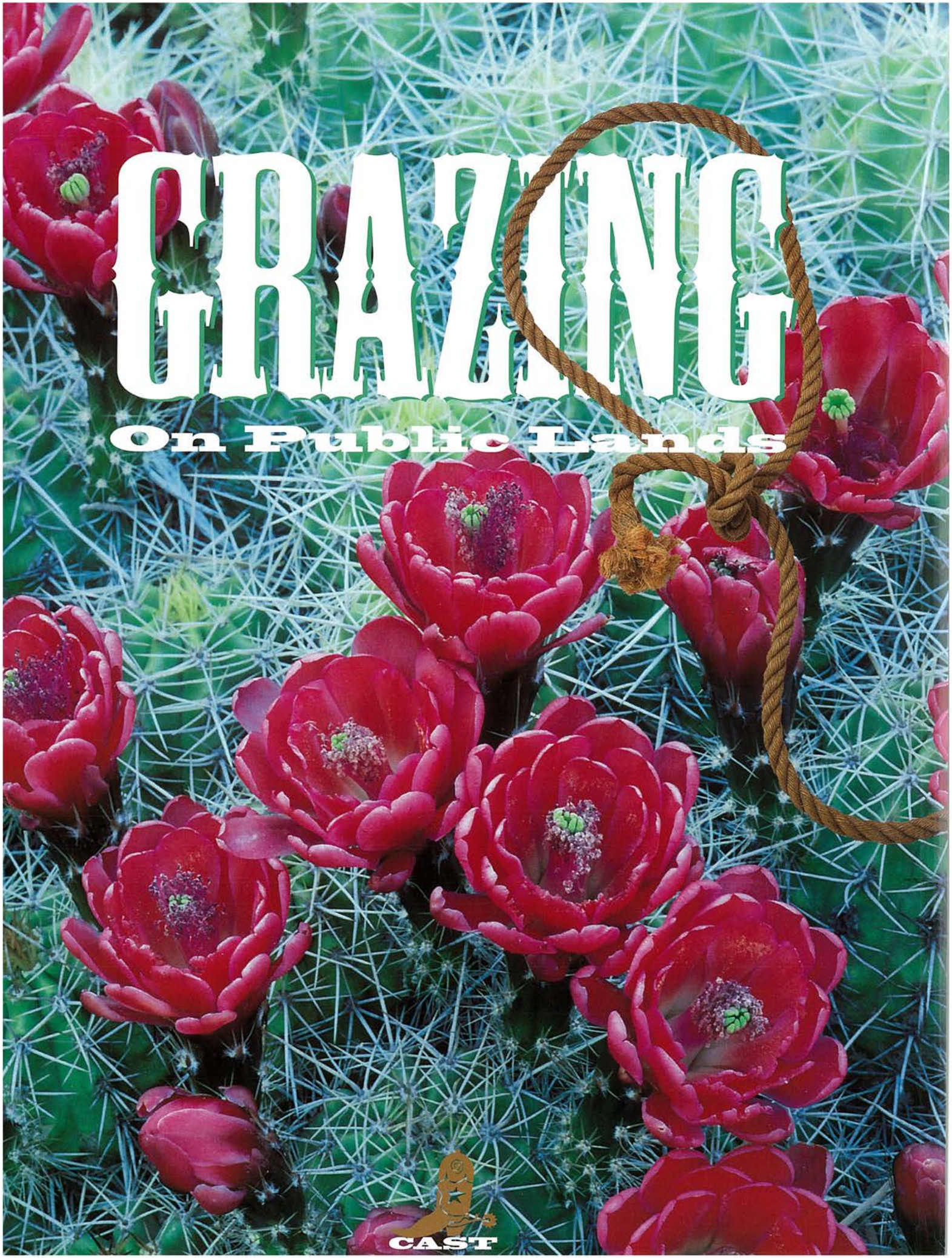
GRAZING
On Public Lands
CAST

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CAST

The Science Source for Food, Agricultural, and Environmental Issues

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Contents

Figures

Tables

Foreword

Following a recommendation by the CAST National Concerns Committee, the CAST Board of Directors authorized preparation of a report on grazing on public lands in the United States.

Dr. William A. Laycock, Department of Rangeland Ecology and Watershed Management, University of Wyoming, Laramie, served as chair for the report. A highly qualified group of scientists served as task force members and participated in the writing and review of the document. They include individuals with expertise in agriculture and resource economics, animal science, environmental science, range science and ecology, and soil science.

The task force met and prepared an initial draft of the report. They revised all subsequent drafts of the report and reviewed the proofs. The CAST Executive and Editorial Review committees reviewed the final draft. The CAST staff provided editorial and structural suggestions and published the report. The authors are responsible for the report's scientific content.

On behalf of CAST, we thank the authors who gave of their time and expertise to prepare this report as a contribution by the scientific community to public understanding of the issue. We also thank the employers of the authors, who made the time of these individuals available at no cost to CAST. CAST recognizes and appreciates the financial support of the U.S. Department of Agriculture/Cooperative State Research, Education, and Extension Service (USDA/CSREES) to partially assist in the development and completion of this report. The members of CAST deserve special recognition because the unrestricted contributions that they have made in support of CAST have financed the preparation and publication of this report.

This report is being distributed to members of Congress, the White House, the U.S. Department of Agriculture, the Congressional Research Service, the Food and Drug Administration, the Environmental Protection Agency, the Agency for International Development, and the Office of Management and Budget, and to media personnel and institutional members of CAST. Individual members of CAST may receive a complimentary copy upon request for a $3.00 postage and handling fee. The report may be republished or reproduced in its entirety without permission. If copied in any manner, credit to the authors and to CAST would be appreciated.

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Interpretive Summary

This CAST report discusses and provides scientific information concerning livestock grazing on public lands in the western United States. Concerns have been expressed that livestock grazing has caused diminished biodiversity, poor range condition, soil erosion, depleted riparian areas, reduced wildlife and wildlife habitat, and decreased recreational opportunities. Another perception is that grazing fees paid to the government to graze livestock on public land are too low.

Approximately 262 million acres of public land in the West are grazed by domestic livestock. The common intermingled public- and private-land ownership patterns resulting from railroad land grants, homesteading, and other programs cause management problems for both federal and private land owners and managers.

Sustainability of Grazed Ecosystems

Proper grazing of rangelands is sustainable. For several decades following settlement, however, western public rangelands were not managed and most were overgrazed. Livestock grazing was regulated first in 1897 on the Forest Reserves and then in 1934 on the rest of the public rangelands. After management began, deteriorated range conditions began to improve. United States rangelands, with some exceptions, are now in their best condition this century.

Range Condition

The range condition concept used in the United States predicts that, in areas where species composition has changed due to grazing, cessation of grazing will result in return to the former "natural," or "climax," state. Newer ecological information indicates that this may not occur in a time frame meaningful to management, i.e., years to decades, especially in ecosystems dominated by shrubs. Restoration of areas to their "presettlement" state may be impossible or require greater manipulation than a mere decrease of grazing. Newer range-condition models better explain the dynamics of rangelands but have not been adopted.

Effects of Grazing on Other Rangeland Uses and Values

Biological Diversity: Livestock grazing can either increase or decrease diversity. Both ungrazed and heavily grazed areas often will be less diverse than moderately grazed areas.

Riparian Areas: Stream corridors in the West have been altered by road building, mining, timber harvesting, recreation, diverting water, and irrigating as well as by grazing. Improper livestock grazing can damage riparian areas. Most riparian areas, however, can be grazed safely if stocking rate, season, and length of grazing period are proper.

Wildlife Habitat: Well-managed livestock grazing generally is compatible with habitat needs for many game and nongame wildlife species.

Timber Production: Many western mature forest types have minimal or temporary forage values. Managed grazing, especially by sheep or goats, can stimulate growth of young trees by removing competing plants.

Recreation: The impacts of livestock grazing on outdoor recreation and aesthetics vary. Conflicts occur but well planned livestock grazing and recreation can peacefully coexist for mutual benefit.

Tools for Management of Rangelands

Grazing systems rotate use among pastures and control time of grazing, stocking rate, and utilization levels.

Fire was a natural part of most rangelands. Fire-return intervals lengthened because early heavy grazing and deliberate fire control depleted fine fuels. Without fire, sagebrush and juniper trees invaded areas. Fire now is being returned to many ecosystems.

Other Range Improvements such as herbicides, mechanical methods, and biological controls (including grazing) can be used to manage unwanted shrubs and weeds.

Seeding can increase forage production or ground cover for erosion control, but costs are high. Most seeding is done on drastically disturbed sites.

Socioeconomic Implications of Public-Land Grazing

Future of Public-Land Grazing

In 1992, a 48% increase in demand for grazed forage was predicted to be met, mainly from private rangelands by 2030. The structure of the western ranching industry and the low productivity of western rangelands make it unlikely that this projected increased forage demand can be met exclusively from private rangelands. A decline in public-land grazing also was predicted.

About 20% (6 million) of beef cattle in the United States are in the 11 western states. More than half of these animals graze on the 262 million acres of Bureau of Land Management or U.S. Forest Service lands. Federal grazing permits complement the common cow-calf and cow-calf-yearling operations and help stabilize the western livestock industry. In most western states, beef cattle are the highest or the second highest income producer in agriculture.

When grazing on public lands was initially regulated by the federal government, permits to graze allotments were awarded to local ranchers who owned private land and/or water rights and historically had used these rangelands. In western states in which a large percentage of land is federally owned, there is insufficient private land to substitute for public land, should grazing be prohibited on it.

The Grazing Fee Issue

Private grazing rental rates are higher than the federal grazing fee but the two types of leases are not analogous. Most federal land is extensive, steep, and difficult to manage; homesteaders settled on more productive lands. Also, private leases generally include all improvements and may include management and exclusive use of the land. Federal grazers must share the land with other users; and management agencies restrict the time and pattern of livestock grazing, require construction and/or maintenance of improvements, and impose ever-increasing overhead (nonfee) costs.

If federal grazing fees were increased to the level of private lease rates, grazing on public lands would not be economically feasible for many public-land-dependent livestock ranchers and would contribute to the decline of western rural communities. Some ranchers priced off of public lands would have to sell their livestock and subdivide or sell their private-land holdings to developers. Others would greatly intensify their livestock operations on private land. Either action can have serious ecological consequences and affect valuable winter wildlife habitat for big game herds.

Executive Summary

Livestock grazing on public lands in the United States has come under increasing public scrutiny and, from some sources, criticism. Concerns have been expressed that livestock grazing has caused diminished biodiversity, deteriorated range condition, soil erosion, desertification, depleted watershed and riparian condition, decreased wildlife populations and wildlife habitat, and decreased recreational opportunities. Another controversial aspect of grazing on public land is the perception that the grazing fee or lease rate paid to the government to graze livestock on public land is too low. This paper discusses and attempts to provide up-to-date scientific information relating to these issues.

What Are Public Rangelands?

Of the total of 307 million acres (a.) of federal land in the West, the Bureau of Land Management (BLM) administers 57% and the Forest Service (FS) administers 43%. In the western states, domestic livestock grazing is the most widespread and extensive use of the federal rangelands. Approximately 262 million a., or 85%, of federal land in the West is grazed by domestic livestock part or all of the year.

When the West first was settled in the mid- to late-1800s, what are now federal rangelands were "open range" and available for grazing to anyone. Livestock grazing on federal lands was regulated first in 1897, on the lands withdrawn from the public domain as Forest Reserves (now National Forests) and administered by the General Land Office (now administered by the FS). In 1934, the Taylor Grazing Act began regulation, by what is now the BLM, of grazing on the remainder of the unreserved public-domain rangelands.

Intermingled public and private land ownership patterns exist throughout the West as a result of land grants to railroads and the states, various federal land reservations, and the selection of the more productive land by homesteaders. Much of the arable land and that along streams and around any water source went into private ownership through homesteading or purchase. Thus, many well-watered and productive private lands were surrounded completely by poorly watered and generally less productive public lands. This led to an intermingled land ownership pattern, which presents unique management challenges and problems for both federal and private land owners and managers.

The intermingled land ownership pattern also led to ranching operations best suited to this situation. In the Southwest, many ranchers maintain livestock on public land all year. In the northern and more mountainous parts of the West, however, the more productive private land is used primarily to grow hay and grain to feed livestock during the winter. Livestock typically are on BLM lands in spring and fall, on higher FS lands in the summer, and on private lands in the winter. Many migratory wildlife species follow the same pattern of seasonal use. The loss of either type of ownership of public rangeland (BLM or FS) undermines the operation of many western ranchers. This and other implications to rangeland resources are discussed below.

Sustainability of Grazed Ecosystems

Most of the criticisms of livestock grazing deal directly or indirectly with sustainability issues. Sustainable rangeland management implies that the use of the resource will not jeopardize future productivity. Sustainability has social, economic, and ecological dimensions.

For several decades after settlement, the limited carrying capacity of rangeland was understood poorly, and the resulting high level of livestock use was unsustainable in many areas. Public ownership and common use of large areas of rangeland provided no incentive for management and resulted in widespread overgrazing. After public rangelands were put under management, deteriorated range conditions began to improve. Proper grazing of livestock is sustainable on the great majority of both private and public western rangelands. Properly managed grazing is beneficial to many plant communities.

Grazing by any large animals affects rangelands mainly by defoliating and trampling plants or disturbing the soil. Grazing too severely can, among other things, change composition of plant species and leave soil exposed and prone to erosion. Major changes in vegetation composition have occurred in some areas as a result of livestock grazing. Some perennial bunchgrass rangelands in California and in the intermountain area of southern Idaho and surrounding states have been converted to annual grasslands. These changes, set in motion more than 100 years (yr) ago, are largely irreversible.

In other parts of the West, shrubs such as sagebrush or mesquite and trees such as juniper have increased in density and/or area occupied since settlement. Early improper livestock grazing partly caused this increase of woody plants. Deliberate control of natural fires, which previously restricted the density and area occupied by such species, also played a role.

Grazing and Other Rangeland Uses and Values

Range Condition

The concept of range condition evolved because managers needed a standard to measure the effects of management. The Society for Range Management (1989) defined *range condition* as "the present state of vegetation of a range site in relation to the climax (natural potential) plant community for that site. It is an expression of the relative degree to which the kinds, proportions, and amounts of plants in a plant community resemble that of the climax plant community for that site."

The range condition concept currently used in the United States predicts that grazed rangelands will return to their former "natural" state (the "climax" for the area) if grazing is removed or decreased drastically. This includes those converted from perennial to annual grasslands, where shrubs or trees have become too thick or have invaded, or where other changes in species composition have taken place. More recent ecological information indicates that this return to a former state does not take place in a timeframe meaningful to management (years to decades), if at all, especially in ecosystems dominated by shrubs or exotic species. Thus, the basic assumptions of the currently used range condition concept or model may be invalid in some situations. Restoration of areas to their "presettlement" state may be impossible or require a great deal more input than manipulation or reduction of grazing. New models have been proposed to help managers better understand the actual dynamics of arid and semiarid rangelands, but they have not yet been adopted by public rangeland managers in the United States.

More recently, the National Research Council (1994) proposed that the term *health* be used instead of *condition. Health* was defined as "the degree to which the integrity of the soil and the ecological processes of rangeland ecosystems are sustained." The rangeland scientific community has been skeptical of the appropriateness of the term because of the analogy to an individual organism. Public-land management agencies (BLM and FS) have begun to use the term extensively.

The authors of this report believe that the new concept Desired Plant Community (DPC) is a better approach than any measure of condition or health for defining the desired end point for management of a specific area of rangeland. The DPC defines as its goal the specific plant community that is possible on a site (defined by climate, soil type, and land form) and that best meets a management plan's objectives, considering all the potential values and uses for that site. As a minimum, the chosen DPC must protect the site from erosion or other degradation. The DPC, once described for a site, serves as a common focus for concerned citizens and management agencies by giving everyone a common objective on which to focus management activities. Livestock grazing or rest, fire, and a variety of other tools can be used to move the vegetation toward the DPC objective.

Present Condition of U.S. Rangelands

In spite of allegations to the contrary, the authors of this CAST report agree with earlier statements by range scientists that, with some exceptions, U.S. rangelands are in the best condition they have been this century. Long-term trend data from both the BLM, for public rangelands, and the Natural Resources Conservation Service (formerly the Soil Conservation Service), for private rangelands, support this conclusion.

Biological Diversity

One of the charges leveled against livestock grazing on public lands is that it has diminished diversity. *Biodiversity* is defined by West (1993) as "a multifaceted phenomenon involving the variety of organisms; the genetic differences among them; the communities, ecosystems and landscape patterns in

which they occur; and the interactions of these components." Typical descriptions of community-level diversity have focused on numbers or distribution of individual species. Biodiversity is a much broader concept, however.

Depending on how livestock grazing is managed, it can either increase or decrease diversity. Both ungrazed and heavily grazed areas will be less diverse than moderately grazed areas. Heavy grazing, especially if it alters structural diversity, e.g., removes trees or shrubs, will decrease diversity. At community and landscape levels, moderate grazing should increase biodiversity because livestock do not graze uniformly. Certain areas usually remain ungrazed while others are grazed at various levels, including heavy utilization. This increases the patchiness of vegetation, which tends to increase diversity.

Watershed and Riparian Areas

Stream and river corridors in the West have been altered by human uses such as road building, mining, timber harvesting, recreation, diverting water, and irrigating. On rangelands, an additional impact has been from past improper livestock grazing. All impacts can alter hydrological processes by affecting water flow, erosion, deposition, and channel morphology.

Riparian vegetation and consequently livestock grazing management are critical to fish and other wildlife habitat because of the influence on channel morphology. Livestock trampling can widen streams, cause the loss of overhanging banks and deep pools, and increase water temperature. Change in structural diversity, especially loss of woody species, caused by grazing or other influences can affect a great many vertebrate species negatively. Most riparian areas can be grazed sustainably by livestock if grazing is during the appropriate season, length of grazing period is proper, and utilization levels do not damage vegetation.

Areas with wide valleys that commonly flood usually produce more forage than any other place in the watershed does. In some areas, such valleys can be fenced as separate riparian pastures, which prevent livestock from congregating in the riparian area during the entire grazing season. These pastures still make abundant riparian forage available for seasonal use.

Livestock grazing can be used to enhance riparian diversity, thereby creating habitats required by a variety of species. On incised or downcut streams, vegetation and grazing management can help create desirable channel forms and functions.

Wildlife and Wildlife Habitat

Uncontrolled grazing after settlement is believed to have damaged wildlife habitat. That type of improper grazing has not occurred over large areas for at least 60 yr. Well-managed livestock grazing generally is compatible with habitat needs for many game and nongame wildlife species.

The relationship between different species of grazing animals can be competitive or facilitative (cooperative). Of the many possible resources for which different animal populations compete, e.g., cover, water, and space, only forage has been studied extensively. Few studies have shown complete exclusion of wildlife species because of competition from livestock.

The facilitative grazing concept implies that grazing by one or more herbivores has positive effects on other herbivore species by altering botanical composition; increasing productivity, nutritive value, or accessibility of certain plant species; or altering structural habitat diversity. These concepts were developed primarily from observation of mixed species ecosystems in East Africa but apply generally to situations involving wild and domestic ungulates in western North America.

Studies of livestock grazing effects on density and diversity of nongame wildlife species such as birds and mammals have had conflicting results. Depending on the ecosystem studied, exclusion of livestock grazing can increase, decrease, or have no effect on density or diversity of any groups of species. Many studies have shown that even if grazing (or lack of grazing) either increases or decreases species diversity, grazed and ungrazed areas often have different species present, and overlap of the same species in the two kinds of areas is low. This means that the diversity in combined grazed/ungrazed areas is higher than if either kind of area is considered alone. Thus, a mosaic of areas receiving different intensities of grazing would have the greatest species diversity at the landscape level. Few studies have considered or measured this problem.

Timber Management

Trees and forage can be produced from the same lands, but many mature forest types in the western United States have minimal or only temporary forage values (mainly after cutting). Before the 1960s, foresters considered grazing by either wild or domestic animals as detrimental to timber production. The concern was that grazing caused physical damage (consumption or trampling) to young trees and undesir-

able soil compaction. Certainly, heavy, uncontrolled grazing by almost any animal can be detrimental to young trees. Recently, research indicates that managed grazing at light or moderate levels can minimize damage to young trees and actually stimulate tree growth by removing competition from shrubs and herbaceous species. Sheep and goats are particularly beneficial in this respect.

