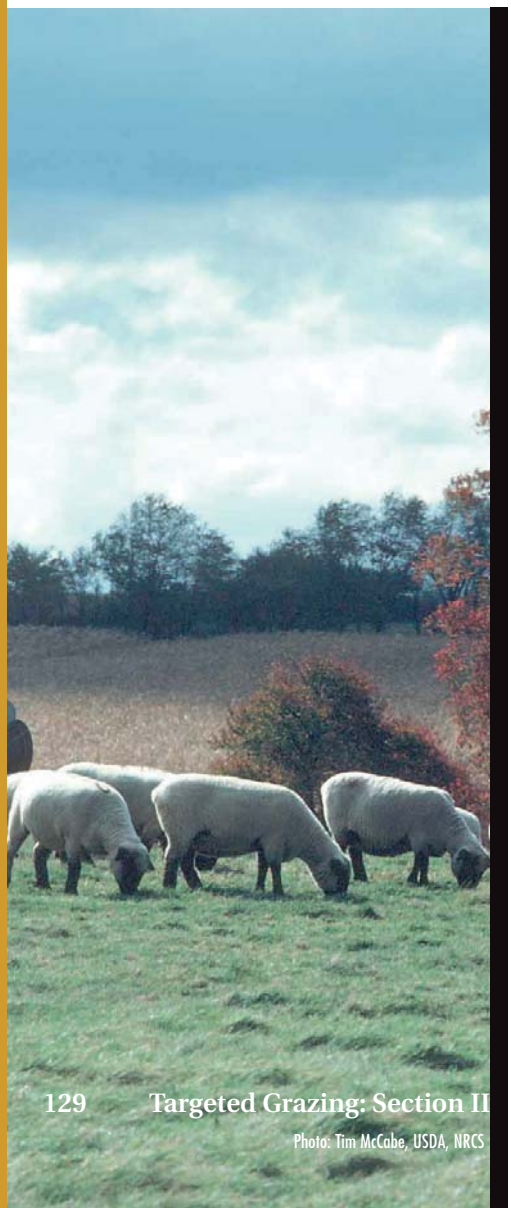


Photo: Tim McCabe, USDA, NRCS

INTRODUCTION

When incorporating targeted grazing into farming systems, livestock producers and farm operators need assurance that the benefits from their activities are worth their investments. This chapter will focus on how integrating grazing, particularly with sheep and goats, into farming systems can offer those benefits. The concepts are not new. Cropping systems were once integrated with livestock production: Livestock gained forage value from crop aftermath, crops were grown to sustain livestock, and livestock were used as implements to produce crops. Today, few cropping systems include livestock.

Sheep and goats are traditionally produced on rangelands or pasture forages and supplemented during winter with harvested feeds. In recent years, sheep and goat producers have made great strides using commercial-scale grazing to control unwanted vegetation like noxious weeds and excess fire fuels. Incorporating grazing into hay and dryland grain production to control weeds and insects has received far less attention. However, such practices not only may increase yield, they can reduce costs, offer new business opportunities, and improve public perception of production agriculture.

On some Great Plains soils, organic carbon levels have declined up to 60% since their initial cultivation.[17] This trend could be reversed by incorporating livestock grazing into cropping systems, a practice currently used on less than 10% of agricultural land. Integrated crop and livestock systems could reduce reliance on synthetic fertilizers to maintain soil fertility, pesticides to control weed and insect pests, and depreciable equipment, fossil fuel, and burning to remove crop residues. These cropping inputs are becoming less feasible for both economic and environmental reasons. Integrated low-input systems that optimize output per unit of input may be preferred over systems that simply strive to maximize output. Reducing production costs while creating opportunities in the form of low cost livestock production could dramatically alter grain and forage production, at the same time filling increasing consumer demand for food and fiber produced in an environmentally sound manner.

This chapter highlights several techniques for integrating livestock grazing into grain and forage systems, potentially improving profitability and sustainability for crop producers and creating a profitable service industry for livestock producers. It examines the use of livestock to manage fallow, weeds, and insect pests by grazing grain and forage residue, practices that could help farmers reduce pesticides and tillage, allow livestock producers to tap into valuable feed sources, and enable rural communities to embrace new opportunities.

Vegetation Management Opportunities

Presented here are three example settings of opportunities to integrate livestock into cropping systems:

1. Grazing summer fallowed ground on dryland grain systems that rotate each year between fallow and crop production to control weeds and conserve soil moisture and nutrients.
2. Grazing grain crop residues after harvest to facilitate tillage, control unwanted plants, and reduce insect pest populations.
3. Grazing alfalfa with a major emphasis on insect pest control.

Grazing Fallow Ground

In fallow, weeds and volunteer crop plants deplete soil moisture and nutrient reserves. Their unwanted growth on wheat fields can reduce grain yield the following year by 500 to 1,500 pounds per acre.[8, 24] On the Northern Great Plains, about 15 million acres of farmland are rotated into summer fallow annually[26] with up to four herbicide applications to control weeds, making herbicides the most costly input for the system. On fallow ground, pesticide costs averaged $6.08 an acre with minimum tillage and $9.29 an acre with chemical fallow.[16]

Tillage is the most common alternative to herbicides now used to control weeds in summer fallow or fallow management in organic farming. However, tillage can bury crop residue, which decreases soil cover and

Figure 1. Sheep grazing to control weeds in a fallow field in Montana.

increases the potential for erosion. Incorporating grazing could reduce these tillage impacts and offer an alternative to herbicides while being able to control the amount of residue that remains for ground cover.

Many weeds found in summer fallow, like volunteer grain, kochia, Russian thistle, wild oats, and cheatgrass, are highly palatable to ruminants, particularly when plants are in the green leafy stage. Marten and Andersen (1975) documented that several broadleaf and grassy weeds have high forage quality and are as palatable as oats to grazing sheep, suggesting that grazing animals may be effective tools to manage weeds.

Selecting Animals and Management Strategies

Given that sheep prefer forbs and broadleaf plants and their established role in controlling range weeds, they may work better than cattle when the primary goal is to reduce weeds in summer fallow. However, cattle may also be an effective tool when the goal is to reduce biomass or remove volunteer grain. Current work at Montana State University clearly shows that volunteer wheat is an excellent forage resource for any class of ruminant. Goats may also be effective in removing weeds or volunteer crop plants from stubble. Any breed, age, or background of sheep will work for summer fallow grazing if weeds are at an immature stage or the predominant weed is volunteer grain.

The animal's nutritional needs should be aligned with land management goals. Current research by Hatfleld and co-workers at Montana State University indicates that cull ewes, yearling rams, and wethers do an excellent job of removing weeds and volunteer crop plants. With the potential high nutrient content of young weeds, lactating ewes could be incorporated into fallow management. However, when weeds become scarce during the end of fallow grazing, the animals may need supplements, particularly protein, to meet nutrient demands, or animals with low requirements, like dry open ewes, could be used. If land management is the primary task and source of income, wethers, with their relatively low nutrient demands, may be appropriate, especially when combining fallow management with other vegetation management jobs. It should be noted that using fine-wooled breeds of wethers on a low but consistent nutrient program also has the potential for producing fine, high quality wool.

Soil compaction may be a concern when integrating livestock into cropping systems. Studies have shown that cattle grazing wheat fields do compact the soil to some degree,[28] while sheep have less impact. Murphy et al. (1995) compared cattle and sheep grazing on smooth-stalked meadowgrass-dominant white clover sward. At similar stock densities (32 animal units per acre), soil compaction was 81% greater with cattle than with sheep. They speculated that the shape and small

size of the sheep hoof might churn and till up the soil rather than compress it. Plants grew more vigorously under sheep, probably because they cycled higher levels of nutrients and created less soil compaction.

Grazing may cause slightly more compaction than chemical and mechanical summer fallow. But even if grazing does cause some compaction, freezing and thawing over winter and pre-planting tillage can alleviate the impact.[23]

When grazing summer fallow, timing is critical. The crop producer wants weeds and volunteer crop plants removed before they consume too much water and soil nutrients. The livestock producer wants the animals to consume weeds and volunteer grain plants while they are still palatable and nutritious (Figure 1). Fortunately, the time of grazing for optimum fallow management generally coincides with the time when plants are most nutritious and palatable. When plants mature and initiate flowering and seed production, they begin to use large amounts of soil moisture and nutrients. At this stage, most have relatively low fiber content and crude protein values in the mid-teen to low 20% range, providing excellent feed. However, many also accumulate unpalatable compounds (i.e., tannins, oxalates, or terpenes) and become less desirable to grazing animals. Current research at Montana State University by Hatfield and co-workers indicates that some fallow weeds, like common mallow, have a fairly short period for aggressive consumption by sheep. But when the target weed is the only green, lush forage available, consumption is generally high.

The best time to initiate grazing for fallow management typically coincides with the best time for herbicide application for fallow management. As with mechanical and chemical fallow, the number and timing of grazing applications per season will vary with weed type, soil moisture, and weather conditions. In two years of work at the Fort Ellis Experiment Station by Hatfield and co-workers (Figure 2) the number of grazing applications typically was similar to or slightly greater than the number of chemical and mechanical fallow applications.

Reducing Crop Residue

Cereal crop residues are primarily fibrous carbohydrates, unusable as feed for non-ruminants, like pigs and chickens, and lacking the energy density to warrant processing or transport. Small grain residue, particularly in high production settings, is often considered a hindrance to the primary production of grain. Targeted grazing offers managers another way to handle residue in response to market and environmental goals and restrictions. In the future, burning crop residue may be banned, leaving spreading, baling, and grazing as the only options.

Figure 2. Research plots comparing mechanical, chemical, and grazed fallow on three farming rotations: 1) spring wheat/summer fallow, 2) winter wheat/summer fallow, and 3) spring wheat/spring wheat.

Each year in the United States, nearly 800 million tons of crop residues are produced above the amount needed to prevent soil erosion.[18] In some situations, these residues can hinder grain production and profitability and provide habitat for insect and weed pests.

In dryland operations, spreading straw may work when residue levels are low, but it may not be an option in high production areas or as a sole method of managing residue in dryland operations because of residue buildup. Windrowing and baling can remove the residue, but income from the sale of straw may not always cover the cost of harvest. Livestock can graze spread or windrowed straw. Windrowing the straw before grazing may increase the amount available for consumption, with less loss to trampling, while spreading the straw provides a more uniform biomass cover to help prevent erosion. Depending on farming goals, targeted grazing may be the most economical method of removing residue, particularly if the benefits of insect control and residue processing are considered. Windrowed straw may also expand grazing seasons, although protein supplements may be needed if no volunteer grain or other palatable green material is available. Further, grazing residues may improve soil tilth by incorporating ruminally processed organic matter into the soil. Baling, burning, tillage, and grazing all remove residue, but only grazing can add beneficial material back to the soil.

Many producers view burning grain stubble as an inexpensive, labor-efficient way to remove unwanted crop residue before tillage and seedbed preparation. However, long-term burning can decrease cereal grain yields, reductions that cannot be offset with fertilization.[4] This research also found that while total nitrogen decreased on burned fields compared to normal tillage without burning, nitrate levels actually increased in the burned fields. Many producers also see burning as a viable method of controlling weed, insect, bacterial, and fungal populations. However, Biederbeck and colleagues (1980) reported that the heat from burning only penetrated one-half inch into the soil, offering minimal effects on weed seeds, unwanted insects, and soil-based pathogens.

Field burning can cost up to $4 per acre[25] and, by removing biomass, can preclude potential income from grazing. Mulholland and colleagues (1976) noted that cereal stubble with some green plant growth was a reasonable grazing resource for sheep at stocking rates up to 10.5 animals per acre for 11 weeks. Thomas and colleagues (1990) reported that barley stubble provided a suitable feed resource for weaned lambs stocked at four lambs per acre for 42 days in the fall. Calculated returns range from $5 to $40 per acre in this research. The costly impacts of burning stubble – yield loss, increased fertilizer cost, the cost of burning, loss of grazing revenue, and compromised air quality – increase the potential opportunities for grazing as an alternative.

On some irrigated farms gaining access to fields in the spring may be more important than conserving soil moisture. To facilitate drying, producers may remove residues that hold moisture, as in eastern Idaho, where some potato/grain growers burn excess small grain stubble or cut it close and bale the straw. Burning incurs the costs listed above, and the value of the straw is subject to fluctuating local markets. In addition, burning crop residues releases particulate matter and several gases, including carbon dioxide, methane, carbon monoxide, and nitrous oxide, which can impair air and visual quality.[6] Some producers irrigate or use a rotary harrow or similar implement after fall harvest to encourage remnant spring wheat seed to sprout and fall victim to winter freezing instead of becoming a weed in the next year's rotation crop. Livestock grazing could provide an alternative. In studies with sheep grazing irrigated crop residue, the sheep removed the green and growing volunteer grain along with the cut residue and the standing stubble, subsequently trampling the plant residue into the soils.[9]

Grazing has also been used as an alterative to field burning in the management of bluegrass seed fields.[15] It is important to remove straw and stubble to destroy disease host residue to control disease, insect, and rodent pest populations. Burning, mowing, and grazing also reduce volunteer plant establishment, which could reduce seed quality and cause seed contamination. Finally, removing stubble after seed is harvested reduces thatch accumulation, prevents "sod bound" stand development, and facilitates nutrient cycling. Research at the University of Idaho has shown that seed yield increased with greater residue removal. The highest yielding treatments removed at least 80% of the post-harvest residue, and it was possible to accomplish this level of residue removal by grazing cattle.[15] Grazing post-harvest residue resulted in higher yields than mowing and baling but resulted in lower subsequent seed yield than post-harvest field burning.

Selecting Animals and Management Strategies

Sheep that commonly graze dormant forage during the winter will likely graze grain residue more readily than sheep commonly fed hay. Also, research suggests that

Figure 4. Wheat stem sawfly depositing eggs in a mature wheat stem.

Photo: University of Nebraska, Entomology Department

Figure 3. Sheep grazing crop stubble in Montana, reducing excess crop residue and incorporating organic matter into the soil.

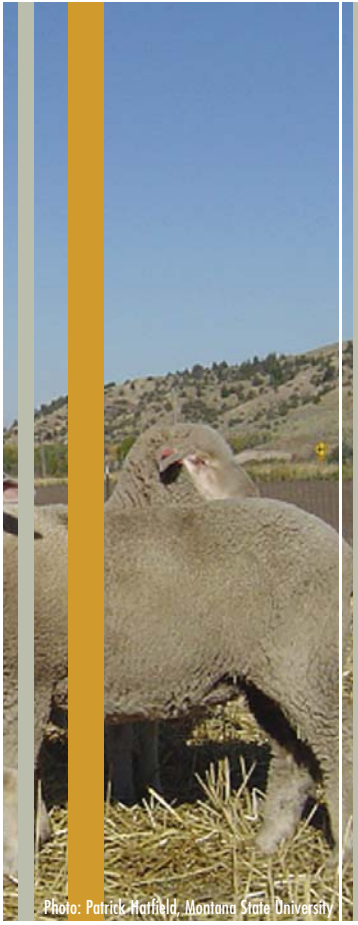


Photo: Patrick Hatfield, Montana State University

rangeland breeds like Targhee possess greater abilities for conserving and recycling nitrogen than breeds like Suffolk, which were developed in a more nutrient-rich environment.[10]

Mature range ewes with nitrogen supplementation or adequate levels of green weeds and volunteer plants can dramatically reduce both cut residue and standing stubble (Figure 3). However, when the goal is to remove weeds without significantly reducing residue cover, the authors speculate that younger sheep like replacement ewe lambs may be preferred.

Grazing to Control Insects In Cereal Grains

Wheat stem sawfly is the most damaging pest, insect or disease, in the Northern Great Plains. In Montana's $1 billion a year grain industry, the economic impact of this insect is estimated at more than $30 million a year.[2] Originally a pest of spring wheat, the sawfly's adult emergence period has gradually shifted earlier, making it a significant winter wheat pest.[20] Adults emerge in early summer, and females lay single eggs within an elongating wheat stem (Figure 4). Eggs hatch and larvae feed on the stem. As wheat matures, the larva completes its feeding and travels to the base of the stem, where it cuts and plugs the stem behind it, forming a sheltered stub for overwintering. Larval cutting weakens the wheat stem, resulting in lodged stems. The wheat stem sawfly passes most of its life – egg through pupae – within a single wheat stem, protecting it from environmental influences and control practices. Insecticides have minimal success because it is difficult in a single application to target a non-feeding mobile insect population that emerges over four to six weeks. Tillage or burning typically have mixed or minimal impact on sawfly mortality, and both are costly and may cause ecological problems (i.e erosion and pollution). In a two-year study using four different farm sites each year, Hatfield and co-workers (in-press) reported higher mortality with grazing than either tillage or burning. Solid stem varieties of wheat have been developed with varying levels of resistance depending on growing conditions, but their yields can be 10 to 25% lower than susceptible varieties. Newer varieties are being developed with improved yield and resistance and higher forage value, but resistance may vary depending on growing conditions and adaptation by the sawfly.

Wheat-fallow production systems, particularly those managed with zero tillage, leave wheat stem sawfly overwintering sites undisturbed. Research has been conducted with the idea that grazing sheep may disrupt the overwintering environment, exposing sawflies to extreme winter conditions that will increase overwintering larval mortality.

Sheep grazing wheat stubble in the fall and spring killed 75% of wheat stem sawfly compared with a no-input control (42% sawfly mortality), tillage (40% mortality), and burning (45% mortality).[11] Hoof action may be as important as consumption on wheat stem sawfly mortality,[11] which means producers can reduce sawfly numbers by extending the period sheep are on the stubble field, initially offering a protein or energy supplement and eventually feeding hay.

Another consideration is insect movement. Burning, insecticides, tillage, and resistant varieties are site specific so they have limited impact on insects that migrate in from other areas. This creates a potential for using strategic grazing to create "buffer zones" around target fields. However, this research has not been conducted and consideration must be given to native plants that might harbor wheat stem sawflies and distances that sawflies are capable of traveling to spread infestations.

Cereal leaf beetle is a major pest of barley, particularly in irrigated systems, in several areas of the West. A large portion of cereal leaf beetle adults overwinter in the standing stubble of harvested fields. The percentage is unknown, however, because many leave the fields and hibernate in riparian areas. Livestock strategically grazing stubble may inadvertently consume adult cereal leaf beetles hibernating there. Depending on the proportion of adult beetles overwintering in the stubble, grazing may reduce the survivors enough to reduce adult and larval damage the following growing season.

The Hessian fly produces two generations annually, one in the spring and another in the fall. In September, the fly lays eggs in seedling wheat or volunteer wheat. The second generation emerges the next spring after overwintering larvae develop into adults. The insect survives the summer in the flaxseed stage in wheat stubble. At this stage, the insect forms a shiny brown, seed-like puparium found at the base of old plant crowns or in the straw near the nodes under the leaf sheaths. Volunteer wheat or wheat planted early will be in the seedling stage when adults emerge. Grazing after harvest can reduce the volunteer crop plants before the fall generation of Hessian flies emerge.

Wheat stem maggot passes the winter in the larval stage in the lower parts of the stems of wheat and other hosts. They pupate in the spring, and adults emerge in June, ovipositing on volunteer and other grasses. The newly hatched maggots enter the leaf sheaths and tunnel into the tender tissues of the stem. Maggots feed for about three weeks before pupating. A smaller fall generation emerges in late August to early September and lays eggs in the new winter wheat crop. Strategic grazing to reduce the abundance of volunteer and susceptible grasses could help to reduce oviposition sites during the mid-summer egg-laying period and significantly reduce the subsequent fall generation.

Grazing volunteer wheat may reduce overwintering populations of brown wheat mite, Russian wheat aphid, and wheat curl mite. Volunteer wheat provides a green bridge for arthropods, and grazing can break the bridge, reducing populations of these damaging pests. Grazing stubble may also reduce wheat jointworm and wheat strawworm.

A variety of insects feed and reproduce in alfalfa fields, decreasing crop quality and quantity. The alfalfa weevil is the most economically damaging insect pest of alfalfa in the United States.[3] In Montana, alfalfa weevil adults aestivate during summer, emerge in fall, and hibernate during winter in leaf litter and around plant crowns. The weevils become active in spring before the first cutting, damaging plant crowns and retarding green-up on subsequent cuttings.

Several management tactics have been tried with varied results. The weevil-tolerant cultivars of alfalfa currently available seldom provide enough protection from damage to justify their use. Biological agents developed to reduce weevil populations below economic thresholds are generally ineffective or too expensive to implement, particularly in the Western United States. Insecticides that target alfalfa weevil larvae, used on a third of U.S. alfalfa acreage, are also costly and require intensive field monitoring to determine when a treatment is economically justified.[7] Dowdy et al. (1992) reported reductions of 67% in weevil eggs and 25% in spring larval numbers in grazed compared to ungrazed plots in Oklahoma. In the Montana research, grazing most likely reduces alfalfa weevil numbers by reducing biomass or significantly changing relative humidity or temperature, making the grazed areas less attractive for ovipositing alfalfa weevil females moving into the fields after hibernation.

The clover root curculio is a weevil affecting alfalfa and clover root systems in the Pacific Northwest. Its life cycle is somewhat similar to that of the alfalfa weevil, suggesting that it would be susceptible to the same cultural control tactics, but only at specific times given the larval feeding strategy. Adults become active in the spring and deposit eggs on the soil surface or on the undersides of leaves of host plants. By May or early June, newly hatched larvae move into the soil where they begin to feed on roots, which means control would likely be most effective during the spring when the female deposits eggs on the soil surface.

Lygus bugs infest alfalfa grown for forage or seed. They overwinter as adults except in the Southwest, where they may be active year round in annual and perennial grasses, broadleaf weeds, some overwintering crops, and plant debris in areas adjacent to agricultural fields. Because of lygus bugs' wide host range, these grasses and broadleaf weeds help to build insect populations early in the spring, causing more damage to alfalfa during the growing period. Suppressing weed hosts in and around alfalfa fields can help to slow lygus bug population buildup. Sheep can graze the weeds that serve as a green bridge, helping to curtail lygus bug populations.

Animal Selection and Management Strategies

Any farming practice that disrupts a vital component of an insect's life cycle has the potential to decrease its population. Correctly implemented livestock grazing has the potential to manage a variety of insects infesting a variety of crops. Cereal stubble with green weedy material was an acceptable grazing resource for sheep stocked at 135 sheep days per acre (Mulholland et al. 1976), and 170 sheep days per acre (Thomas et al. 1990). In fall and spring treatments, at 183 sheep days per acre, a level within the realm of reasonable stocking rates, wheat stem sawfly numbers were reduced on grain stubble used for sheep production.[11] In addition, Hatfield and co-workers also reported significant reduction in crop residues without adversely affecting soil bulk density.[13] The question of similar stocking rates at different durations and intensities of grazing has yet to be addressed.

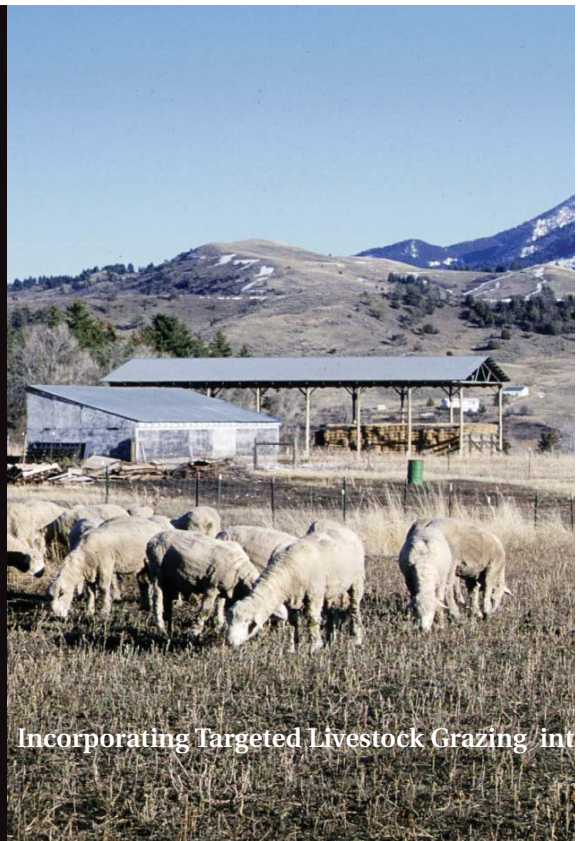
Grazing to Manage Insect Pests in Alfalfa

On alfalfa, Dowdy et al. (1992) reported an overall 25% reduction of alfalfa weevil larvae in grazed compared to ungrazed plots. In another study, adult weevils were reduced in grazed plots by 35 to 100%, and larva were reduced by 40 to 70% in grazed vs. ungrazed plots, depending on sampling date and study year.[7] The reduction may have resulted from reduced biomass, relative humidity, or temperature, making the grazed areas less attractive for ovipositing adults moving into the fields after hibernation. Further, any alfalfa weevil eggs successfully laid in grazed areas would be quickly consumed by grazing sheep, further reducing weevil densities.