Outdoor Recreation and Aesthetics

The impacts of livestock grazing on outdoor recreation and aesthetics on public lands are not clear. Few people like to see trampled areas around stock tanks or stream crossings. Remotely placed stock tanks can minimize the visible effects of livestock on riparian areas. Some people may hike miles to find areas with no evidence of either humans or livestock. Others pay handsomely for the opportunity to ride horses on a dude ranch. Livestock grazing and recreation can coexist peacefully on public rangelands with proper planning and management.

Tools for Management of Rangelands

Many tools exist with which to manage rangeland vegetation. A few are outlined below, and a combination of these usually are used to solve specific rangeland management problems. For example, if rangelands away from riparian or other concentration areas are burned, sprayed, seeded, or fertilized to provide productive, nutritious, and palatable vegetation, cattle may be enticed to use them provided water also is available. Such practices can alleviate certain management problems such as the tendency of cattle to congregate in riparian areas.

Managing Livestock Grazing

Heavy seasonlong grazing often is detrimental. Seasonlong use is not inherently inappropriate, however, if grazing intensity and livestock distribution are managed properly. Other grazing systems involve rotation of use among multiple pastures. Time of grazing and period of rest, stocking rate, and desired utilization levels must be defined.

Fire

Both natural and anthropogenic fires were an important part of most North American rangeland ecosystems before Europeans arrived. Heavy grazing in the late 1800s and early 1900s depleted the fine fuels necessary to carry fires. Along with deliberate fire control, this lengthened fire-return intervals. In many shrub dominated ecosystems, shrubs and trees such as sagebrush and juniper were able to increase in density or to invade areas from which fire previously had excluded them.

Returning prescribed or controlled fire now is being done or considered in many ecosystems. However, burning during "safe" times, such as spring, may have very different ecological effects on the community than the hot, late season fires that occurred naturally. If livestock grazing was removed from public rangelands, increases in fuel loads probably would result in increased wildfire frequency in many ecosystems.

Controlling Unwanted Plants

Unwanted shrubs and exotic weeds may be controlled by chemical, mechanical, and biological methods. Environmental concerns have curtailed herbicide use on public rangelands, but chemicals still are used to keep noxious weeds from spreading. In some rangeland ecosystems, rather intensive grazing by sheep or goats is being used to discourage or to prevent the spread of weeds. Other biological controls, e.g., insects, are being used to supress introduced weed species such as leafy spurge and musk thistle.

Seeding

Seeding of introduced or native species is a common range-improvement practice to increase forage production or ground cover for erosion control. Although it still is appropriate, high costs have led to a considerable decline in the seeding of rangelands over the last several decades. Instead of widespread seeding of single species, such as crested wheatgrass, which commonly was done earlier, seeding now is limited to specific areas and is more likely to consist of a mixture of native species. The majority of seeding now being done is on drastically disturbed sites such as reclaimed strip-mined lands or other areas converted to weeds by repeated fires or other disturbances. Strip seeding of crested wheatgrass or other fire resistant plants can help break up large fire-prone landscapes or protect high-value habitats from repeated large fires.

Socioeconomic Implications of Public-Land Grazing

Future of Western Public-Land Grazing

In 1992, the U.S. Department of Agriculture projected a 48% increase in demand for grazed forage from 1985 to 2030. This increase was projected to be

met mainly from deeded, nonirrigated rangeland. The same report projected a decline in public-land grazing based on extrapolations of public-land grazing from 1970–1987. Close examination of grazing statistics reveals, however, that this decline did not take place. Another rationale for the projected future decrease in public-land grazing was pressure for increased recreational and other uses.

Can the projected increased livestock forage demand be met from private rangelands? The structure of the western ranching industry and the relatively low productivity of rangelands in general make this unlikely. Thus, if this projection of a 48% increase in demand for forage by 2030 is realistic, public-land grazing will have to be increased, not decreased. Because of "Rangeland Reform '94" and similar efforts, public-land grazing is likely to decrease, however, at least in the short term.

Implications of Decreased Public-Land Grazing

About 20% of the beef cattle in the United States, or six million head, are in the 11 western states. These cattle, along with sheep, graze about 500 million a. of land. As indicated earlier, about 85%, or 262 million a., of public land in the western United States is grazed by livestock. More than half the commercial operators with beef-cattle herds in the West hold federal grazing permits.

Cow-calf and cow-calf-yearling ranches are the most common types of cattle operations in the West. Federal grazing permits and leases complement this industry structure and stabilize the western livestock industry, which produces calves for various other types of cattle operations.

When grazing on both the Forest Reserves and the remainder of the public domain was brought under control, permits to graze allotments were awarded to local private ranchers who owned private land (base property) or water rights in the area and historically had used these public rangelands. The intent was to stabilize the livestock industry. Because they are attached to private property, grazing permits on adjoining federal land generally cannot legally be bought by anyone other than the user of the private property to which the allotment is assigned.

The complementary nature of private/public-land ownership characterizes the public-land-dependent western ranching industry. A substantial portion of the beef-cattle industry in the West is dependent on public land. Much of the land is in federal ownership and public-grazing lands are a necessary addition to private-grazing lands. One cannot substitute for the other. In many parts of the West, a large percentage of the land is in federal ownership and there is insufficient private land to substitute for public lands should grazing there be eliminated.

The Grazing Fee Issue

A perennial public-policy issue is the contention that the fee charged for federal grazing should be raised. This argument usually is based on the fact that private grazing rental rates are considerably higher than the federal grazing fee. Another argument for higher grazing fees is that livestock are continuing to damage public rangelands. The preponderance of data, however, show steady improvement in the condition of public lands since the 1930s.

One problem with the public/private comparison is that federal grazing fees and private grazing leases are not analogous. Most federal land is extensive and difficult to manage. Such land remained in the federal domain largely because homesteaders settled only on the more productive lands. Additionally, terms of leases differ greatly. Private grazing leases normally furnish all the necessary improvements, e.g., fences and water, many include management, and the grazer usually has exclusive use of the land. Federal grazing permits must share the land with other multiple users. In addition, the land management agencies greatly restrict time and pattern of livestock grazing, call for construction and/or maintenance of fences, water and other improvements, and impose more stringent overhead costs in the form of increasing demands of federal-land management agency personnel and public interest groups. Thus, private and public grazing leases are not directly comparable.

Consequences of Increasing Grazing Fees Substantially

If federal grazing fees were increased to the level of prevailing private-land-grazing lease rates, grazing on public lands no longer would be economically feasible for a great many ranchers. Many who are public-land-dependent would go out of business. In fact, many holders of federal livestock grazing permits consider the movement to increase federal grazing fees a smoke screen obscuring the drive to curtail severely or to eliminate public-land grazing.

One result of removal of some or all public-land livestock grazing would be declines in the rural communities where ranchers shop and buy supplies. If western ranchers are priced out of the public-forage

market, many will have to sell their cattle and subdivide their private-land holdings or sell them to developers or larger surrounding ranches. Others will have to intensify livestock operations greatly on their available private land.

Homesteaders settled on the more productive lands, including those with water. This makes private lands valuable habitat for many big game animals, especially during winter. Both subdivision and intensification of livestock operations would decrease wildlife habitat seriously. Land-use changes on critical big game winter ranges could preclude use by wild animals. Loss of winter range usually means a diminished ability of the land to maintain total animal numbers. Instead of increasing big game numbers, as many believe the removal of livestock grazing of public land would, removal of grazing could result in smaller numbers of big game in many areas.

1 Current Issues and Perceptions

Introduction

During the last decade, grazing by livestock on public land in the United States has come under increasing public scrutiny. Concerns are that such grazing has caused and is continuing to cause, among other things, diminished biodiversity; deteriorated range condition; increased soil erosion; desertification; depleted watersheds and *riparian* areas, i.e., banks of a river or other body of water; impoverished wildlife habitat; declining wildlife population; and decreased recreational opportunities and experiences. In the minds of some individuals, and to the members of some groups, livestock grazing universally diminishes quality of life.

The other controversial aspect of grazing on public land is that of a *grazing fee*, or the lease paid the government to graze on public land. Some claim that this fee undercuts grazing leases on private land and fails to finance administration of the grazing program on public land. This report addresses these issues.

Resource Degradation

The purpose of this report is to summarize the literature regarding both livestock grazing effects on vegetation and other relevant aspects of rangeland management, so as to answer the question "Is livestock grazing on rangelands sustainable?" The emphasis will be on public rangelands in the western United States, but many of the questions considered will apply to rangelands of any ownership. For instance, although heavy, prolonged grazing can cause many resource degradation problems, does moderate or well-planned grazing cause these problems? Each issue outlined in the introduction will be discussed briefly in this chapter before being developed elsewhere in the report.

Biodiversity

Livestock grazing often diminishes biodiversity (Ehrlich, 1990) when grazing is heavy for prolonged periods, especially if it reduces the structural diversity of vegetation. Moderate grazing, however, results in patchy vegetation, which in turn should increase species- and community-level biodiversity (Heady and Child, 1994; Laycock, 1994; West, 1993).

Range Condition

Heavy grazing of rangelands occurred after livestock were introduced into the western United States in the latter half of the nineteenth century. This exploitive activity was sanctioned by both the public and the government and continued until livestock grazing on public lands was brought under federal management by the passage of the Forest Reserve Act of 1891, the Organic Act of 1897, and the Taylor Grazing Act in 1934. Subsequent advances in grazing management have improved range condition in most locales although active management programs such as those controlling brush recently have been impeded by special-interest groups. This reduction of brush control, together with a reduced frequency of fire, has led to impoverished range conditions in certain areas.

Soil Erosion and Desertification

The amount of soil lost in the last century and in the early part of this century is mostly undocumented; in any event, although soil erodes from improperly grazed rangelands, losses from grazing do not equal those from cropping. Desertification is related to soil erosion and to loss of productive potential. Dregne (1977) and an unpublished United Nations report have indicated that 85% of the western United States is moderately to severely desertified. That these claims are based on faulty information and are overstated will be discussed in detail.

Watersheds and Riparian Areas

Floods caused by decreased protective plant cover followed the period of heavy, uncontrolled grazing in the last part of the nineteenth century and in the first part of this century. But because grazing has been controlled since 1934 and range condition generally

has improved as a result, protective soil cover on most upland areas has increased and the frequency of floods from rangeland areas has decreased.

Conditions on riparian areas have not improved to the extent that those on upland areas have. The U.S. Environmental Protection Agency (1990) states that riparian areas in the West are in their worst condition since written records have been kept but provides no data on conditions or trends. Initially, very few recognized the importance of riparian areas, which were considered "sacrifice areas" on which heavy use could be condoned to promote appropriate use of uplands. With the increased realization of the importance of riparian areas to water quality, fishery, wildlife habitat, recreation, and multiple other rangeland uses, since 1974 public-land management agencies have begun to emphasize reclamation. The degree of success enjoyed by agency efforts and practices to improve riparian areas and fisheries habitat will be discussed (Figure 1.1).

Wildlife Population and Habitat

Damage to wildlife habitat is believed to have occurred in the earlier era of uncontrolled grazing, but the residual damage has not been quantified. Certainly, wildlife populations were decimated by uncontrolled hunting and trapping. Yet well-managed livestock operations on productive rangelands generally are compatible with wildlife habitat for many species. This is evidenced by the fact that populations of most big-game species are greater than at any time this century (U.S. Department of the Interior, 1990b) (Figure 1.2). In most instances, management plans can accommodate needs for species of concern.

Recreation/Aesthetics

Until the last few decades, rangelands in the United States traditionally were considered to have little recreational value. But a wealthier, more sophisticated population with more disposable income and more leisure time has increased its demands on rangelands for many types of recreational activities. Some activities are perennial, e.g., hunting and fishing; others based on hiking, camping, solitude, or appreciating the wilderness are gaining popularity even on rather remote rangelands rarely used for recreation 50 years ago.

Grazing Fees

Most proponents of increased federal grazing fees cite higher rental rates associated with private pasture and private rangeland. Others argue that current grazing fees, based on the formula in the 1978 Public Rangeland Improvement Act (PRIA) reauthorized under Executive Order 12548 of February 14, 1986, generate insufficient revenue to cover the cost of administering grazing programs in the Forest Service (FS) and the Bureau of Land Management (BLM). Both arguments usually conclude with the plea to end "subsidized" federal grazing and to charge grazing fees equal to the "fair market value" of private forage.

Private lease rates do not determine the fair market value. Advocates of increased grazing fees either ignore or fail to understand that permittees purchase grazing privileges whose market prices are linked to the costs and the benefits of grazing on that land. Furthermore, public leases routinely incur greater expenses for fence and other range improvements,

Figure 1.1. Riparian area in western mountains. Photograph courtesy of Marty Vavra, Oregon State University, Burns.

Figure 1.2. Magnificent bull elk in Wyoming. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

construction, and maintenance; animal management not provided by the leasor; and public involvement, e.g., meetings and vandalism. The cost of private or public forage thus may be the same. Private-grazing leases are for single use with no provisions for sustaining other values, e.g., wildlife habitat, whereas public-land leases demand restrictions for multiple use. Moreover, land-management agencies would incur administrative costs whether or not livestock were grazed.

Because no fees are charged for certain other consumptive uses of federal land, e.g., hunting and fishing, there may be other motives behind the drive to increase federal grazing fees. Indeed, familiar slogans such as "Cattle Free by '93" call for removal of grazing from public land altogether (Ehrlich, 1990; Jacobs, 1991). The movement to increase federal fees at times obscures the purpose of curtailing or eliminating public-land grazing.

Geography and Land Ownership in the West

Those trying to remove livestock from public land seem to believe that management of this land is and can be separated completely from management of private land in the West. Because of complicated and intermingled land ownership patterns, this assumption is both mistaken and naive: individual ranches and entire watersheds may be a mix of FS, BLM, state, and private lands. Yet proper land-use can occur only when a common plan is in place over all ownerships within a watershed.

Without access to public land for grazing, many ranches currently providing open space and wildlife habitat would be forced to sell or to intensify use of their private land. In some areas, the new owner of these private lands would convert them to ranchettes or subdivisions or take other actions detrimental to wildlife and to other assets the value of which society takes for granted (Williamson, 1992). Intensified use of private land also may degrade resources such as wildlife habitat. Such eventualities should be weighed carefully before actions are taken to remove livestock from public land.

Settlement

To understand both land-use patterns and land management strategies in the West, an historical perspective is essential. Before U.S. settlers owned western land, it belonged to the U.S. government, which had acquired vast holdings from France, through the Louisiana Purchase, Mexico, and Native American tribes. The intent of the government was to stimulate settlement of the West and promote the economic development of the region by transferring land ownership from the public to the private sector, as had occurred in the East.

Fur trappers, traders, and prospectors were in the West in small numbers early in the nineteenth century, but in 1841 many travelers on the Oregon, Mormon, and California trails began crossing the Great Plains and the Great Basin. Dorn (1986) estimated that 350,000 people crossed Wyoming on these trails in the 1840s and the 1850s. Soon after the Civil War, in the late 1860s, stock raising in the Plains and the Intermountain region began with the arrival of trail herds of Texas longhorn cattle. By granting land to the railroad, earlier government land disposition decisions encouraged settlement and development of infrastructure. When the transcontinental railroads were built, the government gave the railroad companies alternating sections for more than 20 miles on either side of the proposed right-of-way. The intent was for the intermingled government lands to become privately owned through homesteading and other land-acquisition methods.

The first major legislation to encourage settlement of western lands and to transfer public lands to private ownership was the Homestead Act of 1862, which allowed a person to occupy, to farm, and eventually to gain title to 160 acres (a.). On the productive lands of the Midwest, this was enough land to maintain a family, especially if a husband and a wife each homesteaded adjacent tracts. As the lands in the eastern Great Plains became settled in the 1880s, great numbers of homesteaders began to reach the western plains and the mountains. But except for river bottoms and irrigable floodplains, most such lands were ill suited to farming, and 160 a. was too small an area on which to graze livestock sufficient to sustain a family. Homestead size in the West remained inadequate even when increased to 320 and then to 640 a.

The transcontinental railroad, the arrival of great numbers of homesteaders, the invention of barbed wire, and the severe blizzards of 1886–1887 (Mitchell and Hart, 1987) changed the nature of the western livestock industry from extensive to intensive uses. Although large tracts of public land continued to be grazed with no controls, grazing on the Forest Reserves (later to become the National Forests) was controlled beginning in 1897. In 1934, the Taylor Grazing Act regulated grazing on the remainder of the western public domain.

Grazing privileges on Forest Reserves and on other public lands were given to ranchers who owned or controlled the livestock that they grazed, could prove prior use, and had base property sufficient to sustain livestock when not on public land. This local control was insisted on by local ranchers, who wanted security of tenure, stability of local economies and prohibition of rangeland use by itinerant livestock (mainly sheep), who had exacerbated serious overstocking on and overuse of rangelands.

Public and Land Ownership Patterns

Intermingled land ownership patterns resulted from grants of land to railroads and to states, federal land reservations, and the selection of the best agricultural lands for homesteading. The most arable land, along streams and around any water source, went into private ownership through homestead or purchase. In this way, many private lands became surrounded completely by poorly watered and generally less productive public lands.

The intended privatization of land did occur on the Plains and in other isolated areas. Large rangeland areas in the West, however, never were transferred to private ownership; the present patchwork of private and public ownerships resulted. This pattern, which is associated with early railroad grants, is the most extreme example of the intermingling of ownership in the West. Even where large blocks of private and public lands occur, separately they often do not make up whole ecosystems or management units for either livestock or big-game animals. Land management problems are similar throughout the West.

State owned lands in western states to support public education also contribute to the intermingled land ownership pattern. States typically received title to Sections 16 and 36 in each township and at times "blocked up" their holdings by trades and agreements with the federal government. The scattering of state owned lands complicates management of land with an already highly intermingled ownership pattern.

Effect of Intermingled Ownership on Management

How does intermingled land ownership affect land management? Most commercial ranchers in the 11 western states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) have FS and/or BLM rangeland leases as indispensable parts of their ranching operations. In the Southwest, many ranches run on public land almost yearlong. In the northern and more mountainous parts of the West, private land is used primarily to grow hay and grain to feed livestock during winter. Livestock typically are sustained on BLM lands in spring and fall and on higher FS lands in summer. Many large ranches also lease scattered sections of state land. Thus, loss of use of one or of both types of public land could undermine the operations of many western ranchers.

Some wildlife species may migrate in much the same pattern as the livestock operations already described do, spending summer in the mountains on FS land and spring and fall on BLM land. They may spend much of the winter on private land because it generally is lower in elevation and much more productive than nonhomesteaded public land. In many regions, up to 70% of big-game animals remain on private land during winter, a season critical to the survival of most such species.

Effect of Removing Livestock from Public Land

If livestock were removed from public land either by outright banning or by increasing grazing fees such that few ranchers could afford them, economic and ecological consequences would be widespread. Individual ranchers, local communities, and states would experience economic consequences. Ranchers only minimally dependent on public-land grazing and not heavily in debt might be able to stay in business by intensifying management of their own land. Those ranchers wholly or primarily dependent on public-land grazing to round out their operations probably would go out of business, and their private lands would be sold. Even if their lands were bought by a neighboring rancher, the local community would lose part of its tax base because the lost federal animal unit months of livestock forage would mean fewer livestock and less sales revenue.

In resort or popular recreation areas, private land put on the market by forced sale might be bought by speculators or developers and subsequently converted to 40-a. "ranchettes" or otherwise developed (Williamson, 1992). If the land whose use was converted from ranching and open space to development was critical big-game winter range, the new use usually will result in lost winter habitat base. Other wildlife species also could be affected adversely, even on ranches that stayed in business. Intensifying livestock operations on private land also could diminish the value of that land as winter range for big game and as habitat for other wildlife species. Because winter

range often is the habitat most critical for maintaining populations, either scenario could lead to smaller, not to larger, big-game populations after the removal of livestock from public land. Some game populations also would decrease because of the lost symbiotic habitat relationship with livestock (Anderson and Scherzinger, 1975).

Costs of Managing Public Rangelands

Recognizing the importance of sustainability and the demand for nonagricultural uses has increased land management costs greatly, including those associated both with hiring professionals trained in a variety of disciplines and with communications among such staff. Costs for managing public-land commodity production generally exceed those for managing private land.

Some therefore argue for the elimination of commodity production on rangelands. Indeed, increasing fees to pay administrative costs often would have the same effect. Others argue that the increased costs of sustaining environmental quality and biodiversity and certainly other land uses should not be paid by the commodity user. They fear that expecting agricultural users of *marginal lands*, i.e., lands that could not be given away during the homestead era, to pay for government management of these lands is among some parties a strategy to eliminate commodity use.

Not surprisingly, some of the highest costs already discussed as associated with public-land grazing are those of the administrative and legal forms of public involvement. These costs increase when affected individuals or interest groups either request additional information or appeal so as to delay decisions with which they disagree.

2 Current Grazing Laws and Public Policies

Introduction

"Rangeland Reform '94," an administrative initiative spearheaded by Secretary of the Interior Bruce Babbitt, captured the attention of the American public, resulted in a Senate filibuster of the initiatives proposed for codification in an amendment to the FY94 Interior and Related Agencies Appropriations Bill, and shook the rural West. Not since a comprehensive public-land grazing bill, i.e., the PRIA, was discussed in the 1978 Congress has such attention been focused on western federal rangelands and on their most extensive use: regulated domestic-livestock grazing. Then as now, much of the debate centered on federal-rangeland grazing fees, only one of the issues of the bill.

Grazing fees are symbolic of the broader western federal-rangeland policy problem, which involves property rights and conflicting interests. In the West, ranchers have de facto *usufructuary rights*—i.e., the right to enjoy the advantages of another's property provided that such property is not destroyed or damaged—to graze livestock on the surface forage of federal lands and to appropriate for stock watering and other purposes the water originating on or flowing through those lands. Public rights are imposed statutorily on private lands and appropriated water rights, and multiple demands exist on all western land and water resources. Not enough land or water is available to satisfy all demands.

A brief historical review of the settlement of the West may shed light on the federal government's policy dilemma by answering these questions: What are western federal rangelands (Table 2.1), and why are they in federal ownership? What has been the history of regulated livestock grazing on federal rangelands? What is the present structure of the federal-land-dependent western livestock industry? A better understanding of the answers to these questions will help frame the current public-policy debate.

Table 2.1. Percent of land in the 18 western states in federal ownership in 1982 (Holechek et al., 1995)

State	Percentage
Alaska	89.5
Arizona	40.2
California	47.4
Colorado	36.0
Idaho	64.8
Kansas	1.4
Montana	29.5
Nebraska	1.4
Nevada	81.7
New Mexico	33.3
North Dakota	5.1
Oklahoma	4.0
Oregon	48.9
South Dakota	6.4
Texas	2.1
Utah	61.0
Washington	28.4
Wyoming	49.1

Source: U.S. Department of the Interior, 1983.

Public Lands and the Federal Land Management Agencies

Of the more than 2.27 billion a. of land in the United States, 649 million a., or 29% of the nation's land surface, are owned by the federal government (U.S. Department of the Interior, 1993) (Table 2.1). Most federal land, some 588 million a. (90.5%), is either original public-domain land that never left federal ownership or *acquired land*, i.e., land obtained by the federal government through purchase, condemnation, gift, or exchange. Acquired lands account for 61.8 million a. (9.5%) of federally owned lands. A large share of these acquired lands, including the 11.3 million a. of submarginal Great Plains lands purchased and condemned by the Federal Emergency Relief Administration and its successors, was obtained under various New Deal programs between 1933 and 1940.

Public-domain lands include both lands once available for disposition under homestead laws and lands reserved for a specific public-purpose such as timber

production. For example, original Forest Reserve lands were withdrawn under the authority of The Forest Reserve Act of 1891; most of which became part of the National Forests. Another example, one relevant to the current policy debate, was President Franklin Roosevelt's November 26, 1934 Executive Order No. 6910, which withdrew all remaining unreserved and unappropriated public-domain lands in the Great Plains region from settlement or sale (Peffer, 1951). These lands were reserved primarily for grazing projects and for additions to wildlife refuges, Indian reservations, and National Parks. Supported vigorously by the FS (Wallace and Silcox, 1936, 485–486), the action was similar to but went further than the Taylor Grazing Act, passed a few months earlier (June 28, 1934), which authorized the Secretary of the Interior to establish grazing districts on unreserved public-domain lands pending their final disposal. Resource conservation, land use planning, and regulated livestock grazing as a preferred land-use were common themes in both the administrative and the congressional initiatives of 1934.

What and Where Are the Western Federal Rangelands?

Section 3(a) of the PRIA of October 25, 1978 defines the *federal rangelands* as including "lands administered by the Secretary of the Interior through the Bureau of Land Management or the Secretary of Agriculture through the Forest Service in the sixteen contiguous Western States on which there is domestic livestock grazing or which the Secretary concerned determines may be suitable for domestic livestock grazing" (43 USC 1902). "The term 'sixteen contiguous Western States' includes the states of Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming" (Section 3[i] of PRIA). Additionally, about 132,000 a. of federal rangeland exist in Texas.

The *western federal-rangeland states* are the 16 western public-rangeland states and Texas. Of these 17 states, 11 are subject to the grazing fee formula established in the PRIA. National grassland states of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas were exempted from the PRIA formula fee contained in Section 6.

This operational definition of the *western federal rangelands* is important because it defines them as being more extensive than the more publicized BLM grazing-lease lands (Taylor Grazing Act Section 15 lands), the BLM grazing districts (Taylor Grazing Act Section 3 lands), and the FS's National Forest grazing allotments. The western federal rangelands also include the national grasslands of the nine Great Plains states. Just more than half (51%) of total national grassland acreage is contained in six national grasslands located in the Dakotas.

Domestic livestock grazing is the most widespread and extensive use of western federal rangelands, which in the 16 western federal rangeland states consist of some 307 million a. The BLM administers 57% of this acreage; the FS administers 43%. Approximately 262 million a., or 85% of total western federal-rangeland acreage, were eligible during part of the year for domestic livestock grazing in combination with other commodity and amenity uses (U.S. Department of Agriculture and U.S. Department of the Interior, 1992).

These grazable western federal-rangelands include approximately 165 million a. administered by the BLM, or 94% of BLM lands in the western federal rangeland states (Figure 2.1); and 97 million a. of the National Forests and the national grasslands, or about 73% of the total federal-rangeland acreage in the western region of the National Forests system (Figure 2.2). The BLM, then, is a western federal-rangeland management agency with a strong livestock-use focus. The FS manages less federal acreage and has a natural scope rather than a livestock-use approach. However, under the auspices of the Federal Land Policy and Management Act of October 21, 1976 and the National Forest Management Act of October 22, 1976, both the BLM and the FS manage their lands for multiple uses and users, including domestic livestock grazing.

Figure 2.1. Dry rangeland in Oregon. Photograph courtesy of Marty Vavra, Oregon State University, Burns.

For Whom are the Western Federal Rangelands Managed?

Multiple-use management implies multiple user groups and multiple interests in federal-land use and resource pricing policy. As public policy evolves and additional uses are legitimized in federal-land law, newly recognized users demand access to already fully allocated federal land resources. Thus, upward pressure is exerted on the values of federal resources previously devoted to customary or traditional uses such as grazing.

The controversy surrounding federal-grazing fee/rangeland resource use is not really a debate over the appropriate price of federal-rangeland forage resources but one over priorities among alternative federal rangeland resource uses (Burkhardt and Obermiller, 1992). The federal-grazing fee issue can be neither understood thoroughly nor debated constructively if the question of pricing is separated from the issue of the relative importance of domestic livestock grazing among several authorized multiple uses of federal rangelands.

The final report of *One Third of the Nation's Land* recommended comprehensive changes in federal-resource law and the Public Land Law Review Commission (PLLRC) (1970). This commission recognized the roots of the federal-land use debate. According to the PLLRC, six distinct groups have various interests in the federal grazing fee and in more fundamental federal-rangeland use policies:

1. **The national public.** Taxpayers who seek public policy to sustain environmental quality and production capability, who want to keep consumer prices low, and who want federal-resource management programs to recover administrative costs.
2. **The regional public.** Commercial interests in regional employment and economic growth who advocate community stability as a federal-land management goal and who want to retain access to federal rangelands and resources.
3. **The federal government as sovereign.** Those who want to ensure equal access for all potential users of federal rangelands and for those who otherwise promote the general welfare while refraining from unfair business practices vis-à-vis the private sector.
4. **The federal government as proprietor.** Federal agencies or personnel who share with the national public a desire to recover the costs of administering federal-rangeland use programs and who seek a return on productive assets while sustaining the long-term productive capacity of federal rangelands.
5. **The state and local governments.** Entities that derive revenues in lieu of taxes and commercial income from the private uses of federal rangelands and thus seek an equal voice in the implementation of environmental, land use, and land disposition programs.
6. **The users of federal lands and their resources.** Parties that seek, as state and local governments do, to participate in federal-rangeland management and use decisions, that demand equal access under the explicit terms and conditions of use agreements, that expect fair compensation for abridgment of such terms and conditions, and that advocate federal-resource pricing standards consistent with the values of federal-rangeland resources to their users.

Figure 2.2. National Forest rangeland. Photograph courtesy of Marty Vavra, Oregon State University, Burns.

In short, the PLLRC identified numerous groups, all of which have legitimate interests in the management and the use of federal lands. The commission assigned no priorities to these groups. Regional public, state and local governments, and users all can be recognized because of their local proprietary interest in management, use, and disposition of federal rangelands. The issue is one of federal versus local supremacy and is the crux of the federal-rangeland policy debate.

Origins of Regulated Public-Land Grazing

Domestic livestock grazing first was regulated on western public-domain lands that were withdrawn from commercial use and reserved as federal forests. Regulation of domestic livestock grazing was prompted largely by concerns about (1) timber losses due to escaped fire from encampments of migratory sheepherders and (2) water supply—especially water quality—problems due to overgrazing near the headwaters of streams providing downstream communities with domestic and municipal water (U.S. Department of Agriculture, 1902).

Concerns about soil erosion, deteriorated range condition, and livestock industry instability brought the remaining unreserved public-domain rangelands under regulation in 1934. The development of regulatory laws, together with federal-land management agency practices, created the present western federal-rangeland grazing system. The historical development and functioning of western federal-grazing institutions have important federal land-use policy implications.

Federal Forestlands

Livestock grazing on federal lands first was regulated in 1897 on the Forest Reserves administered by the General Land Office of the USDI. Gifford Pinchot, then Chief of the USDA's Division of Forestry, implemented this regulation (Steen, 1976). A permitting system was extended to established operators grazing sheep and cattle on spatially identifiable land parcels subsequently called *grazing allotments* and located in the Forest Reserves of the western United States. The goals of the permitting system were (1) to ensure sustainable stocking rates, (2) to use carrying capacity with respect to grazing as the determinant of allotment size, (3) to grant permits equitably, and (4) to maintain under permit terms and conditions flexibility in the regulation of grazing.

The primary mechanism used to regulate grazing was that of the grazing permit attached to *commensurate base property*, i.e., deeded land or private water right. Commensurate base property was linked by the permit to the grazing allotment. The commensurability requirement was imposed because the comparatively sedentary cattle operators hoped to drive competing transient sheepherders away from grazing areas used by both (Rowley, 1985).

The Transfer Act of February 1, 1905 conveyed 85,627,472 a. in 83 Forest Reserves from the USDI to the USDA. The act also allowed all stumpage receipts, grazing fees, and other revenues from the sale of Forest Reserves resources to be placed in a special Department of the Treasury fund to be used for the "protection, administration, improvement, and extension of the reserves."

Pinchot refined the USDI permitting system by extending the standard permit term to 10 years subject to renewal (subsequently called *term permits*) and by requiring permittees to own sufficient nearby commensurable base property to support the permitted number of livestock during that part of the year when they were not grazing on Forest Reserves lands.

On July 1, 1905, Pinchot published his first set of comprehensive regulations governing the management of the Forest Reserves. His *Use Book* devoted considerable attention to domestic-livestock grazing regulation, the objectives of which were (1) to conserve resources, (2) to protect the financial welfare of permittees, and (3) to protect original permittees from outside competition (Steen, 1976). By stating that the "forest reserves . . . are patrolled and protected, at Government expense, for the benefit of the Community and home builder," the *Use Book* (U.S. Department of Agriculture, 1905) clearly indicated that local residents would have preferential and enforced rights to use the resources of federal forest-land.

On his own authority as chief, that is, without explicit congressional sanction, Pinchot installed an administratively determined grazing-fee effective in the 1906 grazing season. An administered fee was selected over competitive bidding because the latter "would have jeopardized the necessary continuity for stock production" (Steen, 1976). The basis for the grazing fee was "reasonableness" in terms of the value of the permit to the permittee; as noted, resulting fee receipts were used to manage and to expand the Forest Reserves system. By 1907, when the Forest Reserves were renamed the National Forests, the system had expanded from 86 to 168 million a.

Livestock operators protested both the imposed grazing fees and the permitted stocking-rate reductions implemented in 1897 and maintained after the Forest Reserves was transferred from the USDI to the USDA. These protests notwithstanding, Chief Pinchot stated in the *Report of the Forest Service for 1906* that "opposition to the fee [was] disappearing":

> There is no longer any doubt as to the advantages of preventing conflict and overgrazing on the ranges. Under restricted grazing cattle and sheep keep in better condition and yield a better profit, and the range is not injured. . . . Every effort is being made

to give the stockmen the fullest practicable use of the range. Small nearby owners have the preference, larger regular occupants come next, and owners of transient stock come third. (U.S. Department of Agriculture, 1907)

On the Public Domain

Elsewhere in the West, livestock grazing remained unregulated on 200 million a. of vacant, unappropriated, and unreserved public-domain rangelands (Muhn and Stuart, 1988). Ultimately, western public-domain lands became increasingly crowded and progressively overgrazed.

> As competition for forage tightened, along with the conflicts between sheep and cattle and between stockmen and "nesters," the dominant effort of most stockmen to gain or retain control of the range overshadowed any thought of resultant damage, and led even at times to the malicious "trampling into dust" of areas of feed, to drive back crowding neighbors, or in retaliation. No responsibility was felt for preserving the range for the future. . . . It was all free, open grazing; Uncle Sam owned it, and it was a clear case of first come first served and devil take the hindmost. (Wallace and Silcox, 1936)

"The root of the problem was that the federal government was not meeting [their] needs. Stockraisers had to have more than 160 a. of range for their herds" (Muhn and Stuart, 1988), the limitation contained in the Homestead Act of June 2, 1862.

As it became evident that parcels of this size usually were too small for successful homesteading west of the 98th Meridian, the size was increased. The Enlarged Homestead Act of 1909 increased the limit to 320 a., and the Stockraising Homestead Law of 1916 increased the limit to one full section (640 a.). As early as 1878, John Wesley Powell had recommended to Congress that if the semiarid West was to be homesteaded successfully, ". . . a large acreage (2,560 a. minimum) of range land [would be needed] to round out an economic home unit" (Wallace and Silcox, 1936). Because private-land ownership opportunities were limited by institutional restrictions and climate, the public domain provided the complementary balance of the forage supply. Still, there was not enough land to go around.

By the early 1930s, the severity of the overgrazing problem coupled with social and environmental instability led both the administration and the Congress to conclude that "maladjustments" in agriculture west of the 98th meridian—which runs through the eastern Dakotas, Nebraska, Kansas, Oklahoma, and Texas—needed correction. One outcome, the 1930s New Deal era private-land acquisition programs in the Great Plains and in parts of the West, considered regulated livestock grazing preferable to cropping in the semiarid West.

Similar concerns about the state of unreserved public-domain rangelands led various western congressmen to introduce a series of general grazing-lease bills. Although pockets of opposition to regulated grazing were strong, instabilities accentuated by drought and economic depression had by 1934 created a climate favoring legislative passage. The Taylor Grazing Act of June 28, 1934, which President Franklin Roosevelt called " . . . a great step forward in the interests of conservation, which will benefit not only those engaged in the livestock industry, but the nation as a whole" (Muhn and Stuart, 1988), resulted. Public-policy purposes served by that act were "to stop injury to the public grazing lands by preventing overgrazing and soil deterioration; to provide for their orderly use, improvement, and development; to stabilize the livestock industry dependent on the public range."

The Taylor Grazing Act was patterned in part after Pinchot's system of regulated grazing on the National Forests. The most significant difference was that, for the first time, the secretary of the Interior was given explicit statutory authority to level "reasonable" grazing fees as an independent element of a comprehensive mandate, which included as separate elements control over priority and amount of permitted livestock grazing, i.e., *grazing preference*. Definition of a "reasonable" grazing fee also was within the secretary's purview. For many years thereafter, the administrative interpretation was that the grazing fee should cover the costs of administering a minimal public-domain grazing program allowing for the quantity of forage authorized for use under the terms of Taylor Grazing Act Sections 3, *Grazing District Permits,* and 15, *Grazing Leases* (U.S. Department of Agriculture and U.S. Department of the Interior, 1992).

Lessons from the Evolution of Western Grazing Permits

Inasmuch as the legislative developments discussed are the century-old roots of the current federal-rangeland reform and grazing fee debate, it is not surprising that opinions are entrenched. The six les-

sons that are keys to understanding the debate will be summarized next.

Most significant, perhaps, is the fact that the western federal-rangeland forage market is not and never was an open and competitive market in which price, i.e., grazing fee, and quantity, i.e., amount of federal forage taken, vary in relation to one another. Price, or fee, always has been set administratively and at least initially was based on a set of "reasonableness" criteria in relation to costs incurred by the federal government as proprietor. Proprietary responsibilities include providing permittees access to permitted federal-rangeland forage supplies and enforcing the terms and the conditions of grazing permits. Likewise, quantity, or authorized use levels or stocking rates, always has been set administratively according to land resource conservation criteria and independent of fee level.

Second, the permit to graze, awarded on the basis of prior-use pattern, e.g., grazing location, customary season of use, and associated stocking rate; and enforced against trespass by the federal government as sovereign, has the attribute of a partial property-right. Federal-land management agencies consistently have referred to that right as a *privilege*. To the permittees, however, as well as to some economists and to the Internal Revenue Service, which attaches estate taxes to grazing permits (Quigley et al., 1988), the permit is a valued usufructuary right remarkably similar to an appropriate water right.

Third, the value of the permit accrues as a result of federal-land laws restricting homesteads to between 160 and 640 a. To the extent that privately owned feed and forage resources were associated with these relatively small acreages, a viable commercial ranching operation was possible with the permit; in some areas, the operation was not viable otherwise. Today, fee-simple base properties can be rearranged in some areas, but probably at an additional cost per unit output, if each such property were to lose its federal grazing permit. In either context, the permit value is a usufructuary value accruing to existing operations holding a federal grazing permit. The permit's usufructuary value is the direct result of the original homestead laws and the commensurate base-property restriction required as a condition as the conveyance of the permitted right to graze livestock on a specific allotment at a certain stocking rate and during a certain use season (Torell et al., 1992) and to reap the profit a prendre therefrom (Obermiller, 1993).

The magnitude of the permit's value, which accrues to base property (Harbison, 1991), depends on the stocking rate and use season in relation to owned base-property feed and forage resources and takes into account the fee and nonfee costs of using the permitted forage. The grazing fee, one cost associated with the use of permitted federal forage, usually constitutes only about 10% of federal-forage use cost (Bartlett et al., 1993; Obermiller, 1992a; Obermiller and Lambert, 1984).

Fourth, the permit is at least in part a renewable leasehold granting long-term seasonal (or year-round) use privileges to the federal-rangeland rancher. By means of it, the rancher, or permittee, can maintain an economically viable ranch unit year-round. Federal-rangeland forage and space (the spatially defined grazing allotment containing an authorized quantity of livestock forage), not short-run production substitutes for privately owned land and other resources. Whereas it is true that at some federal-grazing permit prices (either fee level or total forage-use cost) it may be less expensive to use an alternative private-sector forage source such as purchased hay or leased private pasture, the marginal cost of purchased hay as a substitute for grazing-season forage is in reality higher than the marginal revenue from the use of hay. In short, hay is not an economically viable substitute for the seasonal supply of grazed forage. In many areas in the West, no private-sector range or pasture is available as an alternative to permitted federal-forage land. So given the existing structure of existing feed and forage supplies, the federal grazing permit is a complement to the feed and forage supplies owned by the permittee.

Fifth, because permits are renewable long-term use agreements given preferentially to small local ranches traditionally dependent on nearby federal rangelands, rural communities have developed in proximity to federal-rangeland ranches. The stability of federal-rangeland-dependent communities is linked to the stability of permitted ranching operations, for these communities act in part as local permitted ranching service-centers. This fact helps explain the intensity of local interest in field hearings on the federal grazing fee and on related federal-rangeland reform issues. As the PLLRC pointed out, there are legitimate (1) regional-public and (2) state and local government interests in the federal-rangeland resource and its access price.