These data show the potential for grazing alfalfa regrowth for winter pasture and weevil management. However, the impacts of grazing on alfalfa must be also considered, including 1) optimum season and time of grazing to enhance insect mortality, 2) grazing at the appropriate season and time to avoid adversely impacting stand longevity, and 3) grazing at the appropriate season and time to avoid bloat. Although forage biomass was reduced 73 to 98% by the end of the grazing period in the study by Goosey et al. (2004), hay yields at harvest did not differ between grazed and ungrazed plots (Figure 5). In addition, crude protein, acid detergent fiber, and neutral detergent fiber did not differ between grazed and ungrazed plots. Canadian scientists suggest that after the stand has been exposed to three days of 20°F lows, grazing or cutting will not impact stand longevity. This coincides with recommendations for preventing bloat in animals grazing alfalfa.

Figure 5. Sheep grazing alfalfa aftermath in Montana. In this study, grazing reduced harmful insect infestations without impacting hay production. The fenced control plot shows the effectiveness of grazing excessive alfalfa biomass, which can harbor harmful insects.

Photo: Patrick Hatfield, Montana State University



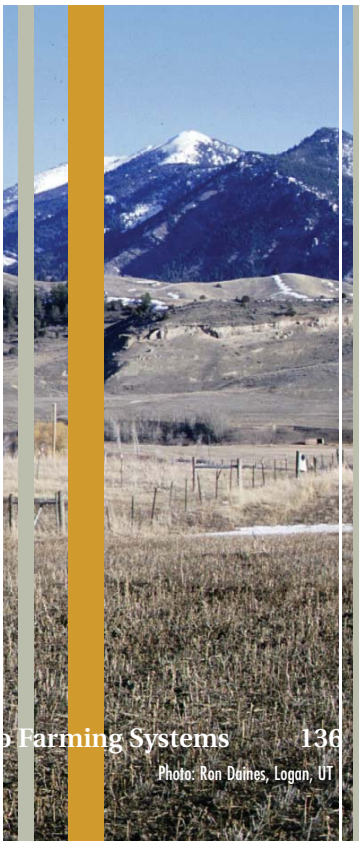


Photo: Ron Daines, Logan, UT

Animal Selection and Management

Alfalfa residue has high nutritive value, so adapting animals and breeds suited to low-nutrient and high-fiber diets may not be an issue. Any class of sheep, goats, or cattle will likely be effective. Timing to maintain stand longevity, minimize risk of bloat, and limit soil compaction is more important than animal selection. Likewise, stocking duration and intensity are more important than breed or class of animal for grazing crop residue to control insect pests.

Animal Production Considerations

An excellent feed resource can be provided when fall rains or irrigation and sufficiently high temperatures germinate volunteer grain and stimulate weed growth. Likewise, small grain residue can be an excellent feed resource, but it's important to watch for bloat and acidosis in sheep that eat spilled grain. Sheep and goats can also be returned to fields that have enough snow to supply drinking water to graze stubble and residue, although a protein supplement may be required. The longer the sheep spend in a field, the greater the chance for killing insects. Adding harvested feeds to stubble fields can increase that time.

A ewe's cycle can be used to advantage in grazing to manage resources. The period of high nutrient demand runs from the last six weeks of a five-month gestation through the first six weeks of lactation. Outside this period of high nutrient demand, when the ewe is at or near maintenance requirements, she can be used to manipulate low quality forage without hindering performance.

Research at the U.S. Sheep Station compared stubble grazing with confinement hay feeding.[9] Ewes in average to slightly better than average body condition were grazed on residue during early and mid gestation. For late gestation and early lactation, ewes were moved to native range and lambed starting in mid May. Ewes grazing alfalfa and grain residues maintained adequate body weight and had the same reproductive performance as their confined counterparts (Figure 6). If green weeds and volunteer grain plants are absent, protein and non-protein nitrogen supplements, like urea or biurette, can enhance grain residue intake and digestibility.[14]

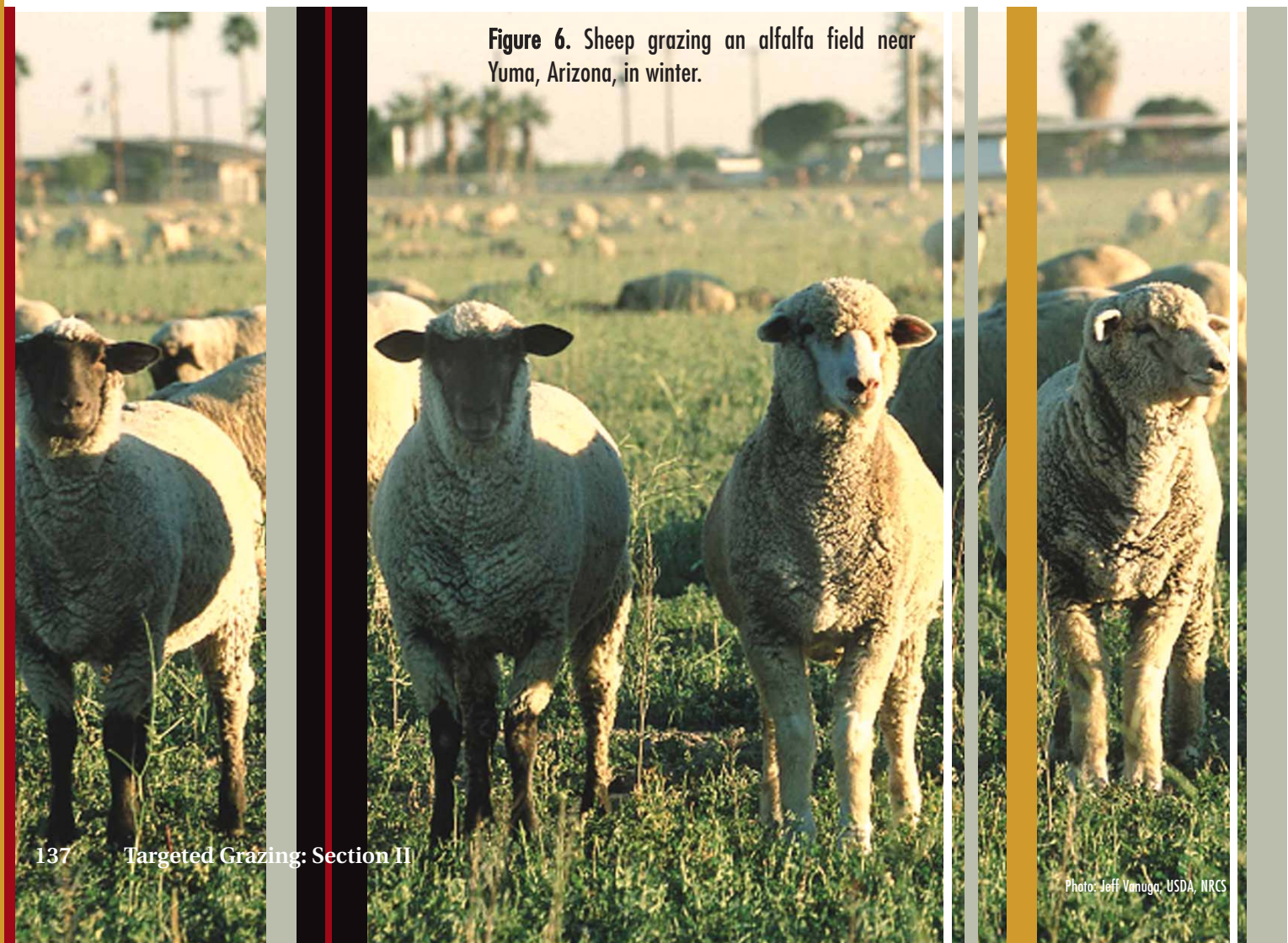


Figure 6. Sheep grazing an alfalfa field near Yuma, Arizona, in winter.

Photo: Jeff Vanuga, USDA, NRCS

CONCLUSION

Integrating livestock into farming and natural resource management may have the added benefit of enhancing rural development through low-capital entrepreneurial opportunities based as much on the concept of landscape management as on traditional meat and wool production. The largest constraint to entering a land-based agricultural industry is often the purchase of land. Integrating livestock into farming systems for residue, weed, and insect control may allow entry for new and existing entrepreneurs by generating income through residue harvest and landscape management. Success in this arena will require that operators view themselves as vegetation managers as much as meat and fiber producers and develop an expanded view of the resources they need. For example, those involved in fallow and range weed management may also need to own and operate a spray rig. A stubble management enterprise may also own a baler as a way to remove residue in addition to grazing. The point is to view the enterprise more broadly than that of a commodity producer to provide the full service a client is seeking in a timely manner.

Literature Cited

[1]Biederbeck, V.O., C.A. Campbell, K.E. Bowren, M. Schniter, and R.N. McIver. 1980. Effects of burning cereal straw on soil properties and grain yields in Saskatchewan. *Soil Science Society of America Journal* 44:103.

[2]Blodgett, S.L., H.B. Goosey, H.B., D. Waters, C.I. Tharp, and G. Johnson. 1996. Wheat stem sawfly control on winter wheat. *Arthropod Management Tests* 22:331-332.

[3]Blodgett, S.L., A.W. Lenssen, and S.D. Cash. 2000. Harvest with raking for control of alfalfa weevil (Coleoptera: Curculionidae). *Journal of Entomological Sciences* 35:129-135.

[4]Dormaar, J.F., U.J. Pittman, and E.D. Spratt. 1979. Burning crop residues: Effect on selected soil characteristics and long term wheat yields. *Canada Journal of Soil Science* 59:79.

[5]Dowdy, A.K., R.C. Berberet, J.F. Stritzke, J.L. Caddell, and R.W. McNew. 1992. Late fall harvest, winter grazing, and weed control for reduction of alfalfa weevil (Coleoptera: Curculionidae) populations. *Journal of Economic Entomology* 85:1946-1953.

[6]Environmental Protection Agency (EPA). 1998. Policy planning to reduce greenhouse gas emissions. second edition. *Available at:* http://yosemite.epa.gov/oar/globalwarming.nsf/uniquekeylookup/shsu5bumxf/$file/guid_doc.pdf?openelement. *Accessed 25 August 2006.*

[7]Goosey, H.B., P.G. Hatfield, S.L. Blodgett, and S.D. Cash. 2004. Evaluation of alfalfa weevil (Coleoptera: Curculionidae) densities and regrowth characteristics of alfalfa grazed by sheep in winter and spring. *Journal of Entomological Sciences* 39:598-610.

[8]Greb, B.W. 1981. Significant research findings and observations from the Central Great Plains Research Station and Colorado State University Experiment Station cooperating, Akron, Colorado: historical summary 1900-1981.

[9]Hatfield, P.G., S.L. Blodgett, G.D. Johnson, P.M. Denke, R.W. Kott, and M.W. Carroll. 1999a. Sheep grazing to control wheat stem sawfly, a preliminary study. *Sheep and Goat Research Journal* 15:159-160.

[10]Hatfield, P.G., W.A. Head, Jr., J.A. Fitzgerald, and D.M. Hallford. 1999b. Effects of level of energy intake and energy demand on growth hormone, insulin, and metabolites in Targhee and Suffolk ewes. *Journal of Animal Science* 77:2757

[11]Hatfield, P.G., S.L. Blodgett, T.M. Spezzano, H.B. Goosey, A.W. Lenssen, R.W. Kott, and C.B. Marlow. 2007a. Incorporating sheep into dryland grain production systems: I Impact on over-wintering larva populations of Wheat stem sawfly, *Cephus cintus* Norton, (Hymenoptera: Cephidae). *Small Ruminant Research* In press: Anticipated in Volume 67:209-215.

[12]Hatfield, P.G., A.W. Lenssen, T.M. Spezzano, S.L. Blodgett, H.B. Goosey, R.W. Kott, and C.B. Marlow. 2007b. Incorporating sheep into dryland grain production systems: II Impact on changes in biomass and weed frequency. *Small Ruminant Research* In press: Anticipated in Volume 67:216-221.

[13]Hatfield, P.G., H.B. Goosey, T.M. Spezzano, S.L. Blodgett, A.W. Lenssen, R.W. Kott, and C.B. Marlow. 2007c. Incorporating sheep into dryland grain production systems: III Impact on changes in soil bulk density and soil nutrient profiles. *Small Ruminant Research* In press: Anticipated in Volume 67:222-231.

[14]Hennessey, D.W. 1996. Appropriate supplementation strategies for enhancing production of grazing cattle in different environments. *In:* M.B. Judkins and F.T. McCollum [eds.] Proceedings of the 3rd Grazing Livestock Nutrition Conference. *Proceedings of the West. Section American Society of Animal Science* 47 (suppl 1):1.

Literature Cited

[15]Holman, J.D. 2004. Alternatives to Kentucky bluegrass field burning. *Available at:* http://www.ag.uidaho.edu/bluegrass/FromJohn/Kentucky bluegrass/Presentations/Alternative to field burning-research update.pdf. *Accessed 26 August 2006.*

[16]Johnson, J.B., W.E. Zidack, S.M. Capalbo, J.M. Antle and D.F. Webb. 1997. Pests, pesticide use, and pesticide costs on larger central and eastern Montana farms with annually-planted dryland crops. Department of Agricultural Economics and Economics, Montana State University Departmental Special Report #23.

[17]Krall, J.M. and G.E. Schuman. 1996. Integrated dryland crop and livestock production systems on the Great Plains: extent and outlook. *Journal of Production Agriculture* 9:187-191.

[18]Lechtenberg, V.C., R.M. Peart, S.B. Barber, W.E. Tyner, and O.C. Doering, III. 1980. Potential for fuel from agriculture. Proceedings, 1980 Forage and Grassland Conference, Louisville, Kentucky.

[19]Marten, G.C. and R.N. Andersen. 1975. Forage nutritive value and palatability of 12 common annual weeds. *Crop Science* 15:821-827.

[20]Morrill, W.L. and G.D. Kushnak. 1996. Wheat stem sawfly (Hymenoptera: Cephidae) adaptation to winter wheat. *Environmental Entomology* 25:1128-1132.

[21]Mulholland, J.G., J.B. Coomb, M. Freer, and W.R. McManus. 1976. An evaluation of cereal stubble for sheep. *Australian Journal of Agriculture Resources* 27:881-893.

[22]Murphy, W.M., A.D. Mena Barreto, J.P. Silman, and D.L. Dindal. 1995. Cattle and sheep grazing effects on soil organisms, fertility, and compaction in a smooth-stalked meadowgrass-dominate white clover sward. *Grass and Forage Science* 50:183-190.

[23]Radford, B.J., D.F. Yule, D. McGarry, and C. Playford. 2001. Crop responses to applied soil compaction and to compaction repair treatments. *Soil Tillage Research* 61:157-166.

[24]Schillinger, W.F. and F.L. Young. 2000. Soil water use and growth of Russian thistle after wheat harvest. *Agronomy Journal* 92:167-172.

[25]Stevens, R.H. Aljoe, T.S. Forst, F. Motal, and K. Shankles. 1997. How much does it cost to burn? *Rangelands* 19:16-19.

[26]Stewart, B.A. 1988. Dryland farming: the North American experience. pp. 54-59 In Challenges in Dryland Agriculture. A Global Perspective. Proceedings International Conference on Dryland Farming. 15-19 August, Amarillo/Bushland, TX.

[27]Thomas, V.M., A.L. Frey, R.F. Padula, C.M. Hoagland, and C.K. Clark. 1990. Influence of supplementation on weight gain of lambs grazing barley stubble. *Journal of Production Agriculture* 3:102-108.

[28]Winter, S.R. and P.W. Unger. 2001. Irrigated wheat grazing and tillage effects on subsequent dryland grain sorghum production. *Agronomy Journal* 93:504-510.

Photo: ASI

SECTION III:
Guidelines for Specific Plants

CHAPTER 15: Grazing and Browsing Guidelines for Invasive Rangeland Weeds.....142

CHAPTER 15:
Grazing and Browsing Guidelines for Invasive Rangeland Weeds

By Linda Wilson, Jason Davison, and Ed Smith

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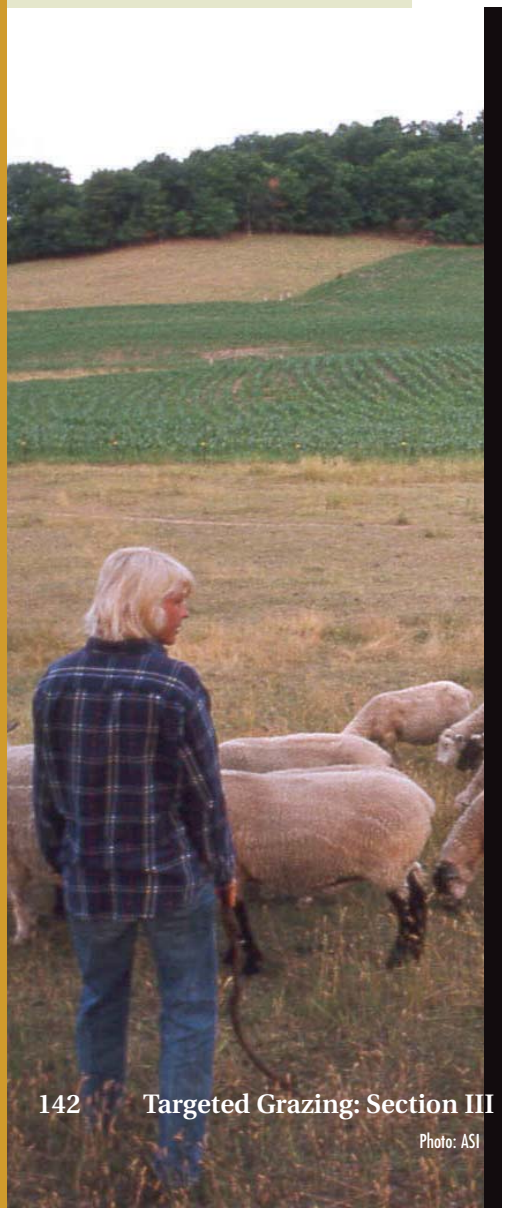
GRAZING GUIDELINES



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INTRODUCTION

When stories of using livestock to manage invasive plants hit the media they take on the aura of a "silver bullet," with headlines like: "Goats to Restore Battered Landscapes," "Sheep and Goats Can Help Wage War On Weeds," "Clearing The Bosque With Goat Power," "Ranchers Harnessing Hoofed Weed Whackers," and "Sheep and Goats: Ecological Tools for the 21st Century." In reality, applying livestock grazing to manage weeds and other vegetation is a meticulously honed and finely skilled practice. Behind the headlines are livestock managers and others who provide grazing services and understand how to apply the right animals at the right time and in the right amount for specific vegetation and landscape problems.

This section provides guidelines for prescription grazing and browsing on specific plant species. The guidelines are intended for resource managers, livestock producers, contract grazing service providers, and anyone interested in targeting grazing to manage vegetation.

The guidelines were developed from phone interviews between October 2005 and February 2006 of about 100 people from California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, Utah, Washington, and Wyoming. Interviewees responded to a list of 27 questions aimed at capturing their knowledge and experience of prescription grazing for vegetation management. Respondents included a broad range of practitioners, contract grazers, researchers, and extension educators. In addition to phone interviews, a survey of the literature was conducted of the Internet and published articles (journals, bulletins, reports, proceedings, etc.).

The results are compiled in a handbook and CD titled "Livestock Grazing Guidelines for Controlling Noxious Weeds in the Western United States." In addition to most of the plant species addressed in this section, the handbook encompasses 26 noxious weed species – a list of all noxious weeds common to at least two of the nine Western states listed below. The handbook and CD are being distributed to Cooperative Extension and NRCS offices in California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. (The project was funded by a grant from the Western Sustainable Agriculture Research and Education Program.)

Each guideline suggests the type and class of livestock, the grazing objective, growth stage for treatment, intensity and duration of treatments, palatability of the plant, plant response to grazing, the potential effectiveness of the grazing treatment, and the potential for integrating targeted grazing with other control methods. Other management considerations are provided case by case. Based on the handbook and other information, guidelines are provided for these plant species:

Forbs (herbaceous, broad-leaved plants):

- Bull Thistle
- Canada Thistle
- Diffuse Knapweed
- Hoary Cress (or Whitetop)
- Kudzu
- Leafy Spurge
- Musk Thistle
- Perennial Pepperweed (or Tall Whitetop)
- Russian Knapweed
- Scotch Thistle
- Sericea
- Spotted Knapweed
- Tansy Ragwort
- Yellow Starthistle

Woody Plants:

- Blackberries
- Juniper Trees
- Multiflora Rose
- Pine
- Saltcedar

Grasses:

- Cheatgrass
- Medusahead

FORBS

Bull Thistle
Cirsium vulgare

Description:

Bull thistle is a large, coarse, tap-rooted biennial plant that grows up to 7 feet tall. Rosette leaves are pubescent, oblong in shape with small spines at the tips of deep lobes. Flowering plants have a few to many branched stems covered with fine white hair resembling cobwebs. Stem leaves are spiny and alternate, and the leaf blades grow along the leaf stem giving them a "winged" appearance. Each branch produces one or more large flowerheads about 2 inches in diameter and surrounded with stiff spiny bracts. The flowers are rose to purple, maturing into pale brown seeds with dark streaks and a feathery plume of bristles growing from one end.

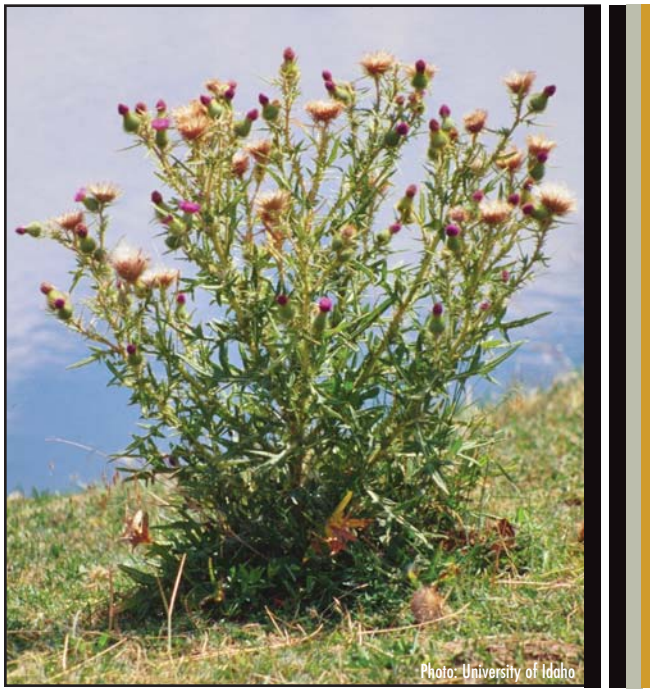


Photo: University of Idaho

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Prevent seed production, reduce plant size and vigor.

Growth Stage for Treatment – Graze bull thistle heavily during the rosette to bolting stage. Repeated grazing at approximately two-week intervals will be necessary to prevent flowering and seed production. May need to graze only once in a season if grazing occurs in the early flowering stage. A minimum of three successive years of grazing is needed to reduce populations.

Potential Effectiveness – Sheep and goats will readily graze bull thistle. Cattle will not graze bull thistle beyond the late bud stage. Grazing works best when combined with a fall herbicide treatment. Grazing reduces plant size, density, and reproductive efficiency.

References:

Lym, R.G. 2004. Perennial and biennial thistle control. North Dakota State University Extension Service. W-799. *Online at:* http://www.ext.nodak.edu/extpubs/plantsci/weeds/w799.pdf. *Accessed 03 August 2006.*

Sullivan, P.G. 2004. Thistle control alternative. ATTRA National Sustainable Agriculture Information Service. *Online at:* http://attra.ncat.org/new_pubs/attra-pub/PDF/thistlecontrol.pdf. *Accessed 03 August 2006.*

FORBS

Canada Thistle
Cirsium arvense

Description:

Canada thistle is a perennial plant that grows from a vigorous, spreading root system. It grows up to 4 feet in height with multiple branches growing from a single, heavily ridged stem. The spiny leaves are deeply lobed, oblong, and up to 6 inches in length. Stem leaves are clasping and alternate. Each stem produces several flowerheads armed with small spines. The flowers are small and lavender to purple in color; male and female flowers grow on separate plants (dioecious). The smooth, light-brown seeds bear a white plume of hairs.

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Begin grazing when rosettes are green and begin to sprout. Remove animals when grazing shifts to desirable species and then regraze new sprouts.

Growth Stage for Treatment – Graze during the seedling through late vegetative stage, with regular removal of top growth throughout the season. Graze often enough to prevent flowering. Grazing treatment will need to be repeated at least three years. Goats will graze older plants.

Potential Effectiveness – Goats, sheep, and cattle can damage Canada thistle with repeated grazing to prevent flowering. Goats are the preferred grazing animal, followed by sheep and cattle. Sheep and cattle prefer to graze this plant when it is young before spines develop. Grazing is most effective when repeated during the season and for multiple seasons to prevent seed production and to deplete root reserves. Plants are smaller and weaker in successive years after repeated grazing. Most information suggests best results are achieved when grazing is combined with herbicide treatments.

References:

Integrated Pest Management Practitioners Association (IPMPA). 2000. Canada thistle. IVM Technical Bulletin. *Available at:* http://www.efn.org/~ipmpa/Noxcthis.html. *Accessed 03 September 2006.*

De Bruijn, S.L. 2006. Biological control of Canada thistle in temperate pastures using high density rotational cattle grazing. *Biological Control* 36:305-315.