Sixth, Congress—in the Taylor Grazing Act and other legislation—and federal-land management agencies historically have acknowledged that (1) economic stability at the ranch, local community, and western livestock industry levels and (2) both on-site and off-site resource conservation are the basic goals of federal-rangeland management and use policy. The

term *sustainability* as applied to federal-rangeland management, use, and pricing therefore has socioeconomic as well as environmental connotations, as reflected in the legitimacy of interests represented by the six groups identified by the PLLRC in the federal-rangeland policy debate.

Social and Economic Implications

Each of the six lessons have a bearing on market behavior in the western rangeland livestock industry, and all have equally strong implications for changes in the fee policy.

1. The "commensurable base-property" requirement imposed by the sovereign federal government, as a condition for authorized public-rangeland livestock use, is an institutional restriction on freedom of entry into the federal-rangeland forage market. The market therefore functions inefficiently. At least in the short term, the commensurability requirement makes competitive bidding, as a means of establishing grazing fees, destabilizing. If competitive bidding were used to price federal forage, the federal government probably would be required to impose fewer restrictions on grazing permit use (Obermiller and Bartlett, 1994a,b). Given the commensurability requirements and the business management implications for federal-rangeland management agencies, competitive bidding likely would not be acceptable politically to either the federal-rangeland ranching industry or the federal bureaucracy.
2. The relative scarcity of private-forage alternatives to federal-rangeland forage during the permitted season of use implies that permittees are price-takers with little market power vis-à-vis the federal government. Because permittees see no viable market alternative to federal forage during the permitted season of use, the federal-rangeland ranching industry will oppose in the political arena administrative or congressional attempts to increase federal grazing fees.
3. Even if fees remain at current levels, reductions in grazing-permit forage preference and authorization level can be expected to exert significant upward pressure on and otherwise to disrupt private-rangeland rental rates in local markets. To the extent that federal grazing fees are based on private-pasture and -rangeland rental rates and there is federal/private-forage market interdependence, major reductions in federal grazing authorizations would be expected to increase grazing fees (Collins and Obermiller, 1992).
4. Because the permittee is a price-taker unable to pass fee increases along to the consumer, any increase must be absorbed by the federal-rangeland rancher; this process represents a transfer of wealth from the private-ranching sector as tenant to the federal government as proprietor and landlord. If the tenant, or permittee, is operating at the financial margin, markedly increased fees may lead to either operation closure or sale to a larger operation. Industrial destabilization is possible.
5. If federal grazing fees increase, all other things being equal, permit values and therefore ranch values will decline (Obermiller, 1991; Torell et al., 1992; Torell et al., 1993). As the values of capital assets decline, so does the ability to borrow against them. The expected result is asset devaluation in the western federal-rangeland ranching sector and reduced levels of both private investment in and maintenance of range improvements, especially on federally owned rangelands—a result at odds with statutory goals expressed in section 3 of the Taylor Grazing Act.
6. The federal-rangeland ranchers least able to afford markedly higher fees are likely to be highly leveraged sole-proprietors. In American agriculture, such operators tend to be younger, newer entrants into the industry. If the same tendency exists in the federal-rangeland ranching industry, increased fees will have demographic consequences for the structure of the western ranching sector.
7. That segment of the western livestock industry holding federal grazing permits tends to be small to medium-sized family-ranch enterprises (Obermiller, 1994; U.S. Department of Agriculture and U.S. Department of the Interior, 1992). According to the secretaries, 90% of the BLM permittees and 81% of the Forest Service permittees retain medium to small family-operations.

Approximately 17 million federal animal unit months are authorized under the existing 26,900 federal grazing permits. Average grazing-authorization is about 750 animal unit months per permit. Some are group permits, e.g., the BLM Rock Springs, Wyoming Grazing Association grazing permit with an authorization of nearly one million animal unit months shared by more than 30 permittees, each of whom uses on average approximately 3,000 animal unit months. Some ranchers hold more than one grazing permit. Still, sim-

ple mathematics suggests that when average permitted use season is four to five months, average herd size on federal allotments would be about 170 cows. Nationwide, average cow herd size is 174. The rule-of-thumb minimum herd size for a one-family rangeland ranching operation is 300 to 400 cows (U.S. Department of Agriculture and U.S. Department of the Interior, 1992).

Small ranching operations do not enjoy economies of size and therefore are less able to absorb fee (or other grazing cost) increases than large operations are. Thus, as federal grazing fees and/or regulatory compliance costs increase, so will average size of permittee enterprise. Yet this outcome is inconsistent with the purposes of the permitting system, which includes preferences for smaller family-ranching operations.

8. Family ranching operations buy most ranch inputs in local markets and thereby stabilize local communities and stimulate local economic activity. For reasons already given, increases in federal grazing fees likely will lead to a decline in the number of small family-ranches holding federal grazing permits. If the large ranching operations displacing smaller operations do not make local purchases to the same extent, rural communities that are service centers for the ranching sector will tend to be destabilized.

3 Grazing and Rangeland Ecosystem Sustainability

What Does *Sustainability* Mean?

Sustainability has both social (economic) and ecological dimensions. The sustained-yield principle, which underlies rangeland and forestland management, implies that use of a resource should not undermine future productivity. Land usage that is not sustainable can lead to *desertification*. Although use of the term *sustainable agriculture* has become widespread recently in the context of agricultural production, concern for the conservation of soil and nutrients is long-standing in agriculture.

To answer the questions of whether and under which conditions, if any, livestock grazing is a sustainable use of public lands, *sustainability* must be defined. Subsequently, a distinction between proper and improper grazing must be made.

West et al. (1994) assert that society's most general and permanent need is that management maintain ecosystem integrity. In a sustainable livestock production system on rangeland, productivity as measured in terms of meat or fiber off-take does not decline. Constant or improving livestock production indicates that the amount of forage produced has not declined significantly in terms of either quantity or quality and that site productive potential has not yet been diminished. By implication, rangeland vegetation has not changed—or forage value of vegetation has not declined, and soil has not been lost.

Although it has been proved around the world as well as in the western United States that unrestricted livestock grazing is unsustainable, proper grazing of livestock is sustainable on the great majority of rangelands (Pieper, 1994). *Sustainable livestock grazing*, like *sustainable agriculture*, sometimes has been defined as practice that "maintain[s] options in land use for future generations." Such a definition implies that the long-term productive potential of the site will not be limited by land use. Potential productivity of a site depends on climate, topography, soil-moisture relations, and soil nutrient-supplying capacity, factors determining rangeland vegetative production capacity and therefore animal carrying capacity.

Because climate and topography essentially are unaffected by land use, long-term site potential would be diminished by means of an irreversible loss of soil moisture and/or nutrient supplying ability. Accordingly, although livestock production could decline as a result of vegetative changes due to grazing or to other causes, basic biological productivity of the site might not change. Only if the site's capacity to produce vegetation had declined as a result of grazing use could such use be described as *unsustainable*.

Finally, some have asked whether economically impracticable land-use can be considered sustainable. This is a relevant question, for the three aspects of sustainability depend on stocking rate. A very low livestock stocking rate may have little or no effect on forage production, site productivity, or competing land uses, but may be economically infeasible. Therefore, the determination of whether livestock grazing is a sustainable use of rangeland must take into account a practical stocking rate for an economically viable livestock production enterprise. In this discussion, sustainable livestock grazing is considered the stocking-rates and management strategies at a practical economic level and production method, as well as maintenance or enhancement of the long-term productive potential of the site.

Is Livestock Grazing on Public Rangelands Sustainable?

General Effects of Grazing on Plants and Soils

Grazing by any herbivore usually if not always results in changes in the composition of vegetation, or in the relative abundance of plant species. Plant species adapt in a variety of ways to defoliation by grazing animals, whose preferences for plants differ. Thus, the effects of grazing are not uniform across plant species. Depending on the intensity, frequency, and season or growth stage at which plants are grazed, the vigor and/or reproduction of certain species may be reduced relative to that of others, and changes in relative abundance can result.

Trampling by grazing animals on plants and soils also can affect plant composition and/or productivity by influencing microclimate as well as soil moisture and nutrient supplying capacities. Fire, insects, disease, drought, unusually wet seasons or years, changes in water table, or flooding also can affect species vigor, competitiveness, and reproductive success. Changes in species composition therefore may result from many diverse factors, e.g., weather and fire, as well as from grazing.

The term most commonly used to define the ecological potential of an area is *climax*, that is, the end point—or optimal plant-community resulting from vegetative succession. These climax plant communities are assumed, often simplistically (c.f. Laycock, 1994; Pieper, 1994), to be stable and long lived.

Malin (1956) warned of the problem of defining portions of earth space. He asserted that any definition must include time as a quality. Conditions have been such in some environments that no major changes have occurred over long periods. Walter (1973) stated that many of the world's grasslands, including the North American prairie and steppe, are climax grassland types maintained by a combination of drought and fire. In other areas, extremes in temperature and moisture have altered vegetation. Malde (1964) speculated that arroyos and wind deflation, for example, are merely the results of climatic shifts toward less frequent but occasionally more intense rainfall and are not the result of any overall change in average precipitation. Such a change in rainfall pattern would produce scanty vegetation and dry soil subject to erosion. Overgrazing may be one cause of arroyos in the Southwest, which began forming in about 1880. However, roads or railroads built after the arrival of Europeans and climatic causes cannot be discounted as contributing (Bull, 1991). Fire is a periodic occurrence in certain systems and prevents the development of climax communities (Figure 3.1) or inhibits their stability.

Malin (1956), who championed the concept of "steady states," held that the assumptions of climax theory were essentially flawed, that civilization always was destructive, and that it was the role of the informed citizen to restore what had been destroyed. Human intervention in ecosystems has been a real and dramatic force of change. Drastic natural changes or *disasters*, however, always have occurred and are not understand fully. Defining what should be now and providing a pathway to return to that state is in most instances rendered impossible by changes wrought by nature and by civilization. What must be developed is an economically sound management pathway providing the essentials of vegetative cover, water-holding capacity, and landscape conservation (Malin, 1956).

Historical Changes in Rangeland Vegetation

The possibility of returning to a pristine or an unspoiled environment by eliminating grazing is a common misconception. The landscapes greeting the first settlers of the New World already had been affected by man. Native Americans actively managed landscapes from coast to coast. They used fire to develop "user friendly" plant communities and extended the prairie eastward, maintained deforested conditions in the eastern United States and in parts of the Rocky Mountains, controlled shrubs and trees in the Great Basin, and burned much of the swampland of the Southeast (Chase, 1986; Houston, 1982; Pyne, 1982)

Fires set by the Native Americans helped maintain desired plant communities, thereby providing food for hunted animals and maintaining plant species harvested directly for food or used for tools, baskets, and construction. Fire also served as a tool in the driving of game, in warfare, and during intertribal intimidation. The environment of North America that so impressed European immigrants was molded to a great extent by the Native Americans and their use of fire (Pyne, 1982). This is not to discount the importance of lightning-caused fire, which has driven evolution for eons: many rangeland plant communities in fact were well adapted to fire long before humans crossed the land bridge from Asia.

Vegetation has changed considerably on much of the western rangeland since the major influx of European settlers, from 1870 to 1890. For the most part,

Figure 3.1. Fire is used to control sagebrush. Aspen in the background. Photograph courtesy of William A. Laycock, University of Wyoming, Laramie.

changes have involved increases in woody and/or annual plant populations at the expense of perennial grass and forb populations. In certain areas, plants increasing in abundance were part of the presettlement ecosystem and simply became more abundant. In others, shrubs spread to sites on which they had not previously occurred, or exotic plants, particularly annual grasses and forbs of Mediterranean origin, invaded native-plant communities. Examples of vegetative changes occurring throughout the Great Plains and the West since the immigration of Europeans follow.

1. **California annual grasslands and oak woodlands.** Formerly composed of cool-season bunchgrasses, sometimes with an overstory of oaks, these winter-rainfall grasslands now are composed almost entirely of annual plants, 80 to 90% of which have Mediterranean origins (Heady, 1958). This change began early in U.S. history, with the settlement of California by Spaniards in the late seventeenth century.
2. **Intermountain sagebrush lands and salt desert shrub lands** (Figure 3.2). In the valleys and the foothills between the Sierra Nevada and the Rocky Mountains, cool-season bunchgrasses, e.g., bluebunch wheatgrass (*Agropyron spicatum)* and Idaho fescue (*Festuca Idahoensis)*, occurred with sagebrush (*Artemisia tridentata* and others) in areas with high precipitation rates and nonsaline soils. Because grazing by livestock was heavy after settlement in the late 1800s and because fire frequency decreased, the proportion of sagebrush to perennial grass increased over large areas (Miller et al., 1994; Young, 1994). Perhaps more significant, the sagebrush grassland in southern Idaho and in similar areas was invaded by exotic annual grasses—notably cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum asperum)*—and by other noxious weeds (Miller et al., 1994). Here, an increase in fire frequency due to the high flammability of annual fuels prevents a return to perennial vegetation. Poorly drained soils at low elevations were dominated by desert shrubs, e.g., saltbush, with a sparse understory of perennial grasses. Primary changes in this zone have decreased the amount and productivity of both shrubs and herbaceous plants, with somewhat increased proportions of plants unpalatable to livestock (Whisenant, 1990; Young et al., 1979).
3. **Pinyon-juniper woodlands.** This type of vegetation occurs over a very broad range of conditions, from central Texas through most of the 11 western states (Figure 3.3). It occurs generally in the elevation and precipitation zone between desert shrub or grassland types below and pine forest types above. Over the last century, an increase in the abundance of juniper throughout most of its range, either by thickening of existing stands or by invasion into adjacent vegetation types (grassland, sagebrush, or pine), where it was not a significant component one century ago, has been observed (West, 1988). Reduced fire frequency often has been implicated in this expansion, and fuel reduction due to grazing probably played an important part (Pieper, 1994). Climate change also seems to have been involved (Van Devender and Thomas, 1987).

Figure 3.2. Salt desert shrub land west of Kanosh in Millard County, Utah. Photograph courtesy of Roger E. Banner, Utah State University, Logan.

Figure 3.3. Mature pinyon-juniper community on Alkali Creek Road in the Colorado Plateau in San Juan County, Utah. Photograph courtesy of Roger E. Banner, Utah State University, Logan.

4. **Southwestern grasslands and desert shrub lands.** From California and southern Nevada to southwestern Texas and into Mexico, moist valleys and foothills are occupied by semidesert grasslands. Low, dry areas are occupied by hot-desert shrub vegetation (Figure 3.4). Three main climatic types are the *Mojave* (winter peak precipitation), the *Sonoran* (winter and summer peak precipitation), and the *Chihuahuan* (summer peak precipitation). Over the last 100 years, shrub—especially mesquite (*Prosopis grandulosa)*—populations have increased greatly in the former grasslands of this area and perennial-grass populations have decreased. Archer (1994) suggested that "these changes have been (1) rapid, with substantial changes occurring over 50- to 100-year spans, (2) nonlinear, (3) accentuated by climatic fluctuation, (4) locally influenced by topoedaphic [soil related] factors, and (5) nonreversible over time frames relevant to management." Whereas, in desert shrub lands, little change has occurred in the shrub component. Perennial grasses never were abundant except in swales where moisture accumulated. Exotic annuals now are extensive and provide substantial competition in desert shrub and certain grassland areas, especially in Mojave and Sonoran regions.
5. **Great Plains grasslands.** These grasslands extend north to south from Canada into Mexico and west to east from the Rocky Mountains to the eastern forests. In areas not converted to cropland, perennial shortgrasses, midgrasses, and tallgrasses predominate (Lauenroth et al., 1994) (Figure 3.5). Since settlement began in the northern and the central plains, little change has taken place in the basic character of these grasslands except where they are cultivated. Shrub and tree species numbers have increased somewhat, especially along drainages. Parts of the southern plains—mainly in Texas and New Mexico—have been invaded by shrubs such as mesquite (Archer, 1989; Glendening, 1952; Paulsen and Ares, 1962). Exotic plants are less invasive than in most other regions.
6. **Chaparral, mountain browse, and open forest rangelands.** It is difficult to generalize about these foothill and mountain types, which differ greatly from area to area (Figure 3.6). In most instances, the number of shrubs and trees either has increased or has remained approximately the same during the last century. Understory vegetation often is more a function of overstory density than of grazing. Decreased frequency has played a role where woody plants have increased.
7. **Riparian areas.** Again, because of the diversity of plant types, it is difficult to generalize about change in these areas. The most common change in meadow and floodplain vegetation relates to the effects of *gullying*, or arroyo cutting, which incises stream channels and thereby decreases overbank flooding and subirrigation effects and draws down high water-tables. The result is comparatively *xeric vegetation*, i.e., vegetation adapted to a dry environment, and decreased total production of meadow vegetation on former floodplains. Along numerous streams, the woody plant component common to many riparian systems has been degraded or lost. However, the accumulat-

Figure 3.4. Saguaro cactus land near Tucson, Arizona. Photograph courtesy of Phillip J. Urness, Utah State University, Logan.

Figure 3.5. Tallgrass prairie containing blazing star *(Liatris pycnostachya),* gray-headed coneflowers *(Ratibida pinnata),* and other forbs and grasses in Iowa. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

ed effects of poor grazing-management, roading along streams, channelization, irrigation diversion, and upland management generally have degraded most riparian areas.

Reasons for Historical Changes in Vegetation

The changes—or lack thereof—just described have been observed since the late nineteenth century, after major Anglo settlement of the West. Before reaching the West in great numbers, European immigrants had been confined to certain mining districts antedating the Civil War and to Spanish and Mexican settlements founded from Texas to California in the late seventeenth century. Observations of vegetation before large-scale settlement are contained in the records of explorers, military men, and the like, but there is little quantitative data or photography before around 1870 to 1880—and not much then.

Thus, there is little agreement on how much change has occurred. For example, some speculate that juniper "increases" in many areas have been merely the regrowth of juniper cut for fence posts, mine timbers, railroad ties, and fuel in the mid to late 1800s (Young and Budy, 1979). Early accounts of the occurrence of mesquite and other woody vegetation in the Southwest differ greatly depending on time and location. The same is true regarding the extent of gullying, or arroyo cutting. Nevertheless, it generally is accepted because of considerable evidence since 1900 that widespread changes in both vegetation and valley bottom erosion have occurred.

Because changes in rangeland vegetation and arroyos were observed to begin from about 1880 to 1920 and because this period saw the rapid influx of large herds of cattle and sheep from Texas and California onto western rangelands, livestock grazing often is cited as the cause of these changes. Livestock numbers had increased very rapidly to levels generally much higher than those today. Before establishment of the National Forests at the turn of the century, livestock grazing on federal lands was uncontrolled, as was grazing on most public-domain land until the Taylor Grazing Act (1934). Grazing was continuous and very heavy compared with modern practices. The abundance and the vigor of perennial grasses and of other palatable plants were diminished greatly, and soil erosion increased as a result of both cover loss and compaction and disturbance by livestock over vast areas. It was natural that ranchers and range managers in federal agencies and in universities would conclude that the observed increases in shrubs and annuals and in arroyo cutting resulted from overgrazing. This conclusion persists among many conservationists and range managers.

Figure 3.6. Camas meadow in Targhee National Forest, Idaho and Wyoming. Photograph courtesy of William A. Laycock, University of Wyoming, Laramie.

However, the various Homestead Acts beginning in 1862 also contributed to the decline of some of the most productive lands of the West. Soils on homesteaded lands typically were the deepest available in their locale, and vast acreages were plowed in a vain attempt to grow crops in arid or semiarid areas. Concomitant with this ill-fated attempt at cropping was the importation of exotic plants, which ultimately outcompeted natives for abandoned homestead lands and prevented a return to native conditions.

But even when the impact of early livestock grazing on vegetation and soil is granted, it has not been established that widespread vegetative change and arroyo cutting were due only or even primarily to livestock grazing. Coincidence of grazing with initial vegetative change does not indicate cause and effect. Other historic activities, e.g., the building of roads and railroads; the widespread cutting of trees for timber, fuel, and other uses; the building of dams and diversions for irrigation; the mowing and the grubbing of grass for hay; and the control of wildfire to protect property and forage, coincided with the widespread grazing of livestock and may have figured more prominently in the transformation of native ecosystems (see previous discussion under "General Effects of Grazing on Plants and Soils" and Malin, 1956). Moreover, the late 1800s and the early 1900s were marked by extreme weather events, that is, by drought and flood, which alone or in combination with grazing and other land-uses could have triggered the changes observed. Many researchers have concluded that reduced fire incidence resulting from reductions in avail-

able fuel that were caused by grazing and deliberate efforts at fire control were the primary reasons for observed increases in shrub and tree populations.