Donald, W.W. 1990. Management and control of Canada thistle *(Cirsium arvense). Review of Weed Science* 5:193-250.

Morishita, D.W. 1999. Canada thistle. *In:* Sheley, R.L. and J.K. Petroff [EDS]. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. p 162-174.

FORBS

Diffuse Knapweed
Centaurea diffusa

Description:

Diffuse knapweed is a biennial, short-lived perennial or sometimes annual plant. It grows about 2 feet tall from a single branched stem. Rosette leaves are about 6 inches long and thinly divided, whereas upper stem leaves are smaller and smooth-edged. The stem is rough to the touch. Each branch produces a single flowerhead at the tips. The flowers vary from white to pinkish. Bracts on the flowerheads bear small, yellowish spines with small teeth-like projections along the sides. The seeds are brown to grey and tipped with a light-colored plume that drops off as the seed ripens.

Photo: University of Idaho

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Graze heavily at least twice each year to prevent flowering and for three or more years to reduce populations.

Growth Stage for Treatment – For sheep, it is best to graze diffuse knapweed in the rosette or bolted stages. Goats will graze all growth stages. Palatability for cattle quickly declines beyond the bolting stage. A minimum of two grazing treatments per year is necessary to prevent seed formation, and a minimum of three years is required to reduce populations.

Potential Effectiveness – Diffuse knapweed is readily grazed by sheep, goats, and cattle up through the early vegetative stages. Palatability is reduced as the plant ages especially for sheep and cattle. Diffuse knapweed is not as palatable as spotted knapweed. Targeted grazing can reduce plant vigor, size, and flower production. Long-term control depends on the prevention of flower and seed production. Grazing must be applied at least twice per year over several years to be effective. Remove livestock for approximately two weeks and regraze to prevent seed head formation. Grazing is most effective when combined with herbicide treatments.

References:

Beck, K.G. 2000. Diffuse and spotted knapweed. Colorado State University Cooperative Extension. Fact Sheet No. 3.110. 2 p.

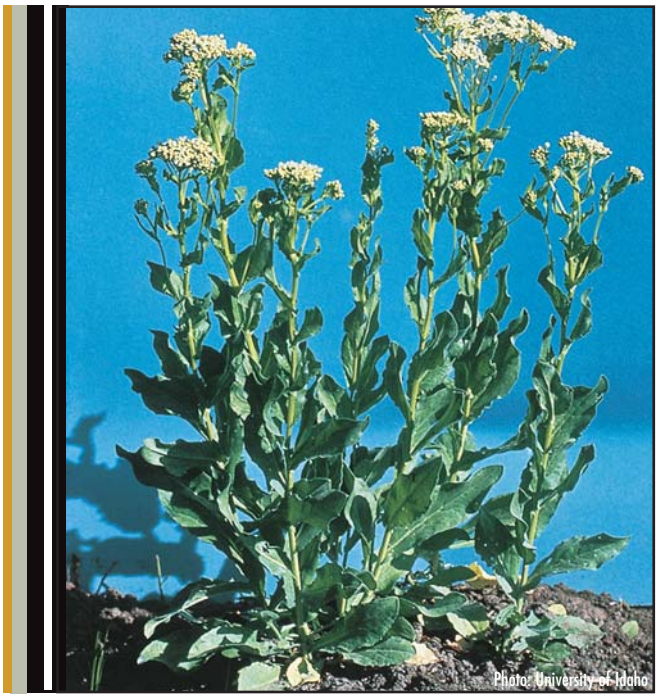
Beck, K., J.R. Sebastian, and L.R. Rittenhouse. 1998. The influence of cattle grazing on diffuse knapweed populations. *In:* Colorado. Proceedings, Western Society of Weed Science. 15:63 (Abstract)

Roche, B.F. and C.T. Roche. 1999. Diffuse knapweed. *In:* R.L. Sheley and J.K. Petroff [EDS.]. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. p 217-230.

Sheley, R.L., J.S. Jacobs, and M.F. Carpinelli. 1998. Symposium – Distribution, biology, and management of diffuse knapweed (*Centaurea diffusa)* and spotted knapweed *(Centaurea maculosa)*. *Weed Technology* 12:353-362.

FORBS

Hoary Cress (or Whitetop)
Lepidium draba (or *Cardaria draba)*



Description:

Hoary cress is a perennial plant that grows up to 2 feet tall. It reproduces by seeds and from a deep, spreading root system. Plants begin growth early in the spring with leaves that are grey-green in color with short stems. The leaves are longer than wide, with rounded tips and smooth to slightly toothed edges. Stem leaves are alternate and clasping. Plants bloom in the spring. The flowers are small, and white with four petals, arranged in dense, flat-topped clusters. Seeds are produced in heart-shaped pods, with each pod producing two reddish brown seeds.

Management Guidelines:

Type and Class of Livestock – Sheep and goats; considered mildly toxic to cattle.

Grazing Objective – The objective is to prevent flowering and maintain removal of 85% of top growth during the growing season.

Growth Stage for Treatment – The best time to graze is before flowering. Palatability is considered to be low for all classes of livestock, and decreases rapidly as plants bloom and mature. As with all deep-rooted perennial plants, the treatments would have to be repeated at least two times per year. Literature indicates at least three years of grazing is necessary to reduce populations of hoary cress. Grazing hoary cress is considered impractical because of low acceptance by livestock and the potential for poisoning.

Potential Effectiveness – Sheep and goats will consume hoary cress more readily than cattle. Cattle will consume hoary cress but, glucosinolates in large quantities may be toxic. Little information is currently available on the effectiveness of targeted grazing of hoary cress. Surveys and literature disagree on the potential of controlling hoary cress with grazing because of palatability and toxicity issues. However, repeated grazing may reduce plant vigor and flower production.

References:

Chipping, D. and C. Bossard. 2000. *Cardaria chalepensis* (L.) Hand-Mazz. and C. draba. *In:* C. C. Bossard, J.M. Randall and M.C. Hoshovsky [EDS.]. Invasive plants of California's wildlands. Berkley, CA: University of California Press. p. 80-86.

McInnis, M.L., L.L. Larson and R.F. Miller. 1993. Nutrient composition of whitetop. *Journal of Range Management* 46:227-231.

McInnis, M.L., L.L. Larson, and R.F. Miller. 1990. First-year defoliation effects on whitetop (Cardaria draba (L.) Desv.). *Northwest Science* 64:107 (Abstract).

Sheley, R. and J. Stivers. 1999. Whitetop. *In*: Sheley, R.L. and J.K. Petroff. [EDS]. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. p. 401-407.

FORBS

Kudzu
Pueraria montana

Description:

Kudzu is a fast-growing, climbing, semi-woody perennial vine in the pea family. The leaves are alternate and compound, with three broad, hairy leaflets up to 4 inches across. Leaflets may be entire or deeply lobed. Individual flowers, about ½ inch long, are purple, highly fragrant, and borne in long hanging clusters. Flowering occurs in late summer. Three to 10 hard seeds are produced in flat, hairy, brown seed pods.

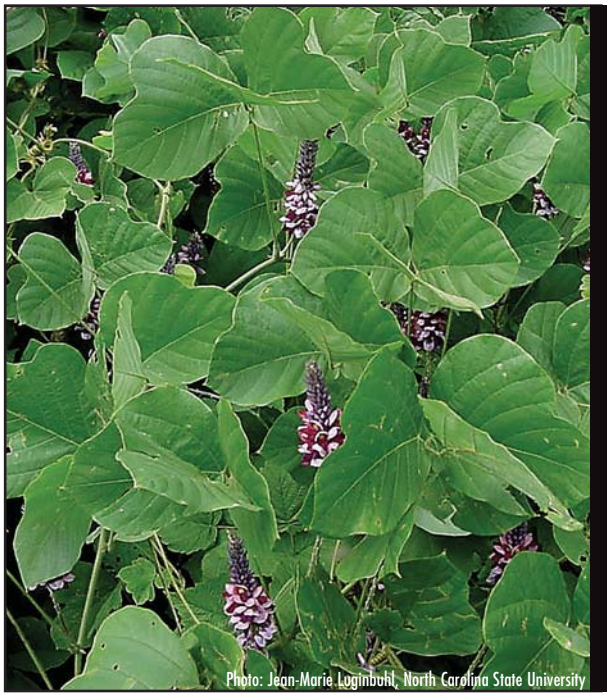


Photo: Jean-Marie Luginbuhl, North Carolina State University

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Continuous grazing to remove 80% of biomass each season.

Growth Stage for Treatment – Kudzu can be grazed throughout the growing season. Frost will damage the aerial parts without killing the plant. Livestock will readily consume kudzu leaves and terminal stems. Three to four years of continuous or controlled, repeated grazing is necessary to suppress this plant.

Potential Effectiveness – All types of livestock consume kudzu, but cattle have shown the greatest success in eradication. High grazing intensity and repeated defoliation throughout the growing season will deplete starch reserves in tubers and weaken the plant. Grazing intensity should be high from the start of the grazing season to repeatedly defoliate and weaken the kudzu vines. Grazing must be repeated for at least three seasons to suppress kudzu to negligible levels. Spot spraying herbicides after the grazing treatment will kill any residual plants. All information indicates that grazing is the most practical method for controlling kudzu.

References:

Ketchersid, M.L. 2006. Kudzu? In Texas? No way!!! *Available at:* http://www-aes.tamu.edu/mary/kudzu/kudzu.htm. *Accessed 12 July 2006.*

Miller, J.H. 2006. Kudzu eradication and management. *Available at:* http://www.pfmt.org/standman/kudzu.htm. *Accessed 12 July 2006*.

Tennessee Department of Forestry. 2006 Control of grapevines and kudzu. *Available at*: http://www.tennessee.gov/agriculture/forestry/health/vines.html. *Accessed 12 July 2006*.

Terrill,T.H., S. Gelaye, S. Mahotiere, E.A. Amoah, S. Miller, and W.R. Windham. 2003. Effect of cutting date and frequency on yield and quality of kudzu in the southern United States. *Grass and Forage Science* 58:178-183.

FORBS

Leafy Spurge
Euphorbia esula

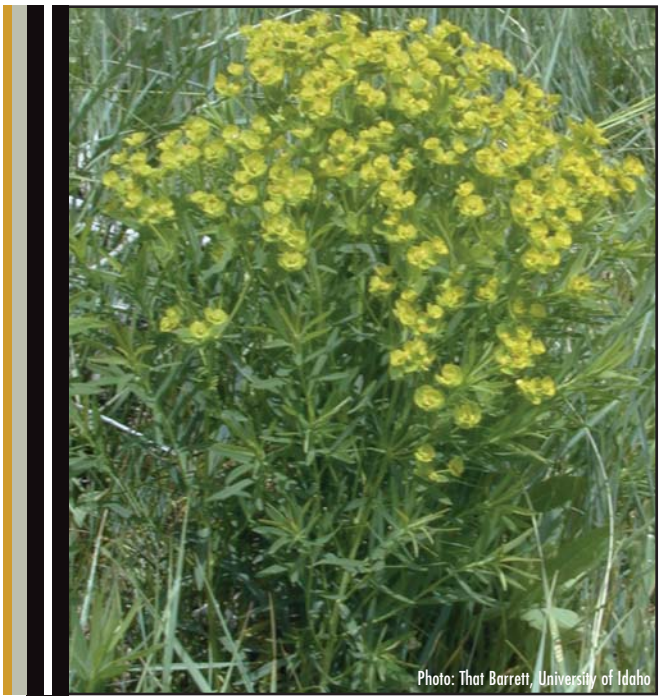


Photo: That Barrett, University of Idaho

Description:

Leafy spurge is a long-lived perennial plant that can grow up to 3 feet tall. The leaves are long, narrow, and about 4 inches long. Leaf edges are smooth, hairless, and wider toward the tip. They grow in an alternate pattern along numerous smooth stems that produce multiple branches near the top. The stems and leaves are filled with white sap that oozes when the plant is broken. The flowers are a bright yellow-green color, tiny and grow above two to three heart-shaped leaf-like structures of the same color. The fruit is a capsule divided into three compartments, each containing numerous small, smooth, gray- to brown-colored seeds. The root system spreads horizontally and vertically to depths up to 30 feet. New plants can emerge from buds along the horizontal roots. The entire plant turns a bright red color in the fall.

Management Guidelines:

Type and Class of Livestock – All classes of sheep and goats; not recommended for cattle.

Grazing Objective – Remove 95% of top growth; graze regrowth after first treatment; prevent flowering and seed production.

Growth Stage for Treatment – Grazing should occur in the vegetative to flowering stage. Sheep may need to learn to eat leafy spurge and prefer younger plants whereas goats readily eat leafy spurge at all growth stages.

Potential Effectiveness – Sheep and goats readily eat leafy spurge after it has been introduced into their diets. It is considered to be somewhat toxic to cattle and horses. Sheep and goats are very effective at reducing biomass on an annual basis when leafy spurge is grazed to a moderate to severe level of utilization during the vegetative to flowering stage of growth. Grazing effectiveness can be low the first year as plants can produce a flush of new growth the second year. Suppression of high density infestations will likely occur after four or more consecutive years of grazing treatments. Grazing multiple times per year may be needed in moist or riparian areas. Integrating grazing with herbicides and biological control may provide the most effective strategy for long-term management of leafy spurge.

References:

Bartz, S., B. Landgraf, P. Fay, and K. Havstad. 1985. Leafy spurge as a forage component for ewes and lambs. *SID Research Digest* Winter:39-42.

Fay, P.K. 1991. Controlling leafy spurge with animal grazing. *In:* L. James, J. Evans, M. Ralphs, and R. Child [Eds.]. Noxious range weeds. San Francisco, CA: Westview Press. p. 193-199.

Lacey, C.A, R.W. Knott, and P.K. Fay. 1984. Ranchers control leafy spurge. *Rangelands* 6:202-204.

References:

Lacey, J.R. and R.L. Sheley. 1996. Leafy spurge and grass response to picloram and intensive grazing. *Journal of Range Management* 49:311-314.

Lajeunesse, S.R. Sheley, R. Lym, D. Cooksey, C. Duncan, J. Lacey, N. Ress, and M. Ferrell. 1995. Leafy spurge: Biology, ecology and management. Montana State University Extension Service. Extension Bulletin EB 134:25.

Landgraf, B.K., P.K. Fay, and K.M. Havstad. 1984. Utilization of leafy spurge by sheep. *Weed Science* 32:348-352.

Lym, R.G. and D.R. Kirby. 1987. Cattle foraging behavior in leafy spurge infested-rangelands. *Weed Technology* 1:314-318.

Lym, R.G., K.K. Sedivec, and D.R. Kirby. 1997. Leafy spurge control with angora goats and herbicides. *Journal Range Management* 50:123-128.

Muller, B., P.K. Fay, and M.K. Petersen. 1990. Feeding leafy spurge to cattle. *Proceedings of the Western Society of Weed Science* 43:31-33.

Olson, B.E. and R.T. Wallander. 1998. Effects of sheep grazing on a leafy spurge-infested Idaho fescue community. *Journal Range Management* 51:247-252.

Olson, B.E., R.T. Wallander, and R.W Knott. 1997. Recovery of leafy spurge seed from sheep. *Journal of Range Management* 50:10-15.

Olson, B.E., and J.R. Lacey. 1994. Sheep: A method for controlling rangeland weeds. *Sheep Research Journal* (Special Issue):105-112.

Sedivec, K., T. Hanson, and C. Heiser. 1995. Controlling leafy spurge using goats and sheep. North Dakota State University Extension Circular R-1093.

Stoneberg, S. 1989. Goats make “cents” out of the scourge of leafy spurge. *Rangelands* 11:264-265.

Walker, J.W., K.G. Hemenway, P.G Hatfield, and H.A. Glimp. 1992. Training lambs to be weed eaters: Studies with leafy spurge. *Journal of Range Management* 45:245-249.

Walker, J.W., S.L. Kronberg, S.L. Al-Rowaily, and N.E. West. 1994. Comparison of sheep and goat preferences for leafy spurge. *Journal of Range Management* 47:429-434.

FORBS

Musk Thistle
Carduus nutans

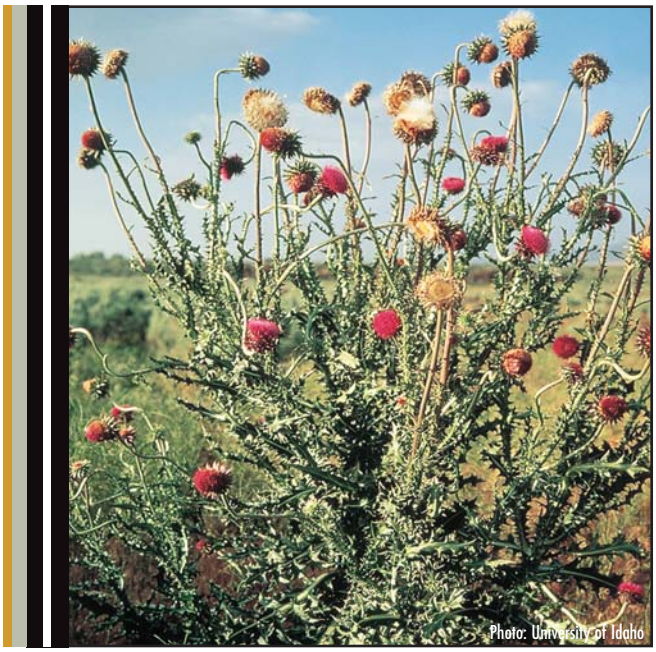


Photo: University of Idaho

Description:

Musk thistle, a biennial or occasionally a winter annual plant, can reach a height of 6 feet or more and reproduces by seed. Plants have a large, fleshy taproot. Young plants develop into large rosettes of dark green, deeply lobed, spiny leaves that can be over 14 inches long. Leaves have a light yellow vein. Flowering plants produce single or multiple winged stems, each with smaller leaves and a single terminal flowerhead. Each flowerhead is 2 to 3 inches in diameter and droops at first (giving the plant another common name of nodding thistle). The bracts surrounding each flowerhead are armed with stiff spines. The flowers are pink to rose-purple, maturing into straw-colored seeds with a white plume of soft bristles.

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Prevent seed production, reduce plant size and vigor.

Growth Stage for Treatment – Graze musk thistle heavily during the rosette to bolting stage. Repeated grazing at approximately two-week intervals will be necessary to prevent flowering and seed production. May need to graze only once in a season if grazing occurs in the early flowering stage and site conditions limit regrowth. At least three successive years of grazing are needed to reduce populations.

Potential Effectiveness – Grazing musk thistle reduces plant size, density, and reproductive efficiency. Sheep and goats will readily graze musk thistle; cattle will not graze musk thistle beyond the early bud stage. Grazing works best when combined with a fall herbicide treatment to control new seedlings and escaped plants.

References:

Hull, A.C Jr., and J.O. Evans. 1973. Musk thistle *(Carduus nutans)*: An undesirable range plant. *Journal of Range Management* 26:383-385.

Huwer, R.K., M.J. Neave, P.M. Dowling, W.M. Lonsdale, A.W. Sheppard, D.T. Briese, and D.L. Michalk. 2002. Integrated weed management (IWM) in perennial pasture using pasture and grazing management, herbicide strategies and biological control. *In*: J.H. Spafford, J. Dodd, and J.H. Moore [EDS.]. Perth, Australia: Proceedings of the 13th Australian Weeds Conference. Plant Protection Society of WA. P. 727–730.

Kadrmas, T., and W.S. Johnson. 2002. Managing Musk thistle. University of Nevada Reno Cooperative Extension Fact Sheet FS-02-55. *Available at:* http://www.ag.unr.edu/wsj/Wayne/Managing MuskThistle FS 02-55.pdf. *Accessed 03 September 2006.*

Kristi, R.K. 2001. Competitive effects of cool-season grasses on re-establishment of three weed species. *Weed Technology* 15:885-891.

Lamming, L. 2001. Successfully controlling noxious weeds with goats. *Pesticides and You* 21:19-23. *Available at:* http://www.beyondpesticides.org/infoservices/pesticidesandyou/Winter 0102/Successfully Controlling Noxious Weeds withGoats.pdf. *Accessed 12 July 2006.*

FORBS

Perennial Pepperweed (or Tall Whitetop)
Lepidium latifolium

Description:

Perennial pepperweed is a hardy perennial plant that can reach 6 feet in height under ideal conditions. It reproduces by seeds and from a deep, creeping root system. Basal leaves are waxy and lance-shaped on a long petiole. Stem leaves are smaller with short stalks. Leaves have a prominent white mid-vein. The tiny flowers have four white petals and are arranged in numerous rounded clusters on the ends of the branches. Each flat, elongated capsule produces two seeds.

Photo: University of Idaho

Management Guidelines:

Type and Class of Livestock – All classes of sheep and goats.

Grazing Objective – Remove 85% of top growth with repeated grazing treatments (every three to four weeks) to remove regrowth.

Growth Stage for Treatment – Sheep and goats will readily consume the plants until the early flowering stage, with preference for early vegetative stages. Repeated grazing for several years will be necessary to suppress perennial pepperweed long term.

Potential Effectiveness – Repeated, intensive grazing can significantly reduce perennial pepperweed biomass, density, and height in a single season, but the massive root system rapidly replenishes the infestation. Thus, grazing must be continued for several years to deplete root reserves. Results vary as to the long-term impacts of targeted grazing for plant suppression. Grazing can be combined with herbicide spraying for long-term perennial pepperweed management.

References:

Allen, J.R., D.W. Holcombe, D.R. Hanks, M. Surian, M. McFarland, L.B. Bruce, and W. Johnson. 2001. Effects of sheep grazing and mowing on the control or containment of tall whitetop. *Proceedings of the Western Section American Society of Animal Science* 52:77 (Abstract).

Carpinelli, M.F., C.S. Schauer, D.W. Bohnert, S.P. Hardegree, S.J. Falck and T.J. Svejcar. 2004. Effect of ruminal incubation on perennial pepperweed germination. *Rangeland Ecology and Management* 58:632-636.

Clements, C.D. and J. A. Young. 2006. The use of goat grazing to biologically suppress perennial pepperweed. *Available at:* http://www.ars.usda.gov/research/publications/Publications.htm?seq_no_115=183198. *Assessed 14 August 2006*.

Renz, M.J. 2000. *Lepidium latifolium* L. In: J.M.Randall [Ed.] Element stewardship abstracts. The Nature Conservancy, Arlington, Virginia. *Available at:* http://tncweeds.ucdavis.edu/esadocs/lepilati.html. *Accessed 03 September 2006.*

Ryan, M., S. Donaldson, and W. Johnson. 2002. Perennial pepperweed (*Lepidium latifolium*) in Southern Nevada. University of Nevada, Reno. Cooperative Extension. FS-02-98. *Available at:* http://www.unce.unr.edu/publications/FS02/FS0298.pdf. *Accessed 03 September 2006.*

Williams, C.B., D.W. Holcombe, D.R. Hanks, J.R.Allen L.B. Bruce, B.L.Perryman and GCJ. Fernandez. 2002. Effects of sheep grazing and mowing on the control of perennial pepperweed *(Lepidium latifolium L.). Western Section Proceedings of American Society of Animal Science.* 53:350-352

Young, J.A., D.E. Palmquisk, R.S. Blank, and C.E. Turner. 1995. Ecology and control of perennial pepperweed (*Lepidium latifolium* L.). California Exotic Pest Plant Council. 1995 Symposium Proceedings. *Available at:* http://www.cal-ipc.org/symposia/archive/pdf/1995_symposium_proceedings1796.pdf. *Accessed 03 Sept 2006.*

FORBS

Russian Knapweed
Acroptilon repens

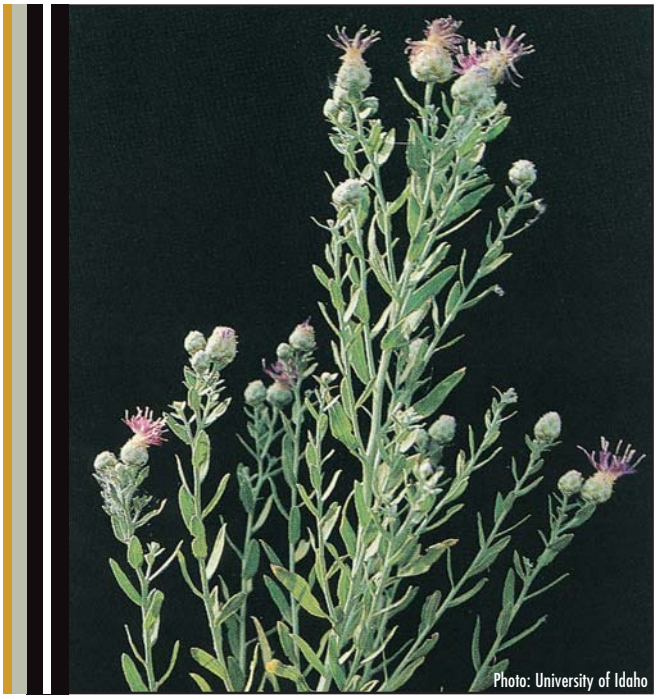


Photo: University of Idaho

Description:

Russian knapweed is a deep-rooted perennial plant that can grow up to 3 feet tall. It reproduces by seeds and from aggressive underground stems and roots. Rosette leaves are lobed and have wavy margins; they are blue-green in color and covered with fine hairs that give the appearance of a fine white powder. Most plants produce a single branched stem that is covered with fine gray hairs. The leaves are about 1 inch long, relatively narrow, linear, and arranged alternately along the stem. Each branch produces one to three flowerheads that are about ¼ inch in diameter and have papery bracts. The flowers are pink to purple. Ten to 15 seeds are produced in each flowerhead.