In short, the extent and the nature of historic changes in vegetation and in arroyo cutting are not agreed upon universally, for the causes of these changes are complex. Heavy and uncontrolled livestock-grazing very likely played a part in change, perhaps primarily as an accelerator, but whether grazing in certain areas was the major cause or even a precondition of change is unclear.

Relation of Historical Changes in Vegetation to Sustainability of Livestock Grazing

The effects of historical vegetative change on livestock production differ with the area considered. In the shortgrass plains, vegetation has changed little, and no evidence exists that livestock productivity has been affected. In the California grassland, although bunchgrasses have been replaced almost entirely by exotic annuals, no evidence exists that livestock productivity has diminished. In sagebrush and pinyon-juniper type ecosystems, partial replacement of grasses by unpalatable woody plants has reduced livestock production capacity but has favored big-game and other wildlife species. Continued increases in woody plants would, however, be expected to decrease wildlife values. Increase or decrease of tree canopy, respectively, has contracted or expanded livestock forage production in many forested rangelands. Shrub invasion of grasslands in the Southwest has reduced perennial-grass production and therefore generally has reduced carrying capacity for livestock.

Where vegetative change led to decreased forage production, former livestock numbers were unsustainable. As pointed out, it is unclear to what extent livestock grazing caused vegetative change or whether vegetative change diminished grazing capacity. If vegetative changes and arroyo cutting were caused by livestock grazing, however, it was largely the result of heavy and uncontrolled grazing from the late 1800s to the early 1900s, not of modern stocking rates or managed grazing.

Whether rangeland vegetation is sustainable in the presence of livestock grazing is an important question. Sustainability demands that no disruption of ecosystem function occur, but determining sustainability becomes difficult in light of periodic climate changes, among other factors. Ecosystems already have been disrupted and fragmented by past overgrazing, cultivation, exotic plant competition, and urbanization "management," e.g., fire suppression and river channelization. Inasmuch as there is an array of disturbance factors, sustainability of certain ecosystems may be impossible even if livestock grazing is eliminated—unless aggressive management systems are in place and functioning permanently.

The prehistoric plant-community frequently does not recover even when grazing is completely eliminated. In southern Idaho, successions of old field and previously overgrazed range have not passed the cheatgrass stage after 50 years of grazing exclusion. In fact, big sagebrush has not been able to reestablish in the old field area (Hironaka, 1986). On Anaho Island in Pyramid Lake in Nevada (Svejcar and Tausch, 1991) and at the Kipukas, or "land surrounded by lava flows," in southern Idaho (West, 1991), exotic annuals invade areas never grazed by livestock. The authors concluded that the opportunity to return to pristine conditions under which the exotic annuals were excluded was minimal.

West et al. (1984) studied sagebrush/semidesert range in west central Utah during 13 years of livestock exclusion and found no increase in native perennial grasses despite some years of above-average precipitation. In fact, further deterioration resulting in more profound dominance by woody species occurred, along with an increase in the exotic annual cheatgrass. The authors concluded that return to the sagebrush/native-grass mixture was unlikely but that a successional deflection was possible because of increased annual-grass populations and grass-fed firestorms, and that human intervention was necessary if native grasses were to dominate.

Sneva et al. (1984) compared data from rangelands grazed in a sustainable manner from 1937 to 1974 with data from adjoining areas excluded from grazing for the same period; before 1937, both areas had been overgrazed severely. Positive changes in native perennial herbaceous vegetation occurred both inside and outside of exclosures. Changes in sagebrush frequency were unaffected by protection or grazing. The primary suppressor of native perennial herbaceous species was brush dominance in grazed and in ungrazed areas. The authors concluded that cattle grazing in moderation allowed positive changes in herbaceous vegetation to occur, that exclusion of grazing would not check the growth of sagebrush, and that forced reduction of brush population would have to occur before native herbaceous vegetation could be stimulated further. Laycock (1991b) diagrammed these relations in a state-and-transition model.

The tendency for woody plants such as sagebrush and juniper to dominate in winter precipitation areas such as the Great Basin is well documented (Miller

et al., 1994; West and Tueller, 1972) (Figure 3.7). Unsustainable livestock grazing may have increased the rate at which dominance was achieved and decreased the fine-fuel load where periodic fire did not control woody vegetation. For ecosystems with competitive woody components, the question may not be whether grazing is sustainable with proper management but rather whether a healthy, functioning ecosystem is sustainable without proper management, including periodic manipulation of the woody component.

Effect of Historical Changes in Vegetation on Desertification

Desertification may be defined in a variety of ways but generally refers to permanent degradation of the productive capacity of land. It is claimed and believed widely that historical vegetative changes on western rangelands are associated with and perhaps a result of biological productivity degradation due to soil erosion and decreased diversity. Doubtless, down cutting or incising of stream channels has diminished the productivity of floodplains by lowering water tables and thereby limiting the moisture available to plants. Likewise, evidence indicates that increases of juniper, mesquite, and possibly certain other shrubs or trees may have caused excessive sheet or wind erosion due to lack of native perennial grasses and forbs in areas such as the Jornada Experimental Range of New Mexico. Numerous studies have shown that heavy grazing (Figure 3.8) can increase sheet erosion by reducing plant and litter cover and by compacting soil. Yet the assumption (Dregne, 1977) that changes in plant species composition, or *range condition*, indicate either a change in the biological productivity of the site or its permanent degradation seems unwarranted.

Two lines of evidence support this conclusion. A number of studies have shown that, in many arid/semiarid systems, plant species composition is not related closely to total biomass production (Chew and Chew, 1965; Frost and Smith, 1991; Tiedeman et al., 1991). This statement obviously would not be true where vegetative total cover or density was reduced drastically, as in livestock concentration areas, campgrounds, or roads. But when vegetative change consists mainly of the replacement of one species by another, such change need not indicate diminished biological productivity (although the change may lead to reduced productivity, as explained previously). Productivity rates may differ somewhat because of vagaries in rooting habit, water-use efficiency, or phenology, etc., but in general there seems no sound basis for concluding that vegetative change connotes land degradation.

This conclusion is confirmed by range managers' experiences with brush control and reseeding. Shrubs invading hundreds of thousands of rangeland acres have been removed, and if necessary native or exotic forage plants have been reseeded. Generally, these "poor condition" rangelands essentially were still as capable of producing forage plants. For example, Dormaar et al. (1978) showed that a crested wheatgrass seeded area still outproduced native range 40 to 50 years after it was seeded. Vallentine and Norris (1964) showed that soil occupied by creosotebush (*Larrea tridentata*) and little else was just as capable of vegetative growth as the soil not invaded by creosote bush.

Although in certain locales soil erosion has dimin-

Figure 3.7. Pinyon-juniper woodland in the Needle Range in Beaver County, Utah. Photograph courtesy of Roger E. Banner, Utah State University, Logan.

Figure 3.8. Example of poor (left) and excellent (right) condition sagebrush-grass rangeland in Idaho. Photograph courtesy of William A. Laycock, University of Wyoming, Laramie.

ished biological productivity irreversibly, there seems no basis for concluding that vegetative changes, whether caused by livestock grazing or other factors, indicate widespread degradation of range productivity. In many instances, of course, such change has been beneficial. For example, increased numbers of mesquite and juniper plants have furnished a valuable fuelwood resource, and increased numbers of woody plants have provided cover to wildlife species such as deer, quail, javelina, and many passerine species.

Sustainability of Managed Livestock Grazing

The sustainability of livestock grazing still needs to be addressed. Long-term studies have been conducted with that topic as a focus, but because western ecosystems respond in a variety of ways to grazing, no answer is applicable to the region generally. Also confounding are the factors contributing to vegetative change: lack of or too-frequent fire, climate change, exotic-plant invasion, livestock grazing system, and past overgrazing. Milchunas et al. (1988) provided an excellent discussion of grassland types and their reactions to climate and to grazing. With the issue's complexity in the foreground, a review of long-term studies, most of which were conducted under unrestricted or seasonlong conditions, will be presented.

Amount of forage utilized by grazing animals is, however, only one factor influencing the sustainability of grazing. Season of utilization, grazing system involved, and overall management are equally, if not more, important. Much of the early research, summarized next, emphasized utilization because the dominant grazing system was seasonlong. Absolute level of utilization has become much less important with the recent advent of rotation, deferred rotation, rest rotation, and other more sophisticated grazing methods involving systematic changes in the season of grazing and other management factors such as duration of grazing and rest, and kind and class of animal.

Prairies east of the Rocky Mountains were grazed extensively by bison and by other ungulates before livestock were introduced (Figures 3.9 and 3.10). The landscape, then, should be suitable for conversion to a livestock grazing system. For 13 years, Klipple and Costello (1960) studied light, moderate, and heavy grazing intensities (30, 40, and 60% forage utilization) in eastern Colorado. Areas excluded from grazing were maintained for comparison. Heavy use diminished both vigor and yield of the dominant grasses, i.e., degraded the range but did not remove the dominant species. At the moderate grazing level, dominant grasses were maintained, highly palatable plants survived, and the range was maintained or improved. Light grazing, which allowed even highly palatable plant populations as well as vigor and yield of dominant grasses to increase, was viewed as a range-improvement practice.

Beetle et al. (1961) studied bunchgrass range in the Bighorn Mountains of Wyoming for eight years. The dominant native grass, Idaho fescue, was maintained at 40 to 45% utilization. If improvement of the range had been a consideration, then lighter use would have been necessary. Because Idaho fescue was the preferred plant for grazing, proper use of that species automatically maintained the others.

Paulsen (1975) summarized range management for sustainable production on seven ecosystems in the central and southern Rocky Mountains. Each ecosystem was capable of being grazed sustainably, and ar-

Figures 3.9 and 3.10. Bison bull and antelope grazing in Wyoming and Montana, respectively. Photographs courtesy of Ty Smedes/ Nature Photography, Urbandale, Iowa.

eas of knowledge still required were noted. Improved riparian-zone- and stream-management were mentioned throughout as high priorities.

Forty-seven years of records for the Jornada Experimental Range were reviewed by Paulsen and Ares (1962) to provide grazing guidelines for the Chihuahuan Desert. The researchers studied communities of black grama (*Bouteloua eriopoda*) and tobosa grass (*Hilaria mutica*), as well as examples of each that had degraded as a result of brush invasion. Utilization levels below 40%, between 40 and 55%, and above 55% were studied. Conservative grazing (less than 40% utilization) was best for black grama, and moderate grazing (between 40 and 55%) for tobosa grass. Regardless of grazing treatment, precipitation level, especially when low, had a greater effect on black grama than any other factor studied did. The grass component in pastures invaded by shrubs declined for both community types, but grass pastures evidenced no such trend.

For optimal use and maintenance of plant communities, the authors suggested (1) that black grama pastures be grazed during dormancy and tobosa pastures during the growing season and (2) that periodic brush control be practiced on shrub invaded areas. Holechek (1991) reviewed work in the same ecosystem and concurred that conservative grazing promoted persistence and productivity of black grama ranges.

On big-sagebrush communities in northwestern New Mexico, no increase in herbaceous cover had occurred during 21 years of exclusion from grazing (Daddy et al., 1988). Moderate grazing resulted in a healthier understory than no grazing did, but heavy grazing undermined community health. Grazing exclusion neither checked sagebrush growth nor enlarged the herbaceous component.

Rice and Westoby (1979) surveyed vegetation inside and outside jackrabbit and livestock exclosures at 19 locations in sagebrush and salt-desert shrub communities in northern Utah. The authors concluded that the classic concept of range succession was invalid because the plant communities studied did not change after cessation of grazing. Observations by Sneva et al. (1984) and by West et al. (1984) already have been discussed. Laycock (1994) presented an extensive review of exclusion studies conducted in the United States, the results of which are in harmony with these studies.

On the other hand, research showing that moderate grazing often is beneficial to the plant community exists. Holechek (1991), Daddy et al. (1988), and Klipple and Costello (1960) mentioned that moderate grazing had a more positive effect on plant community than no grazing did. To substantiate the claim that vegetative diversity is promoted by moderate levels of herbivory, high or low levels of which have the opposite effect, McNaughton (1984) cited literature published from 1925 through 1981. The same researcher (1978) already had discussed several benefits to herbivore affected plant tissue.

This section has dealt with long-term studies of the sustainability of livestock grazing. In many instances, heavy and unrestricted, i.e., seasonlong, grazing was unsustainable (Lang, 1973; Tueller and Blackburn, 1974; Vale, 1975). Grazing livestock, along with decreased fire frequency, may play a role in the conversion of grassland to either shrubland or forestland (Brown and Archer, 1987; Walker et al., 1981). Unrestricted grazing by great numbers of wild ungulates, e.g., deer or elk, also can affect rangelands detrimentally (Chase, 1986; Cole, 1971) (Figure 3.11).

On U.S. public rangelands, plant communities typically have been affected by a variety of perturbations, including past overgrazing and reduction or elimination of fire. If only for watershed purposes, active range management, including appropriate grazing intensity and system, should be applied to return lands to as near optimal a condition as possible. Improved grazing-management may be all that is required in some areas. Some shrub communities in a lower successional but highly stable situation do not respond to a change in grazing intensity or even removal of grazing but require active management such as brush or tree control to return the community to a former condition (Laycock, 1991b, 1994).

Figure 3.11. Madison River, Yellowstone National Park in fall after the 1988 fires. Note how short the meadow has been grazed by elk and bison before winter. Photograph courtesy of Phillip J. Urness, Utah State University, Logan.

4 Grazing and Other Rangeland Uses and Values

The State of Public Rangelands

Grazing Removal: A Treatment

Western range use has altered landscapes, giving rise to vegetation frequently distinct from that existing before North America was settled by either Europeans or Native Americans. Recreating the landscapes present when Lewis and Clark or Fremont first visited the West probably is impossible. Certain ecological sites have become permanent homes to naturalized alien or nonnative plants, other sites at times closely resemble prehistoric plant communities and have much the same potential array of species.

Even an action as seemingly benign as eliminating livestock grazing will shift species composition in degrees ranging from hardly perceptible to dramatic. Removing human influence from a landscape is in fact a treatment whose effect on vegetation can be considered very good to very bad, depending on the viewer's perspective.

Since human settlement, substantial ecological change including the introduction of livestock has occurred in the West (Vavra et al., 1994). An array of new plant species has been introduced, and the relation between herbivores and plants has been altered because the relation between herbivores and predators has been altered. Additionally, the relation between fire and vegetation has evolved as a result of livestock grazing, fire control, weed invasion, and any other actions affecting fuel amount, type, and distribution.

Historically, the removal of fuel by livestock has reduced fire frequency substantially. Removal of livestock would not reverse this tendency; however, the invasion of competitive woody species such as western juniper *(Juniperus occidentalis)* has fireproofed numerous sites by crowding out the understory and thereby removing fine fuels. At other sites, naturalized introduced species such as cheatgrass have greatly increased fine-fuel prevalence and fire frequency. Cheatgrass is adapted better to many nonsandy, arid sagebrush sites than are the native species that it outcompetes. It also is extremely well adapted to fires, fueling those that burn out the competition.

As long as fire control is practiced, fire's historical role in the ecology of the West will remain dramatically altered. Because the influence of fire is pervasive and powerful, vegetation will reflect its presence, absence, or management. Even if humans had the will and the power to allow only those fires beginning "naturally," future fires probably would burn different areas at different seasons and with different frequencies and intensities than fires did before European settlement of the West.

The herbivore population also will reflect the extent and the nature of fire's influence. Domestic livestock species in some areas have replaced native fauna ecologically; in others, they have influenced ecosystem dynamics only minimally or more profoundly than the native fauna have. The interaction of herbivory, fire, and vegetative succession speaks to the need for careful examination of the long-term consequences of management decisions, including the removal of livestock, an act that might be perceived erroneously as "natural."

Range Condition

The range condition concept evolved because range managers evaluating successful management strategies needed to relate to one standard the current situation in a rangeland area. Another, more recent, term is *rangeland health*, which because of its various connotations will be replaced with the term *rangeland condition* in this publication. The Society for Range Management (1989) defines *range condition* as "the present state of vegetation of a range site in relation to the climax (natural potential) plant community for that site. It is an expression of the relative degree to which the kinds, proportions, and amounts of plants in a plant community resemble that of the climax plant community for the site."

Climax Theory: Not a Universal Truth

The range condition model in use in the United States was developed primarily from the writings and

the concepts of Clements (1916), who had studied succession and climax. Sampson (1919) proposed that, by measuring changes in plant species composition, the succession concept could be used to determine whether livestock grazing had had a deleterious effect on rangeland. Dyksterhuis (1949) proposed, based on the same concept, a formal procedure quickly adopted by the Natural Resources Conservation Service (NRCS), other federal land management agencies, and the range management profession as a whole. This system enabled managers to quantify range condition and led to the development of the range-site classification system.

According to Westoby et al. (1989), the system model made these assumptions:

1. There is only one stable state, i.e., the climax.
2. Retrogressive changes caused by improper grazing result in unstable states, which can be reversed by curtailment or elimination of grazing.
3. The pathway of vegetative change as rangelands improve (*secondary succession*) is identical to and the reverse of that in retrogression.

But for many arid and semiarid rangeland vegetation types, these assumptions may be invalid. To identify relatively stable, identifiable assemblages of plants and the transitions between them, Westoby et al. (1989) used a "state-and-transition" model. Laycock (1991b, 1994) indicated that most arid and semiarid rangeland vegetation communities or types in North America commonly have more than one lower successional state that may be quite stable.

The composition or range condition of vegetation in a stable state does not depend significantly on the reduction or elimination of grazing although the traditional range-condition model would predict such a dependency. In response to this difficulty, Friedel (1991) introduced to range ecology the concept of *threshold*, or "a boundary in space and time between two states and the initial shift across the boundary is not reversible on a practical time scale without substantial intervention by the range manager."

Those who advocate removal of livestock from public rangelands assume that increased production and improved range condition and wildlife habitat will result. But because a great many public rangelands are in a steady state, removal of livestock will result in little or no change in upland arid or semiarid plant communities (Laycock, 1994). Managers therefore must be able to recognize the stable state so that they do not expect a change in grazing to effect improvements in range condition in any time frame meaningful to management.

Range *Health* vs. *Condition*

Because the term *condition* is value laden and inexact, the National Research Council's (NRC) Committee on Rangeland Classification (CRC) (National Research Council, 1994) proposed that instead the term *health* be used to classify rangelands. The committee defined *rangeland health* as "the degree to which the integrity of the soil and the ecological processes of rangeland ecosystems are sustained." However, West et al. (1994), summarizing the work of a coordinating committee of Western Region Land Grant Universities, recommended against the use of the word:

> "Condition" and "health" have become value-laden terms. Because societal views and values can change, so does our interpretation of their meaning. "Health" is less appropriate because the metaphor of land as a person returns us to the superorganism style of thinking that plagued the range management profession in earlier years. The most general and permanent need of society is for ecosystems to maintain their "integrity." This is the essence of sustainability.

Despite this warning, the BLM has begun to use the term *health*, and the "Rangeland Reform '94" documents use the word exclusively instead of *condition*. This CAST task force report uses the word *condition*.

Management of Public Rangelands

All uses have costs and benefits, and consequences both known and unknown. Because benefits do not accrue equally among people, any course of land management action will benefit some more than others. This truism holds for preservation as well as for livestock grazing: both are legitimate uses of the land and both appropriate for certain areas. Neither is the sole intent of Congress or the will of the people, and either to the exclusion of the other would not be for the good of society as a whole.

To achieve the greatest good for the greatest number for the longest time is the guiding principle of conservation. Rangeland ecosystems must be understood so that past changes can be explained and future influences predicted. To sustain rangeland resource productivity, rangeland vegetation must protect soils

from accelerated erosion. Once this preliminary condition is met, there are many means by which benefit to society can be maximized. Choosing the best of these means is the preeminent challenge facing natural-resource planners.

Present Condition

All major federal land management agencies in the United States use the aforementioned climax-based range condition model. Because the three major federal land management and advisory agencies—the NRCS, the FS, and the BLM—use somewhat different terminologies and methodologies to determine range condition, comparing condition data from these agencies is difficult. The NRC–CRC (1994) concluded, in fact, that "the available data do not allow investigators to reach definitive conclusions about the state of rangelands."

The authors of this CAST report think that the NRC committee's response is an overreaction to inconsistencies in the data and agree with Box (1990) that U.S. rangelands, with some exceptions, are in their best condition this century. Even though methodologies and concepts have changed somewhat over time, the trend is clear and unmistakable. For example, BLM data (Table 4.1), showing a definite improvement in range condition since 1936, support this conclusion. Acreage in the combined category of *excellent* and *good* has doubled, and that in *poor* has decreased by more than half.