Management Guidelines:

Type and Class of Livestock – Sheep (particularly dry ewes) and all classes of goats.

Grazing Objective – Removal of 80% of biomass.

Growth Stage for Treatment – Early vegetative to flowering. Livestock will consume Russian knapweed reluctantly. It is unpalatable to cattle though it may be occasionally eaten. Patches should be grazed at least three times per season, allowing 8 to 10 inches of regrowth between treatments. Three or more years of successive grazing treatments will be necessary to suppress populations.

Potential Effectiveness – Most of the literature indicates that livestock will not eat Russian knapweed because of its bitter taste. However, survey respondents indicated that under certain conditions sheep and goats will graze Russian knapweed, especially when the plants are young and after the animals have grazing experience. To be effective, grazing must be repeated multiple times each season and for several years. Grazing Russian knapweed may result in reduced biomass and density of plants, but populations may return to pre-grazing density when grazing ceases. Long-term management of Russian knapweed will require an integrated program including herbicides and competitive plantings.

References:

Graham, J. and W.S. Johnson. 2004. Managing Russian knapweed. University of Nevada Cooperative Extension. Fact Sheet FS-04-37. 4p.

Integrated Pest Management Practitioners Association (IPMPA). 2000. Spotted, diffuse and Russian knapweed. IVM Technical Bulletin. *Available at:* http://www.efn.org/~ipmpa/Noxknapw.html. *Accessed 03 September 2006.*

Kettle, R.M. and R.E. Wilson. 1998. Management of Russian knapweed in Nevada. University of Nevada Cooperative Extension. Special Publication SP 98-09. 16p.

Schultz, B. 2005. Identification, biology, habitat, and control of noxious weeds in Humboldt County and adjacent areas of northern Nevada: An introductory handbook. University of Nevada Cooperative Extension. Special Publication 05-18. 49 p.

FORBS

Sericea
Sericea lespedeza

Description:

Sericea is an erect, perennial shrub up to 5 feet tall. Stems are hairy only along the ridges on the stem. Leaves have three leaflets, each less than 1 inch long and less than ¼ inch wide, wedge-shaped (cuneate). Plants flower from mid or late July to October. Flowers have yellowish petals sometimes tinged with purple and are about ¼ inch long. Seeds are borne in pods about 1/8 inch long, broad, and flattened.

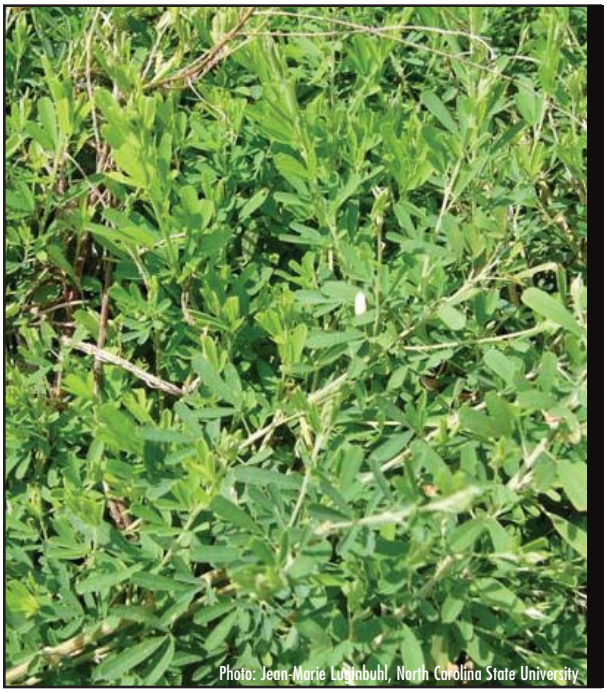


Photo: Jean-Marie Luginbuhl, North Carolina State University

Management Guidelines:

Type and Class of Livestock – All classes of sheep and goats; Sericea can be toxic to cattle.

Grazing Objective – Reduce plant biomass and prevent flowering and seed production.

Growth Stage for Treatment – It is important to graze young plants early in the season. Sericea becomes much less palatable after bloom as levels of lignin and tannins increase with maturity. Two or more treatments are necessary each season, and three to several years are needed to weaken plants.

Potential Effectiveness – Grazed plants are often smaller next year, but plant density has not been shown to decrease with grazing. Early intensive grazing followed by chemical control seems to provide the most effective control of Sericea.

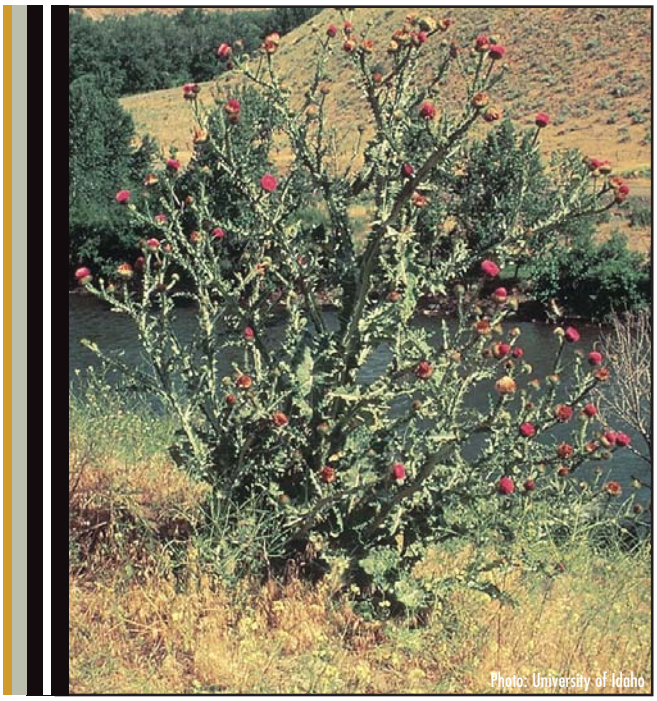
References:

Ohlenbusch, P.D., and T.G. Bidwell. 2001. *Sericea lespedeza*: History, Characteristics, and Identification. Kansas State University Bulletin MF-2408. *Available at:* http://www.oznet.ksu.edu/ library/crpsl2/mf2408.pdf. *Accessed 12 July 2006.*

Vermeire, L.T., T.G. Bidwell, and J. Stritzke. 1998. Ecology and Management of *Sericea lespedeza*. Oklahoma State University Cooperative Extension Bulletin F-2874. *Available at:* http://www.okrangelandswest.okstate.edu/ pdfFiles/OSUextPubs/F-2874.pdf. *Accessed 12 July 2006.*

FORBS

Scotch Thistle
Onopordum acanthium



Description:

Scotch thistle is a tap-rooted, biennial plant that can grow to 12 feet tall. It reproduces by seeds. During the first year rosette leaves can grow to 2 feet long and 1 foot wide. They are densely covered with fine white hair giving them a blue-grey color. The edges of the leaves are very wavy, lobed, and tipped with sharp spines. A thick, upright stem is produced the second year. Stem leaves are deeply lobed, spiny, and alternate. The leaf blades extend along the stem as wing-like projections. The entire plant is covered with fine, dense hairs giving it a wooly appearance. Each branch of the stem produces two to three large flowerheads about 2 inches in diameter. Flowers are bright reddish-purple in color. The seeds are smooth, spatula-shaped, and tipped with a plume of soft bristles.

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Prevention of flowering and reduction of stem density.

Growth Stage for Treatment – Graze Scotch thistle at the rosette to bolting stage. Livestock will graze Scotch thistle with some reluctance, and better results can be achieved after they have some experience with the plant. Heavy to severe utilization, using short-duration, high-intensity grazing practices, provides the best results when repeated for several years to deplete the seedbank.

Potential Effectiveness – Prescribed grazing of Scotch thistle is considered an effective means of control, suppressing flowering and reducing stem density 30 to 50%. Sheep, goat, and cattle grazing is considered effective, although several years of grazing may be needed to reduce populations of Scotch thistle. Maintaining vigorous perennial grass competition is essential to long-term management. Grazing Scotch thistle is very effective when combined with a follow-up herbicide treatment.

References:

Sullivan, P.G. 2004. Thistle control alternatives. National Sustainable Agriculture Information Service. *Available at:* http://attra.ncat.org/new_pubs/attra-pub/PDF/thistlecontrol.pdf. *Accessed 03 September 2006.*

Holst, P.J., C. J. Allan, M.H. Campbell, and A.R. Gilmour. 2004. Grazing of pasture weeds by goats and sheep. 1. Nodding thistle *(Carduus nutans)*. *Australian Journal of Experimental Agriculture* 44:547-551.

FORBS

Spotted Knapweed
Centaurea stobe (or *Centaurea maculosa)*

Description:

Spotted knapweed is a biennial or short-lived perennial plant that grows from 1 to 4 feet tall. It reproduces by seed and has a thick taproot. Seedlings develop the first year into rosettes of narrow, deeply lobed leaves that are up to 6 inches long. The upper leaf surface is rough. Flowering plants produce one to many stems with numerous branches. Stem leaves are smaller and linear, arranged alternately along the stem. A single flowerhead is produced at the end of each branch. Bracts at the base of the flowerhead are black-tipped, which gives them a spotted appearance when viewed from a distance. The flowers are pink to light purple in color and mature into brown seeds tipped with a plume of soft tawny bristles.

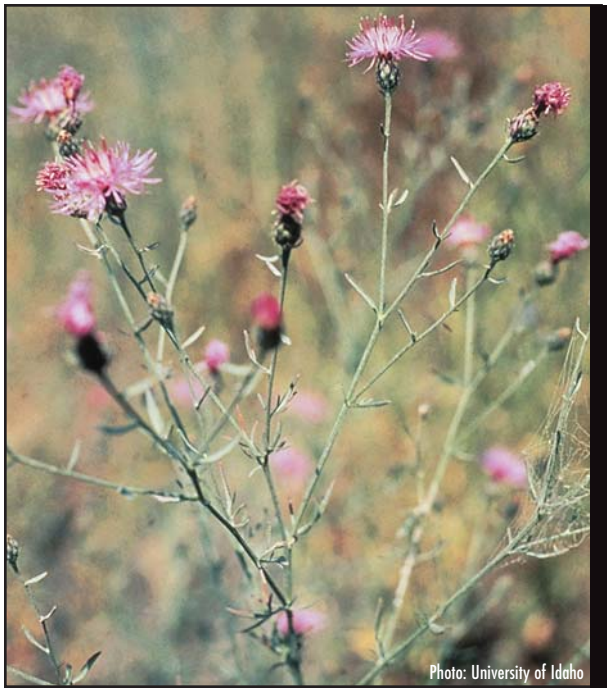


Photo: University of Idaho

Management Guidelines:

Type and Class of Livestock – Sheep and goats.

Grazing Objective – Graze to prevent seed production and reduce biomass.

Growth Stage for Treatment – Graze spotted knapweed heavily during the rosette or bolting stage. Livestock prefer young, smaller plants, but will usually readily consume it at all growth stages. Two grazing periods per year, once during rosette to bolting stage and again in the bud stage, provide the best control. Stem reductions, smaller plants, and lower seed production can occur after three to six consecutive years of grazing.

Potential Effectiveness – Sheep and goats readily graze spotted knapweed, considered to be moderately good forage for livestock. Sheep tend to strip leaves and avoid the fibrous stems of mature plants. Grazing can reduce plant vigor, density, size, flower stems, and seed production. It may be necessary to manage grazing based on degree of utilization of desirable species. Palatability may be reduced as the plant ages because of reduced forage value and the presence of a bitter-tasting compound called cnicin. Sheep digestive systems may suffer if diets are composed of more than 70% spotted knapweed. Grazing is most effective when combined with herbicide treatments.

References:

Kennett, G.A., J.R. Lacey, C.A. Butt, K.M. Olsen-Rutz, and M.R. Haferkamp. 1992. Effects of defoliation, shading and competition on spotted knapweed and bluebunch wheatgrass. *Journal of Range Management* 45:363-369.

Lacey, J.R., K.M. Olsen-Rutz, M.R. Haferkamp and G.A. Kennett. 1994. Effects of defoliation and competition on total non-structural carbohydrates of spotted knapweed. *Journal of Range Management* 47:481-484.

Launchbaugh, K. and J. Hendrickson. 2001. Prescription grazing for *Centaurea* control on rangelands. In: L. Smith [ED.] The First International Knapweed Symposium of the Twenty-First Century. Coeur d' Alene, ID. p. 27-32. *Available at:* http://www.sidney.ars.usda.gov/knapweed/images/proceed.pdf. *Accessed 03 September 2006.*

Maxwell J.F., R. Drinkwater, D. Clark, and J.W. Hall. 1992. Effects of grazing, spraying, and seeding on Knapweed in British Columbia. *Journal of Range Management* 45:180-182.

Olson, B.E. and J.R. Lacey. 1994. Sheep: a method for controlling rangeland weeds. *Sheep Research Journal* (Special Issue):105-112.

Olsen, B.E. and R.T. Wallander. 1997. Biomass and carbohydrates of spotted knapweed and Idaho fescue after repeated grazing. *Journal of Range Management* 50:409-412.

Olsen, B.E., and R.T. Wallander. 2001. Sheep grazing spotted knapweed and Idaho fescue. *Journal of Range Management* 54:25-30.

Olsen, B.E., R.T. Wallander, and J.R. Lacey. 1997. Effects of sheep grazing on a spotted knapweed-infested Idaho fescue community. *Journal of Range Management* 50:386-390.

Sheley, R.L., J.S. Jacobs, and J.M. Martin. 2004. Integrating 2,4-D and sheep grazing to rehabilitate spotted knapweed infestations. *Journal of Range Management* 57:371-375.

FORBS

Tansy Ragwort
Senecio jacobaea

Description:

Tansy ragwort is a biennial or short-lived perennial plant that can grow up to 6 feet tall. It reproduces by seeds and from lateral roots. Seeds germinate in the fall or spring and develop into rosettes the first year. Leaves are serrated, deeply lobed, and grow up to 9 inches long. In the second and subsequent years, plants produce multiple branched stems, with smaller lobed leaves arranged alternately along the stem. Numerous small flowerheads are produced in dense clusters at the ends of the upper branches. The individual flowers are bright yellow with 10 to 15 petal-like flowers surrounding a button-like center of tiny disc flowers. Tansy ragwort has a short taproot that produces many spreading side roots.

Photo: University of Idaho

Management Guidelines:

Type and Class of Livestock – All classes of sheep and cattle. Little information about the use of goats.

Grazing Objective – Prevent seed production and destroy seedlings and rosettes.

Growth Stage for Treatment – Best results are achieved when tansy ragwort is grazed in the rosette and bolting stages. Multiple defoliations during the season may promote a multiple-stemmed, perennial habit. Continuous or rotational grazing is better than a single treatment of short-duration, highly intense grazing. More than two years of successive grazing are needed to achieve adequate control.

Potential Effectiveness – Grazing at the rosette stage is considered to be the most effective time to control tansy ragwort, resulting in reduced plant density and height, defoliation of stems, and reduced seed production. Most sheep readily graze tansy ragwort, which is considered good sheep forage when comprising up to 50% of sheep diets. Multi-species grazing of sheep and cattle is effective in grass pastures infested with tansy ragwort. Grazing combined with vigorous perennial grasses competition provides the best management of tansy ragwort.

References:

Betterridge, K., R.D. Sutherland, R.A. Fordham, K.J. Stafford and D.A. Costall 1997. Conditioning of Romney sheep for ragwort (*Senecio Jacobaea*) control. Proceedings 50th New Zealand Plant Protection Conference p. 482-485. *Available at:* http://www.hortnet.co.nz/publications/nzpps/journal /50/nzpp50_482.pdf. *Accessed 03 September 2006.*

Betteridge. K., P.G. Mcgregor, D.A. Costall, and P.G. Peterson. 2000. Biological control of ragwort: Does sheep grazing affect ragwort flea beetle? New Zealand Plant Protection 53:54-58. *Available at:* http://www.hortnet.co.nz/publications/nzpps/journal/53/nzpp53_054.pdf. *Accessed 03 September 2006.*

Integrated Pest Management Practitioners Association (IPMPA). 2000. Tansy ragwort. IVM Technical Bulletin. *Available at:* http://www.efn.org/~ipmpa/Noxtansy.html. *Accessed 03 September 2006.*

Sharrow, S.T. and W.D. Mosher. 1982. Sheep as a biological control agent for tansy ragwort. *Journal of Range Management* 35:480-482.

Sutherland, R.D., K. Betteridge, R.A. Fordham, K.J. Stafford, and D.A. Costall. 2000. Rearing conditions for lambs may increase tansy ragwort grazing. *Journal of Range Management*. 53:432-436.

FORBS

Yellow Starthistle
Centaurea solstitialis

Photo: Linda Wilson, University of Idaho

Description:

Yellow starthistle is a winter annual plant that can range from 10 inches to over 6 feet in height depending on growing conditions. Fall-germinated seeds quickly develop in deep-rooted rosettes of bright green, deeply lobed leaves shaped like an arrowhead. They grow from 6 to 8 inches long and 1 to 2 inches wide. Plants produce single or multiple branches that have matted hairs giving the plant a gray-green color. The stem leaves are small and linear with smooth edges and sharply pointed tips. The leaf blades extend down the stem giving it a "winged" appearance. A single, bright yellow flowerhead armed with 1-inch stiff thorns is produced on the end of each branch. Both plumed and unplumed brown seeds are produced in each flowerhead.

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Graze heavily at least twice each year to prevent flowering and for several years to deplete seed-bank and reduce plant density.

Growth Stage for Treatment – Sheep and goats will graze yellow starthistle in all growth stages. Cattle will graze in the rosette to bolting stage but will avoid the weed beyond the late bud stage. Two or three treatments are needed if grazed in the rosette or bolting stage; grazing during or after flowering with goats may require only one treatment per year.

Potential Effectiveness – Targeted grazing to control yellow starthistle is strongly recommended for sheep and goats, less so for cattle. Goats are probably the most effective livestock to use for grazing of yellow starthistle because they will readily eat the plant in all growth stages. Grazing reduces plant vigor and plant size and suppresses flower production. Effective control depends on the prevention of flower and seed production, which can be achieved by grazing at least twice a year over several years. Yellow starthistle is highly toxic to horses.

References:

Exotic Pest Plant Council. 2006. Yellow starthistle management with grazing, mowing, and competitive plantings. California, UC Davis. *Available at:* http://ucce.ucdavis.edu/freeform/ceppc/documents/1996_Symposium_Proceedings1824.pdf. *Accessed 12 July 2006.*

Olson, B.E. 1999. Grazing and weeds. In: R.L Sheley, and J.K. Petroff [EDS.]. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press, p. 85-96.

Popay, I., and R. Field. 1996. Grazing animals as weed control agents. *Weed Technology* 10:207-231.

Thomsen, C.D., W.A. Williams, M.R. George, W.B. McHenry, F.L. Bell, and R.S. Knight. 1989. Managing yellow starthistle on rangeland. *California Agriculture* 43:4-6.

Thomsen, C.D., W.A. Williams, M. Vayssieres, F.L. Bell, and N.M.R. George. 1993. Controlled grazing on annual grasslands decreases yellow starthistle. *California Agriculture* 47:36-40.

Thomsen, C.D., W.A. Williams, W. Olkowski, and D.W. Pratt. 1996. Grazing, mowing and clover plantings control yellow starthistle. *IPM Practitioner* 18:1-4.

WOODY PLANTS

Blackberries
Rubus spp.

Description:

Perennial; blooms June to August. Root buds produce trailing reddish stems with sharp spines that can grow more than 20 feet per season. Leaves alternate, palmate, and compound with serrate margins. Flowers five-petaled, white to light pink. Himalayan blackberry is the most widespread and economically disruptive of all the noxious weeds in western Oregon. It aggressively displaces native plant species, dominates most riparian habitats, and has a significant economic impact on right-of-way maintenance, agriculture, park maintenance, and forest production. It is a significant cost in riparian restoration projects and physically inhibits access to recreational activities. It reproduces at cane apices (tips) and by seeds, which are carried by birds and animals. This strategy allows it to expand quickly across a landscape or to jump great distances and create new infestations.

Photo: Linda Wilson, University of Idaho

Management Guidelines:

Type and Class of Livestock – Goats and sheep.

Grazing Objective – Browse blackberries season long to achieve and maintain 95% stem defoliation or complete removal of young stems.

Growth Stage for Treatment – Livestock, especially goats, will readily consume blackberry seedlings and early-season growth. However, sheep or goats can browse blackberries year round, with average stocking rates of three to four animals per acre.

Potential Effectiveness – Goats are ideal for browsing blackberries, because they will consume the entire plant year round. Sheep will eat blackberries but not to the same extent as goats. Goats have the potential to destroy all top growth in a single year of grazing. Shrubs will regrow if grazing stops before the entire plant is destroyed, which may take a few to several years. Season-long browsing may require supplemental feeding of hay during the winter to maintain animal body weight. Grazing by goats or sheep is less costly than chemical or mechanical control of blackberries, especially in rough terrain. However, grazing can be integrated with herbicides or mechanical control. Any control strategy can be considered short-lived unless projects are planned and funded for the long term.

References:

Coos Soil and Water Conservation District. 2000. Grazing for control of Himalayan blackberry. *Available at*: http://coosswcd.oacd.org/himblackberry_text.htm. *Accessed 12 July 2006.*

DiTomaso, J.M. 2002. Pest notes: Wild blackberries. IPM Online. *Available at:* http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7434.html. *Accessed 12 July 2006.*

Faithfull, I. 2004. Blackberry management. Land Care Note LC0381. *Available at:* http://www.dpi.vic.gov.au/DPI/nreninf.nsf/9e58661e880ba9e44a256c640023eb2e/8674f52685a08cdcca25704600 0770b6/$FILE/LC0381.pdf. *Accessed 12 July 2006.*

Tasmania Department of Primary Industries, Water, and Environment 2002. Blackberry (*Rubus fruticosus aggregate*). *Available at:* http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/RPIO 4ZW2MF?open#IntegratedManagement. *Accessed 12 July 2006.*

WOODY PLANTS

Juniper
Juniperus spp.

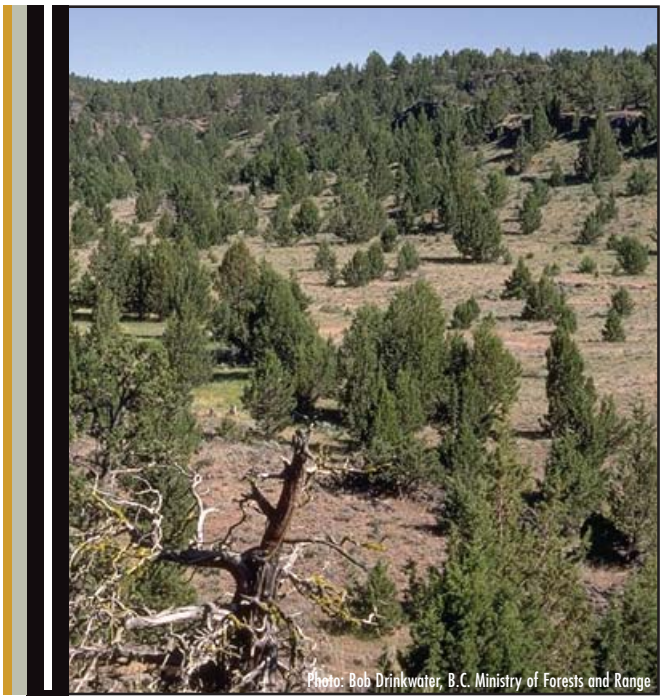


Photo: Bob Drinkwater, B.C. Ministry of Forests and Range

Description:

Juniper is a slow-growing, long-lived evergreen shrub or a small columnar tree. It generally has multiple stems that are spreading or upright. Juniper has a thin brown fibrous bark that peels in thin strips. Twigs are yellowish or green when young, turn brown and harden with age. The leaves are simple, stiff, and arranged in whorls of three with pungent odor. Young leaves tend to be more needle-like, whereas mature leaves are scale-like. The fruits are rounded, berry-like seed cones on short stems that are red at first, ripening to a bluish black. Juniper berries take two or three years to ripen, so that blue and green berries occur on the same plant. Each cone has two or three seeds.

Management Guidelines:

Type and Class of Livestock – Goats.

Grazing Objective – Remove biomass, young plants, and young stems.

Growth Stage for Treatment – Goats prefer seedlings or juvenile juniper plants or young regrowth from cut stems.

Potential Effectiveness – Goats will eat younger parts of the plant before consuming older juniper. Goats can graze year round and can be very effective in controlling juniper. Essential oils, or monoterpenes, that give the plant its distinct odor can deter animals from browsing. Studies have shown that goat breeds differ in their ability to tolerate the chemicals in juniper; Boer-Spanish goats are better than Angora goats. Offering a high energy/protein supplement may enhance goats' acceptance of juniper.

References:

Brock, J.H., 1988. Livestock: Biological control in brush/weed management programs. *Rangelands* 10:32-34.

Fueilendorf, S.D., F.E. Smeins, and C.A. Taylor. Browsing and tree size influences on Ashe juniper understory. *Journal of Range Management* 50:507-512.

Hanselka, C.W. and J.C. Paschal. 1992. Brush utilization on the Rio Grande Plains. *Rangelands*. 14:169-171.

Lyons, R.K., M.K. Owens, and R.V. Machen. 1998. Juniper biology and management. Texas A&M Experiment Station. Bulletin B-6074 9-98.

Pritz, R.K., K.L. Launchbaugh, and C.A. Taylor, Jr. 1997. Effects of breed and dietary experience on juniper consumption by goats. *Journal of Range Management* 50:600-606.

Taylor, C.A., Jr. 2002. Using goats to control juniper. Journal of Animal Science. Vol. 80, Supp. 1 *Journal of Dairy Science* Volume 85 Supp.1 *Available at:* http://www.asas.org/jas/2002abs/jnabs80.pdf. *Accessed 12 July 2006.*

WOODY PLANTS

Multiflora Rose
Rosa multiflora

Description:

Multiflora rose is a vigorous, thorny shrub with clumps of long, arching stems 5 to 10 feet in height. The leaves are divided into five to 11 sharply toothed leaflets, each 1½ to 2 inches long. The base of each leaf stalk bears a pair of fringed bracts. Beginning in May or June, clusters of showy, fragrant white to pink flowers appear, each about an inch across. Small bright red fruits, or rose hips, are ¼ inch in diameter, develop during the summer, becoming leathery, and remain on the plant until spring. Multiflora rose spreads primarily by seeds.

Photo: Jean-Marie Luginbuhl, North Carolina State University

Management Guidelines:

Type and Class of Livestock – Sheep and goats; not recommended for cattle.

Grazing Objective – Graze multiflora rose season long to achieve and maintain 95% stem defoliation.

Growth Stage for Treatment – Sheep and goats readily consume multiflora rose. Effective control requires intensive grazing early in the grazing season, followed by less intensive grazing later in the summer as pasture growth slows.

Potential Effectiveness – Livestock are highly recommended for long-term, sustainable management of multiflora rose. Goats will defoliate multiflora rose up to 5 feet tall. Goats are most effective; they are able to defoliate three times the amount as sheep in a single season. Even though goats or sheep can reduce multiflora rose in one season, it will take several seasons of grazing treatment to kill the plant. Goats or sheep will consume multiflora rose and other brush and open the area for grazing by cattle.

References:

Bryan, W.H. 1994. Mechanical control of multiflora rose. West Virginia University Extension Service. *Available at:* http://www.caf.wvu.edu/~forage/5420.htm. *Accessed 12 July 2006.*

Darlington, J. and B.M. Loyd. 1994. Control of autumn olive, multiflora rose, and tartarian honeysuckle. West Virginia University Extension Service and USDA -NRCS. *Available at:* http://www.caf.wvu.edu/~forage/5412.htm. *Accessed 12 July 2006.*

Green, J.T. Potential for producing meat goats in North Carolina. Meat goat production handbook. *Available at:* http://www.clemson.edu/agronomy/goats/handbook/potential.html. *Accessed 12 July 2006.*

Luginbuhl,J-M. J.T. Green, M.H. Poore and J.P. Mueller. 1998. Use of goats as biological agents for the control of unwanted vegetation. *Available at:* http://www.cals.ncsu.edu/an_sci/extension/animal/ meatgoat/MGVeget.htm *Accessed 12 July 2006.*

WOODY PLANTS

Pine
Pinus spp.

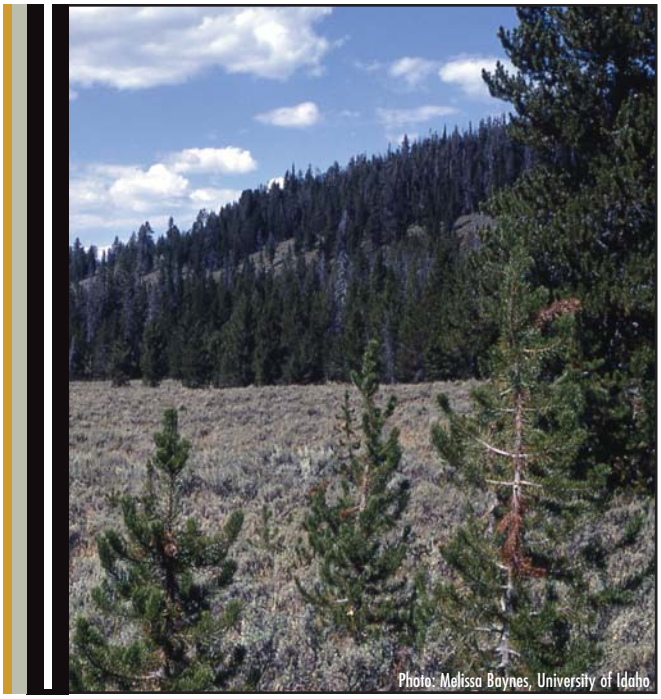


Photo: Melissa Baynes, University of Idaho

Description:

Encroachment of native pine trees into Western rangelands reduces area available for grazing livestock and wildlife.

Management Guidelines:

Type and Class of Livestock – Goats and sheep.

Grazing Objective – Stocking rate should achieve removal of more than half of the terminal leaders and lateral branches of young pine trees.

Growth Stage for Treatment – Browse saplings and juvenile trees during the winter months. Browse pine trees until desirable grasses and forbs have 2 to 3 inches of residual stubble and desirable shrubs have 60% utilization.

Potential Effectiveness – A single season of browsing pine can reduce plant height and diameter growth. Browsing more than half the branches for two consecutive years can kill trees. Higher stocking rates (three to four sheep or goats per acre) will be needed in areas where pine density exceeds 300 trees per acre. Feeding with a high energy/protein supplement can increase the rate of pine browsing. Livestock should not be forced to browse continuously during the winter; a rest period of two to three weeks periodically during the season will provide the greatest overall control of pine encroachment.

References:

Olson, K.C., R.D. Wiedmeier, J.E. Bowns, and R.L. Hurst. 1999. Livestock response to multispecies and deferred-rotation grazing on forested rangeland. *Journal of Range Management* 52:462-470.

McLean, A. and M.B. Clark. 1980. Grass, trees, and cattle on clearcut-logged areas. *Journal of Range Management* 33:213-217.

DelCurto, T., M. Porath, C.T. Parsons, and J.A. Morrison. 2005. Management strategies for sustainable beef cattle grazing on forested rangelands in the Pacific Northwest. *Rangeland Ecology and Management* 58:119–127.

WOODY PLANTS

Saltcedar
Tamarix ramosissima

Description:

Saltcedar, or tamarisk, is a deciduous shrub or small tree growing 12 to15 feet in height and forming dense thickets. Saltcedar is characterized by slender branches and gray-green foliage. The bark of young branches is smooth and reddish-brown. As the plants age, the bark becomes brownish-purple, ridged and furrowed. Leaves are scale-like, less than an inch long, and overlap each other along the stem. Leaves are usually encrusted with salt secretions. From March to September, large numbers of pink to white flowers appear in dense masses on 2-inch-long spikes at the tips of branches.

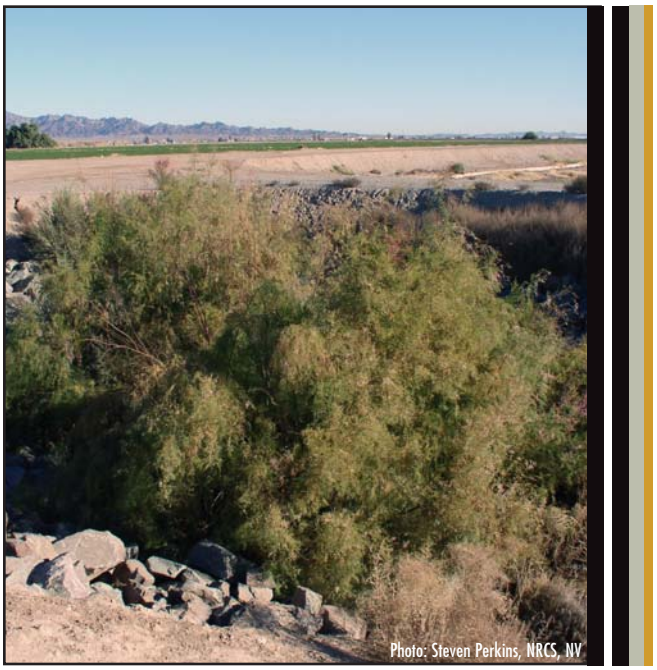


Photo: Steven Perkins, NRCS, NV

Management Guidelines:

Type and Class of Livestock – Goats (especially wethers). Not recommended for sheep and cattle.

Grazing Objective – Severe defoliation to deplete root reserves and prevent establishment of new plants.

Growth Stage for Treatment – Goats have a preference for young shoots, but will readily browse shoots that are up to four years old. Repeated browsing during the season is needed to limit resprouting and to remove new seedlings.

Potential Effectiveness – Browsing of saltcedar is effective to reduce size and density of trees and potentially eliminate saltcedar from specific sites. Goats must consume most or all resprouts and seedlings for at least three to five years. Goats can effectively control and ultimately eliminate saltcedar. They will browse sprouts after mature plants are cut and/or burned. Maintaining a healthy perennial grass understory to prevent seedling establishment is key to long-term management of saltcedar infestations.

References:

Grubb, R.T., R.L. Sheley, and R.D. Carlstrom. 2004. Saltcedar (Tamarisk). Montana State University Extension Service. Montguide MT 199710. *Available at:* http://www.montana.edu/wwwpb/pubs/mt9710.pdf. *Accessed 03 September 2006.*

Jefferson County. 2004. Salt cedar. Weed and pest: Noxious weed information series. *Available at:* http://www.co.jefferson.co.us/jeffco/weed_uploads/saltc.pdf. *Accessed 12 July 2006.*

GRASSES

Cheatgrass (or Downy Brome)
Bromus tectorum

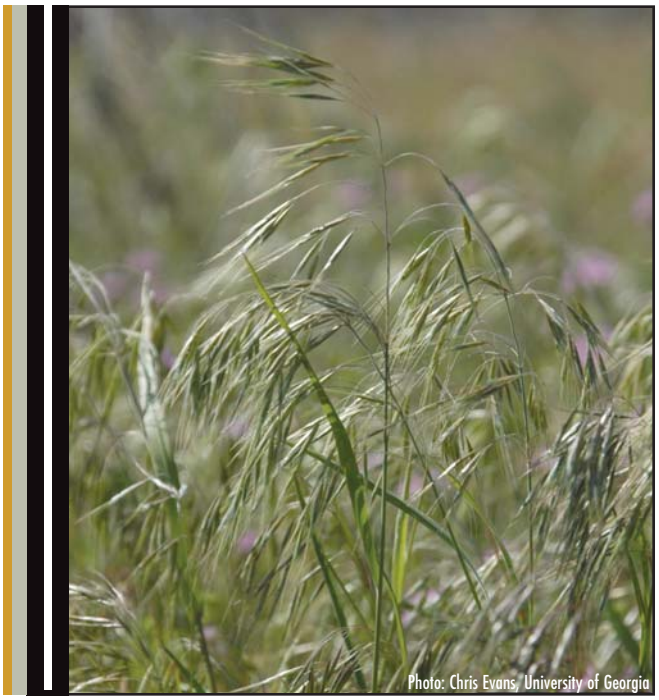


Photo: Chris Evans, University of Georgia

Description:

Cheatgrass is an aggressive winter annual grass that can grow up to 2 feet tall. Seeds germinate in the late winter or early spring. The leaves are flat, wide, and bristly at the base, giving the plant a downy appearance. Each plant can have multiple upright stems. Cheatgrass flowers as an open panicle, each with five to eight florets tipped with a short awn. Plants mature to a wheat color by early summer.

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Intense flash grazing (i.e., grazing for short period) is recommended to remove biomass, decrease plant density, and suppress flowering.

Growth Stage for Treatment – Graze cheatgrass plants as early as possible without harming desirable perennial plants, and repeat grazing to prevent seed production. Livestock readily consume cheatgrass when it is green and before it turns purple. A minimum of two treatments per year is recommended. Two or more years of grazing is required to significantly suppress cheatgrass populations.

Potential Effectiveness – Surveys and literature agree that targeted grazing is an effective tool to control cheatgrass. Heavy repeated grazing for two or more years will reduce plant density, size, and seed production. Grazing must be closely monitored to avoid damage to desirable perennial plant species. Control of cheatgrass can be very effective when livestock are intensively managed and grazing occurs before plants turn purple. Grazing can also be used in conjunction with mechanical methods, herbicides, and controlled burning.

References:

Cook, W.C. and L.E. Harris. Nutritive value of cheatgrass and crested wheatgrass on spring ranges of Utah. *Journal of Range Management* 5:331-337.

Ganskopp, D. and D. Bohnert. 2001. Nutritional dynamics of 7 northern Great Basin grasses. *Journal of Range Management* 54:640-647.

Knapp, P.A. 1996. Cheatgrass (*Bromus tectorum* L) dominance in the great basin desert - History, persistence, and influences to human activities. *Global Environmental Change* 6:37-52.

Mosley, J.C. 1996. Prescribed sheep grazing to suppress cheatgrass: A review. *Sheep and Goat Research Journal* 12:74-80.

Murray, R.B. 1971. Grazing capacity, sheep gains: Cheatgrass, bunchgrass ranges in southern Idaho. *Journal of Range Management* 24:407-410.

Murray, R.B. and J.O. Klemmedson. 1968. Cheatgrass range in southern Idaho: Seasonal cattle gains and grazing capacities. *Journal of Range Management* 21:308-312.

Stewart, G. and A.C. Hull. 1949. Cheatgrass *(Bromus tectorum* L*)* an ecologic intruder in southern Idaho. *Ecology* 30:58-74.

GRASSES

Medusahead Rye
Taeniatherum caput-medusae

Description:

Medusahead is a winter annual grass that normally grows 6 to 10 inches tall. It begins growing in the fall and produces narrow, rolled leaves giving plants a slender appearance. One to several stems grow upright from the base of the plant and produce a dense spike of individual florets each with thin awns 1 to 4 inches long. Flowering occurs in late May to June after other annual grasses. The florets do not easily break apart when mature, as the individual seeds fall out, leaving the long thin bristles attached to the seed head. The plants turn from a wheat color to a very light cream color after the seeds disperse. The plant normally contains large amounts of silica, allowing the dead plants to remain in place longer than other annual grasses.

Photo: Lovina Roselle, University of Idaho

Management Guidelines:

Type and Class of Livestock – All classes of sheep, goats, and cattle.

Grazing Objective – Graze early in season to prevent seed production and reduce medusahead mulch.

Growth Stage for Treatment – Graze winter rosettes in the spring. Palatability drops rapidly as plants flower and mature.

Potential Effectiveness – Grazing causes a decline in plant vigor and density after two years of intensive grazing. Very effective if grazed repeatedly and seed production is prevented. Grazing can be combined with a burning, mechanical methods, and herbicides.

References:

Bodurtha, T.S., J.P. Peek, J.L. Lauer, 1989. Mule deer habitat use related to succession in a bunchgrass community. *Journal of Wildlife Management* 53:314-319.

George, M.R., R.S. Knight, P.B. Sand, and N.W. Demment. 1989. Intensive grazing management on annual range. *California Agriculture* 43:16-19.

Hilken, T.O., and R.F. Miller. 1980. Medusahead *(Taeniatherum asperum)*: A review and annotated bibliography. Agricultural Experiment Station Bulletin 644, Oregon State University, Corvallis.

Lusk, W.C., M.B. Jones, D.T. Torell, and C.M. McKell. 1961. Medusahead palatability. *Journal Range Management* 14:248-251.

Major, J., C.M. McKell, and L.J. Berry. 1960. Improvement of medusahead-infested rangeland. University of California Agricultural Experiment Station. Leaflet 123. 6p.

McKell, C.M., A.M. Wilson, and B.L. Kay. 1962. Effective burning of rangelands infested with medusahead. *Weeds* 10:125-131.

Miller, H. C., D. Clausnitzer, and M. M. Borman. 1999. Medusahead. *In:* R.L. Sheley and J.K. Petroff [EDS.]. Biology and management of noxious rangeland weeds. Corvallis, OR: Oregon State University Press. p. 271-281.

Photo: ASI

SECTION IV:
Applying Targeted Grazing

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CHAPTER 16:
A Primer for Providers of Land Enhancement

By An Peischel

An Peischel is Extension Assistant Professor of Goats and Small Ruminants with both the Tennessee State University and the University of Tennessee Cooperative Extension Programs, Nashville, TN.

10 KEY POINTS

- Targeted grazing is a business – service providers must earn a profit or it won't work.
- Landscape goals should embrace all aspects of the ecosystem – biological and environmental.
- Creating a business plan is a priority for setting goals and objectives.
- Site inventories are critical for preparing an efficient plan of work.
- Healthy animals are necessary for the success of any land enhancement endeavor.
- Equipment for targeted grazing projects can be extensive and its upkeep expensive.
- Effective livestock guardian animals are of utmost value in extensive, isolated, and predator-infested habitats.
- Catastrophes can strike at any time – preparation is panic prevention.
- Hiring and keeping good employees is a major challenge in targeted grazing projects.
- A written contract with a land manager should be agreed upon before a project begins.

Photo: Ron Nichols, USDA, NRCS

INTRODUCTION

Land enhancement can encompass rejuvenating lands, creating firebreaks, reducing fuel loads, abating weeds, improving wildlife habitat, restoring streams and stream banks, cleaning the land – the list goes on. Likewise, the range of potential landscapes for enhancement projects is vast, from farmland to rangeland, from orchards to forests. Many tools are available for land enhancement projects, but carefully controlled livestock grazing is being harnessed more frequently for these activities. The key point for the service provider (the livestock owner) is that enhancing landscapes with targeted grazing is a business. The potential for ecological value from the grazing service cannot be achieved if the service provider cannot profit from the endeavor.

Land and livestock managers engaged in landscape enhancement must maintain biodiversity, understand plant physiology, maintain soil health, and be empowered to make decisions that are environmentally, economically, and socially sound. The management goals for land enhancement must embrace all aspects of the ecosystems – biological and environmental – with project success centering on planning flexibility. In essence, the grazing/browsing service provider is utilizing the natural energy from the sun to accomplish landscape goals. To utilize this natural energy flow efficiently, the service provider dictates the season and timing of treatment and the livestock species to be used for grazing and browsing for a specific project area and target plant species.

Before starting a project using sheep, goats, or other livestock as land-enhancing tools, several assessments must be made. First, the landowner should set a land management goal and describe the final goal for the landscape. This should then be discussed with the targeted grazing service provider. An effective service provider conducts an initial site analysis, stays in communication with the landowner, and makes the final decision as to whether livestock are the best solution to attain the landscape goal. A service provider must be skilled at managing both land and livestock production as well as managing a business. What follows are some major considerations that can facilitate success.

Business Plan

The most important first step for any business venture is a plan. Without a plan, a business won't know where it is or where it's going. A financial plan will help incorporate enterprise evaluation into business decisions. It will generate a profit and loss statement showing gross margin based on gross income and variable and fixed expenses. The planning process will provide the flow, allocation, and value of the different classes of livestock in before-and-after inventories. Planning also involves conducting research and making important first-hand contacts.

Why bother with a business analysis? Because it can show the gross revenue generated for each business segment within the plan, which will help in achieving consistent, predictable production. It will show the cost of generating the revenue and the net profit for each business segment. And it will show whether a reasonable return was obtained for time invested, allowing an assessment of effectiveness and possibly providing information that might lead to the pursuit of other options.

Planning requires developing goals and objectives for the business. The goals of a land enhancement business should be realistic and attainable, and the production management should be sustainable. The business must be marketable, economically feasible, and able to serve the needs of prospective clients.

Site Analysis and Description

For the land enhancement service provider, conducting a quality assessment of the plant communities on a site is critical to the success of the business. The assessment should yield a graze/browse preference list including the time of year the livestock are most likely to select or prefer the target vegetation in the area and the class of livestock most suited for managing the site. Plants targeted for removal must be described and poisonous plants and their toxins identified. Soil textures and their infiltration and percolation characteristics must be understood to address potential erosion.

Sites will need to be monitored with an initial set of monitoring points. Vegetation utilization can be measured and observed with photos, plots, and transects. *(See Chapter 5 for additional detail on monitoring.)* As part of costing out the project, the service provider will need to know how much biomass is available for browsing or grazing. A site's history should be researched, including livestock usage, as a reference for disease potential (e.g., blackleg, leptospirosis, listeria, and caseous lymphadenitis) or contaminants in the soil (e.g., herbicide and pesticide residues) or water (e.g., excessive nitrate and sulfur, salmonella, and *Escherichia coli*).

A base map of the area will show specific sites being considered for land enhancement. The map should include the perimeter, topography, and ecological constraints and exclusions. This will help in understanding fire ecology and identifying shelter options during bad weather. Service providers and their clients must understand and carefully follow wetland regulations, EPA (Environmental Protection Agency) and NEPA (National Environmental Protection Act) requirements, the Endangered Species Act, and Fish and Game Conservation Corridors. Neighbors and adjacent landowners should be briefed fully on the plans for using livestock to enhance land. *(For more information on site analysis, see "Primer for Land Managers" – Chapter 17.)*

Overview of Operations – What It Takes to Make It Happen

Animal Health and Well-Being

Healthy animals are an asset to any land enhancement endeavor. The priority for the service provider is animal welfare and issues related to the health and well-being of livestock. That includes a health maintenance program, a current internal parasite assessment, and the assurance that no known transmissible diseases are present. Another priority is to estabilish each animal's body condition before the project begins and to monitor it regularly throughout the project. If the score falls below an established mark, individuals should be removed from the group or, if necessary, supplemented separately with a high quality forage or ration. Sheep are generally evaluated on a 5-point scale and should have a score of 2.5 to 3 at the beginning of a vegetation project. In general, goats should have a body condition score of 6 at project initiation (the maximum is 9) and not drop below a 4.

The provider must also select the correct species, breed, age, and class of livestock for the targeted land enhancement venture. Animals adapted to the environment, vegetation community, and topography are assets as are animals with experience on previous projects.

Containing and Handling Animals

Fencing and herding, or a combination, are the two practices most commonly used to handle livestock for vegetation management. Portable solar-powered poly-wire electric fencing allows mobility, flexibility, and time confinement on target vegetation. Various types of electric fencing are available; the choice is up to the provider and depends on the specific goal of the landowner. The most important component of electric fencing is the energizer and the grounding system of the energizer and the fence. Depending on the landscape, setting up the fence requires tools like a chainsaw, weed eater, machete, tree pruner, and rope. Here are some other considerations for managing the livestock:

- Portable welded stock panels can assist in loading and unloading trucks and trailers.
- When herding livestock, one or more horses and all pertinent gear are often required.
- Herding dogs are an absolute necessity. The breed should fit the environment and the nature of work expected. Dog food should be of high quality, both in energy and protein. It is important that dogs be fed regularly and excess food removed to ensure that sheep and goats are not tempted to eat it.

Water Requirements

Water is critical to any project. Sheep can consume up to 2.5 gallons of water a day and goats up to 1.5 gallons when it is hot and dry or the vegetation is decadent and stemmy. Fresh, potable water should be available at all times in easily accessible troughs. Water supply location should be specified on base and site maps so the provider knows whether portable or fixed storage tanks are needed. The type of water supply available will determine its method of distribution (siphons, solar pumps, gravity, etc.). Knowing water sources also can aid in rapid fire suppression.

Equipment Needed

In a business venture involving livestock, the amount of equipment needed can be extensive and the upkeep expensive. The targeted grazing service provider typically will need a living facility for herders, water tankers, water troughs and hoses, ATV and wagon, dog kennels and feeders, portable fencing and related materials, portable shelters for inclement weather, mineral/supplement feeders, an array of small hand tools, and tools for machine and engine repair.