Exceptions, where range condition may have declined somewhat in the last decade, include areas in which the FS or the BLM has stopped using range improvement practices such as juniper and sagebrush control. In the absence of both this practice and naturally occurring fires, juniper and/or sagebrush normally thicken, and this results in lower range condition ratings on grazed and on ungrazed areas.

Data from the NRCS's National Resources Inventory indicate similar improvement over a briefer period (Table 4.2). Since 1963, amount of rangeland in combined *excellent* and *good* conditions increased 65%; that in *poor* condition decreased 65%. These private-land data were gathered by researchers using the same concepts and methodologies, and so the upward trends in land condition cannot be dismissed as artifacts of the methods used. Because the condition of private lands unquestionably has been improving over time, similar trends on BLM lands need not be viewed so skeptically.

Although no definitive data on the range condition of FS rangelands over time were available for comparison with BLM and private-land data, a similar trend would be expected because for more than 90 years the FS has managed grazing with the goal of improving range condition of the National Forests.

Desired Plant-Community

The mix of plants growing across a landscape depends on time, weather, grazing, fire, etc. Changes in species composition often can be predicted; some are caused, for instance, by specific management actions. Changes in vegetation usually affect other resources such as water, which should be captured, stored, and released safely; wildlife or livestock, both of which require suitable forage and cover; biodiversity; and beauty.

Composition of vegetation is used by managers to rate rangeland. Plant succession often does lead to a stable plant-community desirable to most people, and in such locales range management usually strives to allow plant succession to progress without disruptive management practice. Management's success can be measured in terms of how closely current vegetation resembles the presumed end point of plant succession.

On many other rangelands, however, no single, stable end point of plant succession occurs, and because the mix of plants for use on the area is suboptimal,

Table 4.1 Trends in range condition on lands administered by the Bureau of Land Management 1936–1989 (U.S. Department Department of the Interior, 1990b)

	Condtition				
Year	Excellent	Good	Fair	Poor	Unclassified
1936	2	14	48	36	—
1975	2	15	50	33	—
1984	5	31	42	18	4
1989	3	30	36	16	14

Table 4.2. Trends in condition on private rangelands, 1963–1987 (Laycock, 1991a)

	Condtition				
Year	Excellent	Good	Fair	Poor	Unclassified
1963	5	15	40	40	—
1977	12	28	42	18	—
1982	3	31	45	17	5
1987	3	30	47	14	6

later stages in succession may be undesirable. People concerned about the condition of rangeland must therefore have in mind clear objectives regarding a desired plant community (Society for Range Management, 1995). An important advantage of objectives is that they provide the foundation for planning management strategies and monitoring results.

For a given ecological site, the desired plant-community description should include the percentage by weight of each species or species group. While describing this community, range managers and other concerned individuals should focus on several important questions regarding land management planning, e.g., (1) What is ecologically and managerially feasible? (2) What will optimize the value of rangeland resources? (3) How will optimization affect other rangeland users? and (4) How will vegetation likely change?

Unless such questions are considered during planning, the goal of rangeland management has been assumed, by default, to be that of stabilizing the end point of succession. Frequently, growth of the vegetation that would produce excellent range condition by such an approach is neither possible nor feasible, and site productivity may suffer.

When the mix of plants or the percentage of the community constituted by each plant differs with time or landscape, the desired plant-community is described either broadly or in terms of short-term and long-term objectives. The exact percentage comprised by several perennial grasses may not concern managers so much as the total percentage of all grasses does. The objective for a plant species or for a species group may differ within a pasture or across a mountain range. The proportions of two species or species groups such as grasses and shrubs may be recognized as functions of either time since the last disturbance such as fire or management treatment. Then the landscape or the assemblage of sites within it can be described as having, in a specified portion of the acreage, a dominant plant-community, e.g., one dominated by sagebrush, and the rest of the acreage by herbaceous plants.

The desired plant-community, once described, serves as a common focus for concerned citizens and management agencies, who, having a common objective, determine and apply management actions. Livestock grazing and rest, fire, and all other tools that can be used to move vegetation toward an objective become options. No tool is inherently good or bad: each has economic, ecological, and social costs and benefits. Livestock grazing often has been used as a tool for vegetative manipulation. For example, the renting of sheep herds to graze and thereby to limit competition between trees and shrubs can be justified economically (Leininger et al., 1989). In most instances, however, the value of forage for livestock justifies the payment of a grazing fee to the land owner for the prescribed grazing treatment. On public land, livestock grazing is managed as a component of multiple use. Use of the land by many for a variety of purposes provides the optimal benefit. But if such a system is to succeed, the practicality of specific grazing and of other management-strategies must be considered during selection and planning of the desired plant-community.

Biodiversity

There is no commonly accepted definition of *biological diversity*. West (1993) defined it as a multifaceted phenomenon involving the variety of organisms; the genetic differences among them; the communities, ecosystems, and landscape patterns in which they occur; and the interactions of these components. Currently, understanding of the genetic variability of rangeland plant species is quite limited except that of a few rare, threatened or endangered species (Figure 4.1).

Discussions of community diversity tend to be value laden, e.g., to concern habitat or fragmentation of the habitat of threatened or endangered species. The typical description of community-level diversity focuses on number of species (*richness*) or on distribution of individuals (*evenness*) in each species. To describe species or community diversity adequately, however, it seems necessary to indicate what will be measured and how, i.e., what the index is and its scale.

Depending on how grazing is managed and biodiversity measured, livestock grazing probably will increase or decrease biodiversity. Both ungrazed and heavily grazed areas often will be less diverse than moderately grazed areas at stand, community, or landscape levels. Heavy grazing, especially if it alters structural diversity, e.g., removes trees or shrubs, probably will diminish plant and animal biodiversity. At community and at landscape levels, moderate grazing probably would increase biodiversity because certain areas will remain ungrazed while others will be grazed to various extents, including heavily. This increases patchiness of vegetation (Kellner and Bosch, 1992), which should increase diversity (Heady and Child, 1994).

Ehrlich (1990), Wuerthner (1990), and others opposed to livestock grazing say that prolonged overgrazing on public lands has decreased species diversity greatly. Range management literature is replete

with evidence that prolonged heavy grazing can change the productivity and/or the composition of most rangeland ecosystems. Certainly, abusive grazing that occurred 100 years ago all across the West may have decreased species diversity, but that degree of heavy grazing has not occurred on managed public lands for at least 50 years. Except in specific locations, moderate grazing during the last half century probably has not decreased species diversity of plants or animals and may have increased general diversity, especially at the landscape level.

Clements (1905) seems to have been the first to point out that diversity in terms of species number is not correlated linearly with succession stage. "The number of species is small in the initial stages; it attains a maximum in the intermediate stages; and again decreases in the ultimate formation, on account of the dominance of a few species." This relation between diversity and succession stage has been ignored by most critics of grazing on public rangelands and by many others.

Figure 4.1. Blowout Penstemon (*Penstemon eriantherus*), an endangered species in the Nebraska sandhills. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

Milchunas et al. (1988) found that the plant species-diversity pattern in grasslands that was caused by different grazing intensities was a function of both grazing history and available moisture. In the tallgrass prairie, i.e., subhumid prairie with a long history of grazing, diversity is limited at low grazing intensities because a few species dominate the canopy. Because of important differences in growth forms, diversity is greater at moderate grazing intensities. With increasingly heavy grazing, diversity declines as shortgrasses dominate greater portions of the community. Johnson (1961) reported similar relations on grazed and on ungrazed rough fescue grasslands in Alberta. Collins (1987) found on a tallgrass prairie in Oklahoma that plant species diversity was least on ungrazed, burned treatments; greatest on grazed and burned treatments; and intermediate on grazed/ungrazed, unburned treatments.

Discussions of the effects of grazing on biodiversity often ignore long-accepted principles of ecology and of wildlife habitat biology. These include the following: (1) plants are distributed in patches (Watt, 1947); (2) grazing usually increases *patchiness*, or habitat diversity (Kellner and Bosch, 1992); (3) *ecotones,* or edges at which various vegetation types meet, are important as wildlife habitat (Leopold, 1933) and create diversity on a landscape level; and (4) grazing generally inhibits the relatively few dominants in a system and promotes numerous secondary species instead (Clements, 1905).

Thomas et al. (1979b) stated that "Wildlife species richness should be approaching the maximum where the average habitat size is approximately 81 hectares. Pay special attention to the emphasis on 'average.' This indicates the existence of habitats both larger and smaller than 81 hectares. The larger habitats will accommodate those relatively few species that require blocks larger than the average while smaller habitats will increase the edge effect." By increasing habitat variety on the landscape level, heavy livestock-grazing in patches, unless quite widespread, improves habitat diversity *and* edge.

At the local level, grazing affects spatial distribution and plant species composition, creating a patchiness affecting avian habitat selection as well as the density and diversity of birds and other animals. Ryder (1980) found that the effects of grazing on avian habitat differed among areas. Where precipitation level is high, grazing may be desirable to open areas up and to increase patchiness and diversity. Effects of soil, slope, and exposure along with amount and distribution of precipitation may be more important than the effects of grazing are on food, cover, and

water for birds (Ryder, 1980).

Many studies have indicated that plant species diversity of seeded native or introduced species is greater on grazed than on ungrazed restored rangeland areas (Figure 4.2), e.g., reclaimed surface-mined lands (DePuit and Coenenberg, 1978; Kleinman and Layton, 1981; Laycock, 1989; Williamson, 1981).

Watersheds and Riparian Areas

In the western United States, early uncontrolled livestock-grazing by cattle and sheep severely overgrazed much rangeland. Concomitant road building, water diverting, mining, farming, and timber harvesting dramatically undermined rangeland productivity in only a few decades. In subsequent decades, rangelands across the West suffered from raging floods exacerbated by damaged watersheds (Forsling, 1931; Reynolds, 1911).

Since then, much research has investigated the links between upland-grazing management and the watershed processes of infiltration and soil erosion. Blackburn (1984) concluded that "Existing studies show no hydrologic advantage to grazing a watershed lightly rather than moderately. Some studies show no difference in soil loss, infiltration capacity, or soil bulk density between light, moderate or ungrazed pastures. Little information supports claims for specialized grazing systems. To evaluate hydrologic impacts adequately, additional studies, both intensive and extensive, should be conducted."

Stream and river corridors in the West generally have been altered by concentrated human use of this valuable part of the landscape, e.g., in road construction, mines, timber harvesting, recreation, irrigation, and water diversion. On rangeland, the most extensive but by no means the only significant impact has been from improper livestock grazing. All impacts have the potential to alter hydrologic processes upstream and downstream by altering the relations among water flow, erosion, deposition, and channel morphology.

Figure 4.2. Cattle grazing on seeded rangeland in Idaho. Photograph courtesy of Grant Heilman Photography, Inc., Lititz, Pennsylvania.

By providing much of the structural integrity for stream channels as well as the roughness needed to reduce water velocity, riparian vegetation has a dominant influence on watershed processes. Riparian systems integrate a variety of channel and floodplain features including *channel entrenchment*, or the inability of floods to spread over a floodplain; width; depth; gradient; sediment supply; substrate size and erodibility; and roughness caused by vegetation and channel form or pattern (Swanson and Myers, 1994).

Because of their influence on channel morphology and watershed hydrology, riparian vegetation and consequently grazing management are critical to the maintenance or to the restoration of fish habitat (Platts, 1991). Streams widening under the trampling of livestock hooves lose the cover of overhanging banks and deep pools. Where riparian vegetation, especially trees or shrubs, has been lost, and where stream channels are unusually wide, increased solar radiation may warm aquatic habitat excessively. Similarly, the loss of heat due to radiation may result in the freezing of streams to the bottom and eliminate much overwinter habitat. Excess sediment from bank erosion and diminished stream power during base flow may affect spawning beds or aquatic insects greatly. At times, the habitat of certain fish becomes degraded while that of possibly less desirable fish improves; at other times, the habitat for all fish is degraded or lost.

Riparian vegetation and therefore grazing management are essential for numerous wildlife species as well, some of which depend on trees or shrubs for nesting habitat and many of which depend on a diversified riparian vegetative structure clearly distinct from the structure of surrounding arid or semiarid rangeland vegetation. Because of their diversity, available water, and habitat characteristics, riparian areas provide critical or at least important habitat for most vertebrates in many range landscapes (Thomas et al., 1979c). To the extent that it enhances riparian diversity, livestock grazing likely will promote wildlife diversity, thereby creating the habitats required by a variety of species. Such grazing, however, easily can destroy specific habitat features and limit both vegetative and wildlife diversity.

Ecological dynamics differ dramatically from upstream to downstream reaches and among the many streams in a watershed or across a landscape. Certain erodible stream-reaches depend more on riparian vegetation and therefore on effective land management than others that may rely on rock armor for stability. Still other reaches erode so rapidly during swift, sporadic flows that they offer little opportunity for vegetative establishment. Even stable streams or streams depending on vegetation for stability differ dramatically in terms of the kinds of vegetation they can produce. The critical first step in riparian as in upland-range management is to develop a set of objectives matching a vision of sustainability and productivity both to the potential responses of stream and riparian ecosystem and to the needs and desires of people.

Effective managers solve obvious problems first. An inventory or even a walk-through often indicates relatively small areas in which livestock concentrate or stream reaches or pastures in which ongoing grazing damage is a problem. A use-map clearly indicates grazing hot spots and directs attention to the causes of any number of riparian grazing problems. To the extent that specific livestock come to riparian areas for specific purposes and at specific times, their behavioral traits can be managed.

Causes of concentrated grazing in a riparian area may include poorly distributed water or salt, grazing when riparian plants are more palatable than upland forage is, grazing with livestock (especially cattle, not sheep) unwilling to travel widely in search of the best feed (Glimp and Swanson, 1994), and grazing for long seasons (even with small stock numbers). Concentrated riparian grazing causes the most serious problems where and when vegetation or streambanks can be damaged most easily. For example, deep-rooted willows may be most preferred and susceptible in the late summer or in the fall (Kovalchik and Elmore, 1992), during which concentrated grazing may remove more than one or two year's growth. Sedges and grasses of a specific height may be needed for trapping sediment and for building streambanks during annual high flows, and on some streams grazing season may need to be adjusted to allow regrowth before winter or before summer cloudbursts (Elmore and Beschta, 1987). The correction of specific problems, whatever their causes, often is the logical first step and should be reflected in management objectives.

Riparian inventories and management plans should consider a comprehensive list of resources, opportunities, and problems and be part of a coordinated management approach (Phillipi and Cleary, 1993) to the entire watershed. Such plans are complicated inasmuch as they take into account water quantity, quality, and timing; fish and wildlife habitat; ranch economics; aesthetics; recreational uses; etc. To be effective, plans also must be concise and flexible.

When people with different types of training and experience are consulted, a variety of viewpoints can develop into a shared vision recorded as a set of clearly-stated riparian management objectives. To keep these objectives concise, important areas that will change in response to management, as well as channel features and plants whose conditions will indicate degree of success, should be emphasized. The proper functioning condition assessment of the BLM (U.S. Department of the Interior, 1993) should help focus attention on specific needs for management. Within a given region, other similar but well-managed stream reaches usually indicate which plants or channel characteristics may be desirable. Classification of riparian factors, including vegetation and stream morphology, can keep objectives fair and focused.

Until all management issues of higher priority have been addressed, streams unlikely to respond quickly to grazing management should not be targeted for riparian management time and money, which are limited. On incised or downcut streams, vegetation and grazing management can help create desirable channel forms and functions on broadened reaches (Swanson and Myers, 1994; Van Haveren and Jackson, 1986). Narrow gullies concentrate the energy of flowing water and are very unstable. Wide gullies spread water and may catch sediment; a meandering, active channel with corner pools and riffles within the old gully can be developed with the use of vegetation. But even on streams with restored riparian vegetation and effective grazing management, outside banks may be too steep for vegetation to prevent meander extension. In such instances, local erosion will continue to widen the floodplain.

Objectives, which must be based on understanding important interrelationships and the potential for change, also must be site or stream-reach specific, achievable, measurable, and economically justifiable. Costs and benefits of any management alternative must account for on-site, downstream, and upstream effects. The potential for downcutting and the effects of sediment delivery rates should be understood, and the fact that some streams are vulnerable, others resistant, and others resilient remembered. Monitoring is essential (Gresswell et al., 1989).

With objectives in mind, the team of individuals with various types of training and experience chooses management actions that may affect land miles away from the benefitting stream. For instance, where

lack of well-distributed water for livestock causes riparian overuse, water development becomes an obvious part of the solution. Sometimes solar power and a well are the cheapest, most reliable means of ensuring ample water; sometimes springs can be developed. Water developed or piped over many miles may pay for itself simply by increasing available forage supply or by allowing well-managed grazing on a flexible schedule. Herding commonly helps distribute cattle over large range-pastures, especially if adequate forage, water, and salt are scattered. A variety of techniques can be used to improve upland-range vegetative productivity or palatability. Improved vegetation in turn may draw cattle from riparian areas or, if cattle are fenced, replace riparian forage during certain seasons.

Wide valleys in which winding streams commonly flood large areas grow more forage than any other place in a watershed does (Figure 4.3). Many valleys thus are or could be fenced as separate pastures. While conserving forage for use when its value may have increased, such riparian pastures keep outside stock from concentrating in the riparian area. When small, productive pastures are controlled, grazing plans can be devised to improve stream channels and to grow more and better forage. Even in small pastures where use is controlled, developing water away from creeks relocates some trampling damage away from sensitive banks (Clawson, 1993). Frequently, springs or tributaries can be piped to a trough, or a pond in the floodplain may fill from a high water-table.

On ranges with cold winters, spring grazing is appropriate because hillside grasses are green and palatable and because cattle rarely concentrate in riparian areas. To avoid upland-range grazing problems, rotation or early grazing allows plants time for periodic growing-season recoveries. Generally, rotation strategies allow riparian and other plants a time to rest, and plants recover naturally from grazing if they have the opportunity to grow when conditions are favorable and growth period is sufficiently long. Grazing rotations that are too long, too frequent, or timed consistently for a sensitive season are stressful for plants.

It is recognized widely that riparian areas can be grazed safely by livestock if they graze during the appropriate season, if grazing period is short and rest period long, and if stocking rate does not overstress key vegetation needed by the riparian system for critical functioning. Along some streams, the small amount of forage available may be worth neither the risk nor the bother of intensive-grazing management; in such instances, exclusion may be best. Gaps in fences between exclosures allow stock to continue using stream water, and the small disturbed area is a minor problem along rocky or well-confined streams. Water piped from the stream to tanks located across the fence is another alternative. One important management consideration is time and money for fence maintenance.

When riparian areas are distributed widely or are an economically important component of the forage base, livestock management focuses on a broad set of multiple-use objectives. To be useful, objectives must be based on an understanding of the many important interrelationships involved and the potential for change in both the short and the long term.

Figure 4.3. Wide riparian valley in Oregon. Photograph courtesy of Marty Vavra, Oregon State University, Burns.

Wildlife Habitat and Grazing

Well-managed livestock operations on productive public- and private-rangelands generally are compatible with habitat needs for many wildlife species, especially in the light of other potentially more adverse uses of these lands (Sharpe, 1992). Almost invariably, however, positive or neutral interactions among certain livestock and wildlife species are accompanied by negative interactions among other species (Severson and Urness, 1994).

Major controversies have centered on poorly managed grazing areas, broadly defined as *overgrazed*, or grazed to excess, a term widely applied but often misunderstood. The Society for Range Management (1989) defined *overgrazing* as "continued heavy grazing that exceeds the recovery capacity of the community and creates a deteriorated range." Greater agree-

ment usually can be found with the statements that much of the damage to wildlife habitat occurred in an earlier era of uncontrolled grazing (Williamson, 1992) and that progress toward recovery has been slow but demonstrable since controls were enacted in the first half of this century.

Featured Species

Programs for wildlife habitat development and research have been chronically underfunded by federal and state agencies. The focus of efforts typically was for consumptive, or game, species, especially wild ungulates such as deer and elk. This state of affairs grew out of traditions rooted in the origins of the Conservation Movement of the late nineteenth century, when the decline in big-game populations was an urgent concern. The result was a broad based, organized effort by governmental and private institutions to create a funding source.

This source was abundant from the first and has had strong staying power. In contrast, interest in nongame species conservation, although historically widespread, began to generate comparable funding and influence only recently. Consequently, considerably greater effort has been expended to minimize grazing impacts on or to maximize benefits to so-called featured species, e.g., wild ungulates (Figure 4.4), waterfowl and upland game-birds (Sedevic et al., 1990) (Figure 4.5), and their habitats (Thomas and Maser, 1983) than has been expended for nonconsumptive wildlife (Figures 4.6–4.8). Recently, the featured species have become the threatened, endangered, or sensitive species listed for special attention.

Relations among the various classes of livestock and native ungulates in most types of North American rangeland communities have been examined extensively. The vast majority of sources tends to assume a predominant interaction, i.e., resource competition, and attempts to assess the magnitude of its impact (Severson and Medina, 1983; Wagner, 1978). Obviously, magnitude of impact is population-density dependent, i.e., a level of combined use is tolerable up to a threshold because spatial or temporal separations occur and resource-use overlaps seldom are complete.

The strictest definition of *competitive effects* includes negative impacts on two or more populations; but some parties have accepted within the definition a unilateral impact, especially when native ungulates and domestic livestock interact (Mackie, 1976). Of the many possible resources, e.g., cover, water, and space, for which grazing populations compete, only forage has been studied extensively; other resources include cover, water, and security space. Mackie (1985) and Lonner and Mackie (1984) suggested that few range studies have shown competitive exclusion and that in fact many have "provided better evidence for coexistence." A similar conclusion was reported by Vavra et al. (1989). Observations that wild ungulates are more abundant or more frequently seen in livestock-free areas may indicate social intolerance between the animals although this proposition seldom has been proved (Nelson, 1982; Peek, 1986).

Because positive as well as negative relationships are possible among wild and domestic ungulates, the major categories of interaction are *competitive* and *cooperative* (Mackie, 1981). The latter has received

Figure 4.4. Bighorn rams along Yellowstone River near Gardiner, Montana. Photograph courtesy of Tom Rosburg, Colo, Iowa.

Figure 4.5. Prairie chicken on booming ground lek in Nebraska. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

much less attention from researchers than has the former. In the short term, benefits to one species can derive directly from increased forage production, access, and quality, all of which can result from the foraging activities of an interacting species (Anderson et al., 1990; Council for Agricultural Science and Technology, 1975; Grover and Thompson, 1986; Jourdannais and Bedunah, 1990). Benefits to a species also can derive indirectly from plant-community composition and structure changes due to progressive, regressive, or neutral successional shifts driven by long-term selective foraging by other species with quite different preferences (Urness, 1990).

The concepts of facilitative grazing and resource partitioning were developed primarily from observations of natural mixed-species ecosystems in East Africa (Jarman and Sinclair, 1979; McNaughton, 1984) but apply as well to common-use situations involving wild and domestic ungulates in western North America (Hanley and Hanley, 1982). The *facilitative grazing* concept implies positive effects of one herbivore or an assemblage of herbivores on other herbivore species by means of the altering of botanical composition, the increasing of productivity or of accessibility to particular forage species, the affecting of forage nutritional quality, and the increasing of habitat diversity by structural altering. The *resource partitioning* concept implies that all animals are, to a degree, selective foragers having evolved to use various portions of plant-community composition (Demment and Van Soest, 1985; Hofmann, 1988). Selective foraging thus can be aided by the actions of associated animal species when unusable plant materials that interfere with foraging efficiency dwindle or are altered by body size, gut morphology, or mouthparts (Hanley and Hanley, 1982; McNaughton, 1978).

Sustained selective foraging by great numbers of one species, whether wild or domestic, causes plant-community compositional change away from the plants most preferred by that species. Thus, cattle

Figure 4.6. Burrowing owl in Nebraska Sandhills. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

Figure 4.7. Upland sandpiper in Nebraska sandhills. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

Figure 4.8. Red fox and kits. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

alone may transform a range with a perennial grass-forb aspect to one in which shrubs dominate (Smith, 1949; West, 1989). On the other hand, concentrations of browsing animals such as goats or deer (Figure 4.9) can attenuate shrub populations, favoring herbaceous species through shifts in competitive advantage. At times, sheep grazing over many winters can diminish sagebrush population and allow the herbaceous understory to increase in vigor and in production (Frischknecht and Harris, 1973; Laycock, 1967).

Rangeland managers increasingly are using these fairly predictable relations to alter community composition and structure for specific goals. Recent symposia (Baker and Jones, 1985; MacMillan, 1986; Peek and Dalke, 1982; Severson, 1990; Vavra, et al., 1994) have explored the potential of prescribed foraging, that is, of the planned integration of domestic and wild ungulates. The best operational examples seem to be on the private ranches with mixed operations, as occur commonly in Texas and are expanding elsewhere in the West (White, 1986).

Figure 4.9. White-tailed buck, a browser on shrubs and trees. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

Despite the prehistoric prevalence of vast grazing herds of bison, elk, antelope, and deer on prairie potholes, waterfowl-breeding habitat in the northern Great Plains and elsewhere, little has been done to assess grazing influence on reproductive success. Indeed, Kantrud (1990) suggested in his review that lack of grazing has led to wetland deterioration and to reduced habitat value in many pothole areas, especially in the eastern sections, where tall, dense stands of emergent vegetation and tree encroachment on pond margins have curtailed waterfowl use greatly. Many duck and shorebird species seem to reproduce much more successfully under light or moderate than under heavy or no grazing.

Additional research is needed, but potential benefits from planned grazing systems involving more than one pasture seem especially positive for waterfowl habitats (Sedivec et al., 1990). Bryant's (1982) review of 214 studies of grazing systems and wildlife habitats showed that most planned grazing systems tend to benefit wildlife more than either yearlong or seasonlong grazing does.

Prescribed livestock grazing on upland game-bird habitat may not engender the generally negative view that less controlled grazing does. Guthery (1986) and Guthery et al. (1990) have characterized as positive the grazing prescriptions and systems that they reviewed in terms of potential for habitat development or impact on northern bobwhite quail in the Southwest—a bird whose habitat needs range from nearly bare areas to dense cover throughout the year—and other species.

Livestock grazing, even when fairly intensive, has not been directly involved in declines of sage grouse or sharp-tailed grouse in the West, but habitat alteration to maximize forage production (seeding grass monocultures to replace native vegetation complexes) has been involved indirectly (Autenrieth, 1981). From 1950 to 1970, use of chemical, mechanical, and prescribed fire means in broadscale brush-control treatments to increase grass greatly affected habitat values over vast areas (Braun et al., 1977). Recently, both heightened sensitivity to habitat needs and efforts to restore habitat have reversed this negative trend in many locales (Heady, 1988). Still, populations respond differently despite improved grazing-management.

Grouse population responses to improved grazing-management, for example, are not universally positive. Many factors in addition to grazing affect upland game-bird populations. These factors depend partly on time and space and are understood poorly because monitoring is sporadic. Extensive wildfires have mod-

ified sage grouse habitats noticeably over large areas of the Snake River Plains in Idaho and the Great Basin, because large monotypic cheatgrass or postfire seeded crested wheatgrass stands are poor habitats for grouse.

Because of their negative effect on both species diversity and vertebrate densities, Graul (1980) warned against planting exotic species such as crested wheatgrass (*Agropyron cristatum*) on rangeland. His conclusion was based on comparisons of large (several-thousand-hectare) blocks of crested wheatgrass with those of native vegetation. The common practice is to plant much smaller (several-hundred-hectare) areas with exotic species. These smaller areas provide increased forage production and, on a landscape scale, increase habitat diversity and edge, thereby stimulating plant, bird, and animal diversity (Laycock, 1980). Such mosaic pastures should be fenced and managed separately whenever possible.

Nonconsumptive Wildlife

State and federal wildlife programs have been driven by economic considerations for many decades, and the constituencies for noneconomic species still are relatively small and of recent origin and influence. Until recently, the direct funding of nongame programs has been meager in comparison to the funding derived from compulsory hunting and fishing licenses self imposed by those constituencies. Only a few specific studies and a number of related descriptions of vegetative community structure and of habitat requirements are the major data sources available regarding nongame wildlife (Holechek et al., 1982; Kie and Loft, 1990; Maser et al., 1984; Oakleaf et al., 1983; Salwasser et al., 1980).

Even prolonged heavy grazing may not be detrimental to all nongame species. For example, the mountain plover nests only in fairly heavily grazed shortgrass steppes. Although it nested originally where the stature of grass had been diminished by buffalo grazing, it now nests successfully only where cattle graze heavily (Graul, 1973, 1975; Ryder, 1980). By limiting the habitat available for nesting, elimination or drastic reduction of cattle grazing could accelerate the decline of the mountain plover. Each environmental state serves as a habitat for specific organisms; whether change of state is good or bad depends on viewpoint, i.e., on whether the viewer's goals and objectives are met as a result.

Riparian areas are the most productive and critical habitats for nongame species and, according to Thomas and Maser (1983), the most disturbed by management activity because they undergo concentrated livestock and recreational use. Symposia have been devoted to this issue (Cope, 1978; Johnson et al., 1985; Menke, 1983), which cannot be explained usefully in a brief review. To summarize, however, grazing has affected nongame habitat values negatively and in direct relation to use intensity and duration. This effect may be most significant where grazing changes vegetative structure by reducing or eliminating tree or shrub layers or by changing hydrology and by shrinking riparian area.

Grazing impact is not without benefit. For example, Marlow et al. (1989) indicate that both limiting grazing access time and delaying use until soil moisture levels in streambanks are low can improve riparian areas markedly. Platts and Nelson (1989) suggest that vegetative types, e.g., sedges, *Carex*, are better able than others to maintain stable streambank characteristics under moderate use. Although certain types do not respond even to light use, significant improvement often has occurred when rotational or other grazing systems have been instituted (Hall and Hampton, 1988). Shrub-willow stands at high elevation in Wyoming thicken with light or no use; cattle increase structural diversity by creating tunnels, which make habitats more attractive for nongame generalist birds (Krueger, 1985a) and for small mammals (Krueger and Anderson, 1985).

In northeastern Colorado, prolonged grazing of a riparian area changed habitat structure by removing most willows (Schulz and Leininger, 1990). Exclosures were 40 ha and covered 2.5 km of stream. Species richness of birds was greater in grazed areas than in the exclosure, but species richness of small mammals was the same in the two areas. Overall, within-habitat diversity of nongame species was similar in the two areas. Because the index of overlap was quite low, species compositions both inside and outside the exclosures differed greatly and between-habitat diversity across the entire riparian zone was great. In short, a mosaic of grazed/ungrazed riparian areas should lead to the greatest overall bird and small-mammal diversity (Schulz and Leininger, 1991).

Kauffman and Krueger (1984) reported that a full-season, short-duration grazing system in Oregon had no effect on the breeding densities of selected migratory birds. In another study (Kauffman et al., 1982), total avian densities were the same for grazed and for ungrazed areas. Wiens (1976) concluded that grazing season influences avian communities on grasslands more than grazing intensity does.

In summer, nongame birds in southern Arizona were more abundant in grazed than in ungrazed ar-

eas; in winter, there was no such difference (Bock et al., 1984). In grazed grasslands, the abundance of individual bird and mammal species was significantly different from that in ungrazed grasslands. But because of their greater mobility and more visual orientation to foraging and to avoiding predators in most open habitats, birds were favored over small mammals. Although neither the grazed nor the ungrazed area had significantly more species than the other did, different species were supported. Diversity therefore was greatest when grazed and ungrazed areas were considered jointly.

Medin and Clary (1990) reported similar results in riparian types in Idaho. In another study, Medin and Clary (1991) compared a riparian exclosure protected from grazing for 11 years with an adjacent grazed area in Nevada and found no differences in terms of bird density, species richness, species composition, total standing crop biomass, or other attributes of breeding-bird communities.

On a cottonwood bottomland in northeastern Colorado, three falls of moderate cattle grazing had little effect on the densities of six bird species using ground shrub resources. In the same area, small-mammal habitat use and seasonal-habitat shift on cottonwood bottomlands were similar on pastures grazed in the winter and on ungrazed areas (Sedgewick and Knopf, 1987).

Upland habitats and grazing interactions have very different effects on nongame wildlife. Wiens and Dyer (1975) stated that breeding-bird density is low and avifaunal variety limited on rangelands generally, even when the land is in a high ecological successional stage.

Very heavy grazing had a negative effect on passerine abundance in riparian areas in southeastern Oregon (Taylor, 1986). Since 1940, bird counts had been 11 to 13 times higher on ungrazed areas than on areas severely disturbed by dredging or heavy grazing. Differences were highly correlated with volume and height of willows, both of which increased with interval since grazing.

Changes in vertical and in horizontal structural diversity have profound influences on birds, but shifts in plant community composition that affect some species adversely usually affect others favorably. Intensive grazing that induces marked vegetative change usually is accompanied not just by reductions in numbers of species but also by shifts toward an avian community composition resembling that in drier or more open habitats. Thus, grazing management tends to alter bird species-composition more than it does bird density. In a fashion, bird groupings parallel successional plant groups as decreasers, increasers, and invaders. But shifts in fauna most closely track shifts in plant community structure from herbaceous plants to either shrubs or trees, or vice versa. These shifts may result from succession or retrogression caused by grazing or simply may be related to the timing of naturally recurring fire. Simplified successional models may mislead.

Small-mammal density of certain rangeland types increases in grazed areas (Bock et al., 1984; Schulz and Leininger, 1991), but density differences may be small. That rodents such as ground squirrels, prairie dogs (Figure 4.10), and kangaroo rats are adapted to heavy grazing regimes and to short grasslands is a positive development for many raptor species, which are provided a large and vulnerable prey base (Snyder and Snyder, 1975). Control of these mammal species by direct (poison) and indirect (nongrazing) means would negatively affect hawks and owls on tall grasslands. A similar relation exists for jackrabbits on grass/shrub ranges over vast areas of the West (Figure 4.11).

Most studies comparing the diversity of grazed with that of ungrazed areas fail to calculate the *diversity*, i.e., species richness or evenness, of the combined grazed/ungrazed area, even when study sites are adjacent. Schulz and Leininger (1991) made such a comparison and found a much greater diversity of birds and small mammals in grazed/ungrazed riparian areas than in either separate treatment. Only when similar analyses are conducted of numerous other rangeland-vegetation types will it be possible to document on the larger, landscape scale the impact of grazing on diversity.

Figure 4.10. Black-tailed prairie dogs in Awapa Plateau, Utah. Photograph courtesy of Phillip J. Urness, Utah State University, Logan.

Figure 4.11. Black-tailed jackrabbit in Montana. Photograph courtesy of Ty Smedes/Nature Photography, Urbandale, Iowa.

The upshot is that livestock grazing intensities from low to high have both negative and positive influences on various nongame bird and mammal species. Because response depends on vegetation type, any kind of prescribed grazing will outrage certain constituencies. Even rare or endangered species might be either helped or harmed by drastic adjustments in present grazing practices, and no generalizations are possible.

Because faunal responses are so variable, the appropriate course may be to provide reasonable spatial (patchiness) and temporal (successional stage) diversity over a landscape *mosaic* (DeGraff and Tilghman, 1980)—or combined ungrazed, lightly grazed, moderately grazed, and heavily grazed area, which probably would maximize diversity in most landscapes. Moderate, well-managed grazing usually results in such a combination.

Timber Management and Grazing

Trees and forage can be produced from the same lands, but mature forest types can have minimal or temporary forage values (Alexander, 1987; Allen, 1988). Much forage is available in the more open zones, e.g., in the ponderosa pine and in drier portions of the Douglas fir. In interior western regions, Douglas fir typically grows on mesic north-facing exposures but is integrated with grassland or grass/shrub communities on other upland aspects; these are grazed as combined units. Other coniferous-forest types, e.g., spruce/fir, lodgepole pine, and cedar/hemlock, either are poor forage producers or at best supply brief flushes of forage after timber harvest and/or wildfire. Such pulses may last 10 to 20 years postdisturbance or less, depending on how rapid natural or artificial regeneration of trees is and the extent of precommercial thinning. Deciduous forests, e.g., aspen, are a special case in the West because they often produce great quantities of forage and therefore are quite valuable to wild and domestic ungulates and to many other users.

Detrimental Effects of Grazing

Early references typically focused on grazing's negative effect on timber management. Before the 1960s, timber managers nearly were unanimous in condemning wild and domestic ungulates as detrimental to timber production. Primary concerns were that soil compaction or structure loss would affect tree growth in grazed forests (Linnartz et al., 1966; Lull, 1959) and that physical injury to young trees from trampling and/or severe defoliation resulting from the removal of shoots and buds would slow growth or leave trees permanently deformed and susceptible to disease (Browning and Lauppe, 1964; Krebill, 1972; Pearson, 1950). The potential for injury is demonstrated by use of goats to control brush and tree sprouts (Wood, 1987).

The magnitude of browsing effects on tree establishment and growth depends on many variables, including animal type and population density, tree species and age, and alternative forage type and availability. The last factors are very much a function of season of forage use, as dictated by understory type, phenology, and attractiveness. Injury, however, may be unrelated to foraging: young trees, for instance, may be damaged severely by ungulate rubbing or scraping (Gartner and Thompson, 1990).

Although trampling of seedlings also is a factor, Shepherd et al. (1951) showed that, despite higher seedling mortality rate, pond-pine seedling growth rates and stocking densities were higher in the Southeast than elsewhere because more seedlings emerged on grazed areas. Seedlings can be uprooted or damaged mechanically by cattle trampling (Alexander, 1987), especially where animals congregate, but seldom have losses been so great that inadequate seedling stocking has resulted (Eissenstat et al., 1982). Similarly, sheep trampling caused no damage to planted Douglas-fir seedlings in southwestern Oregon (Black and Vladimiroff, 1963).

Managed grazing at either light or moderate levels minimizes damage to young trees. Child et al. (1985) reported little injury by goats to shortleaf and loblolly pines in Arkansas if the animals were removed

as they began to consume pine needles in late summer, when other forage became limited. According to Hedrick and Keniston (1966), sheep affected Douglas fir in Oregon negligibly when palatable-forb use was below proper-use standards (50%). McLean and Clark (1980) showed that uncontrolled grazing by cattle on lodgepole pine clear-cuts in British Columbia caused severe trampling damage to seedlings. When grazing was controlled adequately, damage to seedling pines and spruce was minor, and mortality often was insignificant compared with losses due to natural causes.

Heavy grazing may alter normal environmental successional pathways. For example, Baker (1991) described an area in Colorado where Engelmann Spruce (*Picea engelmannii*) was displaced by bristlecone pine (*Pinus aristata*) because grazing had caused a more xeric microclimate.

On trees, the impact of wild ungulates frequently is more severe than that of livestock, especially when the wild population is large and alternative herbaceous and browse forage is scarce (Crouch, 1974). Kosco and Bartolome (1983) observed that cattle and deer grazing in combination in northern California did not browse significantly more seedlings than deer grazing alone did. Damage to very young trees was extensive on coastal Douglas-fir clear-cuts when black-tailed deer population was large (Hines and Land, 1974) but damage was restricted almost completely to the late fall and winter, when other forage was limited. On planted clear-cuts, deer may maintain vegetation in a more open, short-statured condition favorable to animals such as hares and mountain beavers, which also damage trees.

Because they tend to be more attractive forage, deciduous trees generally are more susceptible to browsing damage than conifers are. Aspen, for example, is an important rangeland type in the West, and many palatable herbaceous and browse forages are associated with it in the central part of its distribution (Mueggler, 1985) (Fugure 4.12). Heavy grazing by livestock (Smith et al., 1972) and by deer or elk (Mueggler and Bartos, 1977) can prevent aspen regeneration where small areas are cut or where sprouting response is weak. In contrast, heavy grazing by wild and domestic ungulates seldom prevents regeneration over large cut or burned areas. Because continuous heavy browsing of suckers in mature aspen stands often precludes regeneration, periodic and temporary adjustment of grazing practices so as to allow release of suckers for stand replacement is necessary (DeByle, 1985).

Beneficial Effects of Grazing

The effects of herbivory on establishing trees are not all harmful. Research and management attention on reforestation recently has focused on the use of livestock to control understory vegetation competing with young trees for soil nutrients, moisture, and sunlight. This management practice was compelled by the judicial suspension of herbicide use, the preferred method of foresters, to control early-successional vegetation in California and in the Pacific Northwest (Thomas, 1985). McDonald and Fiddler (1988) reported the use of sheep to control competing vegetation.

Mesic coastal forest types and certain drier interior types produce heavy postfire or postlogging growths of herbaceous species and shrubs, which often compete with newly planted or seedling tree species and reduce their rates of diameter and height growth. Sheep grazing, which decreases competition of both herbs and shrubs with trees, however, increased these growth rates significantly in Douglas-fir plantations (Sharrow et al., 1989).