Photo: ASI

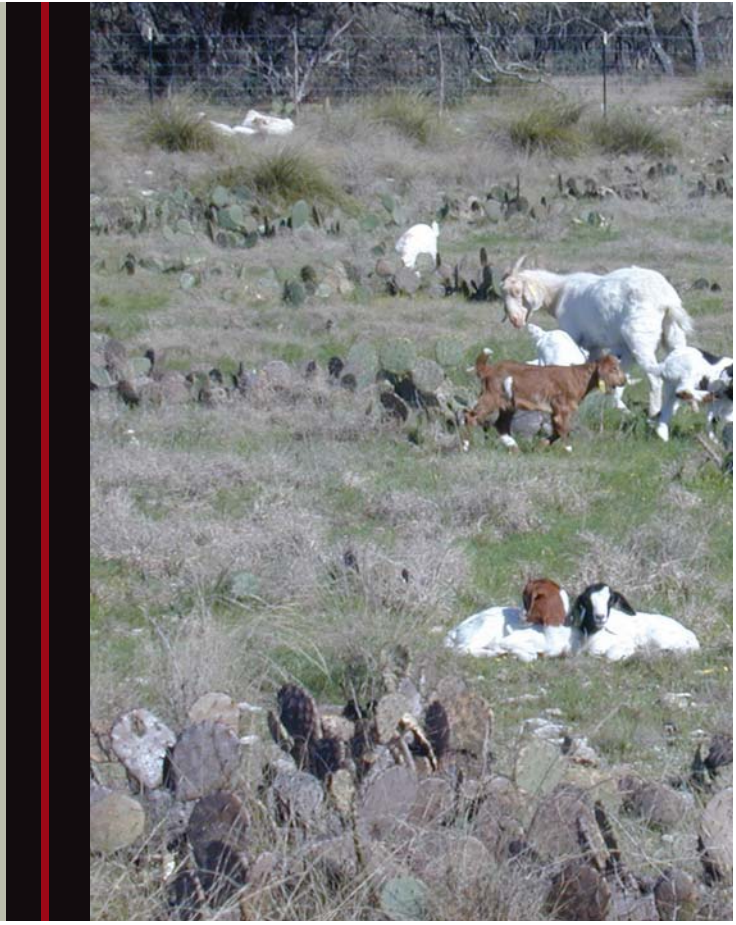


Photo: Karen Launchbaugh, University of Idaho

Transportation will be needed for the livestock, dogs, employees, and gear. Livestock trailers, portable corrals, and loading facilities are also essential.

Livestock Guardian Animals

Effective livestock guardians are of utmost value when working in an extensive, isolated, or predator-infested habitat. In some areas, the most dangerous predators are domestic dogs that have joined as a pack to kill for the thrill. Guardian species and breed will depend on the class of livestock to be protected, topography, type of predator (nocturnal or diurnal), and setting (rural or urban). The age, level of experience, and number of guardians needed should be based on species and aggressiveness of predators, herd size, and animal herding or fencing practices. Livestock guardian dogs under two years old should not be required to put their lives on the line for livestock. They need time to gain experience from a skilled mentor and should be used as visual backup until they are at least two. As the number of guardians increases, each will find its niche in the working scheme of the herd or flock. Each dog's duty within the mob should be understood before a dog is added to or removed from a functioning group.

As with herding dogs, guardian dogs should be fed high energy, high protein food daily in their own feeders, spaced apart, to prevent squabbling and ensure that sheep and goats do not consume dog food.

Supplements

Grazing or browsing animals may need to be supplemented with protein or energy, depending on the deficiencies in the vegetation, desired plant utilization, body condition, weather, and topography. A balanced, chelated mineral and vitamin mix containing less than 10% salt should be available free choice at all times. A base mix can be formulated and individual ingredients added as the chemical composition of the vegetation changes. Sea kelp meal supplies many of the micro elements needed to stimulate the immune system and effectively utilize other macro mineral elements. The mineral and vitamin mix and products like sea kelp meal should be provided in separate all-weather feeders.

Horses, llamas, or donkeys used as livestock guardians may need supplements if the available vegetation is a forage type they normally would not consume. For example, donkeys or horses may perform well as guardians in brushy country, but they do poorly on browse, preferring grass instead.

Crisis and Catastrophe Preparedness

A catastrophe can strike in an instant, be it from fire, weather, natural disaster, or improper management. Preparation is panic intervention. The service provider needs a contingency plan for various events that can arise and the ability to plan and re-plan in light of subsequent events.

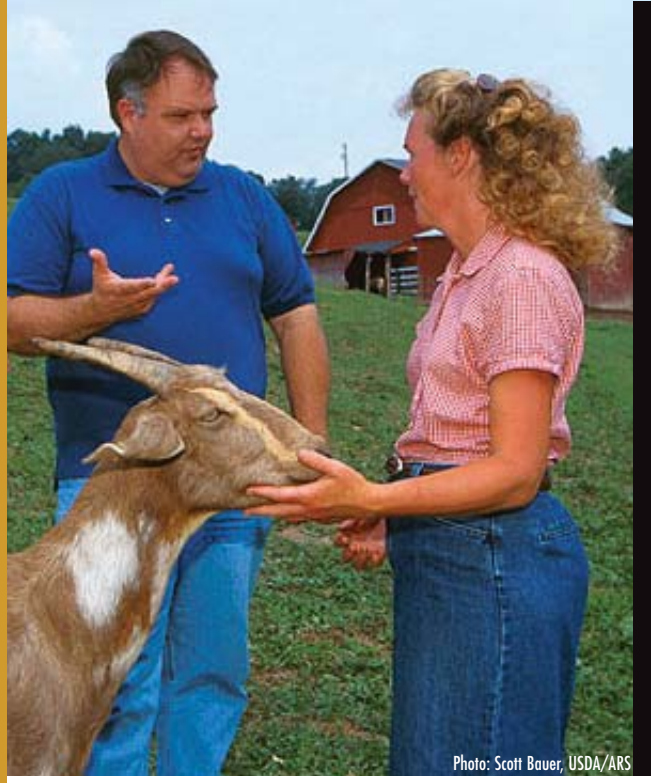


Photo: Scott Bauer, USDA/ARS

As a minimum, a contact and emergency notification list should include all individuals involved in the project, neighboring communities, local authorities (i.e., police, fire, and animal control officers), truckers with the ability to remove livestock on short notice, a radio operator monitoring the fire response team, and the humane society.

Insurance

Because a catastrophe can occur at any time, insurance is a *necessity*. It is vital to carry enough insurance and the correct type of insurance to avoid losing the operation. In addition to consulting a farm insurance agent, legal counsel should be obtained. Each provider will be working under specific conditions that change with each project. When consulting with an insurance agent or legal counsel, the following items should be considered. These are only recommendations; professional advice should be sought when appropriate.

A **Comprehensive General Liability** insurance policy should be purchased. **Broad Form Property Damage** coverage will be based on "what if" a specific situation arises. The probable occurrence of property damage and type of damage that may be sustained is determined by the land enhancement service provider during a site analysis. These concerns should be discussed openly with the client to reach a consensus and purchase a policy that satisfies both parties.

Livestock and Full Mortality insurance covers the animals working on the vegetation and their guardians. Such a policy should cover the replacement value of the animals plus the time and monetary value of lost browsing or grazing for interrupted projects.

Workers Compensation and Health Policies are determined by: a) whether the service provider is a private contractor, b) whether the client has specific demands specified in the contract, c) individual state regulations, and d) pending federal requirements.

Equipment owned should be insured, including coverage for third-party drivers. Equipment includes, but is not limited to, trucks, trailers (with contents covered), ATVs, RV or camper trailer, and fencing materials.

Third-Party Firefighting and Fire Suppression Expense Liability coverage should be considered. When the project involves reducing fire fuel loads, opening defensible spaces, managing ladder fuels, and creating firebreaks, third-party fire insurance should be secured.

Labor

Acquiring and keeping good workers has been a major weak link in the land enhancement business. Before prospective employees are interviewed, the service provider should know the experience and knowledge level employees will need to do specific projects. A site analysis can help determine the number of employees required, the employee knowledge and experience base required, and the salary structure (hourly, daily, monthly, by project, etc.). Costing employees into the business plan should include food allowance, transportation (pickup, ATV, horse, and gear), accommodations (travel trailer, RV, portaloo, etc.), other items (cell phone, first aid kit), and the insurances discussed earlier.

Each employee needs a job description to know what's expected. Potential employees need a chance to digest what the job requires so they can make a valid decision. These expectations will provide the basis for the performance evaluations that will determine job security and pay raises.

The employee and employer should read and discuss the contract together. Then each should sign the agreement in good faith. The contract should include the location of the project(s), time or season of year, duration, and whether the project has job requirements not included in the employment contract. Details for the project may need to be specified as an addendum to the contract. Salary should be specified and indemnity and release clauses included. Indemnity clauses will vary by state, but the work to be accomplished must be identified in the contract. A lawyer should draw up all legally binding contracts or agreements.

Contract and Services Negotiation Considerations

A targeted grazing service provider needs a written contract with the landowner (private, organization, government agency) *before* any land enhancement is started or livestock moved. The landowner should specify in the contract the exact location of the project and provide clearly marked perimeters, information that will determine the dynamics and approach. Specific project goals should be clearly described – abating weeds, reducing ladder fuel, creating firebreaks, restoring ponds, suppressing vegetation. The project goals and site characteristics dictate the number of livestock needed and the breed, age, and class of individuals. Start and end dates should be specified. The lead time for land enhancement contracts can range from two weeks to a year. The time the stock are inclined to eat specific plants will vary through the year, depending on the species of livestock used and the physiological state of the vegetation. To work successfully within a vegetation time frame, an extension or renewal clause agreeable to both parties should be included. This will allow the provider, if necessary, to return to the site several times within a growing season to attain the client's desired landscape.

Fee assessment can be designed creatively for each project and should include a non-refundable setup and delivery charge. A payment schedule, with specific dates and details, should be negotiated along with a specified lead time. The indemnity clause and the work to be accomplished must be defined within the contract. Even though good faith and good management practices will be attempted, animal welfare takes priority.

Contracts and the services offered under those contracts are site specific. Here are some other important items to consider when negotiating a contract:

- Specify the exact name of the land manager and the service provider and include business addresses and phone numbers.
- Identify all local, county, state, and federal environmental legislation, regulations, guidelines, and standards to assure compliance.
- Detail rules regulating any subcontractors.
- Determine terms relating to possible contract suspension or termination.
- Firefighting costs incurred to extinguish a fire not caused by the service provider are the responsibility of the land manager.
- The agreement date and work commencement date should be in writing.
- A security deposit should be retained or withheld to ensure project completion. The deposit should be held in an escrow through a bank, lawyer, or real estate officer.
- The grazing service provider assumes risks and dangers based on the nature of the operation, but any negligence of the land manager is the manager's responsibility and liability.
- Contracts can be suspended or terminated for various unforeseen conditions beyond the control of either party. An agreement, in writing, should designate the number of days before stock need to be removed from the project under unanticipated circumstances.
- If the costs of performing the work increase after the project has started, both parties can agree, in writing, that the additional costs be covered by the land manager or the contract can be terminated.
- If the land manager determines that the acreage to be treated is less than originally stated, the manager is responsible for costs incurred by the service provider.
- The vacated vegetation treatment area should be left in acceptable condition.
- When working in areas with predators, protecting human life is paramount. If firearms are used for protection, they should be lawful and the individuals using them qualified and licensed.
- In a commercial forest or re-forested plantation, the number of trees per acre required to attain a healthy stand as required by the land manager should be known. The condition of the conifers (seedlings) should be monitored and the livestock managed accordingly.
- All conditions regarding water sources (lakes, streams, buffer strips) must be in writing.
- Ready access to high quality water is a major human resource concern.
- An indemnity clause included in the business agreement or contract should be spelled out by legal counsel in the state where the project is conducted. An indemnity clause is engaged to save another from a legal consequence of the conduct of one of the parties or of some other person. It generally obligates the indemnitor to reimburse the indemnitee for any damages. A contract as well as the intention of the parties is binding, so the work being done should be spelled out explicitly in the contract.

TAKE HOME MESSAGE

The targeted application of livestock grazing and browsing holds great potential for accomplishing landscape enhancement. The targeted grazing service provider faces two major challenges in this endeavor: meeting landscape goals and simultaneously running a successful business. Both are essential and require expert knowledge and skill to accomplish. On the one hand, knowledge of vegetation, soils, and animals is required to accomplish the prescribed landscape enhancement goals such as managing weeds and reducing the risk of fire. On the other hand, business savvy and careful financial planning are required to stay in business and continue offering landscape services.

Photo: ASI

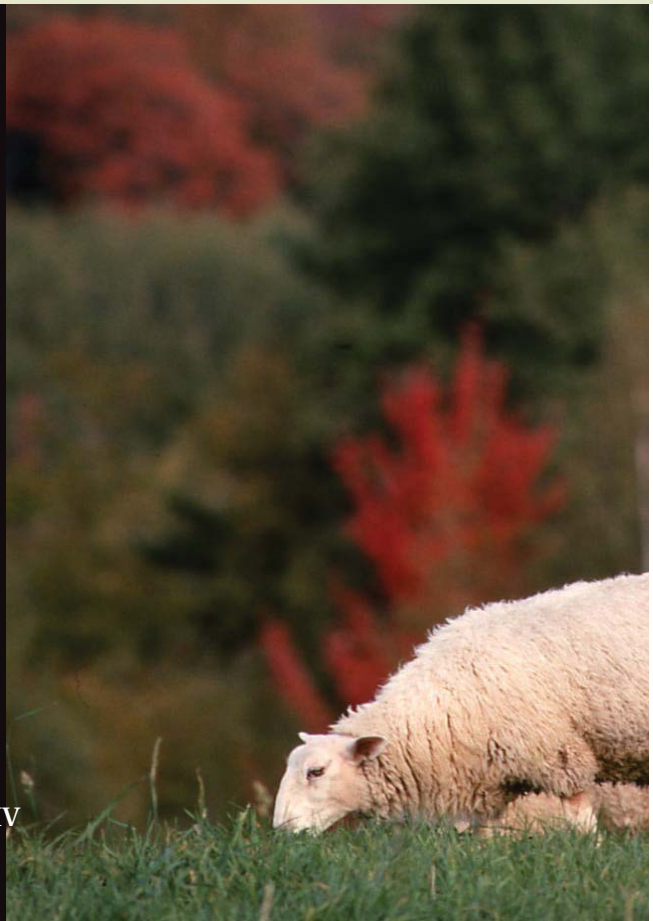


Photo: ASI

Additional Resources

Sheep Production Handbook. 2002 – Version 7. This reference handbook covers the basics of sheep production. Topics include Sheep Breeding, Forages, Handling, Health, Management, Marketing, Nutrition, Predator Control, Quality Assurance, Reproduction, Sheep Care, Wool, and Contact Lists for State Extension Personnel, State Extension Veterinarians, and State Animal Health Officers. Published by the American Sheep Industry Association, www.sheepusa.org.

Nutrient Requirements of Sheep. 1985 - Sixth Revised Edition. The National Research Council publishes this reference book, which uses the latest research in sheep nutrition. Information on nutrient requirements, nutritional deficiencies, and feed quality requirements are presented for all phases of lamb, wool, ewe, and ram production.

Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries. 1981. Published by the National Research Council with detailed information about nutritional requirements of goats in various production systems. This volume is being updated for availability in 2007.

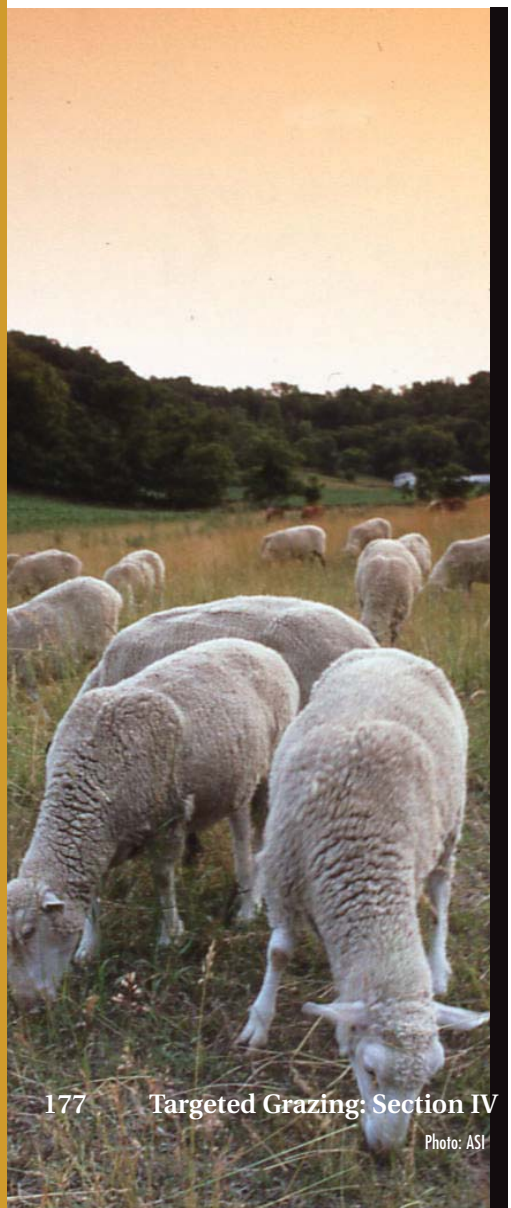
CHAPTER 17:
Contracting for Grazing and Browsing to Achieve Resource Management Objectives: *A Primer for Land Managers*

By D. Dickinson Henry, Jr.

Dick Henry is a grazing contractor and owner of Bellwether Solutions, Concord, NH.

10 KEY POINTS

- Grazing for hire can be a powerful tool for changing and maintaining vegetative composition.
- Land managers should take the time to select the right service provider for the job.
- Targeted grazing is as much an art as it is a science.
- Land and livestock managers need a long-term commitment to alter landscapes.
- A land manager's most important step is clearly establishing long-term goals.
- Open communications can foster harmonious relationships between service providers and land managers.
- Potential service providers need to conduct on-site tours and evaluations.
- Key elements for success are water, livestock placement, transportation, and equipment.
- Service providers must know the applicable regulations and obtain the needed permits.
- The land manager is responsible for determining whether targeted grazing is the right tool for a particular situation.



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INTRODUCTION

Contracting for targeted grazing services is a viable option for land managers with significant vegetation management challenges. This primer is designed to help land managers evaluate whether targeted grazing services will work in their situations and, if so, how they can choose a qualified service provider. Thinking through the following ideas and gathering the suggested materials will help in picking the right grazing service providers for the job. Some of the following suggestions may seem obvious, others counterintuitive. But they should illuminate what targeted grazing services can and cannot do and whether a service provider has enough experience to do the job right.

This primer focuses on points to consider in contracting with a service provider for targeted grazing. It should help address basic questions about whether a grazing prescription is appropriate for a particular problem. It does not provide enough information to teach someone how to operate a contract grazing business or to manage prescribed grazing on a day-to-day basis. That requires greater knowledge than is found here.

Accomplishing Landscape Goals with Targeted Grazing Services

Over the past several decades, controlled, directed grazing and browsing by sheep and goats has evolved into a business. No matter what it's called – targeted grazing, contract grazing, prescribed grazing, managed herbivory, ecological grazing services, or paid-to-graze – this type of grazing for hire is a powerful tool for changing and maintaining the vegetative composition and structure of a wide variety of landscapes. Grazing has been used effectively to reduce fire fuel loads, eliminate invasive and exotic plants, restore water tables, and clear and maintain land in open vistas. Potential applications are virtually endless, limited only by the imagination of land managers, landowners, and service providers.

Targeted grazing services apply grazing animals, under a fee-based contract, to control vegetation and achieve a specific desired plant community. Although grazing is often viewed as a way to remove undesirable plants, it is really a method for creating and maintaining the complex habitat conditions for a desired plant community.

Using the vegetative grazing preferences of animals like sheep, goats, and cattle, one can suppress or eliminate certain undesirable plants from a landscape and encourage other more desirable species. If a landowner's management needs coincide with an animal's grazing preferences, targeted grazing can be a powerful and cost-effective tool for reaching those land management goals.

For targeted grazing services to work effectively, however, the land manager must have a clear long-term vegetative goal. What should the land look like when it has been restored? This is the most important question that a land manager must answer for targeted grazing to be effective. Once the desired outcome is clearly known and described, a skilled service provider can employ the correct animal species and advise the best options to reach these landscape goals.

Effective targeted grazing is as much an art as a science, and the level of experience of both the contract grazer and the animals will be critical to long-term success. A good service provider will properly evaluate whether grazing will or will not work in a particular situation and whether complementary techniques are needed.

Site restoration using grazing entails two phases. The first is to suppress undesirable plants and restore a desired plant community. The second is to maintain that desirable community indefinitely. These two phases use different grazing approaches, take different lengths of time, have different costs per acre, and, in some cases, may even use different species or breeds of livestock.

Economic Costs and Values of Targeted Grazing Services

Land mangers interested in targeted grazing services must have an appreciation of the challenges that contract grazers face if they expect to develop an effective relationship with the service provider. The concept of targeted grazing is easy to grasp, but its implementation is logistically complicated and capital intensive. As opposed to other techniques like mowing or applying herbicides, targeted grazing requires daily care of livestock throughout their lives. Although a few operators have been able to survive a nomadic existence, moving from one job to another over a large geographic area, the future of contract grazing services will likely involve large, long-term contracts on contiguous or proximate land holdings of many hundreds of acres. In these situations grazing service providers can make long-term investments in equipment and animals, provide steady employment for qualified herders, and respond effectively to varying seasonal and annual growth patterns of the target plants. Under these circumstances, a provider can establish a "home farm" where animals can retreat in case of crisis and during winter awaiting the next grazing season.

With long-term contracts on large acreages providers can train workers and provide them with jobs. Such operations can invest in quality control and long-term results, which are essential for assuring that grazing is a reliable tool for land managers.

A challenge for the contract grazing industry is that too few land manager clients are willing to make long-term commitments on significantly large acreages. However, once land managers become familiar with the progress that can be made using livestock to control invasive plants, restore lands to native or desirable plant communities, reduce fire fuel loads, or any number of other applications, and they understand how best to choose a qualified service provider, the targeted grazing service community should grow and prosper.

The cost effectiveness of a targeted grazing service is determined by the value of the change in the vegetative community, for example, reducing fuel loads, saving water, restoring native plant communities, increasing forage yields of pasture, or opening up impenetrable brush for public recreation. The size of an area and the length of a contract make big differences in the service provider's cost per acre. Targeted grazing is capital intensive. A service provider needs enough financial security over a long enough period to recoup the initial investment and make a profit. Land managers unwilling to offer such long-term contracts may have difficulty finding a reliable and skilled service provider. If too few acres are available to sustain a contract, pooling acres with other interested landowners in the immediate vicinity can generate a cost-effective contract. For this collaborative approach to work, the treatment areas must be close enough together to minimize transportation costs.

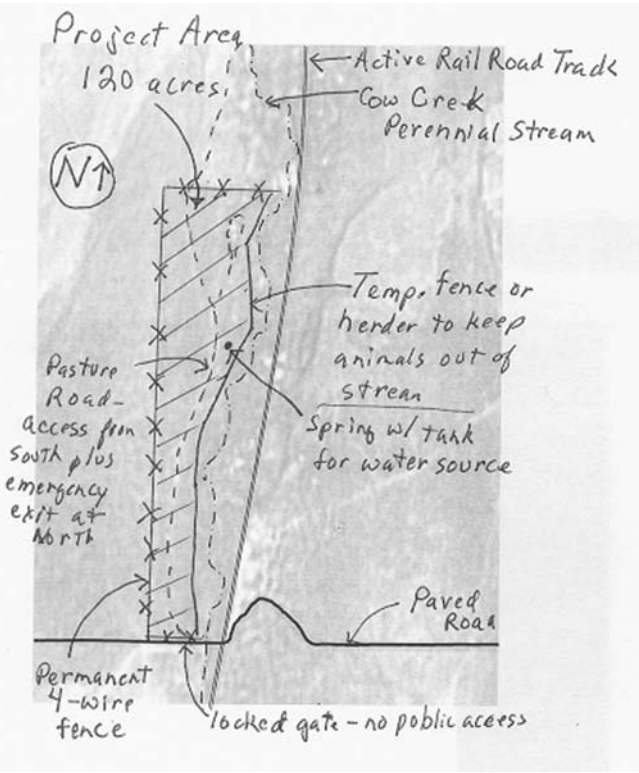
In most situations the current state of undesirable vegetation has taken many years to develop, and grazing prescriptions that address such problems will probably take several years to achieve meaningful results. While carefully targeted grazing can be highly effective for restoring vegetative landscapes, it is not a quick fix.

Creating a Targeted Grazing Service Plan and Contract

The most important step for a land manager is to clearly establish long-term goals. Without a description of what the land manager wants the land to look like – its desirable condition – the land manger cannot expect a grazing service provider to achieve the desired goals. The land manager and grazing service provider must develop a plan and agree on the terms of a contract, including when and where to graze. Trying to eliminate an invasive plant also requires determining what plant community should replace it. Knowing the desired appearance of the landscape is essential to a successful plan and contract, and it allows the land manager and grazing service provider to agree on measurable results. The strategies and tactics for achieving the desired vegetation or landscape outcome are largely the job of the service provider.

Working toward a shared vision of the goals, processes, and intended outcomes can foster a harmonious relationship between the service provider and the land manager. Many potential problems and disagreements can be avoided if the two parties discuss their respective visions at the outset. Writing down key discussion points can keep everyone on the same page and essentially creates the plan and contract. Developing a plan and contract may not be exciting, but it beats the heartburn and problems that can arise without them. Disagreements may still arise, but the process of developing a plan and contract should decrease potential problems. More importantly, communication during the process will help the parties more easily address issues.

Goals and outcomes should be described as measurable results, which will provide both parties with a clear understanding of how success will be determined.



Map Figure 1

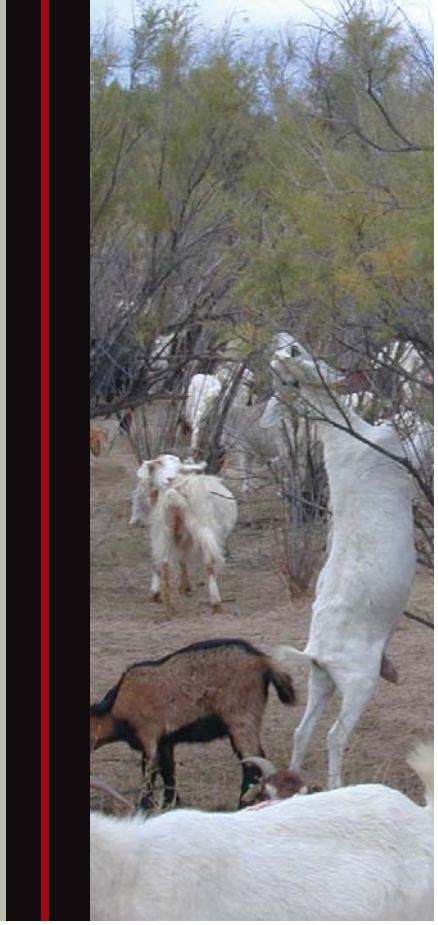


Photo: Karen Launchbaugh, University of Idaho

Measurable results may take many different forms, but the best are based on easily determined quantitative or qualitative characteristics the land should possess when the contract is satisfied. Before and after photographs from fixed positions are often the most practical form of monitoring. Land managers may want to request pictures of previous contracts on similar vegetation types so they know what to expect. Remember the adage, "A picture is worth a thousand words." More quantitative monitoring techniques can be used such as canopy cover, percent composition, biomass, stubble height, fire condition class, fuel load, and average number of plants remaining of the targeted species, but they can significantly increase the cost of the contract.

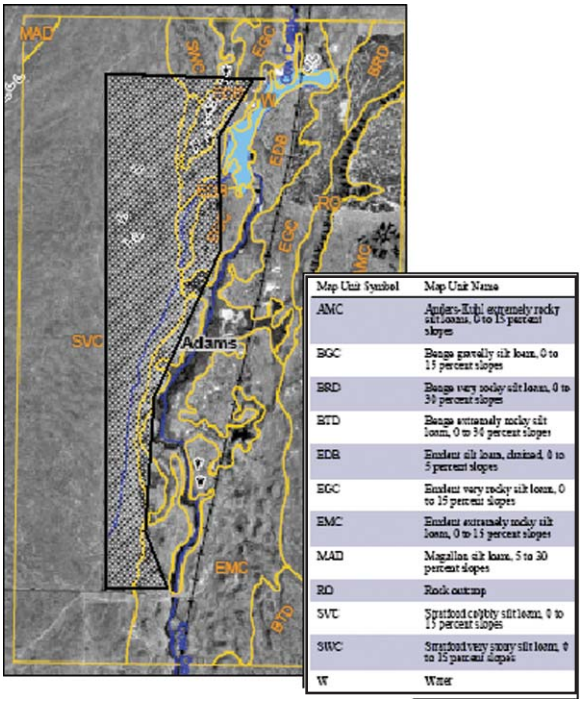
If neither party has experience with specific problems or circumstances, it may be difficult to establish measurable outcomes at the beginning. An experienced service provider will explain what he or she knows or doesn't know about a specific problem. An experiment of a few weeks or months can help determine what is possible or practical. In such cases, a land manager needs to accommodate the service provider's management needs and remain flexible with goals until a realistic outcome can be established.

Site Description and Analysis

Potential grazing service providers will need an on-site tour and evaluation. No reputable provider will take a job without seeing the site. The questions they ask will reveal a lot about them. The land manager should describe the treatment site and provide maps as described below so the service provider clearly understands the boundaries and other important characteristics. Lack of such information can hamper the provider's ability to accomplish the objectives, cause bad relations, and even create liability. The land manager and service provider should inspect the site before the project starts to view issues of significance. A good map can show many of the site characteristics that should be described or analyzed. Here are several characteristics to consider:

Boundaries. A base map of the project area should show the perimeter of the area to be treated and any exclusion areas that should remain untreated. Fences or landmarks that delineate the property and treatment site should be noted (Map Figure 1).

Topography. The base map should provide basic information about topography, which can influence the behavior of grazing animals and must be considered when planning the treatment.



Map Unit Symbol	Map Unit Name
AMC	Ayden-Tuthill extremely rocky silt loams, 0 to 15 percent slopes
BGC	Benge gravelly silt loam, 0 to 15 percent slopes
BRD	Benge very rocky silt loam, 0 to 30 percent slopes
BTD	Benge extremely rocky silt loam, 0 to 30 percent slopes
EDB	Ensilert silt loam, drained, 0 to 5 percent slopes
EGC	Ensilert very rocky silt loam, 0 to 15 percent slopes
EMC	Ensilert extremely rocky silt loam, 0 to 15 percent slopes
MAD	Magallon silt loam, 5 to 30 percent slopes
RD	Rock outcrop
SVC	Spurbond cobbly silt loam, 0 to 15 percent slopes
SWC	Spurbond very stony silt loam, 0 to 15 percent slopes
W	Water

Map Figure 2: Soils Map of Project Area (http://websoilsurvey.nrcs.usda.gov)

Vegetation. The overall vegetative composition of the property should be described and areas with target plants delineated. It's important to list all of the known plant species on a site. A good grazing service provider will review this list and point out plants that may pose problems, like poisonous or threatened or endangered species.

Soils and Ecological Sites. Soils influence plant types. Knowing the soil properties on the site will help determine the existing vegetation and what plant communities are possible. Information on soils, combined with topography and climate, can help predict treatment-induced erosion problems. Soils are also the basis for ecological sites, formerly called range sites. Ecological sites delineated on the base map can provide much of the information about vegetation and potential plant communities (Map Figure 2). Soils maps delineating soils and describing ecological sites are available at the local office of the Natural Resources Conservation Service (look in the phone book under United States Government, Department of Agriculture) or on the Internet at the Web Soil Survey http://websoilsurvey.nrcs.usda.gov or Ecological Site Information System http://esis.sc.egov.usda.gov/.

History of the Site. A good history of land uses of the project site is helpful. Have animals grazed on the site before? If so, what kind, how long ago, and to what purpose? Several animal diseases can survive in the soil of grazed land for many years. Past problems with animals may also indicate the presence of poisonous plants. Knowing past land uses, including soil contamination, agricultural uses, municipal dumps, and old settlements, can help the grazing service provider keep animals healthy and avoid problems or losses.

Neighbors and Other Users. Nearby landowners should be informed that animals will be used on the property and why they're there. This can eliminate surprise and help avoid conflicts. The service provider should also be informed about ATV and hiking trails that cross the property and whether hunting is active on the site. The land manager should discuss how herders and others should respond to visitors and the kinds of signs or notifications that are appropriate. Keeping a service provider informed about these issues will go a long way toward avoiding problems.

Water. The site map should indicate water sources both on and near the property – streams, ponds, wells, and rivers – with a brief description of the water quality for each. The distance to off-site water and whether it is potable should also be noted. A good service provider will have water-hauling capability – tank trucks or trailers and water pumping and storage capacity – whether drawing water from on or off the site. Also, any wetland or water course issues related to animals drinking directly from them should be clearly indicated. Catchment areas, watersheds, and historical flood zones should be identified. If flash flooding is a problem in the area, the service provider needs to know this to plan escape routes.

Fire. What is the area's fire history? How long since the last fire and what is known about fire behavior and the prevailing winds? Such information helps the provider plan escape routes and retreat areas.

Animal Welfare

The grazing service provider's first priority is always the animals' welfare. While the service provider is managing the animals to reach the desired vegetative outcome, results cannot be achieved if the animals are placed in danger. Situations may arise that force the provider to remove the animals for their protection. These may include fire, flooding, poisonous plants, or the lack of adequate forage. A good provider will anticipate many of these contingencies, but no one can anticipate all of them, especially concerning weather and fire. When such problems arise, both parties need to be prepared to determine whether animals can return and finish the job or whether the site has become unsuitable for targeted grazing or browsing.

Principle Requirements for a Project to Succeed

Water

Clean, plentiful water must be available on site or near enough to be hauled or for the animals to be trailed to it. If there is no on-site water, the land manager should help the service provider find a source for filling 500- to 1,000-gallon tanks easily and quickly.

Livestock Placement

How the animals are managed will depend largely on the target plant species and landscape goals. In some cases herding will be most effective. In others, temporary fencing will be needed. Palatability of the target plant, time of year, weather, and site conditions will also determine management. Some sites may be too rugged to fence, others so urban that fencing is the only solution. Requirements and particular preferences should be clearly stated.

Transportation

Moving animals to and from the site is critical. At least two avenues of access are needed. Can a large truck, semi, or gooseneck access the site easily? In the event of flood or fire is there a second means of egress? Does the vegetation plan require the service provider to move animals on and off the site repeatedly or can they be grazed continuously on the site for a month or more? Transportation can greatly increase a project's cost so it may be helpful to design a plan so that when the first pass is completed it is time to start the second pass. This may require several hundred acres or more depending on rainfall and vegetation. With 100 inches of rain a year, kudzu grows back faster than does leafy spurge with 15 inches of rain a year.

Equipment

Equipment requirements will vary depending on terrain, number of animals, and weather conditions. Most grazing service providers will have adequate trucking for animals and water, good fencing and the means to move it around, pickup trucks, ATVs, maybe a tractor, tank trucks, water troughs, and portable handling equipment. Equipment needs also will vary by site, contract requirements, and vegetation goals. This is a capital-intensive business. Land managers should be skeptical of anyone who plans to show up with a couple of cattle panels and a pickup truck.

Theft

If theft is known to be a problem in the area to be grazed, the service provider needs to know so he or she can plan to prevent the loss of equipment and animals. Service providers cannot afford to lose expensive equipment like fence chargers, fences, or pumps. Such information can also protect herders from personal risk. Before the contract work begins, it should be agreed who is responsible for losses and who will pay for lost animals and stolen equipment. This also applies to losses from fire, flood, or other natural causes.

Crisis Management

As with any land management activity, things can go wrong. Crises will occur less frequently with an experienced service provider, and the degree of loss can be much less with appropriate planning and preparation. Again the conditions of the site make a big difference. Animals that escape from a pen in a rural area and start grazing tomorrow's acreage do little harm, unlike animals in an urban setting that get onto a highway or devour someone's garden. Emergency contacts should

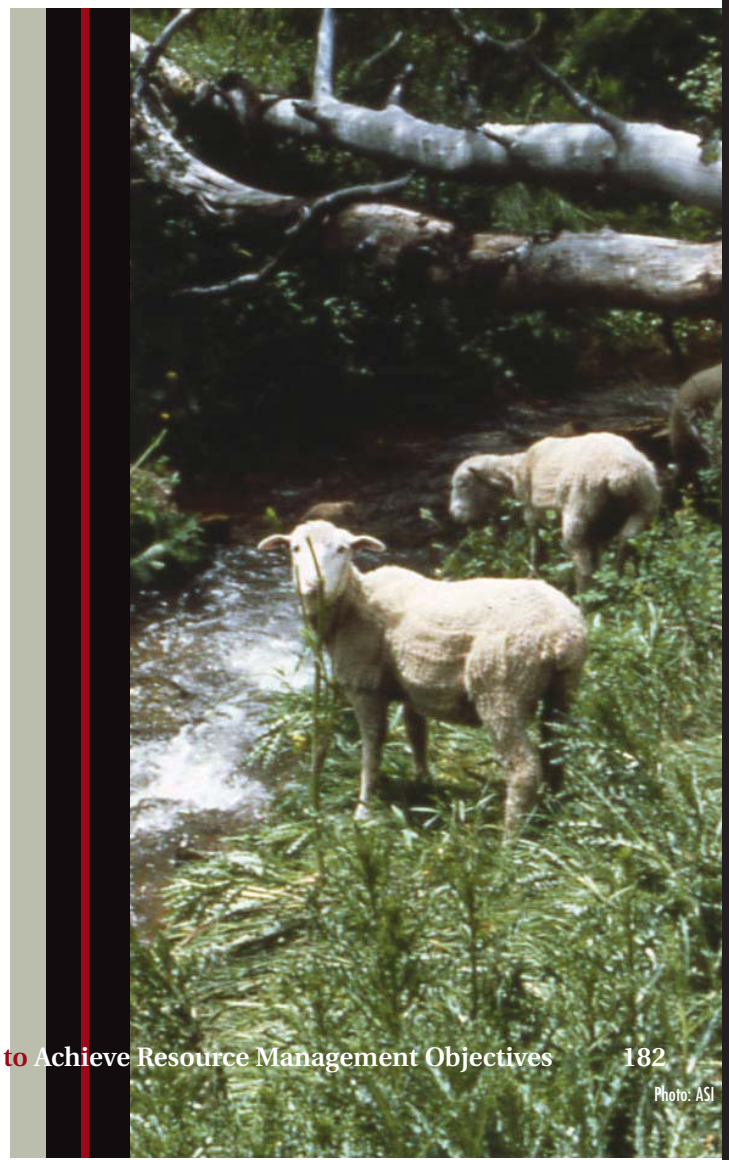


Photo: ASI

be posted at the project site and all participants should maintain a current contact list of local authorities and emergency services. In the event of a crisis, the service provider needs to get on site as quickly as possible. Cell phone numbers of the herder and everyone up the service provider's chain of command should be available to the land manager and to local police and animal control officers so that if they are the first to be contacted they can reach people who can solve the problem. It's a bad idea to have a local police officer trying to herd animals in the middle of the night. Notifying key players before the project begins can minimize surprise and confusion and speed response times.

Fire

Fire poses a special management problem. An area that has been heavily grazed is less likely to burn, but the service provider will always want to remove animals in danger. That is why it is important to know previous fire behavior and to have two means of egress established. In case of fire, evacuate personnel first, then animals, then equipment. When in doubt – get out.

Extreme Weather

Lightning, freak snowstorms, hurricanes, hail, and floods are serious problems. A grazing service provider will need a safe, fenced retreat area where animals pulled from a project can go on short notice. Land managers may have better access to weather information and should inform the service provider when bad weather is forecast.

Regulations and Permits

A wide variety of local, state, and federal regulations may or may not relate to targeted grazing services. Be sure to review the following:

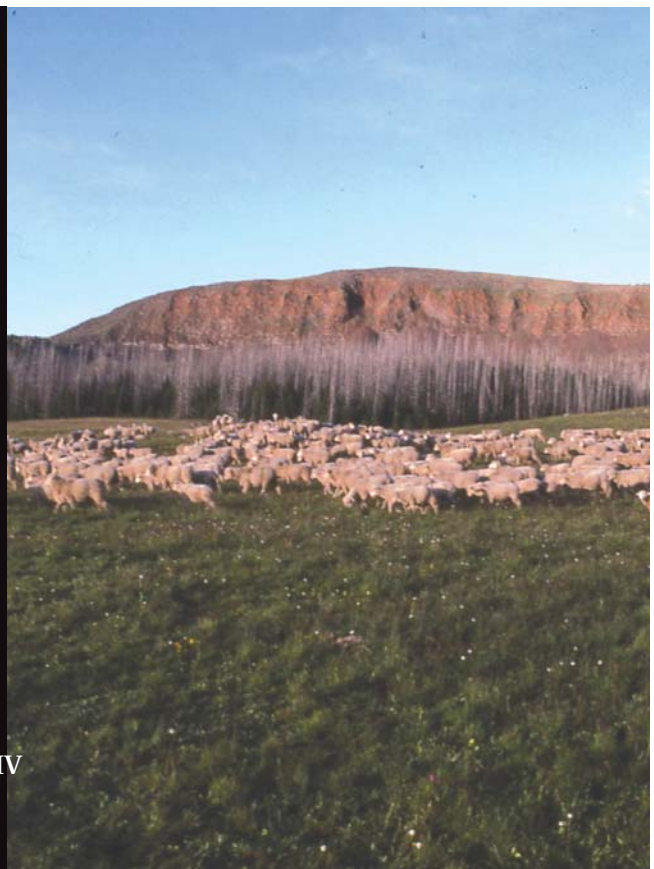
Wetlands Regulations and EPA, NEPA, and agency requirements. Working with the U.S. Forest Service, Bureau of Land Management, Park Service, or other federal land management agency requires compliance with federal regulations and agency-specific policies. State or county regulations may also apply.

Zoning Restrictions. In suburban or urban areas, a variety of regulations relating to the presence of livestock within city limits may apply. The regulations can be complied with or may be waived. But knowing them in advance allows for obtaining the necessary permits before the animals arrive.

Endangered Species. Endangered plants or animals, or their habitat, in the area targeted for vegetation management may impose seasonal bans, stipulate areas of non-use, or restrict specific activities. Federal and state fish and wildlife agencies can explain area requirements.

Livestock Health and Identity. Grazing service providers should maintain and provide health records for important communicable diseases. Animals that are hauled across state boundaries must also be accompanied by brand or identity records and meet state health requirements.

Photo: ASI



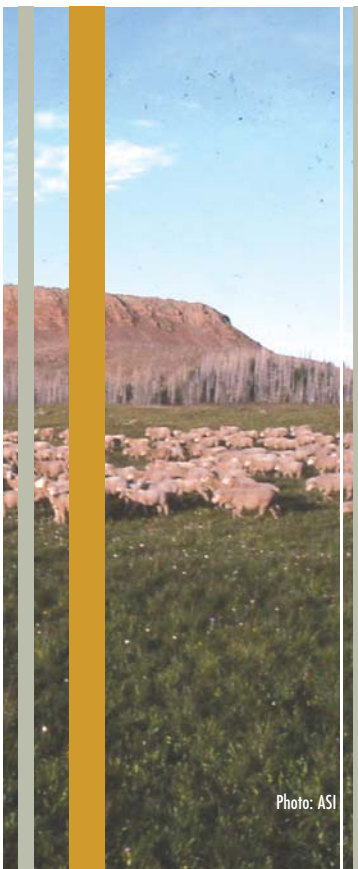


Photo: ASI

Contract Details

At a minimum, a good contract will contain the following:

- **Where.** A detailed map that identifies the perimeter of the contract area and any areas within the overall area that should remain ungrazed. The land manager should clearly flag these exclusion areas before the contract begins and, if possible, before site visits with potential service providers.
- **Time Frame.** The service provider will determine the timing for achieving vegetation management goals only after a site visit. Contract duration will depend on weather, climate, condition of target plants, time of year, and desired outcomes. If multiple grazing passes are required, notification procedures should be worked out before the service provider returns for successive passes.
- **Up-Front Charges.** Nonrefundable setup and delivery fees are often specified in the grazing contract. For large contracts, a service provider may want one-third of the total annual contract up front to help defray project capital costs.
- **Payment Schedule.** Payment schedules are essential and should include set dates and explicit details of work completed. The land manager should inform the service provider about turnaround time on invoices – 10 days, 30 days, etc. Cash flow is critical to all operators. Late penalties are standard. Prompt payments keep grazing service providers happy and working hard to meet landscape goals. Slow or missed payments will aggravate the relationship.
- **Indemnity Clause or Bonding.** These requirements vary by state. If indemnity clauses or bonds are employed, the work to be accomplished should be clearly defined in the contract. This may include height, percentage of target plant remaining, level of suppression, or other specific vegetation condition. Such conditions or measures may not be possible to ascertain until after a season has shown how the target plants are responding.
- **Insurance.** All service providers should carry liability insurance and list the land manager as an additional insured. Amounts will vary by service provider (some carry as much as $2-3 million) but liability insurance should be a mandatory component of any contract. Service providers must also carry workers compensation insurance on all employees. A performance bond can be used but is not required by law.
- **Natural Disasters.** Disasters happen and can radically change the conditions of a contract overnight. These events can be covered in a contract with a 'Force Majeur' clause. However, goals can still be achieved after the dust has settled, even if it's a year later, as long as parties are reasonable and work together.

Other Issues

Lead Time

Putting together large flocks, finding qualified herders, and assembling the necessary equipment takes time, especially with large contracts. The service provider will not begin this process until a signed contract is in hand. A lead time of two to three month is normal. For large projects, six months to a year is reasonable.

Duration

The parties should discuss and agree to the duration of a particular outcome. Vegetation often looks impressive right after the animals leave. In most cases it will grow back, so there should be an agreement as to how long the "new" condition will persist – 90 days, six months, a year, etc. Spelling that out protects the service provider and prevents disappointment for the client.

Media Management

In many cases, contract grazing will arouse a great deal of media interest. How to handle media queries should be worked out in advance. Is media attention an important aspect of the job? Who should field inquiries? How exposed to public scrutiny will the project be? Can herders handle the public's questions? The service provider's principal task is to accomplish the grazing prescription. Public information demands should not be allowed to hinder job performance. If considerable public interest is anticipated, the expected tasks and who will bear any expense associated with them should be written into the contract.

TAKE HOME MESSAGE

Land managers interested in incorporating targeted grazing as one of their land restoration tools should use these guidelines to determine if their situation is amenable to the use of grazing or browsing to help achieve a desired outcome and to evaluate the qualifications of potential grazing service providers. Make sure the knowledge or experience portfolio of the provider meets the needs for land enhancement. Poor results, including an undesirable plant community and increased soil erosion, can occur if these criteria are not met. The service provider should offer information about previous work experience on various types of sites and target species. Land managers should obtain and check references for previous jobs. If potential grazing service providers have little experience, land managers can assess their performance potential by probing their knowledge of land, plants, and animals and assessing their proposals against the information provided in this handbook. Ultimately, it is the land manager's responsibility to determine if targeted grazing is an appropriate tool for a particular situation and if potential grazing service providers are qualified to conduct the project.

Photo: ASI

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SECTION V:
Getting More Information

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CHAPTER 18:
Additional Resources for Targeted Grazing

Compiled by Linda Coffey, Margo Hale, and Elayne Hovde

Linda Coffey and *Margo Hale* are Specialists for the National Center for Appropriate Technology (NCAT) and work on the Appropriate Technology Transfer for Rural Areas (ATTRA) project. *Elayne Hovde* is a County Extension Educator with North Dakota State University and former Research Assistant with the Rangeland Ecology and Management Department at the University of Idaho.

ADDITIONAL RESOURCES

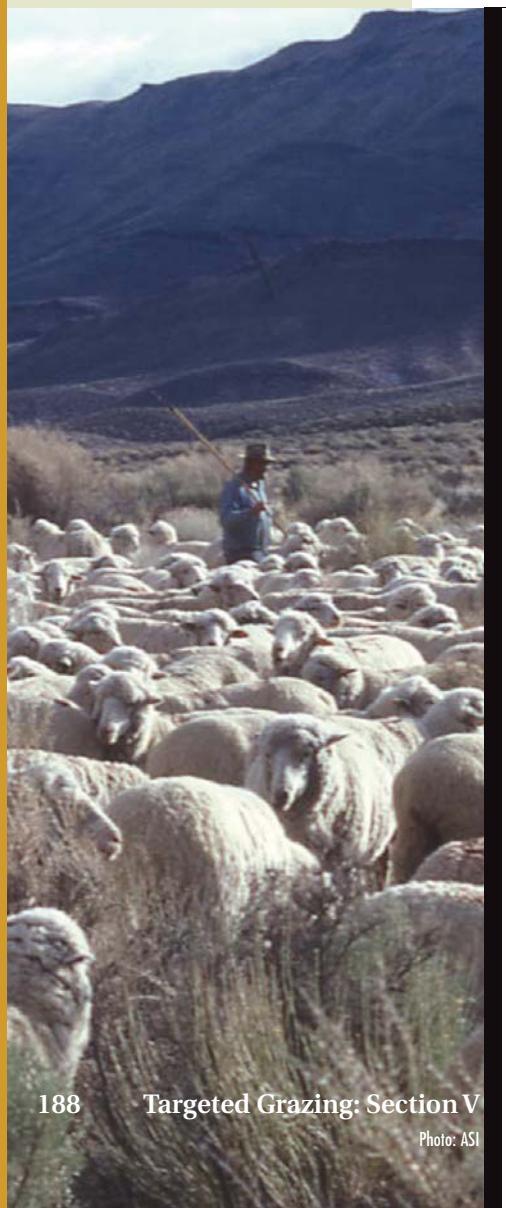

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Photo: ASI

Scientific Articles and Reports:

- DiTomaso, J.M. 2000. **Invasive Weeds In Rangelands: Species, Impacts and Management.** *Weed Science* 48:255-265.
  http://wssa.allenpress.com/pdfserv/i0043-1745-048-02-0255.pdf

- Frost, R.A. and K.L. Launchbaugh. 2003. **Prescription Grazing for Rangeland Weed Management - A New Look at an Old Tool.** *Rangelands* 25: 43-47.
  www.cnr.uidaho.edu/rx-grazing/readings/Frost_Launchbaugh_Rangelands_04.pdf

- Hart, S.P. 2001. **Recent Perspectives in Using Goats for Vegetation Management in the USA.** *Journal of Dairy Science* 84 (E. Suppl):E170-E176.
  www.adsa.org/jds/papers/2001/jds_es170.pdf

- Luginbuhl, J.M., J.T. Green, J.P. Mueller, and M.H. Poore. 1996. **Meat Goats in Land and Forage Management.** In: *Proceedings of the Southeast Regional Meat Goat Production Symposium* "Meat Goat Production in the Southeast–Today and Tomorrow." February 21-24, 1996. Florida A&M University, Tallahassee.
  www.cals.ncsu.edu/an_sci/extension/animal/meatgoat/MGLand.htm

- Luginbuhl, J.M., J.T. Green, M.H. Poore, and J.P. Mueller. 1996. **Use of Goats as Biological Agents for the Control of Unwanted Vegetation.** Presented at the International Workshop *"Use of Trees in Animal Production Systems."* Indio Hatuey Pasture and Forage Experimental Station, Matanzas. November 26-29, 1996.
  www.cals.ncsu.edu/an_sci/extension/animal/meatgoat/MGVeget.htm

- Olson, B.E. and J.R. Lacey. 1994. **Sheep: A Method for Controlling Rangeland Weeds**. *Sheep and Goat Research Journal* 10:105-112.
  www.cnr.uidaho.edu/rx-grazing/readings/Olson_Lacey_Sheep_Res_1994.pdf

- Olson, B.E. 1999. **Grazing and Weeds**. p. 85-96 In: R.I. Sheley and J.K. Petroff, eds. *Biology and Management of Noxious Rangeland Weeds.* Corvallis, OR. Oregon State University Press.

- Olson, B.E. 1999. **Manipulating Diet Selection to Control Weeds**. *In:* K.L. Launchbaugh, K.D. Sanders, and J.C. Mosley, eds. *Grazing Behavior of Livestock and Wildlife*. Idaho Forest, Wildlife & Range Exp. Sta. Bull. #70 Univ. of Idaho, Moscow, ID.
  www.cnrhome.uidaho.edu/default.asxpx?pid=74888

- Popay, I. and R. Field. 1996. **Grazing Animals as Weed Control Agents.** *Weed Technology* 10:217-231.

- Severson, K.E. and P.J. Urness. 1994. **Livestock Grazing: A Tool to Improve Wildlife Habitat**. *In:* M. Vavra, W.A. Laycock, and R.D. Pieper, eds. *Ecological Implications of Livestock Herbivory in the West.* Denver, CO: Society for Range Management. p 232-249.

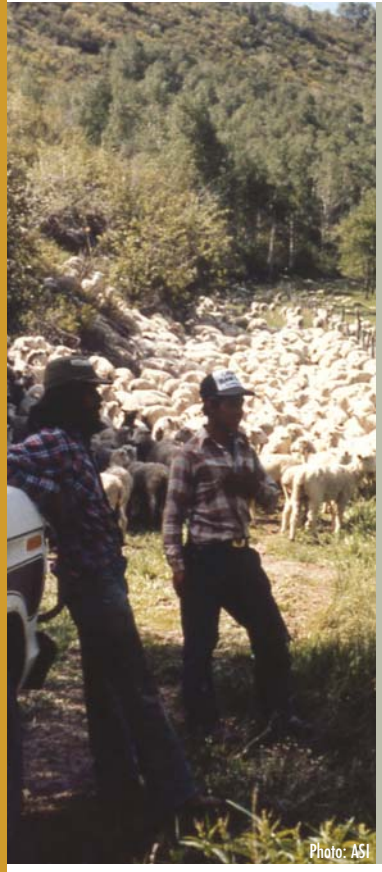
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Photo: ASI

Organizations and Information on the Web:

- *The **University of Idaho** hosts a **Prescription Grazing for Vegetation Management** site that contains links to many articles regarding prescribed grazing, animal behavior, animal production, and noxious and invasive weeds. Many great articles can be found at this site, an excellent source of scientific and popular press articles.* **www.cnr.uidaho.edu/rx-grazing**

- *The **Western Rangelands Partnership** is a group of rangeland extension educators and library information specialists who gather information about rangeland ecology and management and publish it on this excellent searchable website.* **www.rangelandswest.org**

- ***BEHAVE** is an organization of scientists and practitioners dedicated to Behavioral Education for Human, Animal, Vegetation, and Ecosystem management. The BEHAVE website features fact sheets, research findings, announcements of seminars, workshops and field days, and information on ordering materials produced by the BEHAVE consortium.* **www.behave.net**

- ***ATTRA** (Appropriate Technology Transfer to Rural Areas) is a national sustainable agriculture information service that serves farmers and educators who need information about sustainable practices. Contact the technical specialists at ATTRA by calling (800) 346-9140 or access their website. Specialists can search for information, provide references to people with experience, and offer guidance on finding helpful materials.* **www.attra.ncat.org**

- *The **Center for Invasive Plant Management** has a website that includes articles about ecological management, resources, and educational events (including workshops and courses); also lists funding sources.* **www.weedcenter.org**

- ***Livestock for Landscapes*** *provides information and training for using livestock as landscape management tools. This site includes a community and provider network, workshops and consultation, training cows to eat weeds, using goats to reduce fire hazards, resources, and links.* **www.livestockforlandscapes.com**

- *The* ***Maryland Small Ruminant Page*** *is an outstanding source of sheep and goat information. Articles can be found on general weed information, weed identification, noxious/invasive weeds, weed control, along with dozens of articles about controlling weeds with sheep and goat grazing.* **www.sheepandgoat.com/weed.html**

- ***Langston University*** *in Oklahoma hosts the E. (Kika) de la Garza American Institute for Goat Research, which has an interesting website with information about using goats for fire management and brush control. Click on "library" and then look at the Field Day Proceedings, especially those for 2004, 2002, and 2000. See also the web-based training module 15, "Goats for Vegetation Management," by Steve Hart.* **www2.luresext.edu**

- *The* ***Natural Resources Conservation Service*** *national website is searchable and contains information that can help land managers. Contacting state and local NRCS personnel is a great move, as they can assist with soil, water quality, stocking rate, fencing, and many other components of range and pasture management.* **www.nrcs.usda.gov**

- *The* ***USDA Cooperative State Research, Education, and Extension Service*** *provides a wealth of information regarding grazing, weeds, and livestock care and feeding. It links to area county extension offices, where extension agents/educators are available to answer questions on a variety of topics.* **www.csrees.usda.gov**

- *The* ***National Plants Database*** *includes information about more than 43,000 plants, including noxious and invasive plants listed for each state. It provides pictures to aid in identification.* **www.plants.usda.gov**

- *The* ***National Invasive Species Council*** *hosts a comprehensive database pertaining to federal and state activities with invasive species. The site contains specific species profiles, their impacts, and the federal government's response. The site links to other agencies and organizations dealing with invasive species issues.* **www.invasivespeciesinfo.gov**

- *The* ***Society for Range Management*** *is a professional society dedicated to supporting people who work with rangelands and have a commitment to their sustainable use. SRM hosts a website with publications, links to other websites, calendar of events, videos that can be checked out for a small fee, and much more. The Rangeland Ecology and Management journal (formerly the Journal of Range Management) and the magazine Rangelands are both published by SRM and are referenced on their website.* **www.rangelands.org**

- *The* ***American Sheep Industry Association*** *represents the interests of sheep and goat producers located throughout the United States, from farm flocks to range operations. ASI hosts a website of information and publications related to sheep production. The Sheep and Goat Research Journal, published by ASI, can be accessed at their site.* **www.sheepusa.org**

- *The* ***Montana Sheep Institute*** *conducts and provides research on using sheep for weed control. Their website includes a list of recent research and a photo gallery.* **www.sheepinstitute.montana.edu**

CD-ROMs, DVDs, Videos

• Multi-Species Grazing and Leafy Spurge

TEAM Leafy Spurge. 2002.
USDA-ARS Northern Plains
Agriculture Research Laboratory
1500 North Central Avenue
Sidney, MT 59270
406-433-2020
www.team.ars.usda.gov

This CD provides a variety of useful information about using grazing as an effective, affordable, and sustainable leafy spurge management tool. It contains economic reports, the Multi-Species Grazing and Leafy Spurge manual, a PowerPoint® presentation, posters, photos, an extensive bibliography, and more. A great resource.

• GOATS! For Firesafe Homes in Wildland Areas

Kathy Voth
6850 West County Road 24
Loveland, CO 80538
www.livestockforlandscapes.com

This CD/Handbook is designed to provide fire managers, communities, and livestock owners information on using goats to reduce fire danger. It includes expected results and the "hows" of managing animals, choosing treatment sites, developing contracts for services, estimating costs, and starting projects. This is a great CD with some excellent videos.

• Healing the Land Through Multi-Species Grazing

Washington State University Extension. 2004.
VT0119 (also available as DVD0119). Call the Bulletin Office at (509) 335-2857 or 800-723-1763; or write to: Bulletin Office, Washington State University, P.O. Box 645912, Pullman, WA, 99164-5912 USA. Can also be ordered online:
http://cru84.cahe.wsu.edu/cgi-bin/pubs/VT0119.html

This video is about the use of multi-species grazing (cattle, sheep, goats) as a tool in an integrated approach for the control of noxious weeds. It depicts the activities of a two-year regional project funded by the USDA Western Sustainable Agriculture Research and Education Professional Development Program. Thirty participants from four states (Washington, Idaho, Oregon, and California) took part in this project.

Finding More

• SARE Project Reports and Contacts

Sustainable Agriculture Research and Education (SARE) program is a funding source for farmers, researchers, and educators. SARE has funded numerous projects related to using sheep or goats to manage vegetation. Visiting the SARE site and learning about those projects can provide useful information and contacts. Go to ***www.sare.org*** *and then "project reports" and then "search database" and search using terms to limit the results. For example, to find out if there are projects using sheep to graze in orchards, use "sheep and trees" for the terms. The site allows for limiting results to only farmer/rancher projects or only a particular region. In addition to the project reports, SARE offers some publications. Search the main site to find stories and publications that are pertinent; "sheep and goats and weeds" or "sheep and trees" will provide a good start.*

• USDA CRIS System

All research sponsored or conducted by the USDA is required to be documented in the Current Research Information System (CRIS), a unit of the Cooperative State Research, Education, and Extension Service (CSREES). The CRIS database currently includes information covering over 95% of all publicly supported agricultural and forestry research. To learn about pertinent research projects, go to ***http://cris.csrees.usda.gov*** *and click on "search CRIS now." The screen will show project titles and investigators; clicking on "more" provides a project summary, including all progress reports and lists of publications detailing this research.*

• AGRICOLA From the National Agricultural Library

For scientific articles related to prescribed grazing, the most comprehensive database of published works related to agriculture is maintained by the National Agricultural Library. The database can be searched by key word, title, or author to locate relevant articles. Searching is made easy by the electronic catalog called AGRICOLA available on the web at ***http://agricola.nal.usda.gov***

• Sheep and Goat Research Journal

From the American Sheep Industry; go to ***www.sheepusa.org*** *and click on "Research Journal." Then click on the title and to find several issues online, including the 1994 Special Issue: The Role of Sheep Grazing in Natural Resource Management. Also available through libraries.*

• Small Ruminant Research

*Publishes original, basic, and applied research articles, technical notes, and review articles on research relating to goats and sheep (and deer, camelids, and camels). This is the journal of the International Goat Association (****www.iga-goatworld.org****), and access to full-text articles online is available to association members. Copies of the journal are also available in libraries and on the web at* ***www.iga-goatworld.org/srr/index.htm***

• Rangeland Ecology and Management (formerly the Journal of Range Management)

*Published by the Society for Range Management (****www.rangelands.org****). Issues can be found online at* ***www.srmjournals.org*** *and can also be received through subscription. Membership in the Society for Range Management is open to anyone engaged or interested in any aspect of the study, management, or use of rangelands. The Society offers publications and training opportunities and meetings. This journal is peer-reviewed and geared to scholars.*

• Rangelands

Also published by the Society for Range Management and available online or through subscription. Go to ***www.srmjournals.org*** *to access this magazine, which features scientific articles, book reviews, and society news, as well as youth, technology, and policy departments. Information is scientifically correct and presented in a user-friendly, non-technical format.* ***Rangelands*** *is intended for educators, students, rangeland owners and managers, researchers, and policy leaders. Archived volumes of* ***Rangelands*** *from 1978 through 1998 are available at:* ***http://rangelands.library.arizona.edu/rangelands/***

GLOSSARY

Aestivate: To become dormant during the summer or dry season.
Alkaloids: Nitrogen-containing plant compounds that can have several toxic effects on grazing animals. These compounds can be poisonous to animals, causing birth defects, loss of muscle control, or death.
Apical Meristem: The growth point on a plant at the tip of a shoot that causes the shoot to grow longer and can suppress growth of other stems on the plant. When the apical meristem is removed, the stem stops growing, but other stems on the plant may be stimulated to grow.
Axillary Bud: The growth point on a plant located at the junction of the stem and the leaf. New stems or bunches of grasses, shrubs, and trees emerge from axillary buds.
Basal Area: The area at the base of a plant that extends into the soil.
Biological Control (or biocontrol): The practice of introducing natural predators and parasites to harm an undesirable plant or animal. In the case of weed management, biocontrol usually involves introducing an insect or infectious organism, like a disease or rust, to suppress the growth or reproduction of the weed.
Biomass: The total weight of aboveground leaves, stems, flowers, and seeds of plants in an area. This term could include living or dead plant material depending on how it is defined by the user.
Body Condition Score: A value assigned to describe how thin or fat an animal is based on observation and feeling for fat deposits over the spine. Sheep and goats are generally evaluated on a 1- to 5-point scale from emaciated to obese while cattle are generally evaluated on a 9-point scale.
Bolting: The period of a plant's development when it begins to expand its stem to produce flowers and seeds.
Broadleaf Plants: Plants that generally have wide leaves and solid stems. These include forbs, shrubs, and most trees but not grasses, conifers or other plants with needles or grass-like leaves.
Browsers: Livestock and wildlife that feed on stems, twigs, buds, and leaves of shrubs and trees.
Canopy Cover: The percentage of ground area in a plot with plant leaves and stems above it. This would account for the area of the ground that cannot be seen looking from above the vegetation.
Clonal Plants: Plants that reproduce by underground or aboveground runners to create a group of genetically identical plants called a clone.
Cool-Season Plants: Plants that grow most actively in the spring and fall and generally produce seeds in late spring or early summer, then go dormant when it becomes hot and dry. These plants have a type of photosynthesis that uses a so-called “C3" pathway.
Decadent Plant: A plant that is dead or dying.
Decumbent Plant: A plant growth form where stems and leaves grow close to the ground.
Defoliation: The removal or loss of leaves and stems from plants.
Detoxification: Digestive and metabolic processes that render poisonous compounds harmless.
Exotic Species: A plant, animal, or microbe that is not native or endemic to an area.
Fallow: Farmland not planted with crops and that is kept free of weeds for a year or more to preserve and store soil moisture and nutrients for the next year’s crop.
Fine Fuels: Dry and dormant plants with small stems (less than 1/4 inch) that readily ignite and burn quickly in dry conditions. Fine fuels include grasses, broadleaf forbs, and small shrubs.
Firebreak: An area cleared of vegetation that could otherwise readily ignite and spread fire. Firebreaks are often created around houses as a zone to stop or slow a spreading fire.
Forbs: Plants other than grasses, grass-like plants, or shrubs and trees that die back to the ground every year and are not woody. Many wildflowers and weeds are forbs.
Fuel Load: The amount of combustible material in an area, generally including dry and dormant vegetation that will readily burn.
Fuel Continuity: How evenly or patchily combustible material or fire fuel is arranged in an area.
Grasses: Non-woody plants that have long narrow leaves with veins that run parallel to the leaf edge. Grasses have stems that are hollow with nodes or swellings where leaves originate.
Grazers: Livestock or wildlife that consume mostly grasses.

Green Bridge: An area of green vegetation growth that creates a refuge or movement corridor for insects traveling between crop fields.

Green Strip: A narrow band of vegetation planted late. Maturing plants are grown or grazed to delay maturation and stay green when surrounding vegetation becomes dormant and combustible thereby creating a strip to stop or slow the spread of wildfire.

Guardian Animals: Donkeys, llamas, mules, and several breeds of dogs that are selected, bred, and raised to live with and protect livestock from predators.

Herbaceous Plants: Non-woody plants that die back to the ground at the end of every growing season. The roots may stay alive and produce stems in the next year.

Herbivory: The process of animals eating plants (i.e., herbivores) in an ecosystem.

High-Tensile Fencing: Fences created with wires that don't expand when pulled; the wire is strung tightly to resist animal movement through the fence.

Integrated Pest Management (or IPM): An approach to managing pest problems including insects and weeds. A key to IPM is the strategic combined use of chemical, biological, and cultural practices to suppress a pest or pests below some acceptable level of infestation.

Intermediate Feeders: Grazing and browsing animals, including goats, that will eat a variety of grasses, forbs, or shrubs depending on what is nutritious and palatable at the time.

Invasive Species: Plants, animals, or microbes that have moved into an area and reproduced so aggressively that they replace or suppress the species that naturally occurred on the area.

Ladder Fuels: Shrubs and small trees that create a layer of combustible vegetation between the ground and the tree crowns, allowing wildfires to spread into the upper tree canopy.

Lignified: Plant stems that are made hard like wood as the result of the deposition of lignin in the cell walls.

Monitoring: A repeated assessment of land and vegetation conditions over months or years to determine if land management objectives are being met.

Monoculture: A natural or cultivated area where a single plant dominates the plant community.

Morphology: The form or structure of an animal, plant, or microbe.

Multi-Species Grazing: Grazing more than one type of livestock (i.e., cattle, sheep, goat, or horses) on the same unit of land. The grazing can occur at the same time or at different times and still be considered multi-species grazing.

Native Species: Plants, animals, fungi, and microorganisms that are endemic and occur naturally in a given area or region.

Noxious Weeds: A subset of weeds that are designated by weed control organizations or agencies as legally requiring treatment whenever they are encountered.

Orchard Floor: The soil and vegetation between the rows of trees or vines and under the canopy of an orchard crop.

Ovipositing: The laying of eggs, especially referring to insects laying eggs.

Palatability: How desirable or appealing a specific plant is to an herbivore. Highly palatable plants are sought and readily consumed.

Phenology: The timing of growth and reproduction throughout the year or growing season.

Photo Points: Permanent locations from which to take photographs to monitor site conditions over time.

Photosynthesis: The chemical process in plants by which sunlight is captured to convert carbon dioxide and water into sugar compounds and subsequently starches and other plant carbohydrates.

Phytochemicals: Refers to any plant compound, though is generally used to describe plant compounds that can be toxic when eaten by herbivores.

Post-Ingestive Feedback: The sensory feedback gained by an animal after eating a plant. The feedback can be negative, such as nausea, or positive, such as an energy boost or hunger suppression.

Predation: When an animal (i.e, predator) hunts and kills another animal.

Prescribed Grazing: The controlled harvest of vegetation with grazing or browsing animals managed with the intent to achieve management objectives. The term can refer simply to planned grazing or to a very specific time and amount of grazing by a specific species.

Prescribed Fire: The use of a controlled burn in a given area to achieve a desired result or to satisfy a management plan.

Rest Rotation Grazing System: A planned grazing system that allows for a full year of rest from grazing for pastures on a rotating basis. This system requires at least three pastures and one herd. The rotation sequence for each pasture is usually to defer (fall graze), then rest (no graze), then spring graze.

Rhizomes: An underground scaly root-like stem that extends away from the base of a plant and gives rise to new plants.

Secondary Compounds: Plant compounds that appear to play no role in the growth and reproduction of the plant (i.e., primary compounds), but can be repulsive to herbivores and play an important role to protect the plant from grazing or browsing. Secondary compounds include alkaloids, tannins, and terpenes.

Seed Set: The stage in a plant's life, after flowering, when it produces seeds.

Senescence: The aging and dying of leaves at the end of the growing season.

Shrubs: Woody plants with several stems, rather than a central trunk, and a relatively low growth habit compared to trees.

Silviculture: The art and science of growing trees.

Slash: Residue such as limbs or bark from trees or shrubs left on the ground after storms, forest harvesting, or management practices.

Stem Internode: The area on a plant stem between two nodes. (Nodes are swollen areas where leaves and branches are attached.)

Stocking Rate: The number of animals, usually livestock, that graze a given area of land for a specified period of time. Generally expressed in animal unit months per acre.

Stubble Height: The height of stems or leaves that remain after a grazing period.

Tannins: Naturally occurring plant compounds found mostly in shrubs and forbs that reduce forage value by forming insoluble complexes with proteins when eaten.

Targeted Grazing: The application of livestock grazing at a specified season, duration and intensity to accomplish specific vegetation management goals. The term "targeted" refers to the specific plant or landscape that is the aim of controlled grazing practices.

Terminal Bud: The bud, or growth point, located at the end of the plant shoot or twig.

Terpenes (including monoterpenes): Organic compounds found in many trees and shrubs that kill rumen microbes and cause damage to the grazing animal when eaten. Several of these compounds are also called "essential oils" because they have an odor or "essence" giving plants like pines, juniper, or sagebrush their distinctive odor.

Transects: Measures in plots or on points along lines that can quantify plant cover, density, or abundance.

Understory Vegetation: The grasses, forbs, or shrubs growing on the ground surface under the canopy of trees.

Urban/Wildland Interface: The zone where houses and other human structures meet or intermingle with undeveloped rangelands and forest wildlands

Utilization: The proportion or degree of current year's forage production that is consumed or destroyed by herbivores (including insects).

Warm-Season Plants: Plant that grow most actively in the warmest season of the year. These plants have a so-called "C4" type of photosynthesis that allows them to grow throughout the summer and produce flowers and seeds in late summer or early fall.

Wether: A castrated male sheep or goat. Equivalent to the term "steer" for cattle.

Photo: ASI

LIST OF PLANTS
Mentioned in the Handbook

Common and scientific names of plants listed in the text. The reference for scientific names is the U.S. Department of Agriculture PLANTS Database (www.plants.usda.gov/).

Common Name	Scientific Name
Alfalfa	*Medicago sativa*
Barley	*Hordeum spp.*
Bentgrass	*Agrostis spp.*
Birdsfoot Trefoil	*Lotus corniculatus*
Blackbrush	*Coleogyne ramosissima*
Bluebunch Wheatgrass	*Pseudoroegneria spicata*
Bottlebrush Squirreltail	*Elymus elymoides*
Burdock	*Arctium minus*
Canada Reedgrass	*Calamagrostis canadensis*
Canada Thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Crested Wheatgrass	*Agropyron cristatum*
Deerbrush	*Ceanothus integerrimus*
Douglas Fir	*Pseudotsuga menziesii*
Fireweed	*Chamerion angustifolium*
Goatsrue	*Galega officinalis*
Houndstongue	*Cynoglossum officinale*
Idaho Fescue	*Festuca idahoensis*
Japanese Brome	*Bromus arvensis*
Johnsongrass	*Sorghum halepense*
Juniper	*Juniperus spp.*
Kentucky Bluegrass	*Poa pratensis*
Kudzu	*Pueraria montana*
Leafy Spurge	*Euphorbia esula*
Lodgepole Pine	*Pinus contorta*
Lupine	*Lupinus spp.*
Medusahead	*Taeniatherum caput-medusae*
Mesquite	*Prosopis glandulosa*
Mountain Mahogany	*Cercocarpus montanus*
Multiflora Rose	*Rosa multiflora*
Oak Brush	*Quercus gambelii*
Orchardgrass	*Dactylis glomerata*
Oxeye Daisy	*Leucanthemum vulgare*
Pacific Silver Fir	*Abies amabilis*
Perennial Pepperweed	*Lepidium latifolium*
Perennial Ryegrass	*Lolium perenne*
Pinion Pine	*Pinus monophylla*
Ponderosa Pine	*Pinus ponderosa*
Radiata Pine	*Pinus radiata*
Red Alder	*Alnus rubra*
Red Fescue	*Festuca rubra*
Redberry Juniper	*Juniperus coahuilensis*

Common Name	Scientific Name
Reed Canarygrass	*Phalaris arundinacea*
Rough Fescue	*Festuca campestris*
Sagebrush	*Artemisia spp.*
Salmonberry	*Rubus spectabilis*
Saltcedar	*Tamarix ramosissima*
Sandberg Bluegrass	*Poa secunda*
Scotch Thistle	*Onopordum acanthium*
Serviceberry	*Amelanchier alnifolia*
Silver Sagebrush	*Artemisia cana*
Slash Pine	*Pinus elliottii*
Snowberry	*Symphoricarpos spp.*
Soft Chess	*Bromus hordeaceus*
Spotted Knapweed	*Centaurea stoebe*
Subterranean Clover	*Trifolium subterraneum*
Sugar Pine	*Pinus lambertiana*
Tansy Ragwort	*Senecio jacobaea*
Thimbleberry	*Rubus parviflorus*
Timothy	*Phleum pratense*
Toadflax (or Dalmation Toadflax)	*Linaria dalmatica*
Vetch	*Vicia spp.*
Vine Maple	*Acer circinatum*
Western Hemlock	*Tsuga heterophylla*
Western Larch	*Larix occidentalis*
Western Red Cedar	*Thuja plicata*
Western White Pine	*Pinus monticola*
Wheat	*Triticum aestivum*
Wheatgrass	*Agropyron spp.*
White Clover	*Trifolium repens*
Whitetop (or Hoary Cress)	*Lepidium draba (formerly Cardaria draba)*
Wild Oat	*Avena fatua*
Yellow Starthistle	*Centaurea solstitialis*