Similarly, Doescher et al. (1989) reported improved growth of ponderosa-pine and of Douglas-fir seedlings on cattle grazed plantations in southwestern Oregon. Decreased competition for soil water because competing plants were eaten by cattle on grazed areas was believed the reason for significantly increased seedling volume after three years of heavy use in late May and/or in early June. Improved nutrient cycling with grazing also has been suggested as related to improved growth rate of trees (Adams, 1975; Krueger, 1985b).

Grazing sometimes achieves the objective of decreasing understory vegetative height and density but

Figure 4.12. Aspen, an important tree for browsers in the West. Photograph courtesy of Marty Vavra, Oregon State University, Burns.

does not improve tree growth rate. Damage was very light to white spruce and to red pine in northern Minnesota plantations after five years of cattle use (Rustad, 1988), and the mortality of trees was almost eliminated. Growth rates of red and jack pine did not differ, however, from those of same-aged trees in ungrazed areas. Similar relations were reported in California (Allen and Bartolome, 1989; Kosco and Bartolome, 1981, 1983). Under such conditions, an advantage due to wildfire-hazard reduction or simply an additional benefit in resource use may justify livestock grazing of regenerating stands (Leininger et al., 1989; McLean and Clark, 1980).

Forest Management for Wildlife and Livestock

In response to the increased amount and improved quality of forage, both livestock and wildlife are attracted to transitory range in cutover areas. In Colorado, tame deer watched by observers foraged in logged areas three times as long as they did in uncut forests (Wallmo et al., 1972). Preference for logged or burned areas peaks some years after logging or burning events and then declines. For instance, maximum use by elk in western Oregon was observed six to eight years after cutting (Harper and Swanson, 1970). In relatively dry interior forest types before canopy closure, conditions favorable to ungulate use last considerably longer—perhaps more than 20 years (Allen, 1988).

After an initial increase, forage production generally declines inversely but not linearly with tree canopy closure (Bartlett and Betters, 1983). Thus, from the ungulate-use standpoint, tree thinning operations to promote maximum diameter growth between timber harvests also prolong forage availability. Then again, security cover may be as important as or more important than forage for wild ungulates (Thomas et al., 1979a), so cutting and thinning operations must take this need into account.

Outdoor Recreation/Aesthetics

People enjoy various outdoor experiences, and recreation planners use a recreation-opportunity spectrum to illustrate this diversity (Driver et al., 1987). Ideally, there is a mix of opportunities available for those who enjoy rangeland recreation, a mix including land in the wilderness as well as in very developed parks. In most recreational landscapes, the primary requirement is harmony between the recreational experience and the land. Few people enjoy seeing trampled areas around stock tanks or stream crossings. But stock tanks appropriately placed to reduce the riparian impact of watering at a stream often would be acceptable as long as recreational users expected to see livestock and evidence of human activity.

Just as some hike miles to find a valley with no evidence of other humans or livestock (Figures 4.13 and 4.14), others pay handsomely for the opportunity to ride horses on a dude ranch. A very large segment of the public enjoys seeing pastoral landscapes on which cattle, sheep, or horses graze. The opportunity to see rangeland livestock grazing is for many an integral part of a vacation in the West, just as the opportunity to see very old farmsteads and historic landmarks is part of one in the East. For many, animals are a means of connecting with land, history, and cul-

Figure 4.13. Beautiful mountain meadow covered with many species of forbs, grasses, and sedges. Photograph courtesy of Marty Vavra, Oregon State University, Burns.

Figure 4.14. High mountain meadow with yellow lupine. Photograph courtesy of William A. Laycock, University of Wyoming, Laramie.

ture. For example, there is a passionate group of wild-horse enthusiasts who are concerned about the welfare of wild horses.

Management Tools

Many tools, about which comprehensive textbooks have been written, exist with which to manage rangeland vegetation. In this brief section it is impossible to do more than outline some of the principal tools, e.g., grazing and fire, used to control unwanted species or to establish desirable ones.

Grazing

Seasonlong or continuous grazing generally is considered to have been historically excessive on American rangelands. Yet seasonlong use is not an inherently inappropriate management system. If managers use all the proper tools of their field to obtain a fairly uniform grazing distribution after range readiness and if the correct utilization level is reached, seasonlong grazing need be neither destructive nor undesirable (Heady and Child, 1994). The tools applicable in sophisticated grazing as well as in seasonlong grazing systems include stocking rate; fence location; water, salt, or supplement distribution or placement; riding or herding; seeding; fertilization; fire or other brush-control means; and grazing animal distribution.

All grazing systems control the grazing season in individual pastures. Utilization level desired, either overall or of key species, is defined ahead of time and may depend on location, time, and management objectives. Important features dictating grazing system use include when, or at what season, a plant is grazed; how long grazing lasts; how much use is made; and how much time elapses before plants recover between grazing periods.

Kinds (species) and classes (sex or age groups within a species) of animals use rangeland topography and plant species differently, and grazing system managers must take this fact into account. Cattle generally prefer grass whereas sheep often prefer grass, browse, and forbs. In mountainous terrain, cattle tend to stay in bottom, or riparian, areas whereas sheep prefer slopes and hilltops. Thus, grazing by one species will have a different effect on vegetation than grazing by another will. Different sexes or ages, e.g., cows with calves versus yearlings; or breeds, e.g., English, Continental, Zebu, or crossbred types also may use rangeland differently. To achieve range-management design objectives, all these differences must be considered in grazing system design.

Fire

Both naturally occurring and anthropogenic fires were part of most North American rangeland ecosystems before Europeans arrived. But heavy grazing in the last and in the early part of this century depleted the supply of fine fuel necessary to carry a fire. This fact, coupled with the deliberate control of fire after grazing became better managed, lengthened fire-return interval in many rangeland communities. Removing fire or changing return interval alters vegetative composition, and in many shrub dominated ecosystems, shrubs or trees such as sagebrush, pinyon-juniper, or eastern red cedar were able to increase in density and pinyon-juniper invaded areas from which more frequent fires had kept them.

Where soil and climate or heavy grazing allowed adapted nonnative annuals to replace perennials in the understory, fire-return interval decreased. An example of this relation can be seen in the former sagebrush/grass rangeland now dominated by cheatgrass brome. When the area was a sagebrush/perennial-grass ecosystem, fire-return frequency may have been 40 to 110 years. But because dry cheatgrass is so flammable, fire return frequency now may be less than 5 years (Whisenant, 1990). Even if seed of sagebrush or of perennial herbaceous plants was available, this rapid burning cycle would thwart reestablishment.

Removal of grazing would influence fire-return frequency because fire frequency, characteristics, timing, and results are related to the amount of fuel that remains after grazing. With no grazing and increased supplies of fuel, wildfire frequency would increase in certain range ecosystems. Because of the lengthened interval between burns, such fires might be more intense, more expensive, and more difficult to control and might induce plant composition changes that "normal" fires would not.

To be acceptable to society, fire returned to range ecosystems—grazed or not—would need to be controlled or prescribed. Time of year that "natural" fires burned would need to be considered. Burning at "safe" times, e.g., spring, might have completely different effects on vegetative composition than hot fires might, which would have burned naturally in late summer or in early fall. Finally, some controlled burns certainly would escape, and air pollution from fire is a byproduct subject to environmental controls in many areas.

Other Plant-Control Techniques

Herbicides and mechanical or biological controls

are alternative means of managing unwanted plants. In some areas, herbicides are the only way to control noxious plants or to prevent their spread. In others, grazing by sheep or by goats is being used to discourage weeds. The high cost of herbicide use or of mechanical control measures for shrub control probably has limited and will continue to limit these measures on both private and public lands. Environmental concerns have curtailed herbicide use on public rangelands drastically, but chemicals still are used to keep noxious weeds from spreading.

Seeding

Seeding of introduced or native species has been a common range-improvement practice (Laycock, 1982). Although it still is appropriate at times, high costs have led to its considerable decline as a range management strategy over the last two decades. Instead of the widespread seeding of single species such as crested wheatgrass, as was done commonly from 1950 to 1970, seeding now is limited to small, specific areas and is more likely to consist of a mixture of native species than to consist of a monoculture of introduced species. More research has been conducted on breeding and planting exotic species than on native species. Planting success rate therefore often is greater with exotic species.

But monocultures of introduced grasses such as crested or intermediate wheatgrass (*Agropyron intermedium*) or Russian wildrye (*Elymus junceus*) can provide the forage needed to enhance overall management of a rangeland area. These species begin spring growth several weeks earlier than many native grasses do and can provide green, nutritious forage for livestock during and after calving or lambing. Seeding also stabilizes soil, prevents erosion in wildfire areas, and may provide alternative forage to keep livestock off of native rangelands for a time in the spring. In this manner, grazing can begin on native rangelands when plants have reached a later growth stage. Early-spring green growth attracts and nourishes wildlife such as deer, antelope, elk, and rabbits emerging from a hard winter.

In a process called *greenstripping*, or the planting of strips of less flammable native and other species, seedings in southern Idaho have been used to break up large areas of highly flammable cheatgrass brome (Whisenant, 1990). Clumped bunchgrass or species that are green for long seasons, e.g., crested wheatgrass, slow spread of fire. The purpose of greenstripping is to break large areas of highly flammable fuel, e.g., cheatgrass stands, into small areas to facilitate fire control. Then, by increasing fire-return interval, the species planted in the green strips and the native species from adjacent areas naturally can reestablish in the protected area.

Combinations of Range Improvement Practices

Development of areas of productive, nutritious, and very palatable vegetation in areas removed from highly concentrated livestock or big-game animals can alleviate some range management problems, such as the tendency of cattle to concentrate and to remain in riparian areas. If areas away from riparian or other locations of concentration are burned, sprayed, seeded, or fertilized, cattle may be enticed into using them, provided water and salt also are available.

Working Landscapes

Compelling cases usually can be made for both sides of a debate, and indeed there are numerous examples of natural systems gone awry due to human causes. An increasing human population requires food, and the implicit trade-off if land is to be untouched by human enterprise is to intensify use of the land on which food is grown. One alternative is landscapes in which food is produced without intensive chemical or energy inputs. Well-managed livestock grazing is perhaps the nation's most sustainable agricultural enterprise and has the added advantage of keeping landscapes open and pastoral as opposed to subdivided and urbanized.

Much has been said of the benefits of keeping people on the land; indeed, many countries intentionally foster family agricultural enterprises to keep the land settled and the people productive. In much of the West, public and private lands traditionally have been linked in one economic enterprise. If public land no longer was available for a balanced, economically efficient ranch, bankrupt operations presumably would be sold to the highest bidders.

Range managers have developed a number of strategies for alleviating specific grazing related problems or for accomplishing specific goals regarding range vegetation. This progress has been possible because the effects of herbivory on a range ecosystem depend on a number of factors alterable by management. Such factors include date of or vegetative phenology upon grazing initiation and termination; duration of use; season of rest; duration of rest or deferment; and numbers, kinds, classes, and behavior of animals.

Perhaps the range manager's most pervasive prob-

lem, i.e., the tendency for grazing livestock to concentrate in certain areas, is exacerbated by long seasons; large or vegetatively diverse pastures; and poorly distributed water and salt. Where these problems cannot be corrected by more intensive management, they must then be corrected by decreasing animal populations.

Improvements or strategies include grazing when vegetative palatability is fairly even, fencing-in small pastures, grazing in rotation so that areas are affected only occasionally and at different seasons among years, developing additional water sources, distributing salt or supplementation widely, converting primary vegetation from brush to grass, and herding or grazing an increased number of animals for an abridged period.

When grazing strategies for a pasture or, more generally, for a set of pastures are being developed, the physiological response of vegetation is considered along with the tendency of animals to graze each component of it. Plants are affected most profoundly when grazed during their active growth. This is especially true if they do not have the opportunity to recover from defoliation before the end of the growing season. Some species also are affected more by severe or recurrent defoliation occurring before they have the opportunity to recover from prior defoliation than other species are (Caldwell, 1984).

When determining strategy, most managers of grazing livestock consider plant response and grazing-animal nutrition. Often of implicit concern is the importance of wildlife forage quality. On uplands, the early or middle season provides the greatest nutritional value to animals but also, of course, is the time of greatest grazing impact on plants if grazing pressure continues to the end of the growing season. Early grazing of riparian areas often is recommended because soil moisture allows regrowth (Clary and Webster, 1989).

Sophisticated grazing-systems use combinations of the factors rotation, rest, and deferment in two or more pastures. *Rotation* refers to the organized movement of animals from one pasture to another; *deferment*, to the withholding of grazing until a predetermined plant phenological stage is achieved—usually seed ripeness of one or more of the key grasses or other species. *Rest* refers to the withholding of grazing for one year. In pastures with both upland and riparian areas, a form of deferred—or rest—rotation may be necessary. Additionally, forage quality for future grazers generally is enhanced by grazing and regrowing and may be optimal when the plant is recovering from and susceptible to further grazing damage. Many rotation grazing strategies balance the needs for healthy livestock and healthy vegetation.

Numerous grazing systems help vegetation either recover from or minimize the adverse effects of grazing. Although no system is applicable universally, many systems have regional appeal. Each attempts to balance and to compensate for specific seasonal grazing effects within the constraints of a seasonally changing climate.

5 Socioeconomic Implications of Public-Land Grazing

Structure of the Western Public-Land Ranching Industry

If the public-rangeland grazing debate is to serve a useful purpose, Congress and the public need to understand the structure and to recognize the significance of the western livestock industry, and especially how they relate to the industry's seasonal dependence on federal forage.

Future of Western Public-Land Grazing

A 48% increase in grazed forage demand was projected to occur from 1985 to 2030 in the report *Factors Affecting the Demand for Grazing Forage in the United States* (U.S. Department of Agriculture, 1992). Four forage sources were identified, namely, deeded and nonirrigated grazing land, public-grazing land, irrigated grazing land, and crop residue. According to this USDA report, all increased demand for grazed forage (from 431.2 million animal unit months in 1985 to 637.2 million in 2030) would be supplied by deeded, nonirrigated grazing land, of which total national animal unit months supplied would increase from 370.1 million to 585.8 million. Irrigated grazing land animal unit months would hold constant at 9.3 million, as would crop residue animal unit months, at 22.3 million.

A striking conclusion in the 1992 report regarding the western public-land ranching industry was the projected decline in authorized public-land livestock grazing based on extrapolations of public land grazing use in the 1970–1987 period. The report stated that whereas 29.5 million public-land animal unit months were authorized for use by domestic livestock in 1985, grazing authorization would fall to 19.8 million animal unit months by 2030, or by one-third. Only 14.4 million public-land grazing animal unit months would be authorized in the western United States, in contrast to 22.8 million in 1985. Public-land grazing authorizations in the Pacific Northwest would decline by 55%, in California by 33%, in the Southwest by 23%, and in the Rocky Mountain region by 40%. It was assumed that, by 2030, improvements to and increased utilization rates on nonirrigated private-rangelands could compensate for the decline in public-land grazing and could supply the additional feed required for a livestock inventory 40% larger than the 1985 inventory.

The observation period supporting the contention of declining public-land grazing authorizations is not supported, however, by available grazing statistics (Obermiller, 1994). In 1978, approximately 11.1. million animal unit months of grazing use were authorized on BLM lands in the 11 western states. Authorization declined to 10.8 million animal unit months in 1982 but increased to 14.1 million by 1985 and stood at 13.5 million animal unit months in 1992 according to Bennett et al. (1993). Hence, the current BLM public-land grazing trend is stable or up, not down. Available data suggest that National Forest grazing in the western region has remained fairly stable since 1978, ranging from 6.5 million–6.8 million animal unit months.

Why is public-land livestock grazing projected to decline dramatically? According to the recent FS report (U.S. Department of Agriculture, 1992), pressure for recreational and other uses could drive declines in grazing on these lands. If so, deeded, nonirrigated pasture and rangeland would need to increase production by as much as 51% (see Chapter 2).

Is it realistic to assume that livestock forage on private rangelands can offset the loss of production on public lands? Although stating that expansion in nonirrigated private-range forage-production of the indicated magnitude (215.7 million animal unit months) "seems possible," the FS report offers no supporting evidence. The projections indicate that private-forage will substitute for public-forage supplies in the western United States, where almost all public-land livestock grazing occurs. But, for the following technical and economic reasons as well as for the institutional reasons to be summarized, the structure of the western public-land ranching industry seems unlikely to respond in this manner to the loss of public-land livestock forage.

That improvements in nonirrigated private-rangeland forage-production could result in the deeded

rangeland animal unit month increases seems implausible. For example, there are approximately 200 million a. of nonirrigated private rangeland in the western United States. According to the Forest Service report, these lands yielded 130.9 million animal unit months in 1985, for an average productivity of about 0.65 animal unit months/a; in comparison, the 288 million a. of grazed federal rangelands in the West had an average productivity of 10.0 a./animal unit month, or 0.10 animal unit months/a.

Although the report projects an increase of 102.9 million animal unit months, from 172.4 million to 275.3 million, in production from all forage sources by the year 2030, this projected increase is attributed wholly to the improved productivity of western nonirrigated private rangelands. The implication is that private-rangeland forage productivity would more than double—from a current rate of 0.65 animal unit months/a. to a projected rate of 1.375 animal unit months/a. On both economic and technical grounds, private-rangeland enhancements of this order are neither probable nor ecologically feasible.

Decreased Dependency on Public-Land Grazing is Inconsistent with Industry Structure

Cattle are the factories supplying the United States with beef, and they numbered nearly 34 million in 1991, according to Agricultural Statistics Board estimates. Beef-cattle operations range in size from one to several thousand head. There are more than one-million beef-cattle operations in the United States, but only about 90,000, or less than 10%, are defined by the USDA as *commercial*, i.e., having a beef-cattle inventory of 100 head or more (Table 5.1). These 90,000 operations control a little under one-half of national beef-cattle inventory. The average size of a commercial beef-cattle operation in the United States is 174 head—not large enough to support a ranch family but large enough to warrant active herd management.

Table 5.1. Commercial beef cow operations in the United States and the 11 Western States (Estimated from Agricutural Statistics Board Data) (Obermiller, 1992b)

Inventory and operations	United States	11 western states
Beef cows (000)	33,620	6,732
Beef cows in commercial herds (000)	15,633	5,059
Number of commercial operations (000)	90	28
Average commercial herd size (No. head)	174	181

Only 20% of beef-cattle in the national inventory reside in the 11 western states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming). Here, the ratio of commercial to noncommercial operations is larger than in other areas of the nation. Just less than 30% (28,000) of western beef-cattle operations qualify as commercial. These raise three-fourths of all beef cattle in the West.

With 181 beef cattle, the average commercial western ranch is marginally larger than the nation's average beef-cattle operation. The real difference between western ranches and other U.S. beef-cattle operations is twofold. First, small noncommercial beef-cattle operations are less significant in the agricultural economy of the western states than in the economy elsewhere. Second, unlike beef-cattle enterprises in the East, the Southeast, and the Midwest, those in the West depend heavily on federal lands for seasonal forage.

Livestock graze about 500 million a. of land in the 11 western states. Of this land, 262 million a., or over one-half, is public-grazing land administered by the FS or by the BLM. About 85% of all federal lands in the 11 western states is estimated to be grazed by domestic livestock (Obermiller, 1992b; U.S. Department of Agriculture, 1990; U.S. Department of the Interior, 1990a).

In the western rangeland livestock industry, stable cow-calf and cow-calf-yearling operations are most common. Federal grazing permits and leases, which complement industry structure by extending but not substituting for privately owned grazing and haying lands, stabilize the western livestock industry, given its brood cow-herd orientation (which produces calves for other types of cattle operations). This structural dependency and complementarity are tied by law, regulation, and custom to the mixed federal/private-ownership pattern of western grazing lands.

Various laws provide for domestic livestock grazing as an authorized use of western public-rangelands. The FS and the U.S. Department of the Interior, in 1906 and 1936 respectively, implemented grazing permit systems. Initially, permits were awarded to local ranchers who were private-landowners and who historically had used specific parcels of public-domain ranges—parcels subsequently known as grazing *allotments*. This preference approach to the allocation of permits resembles in many ways the assignment of water rights under the Prior Appropriations Doctrine and continues to be a source of continuing con-

troversy over rights versus privileges to graze privately owned livestock on public lands in the West.

Like water rights, grazing permits set an upper limit on the amount of allowed animal unit months. Grazing season, livestock class, and other terms and conditions also are stipulated. Moreover, grazing permits for defined allotments are attached to legally specified, privately owned base properties much like *appurtenant easements*, in which the private base property is the dominant tenement. Two types of commensurate bases exist: water-base permits and commensurate base-property permits.

The water-base permits originally were awarded to livestock operators controlling the only dependable water sources available for stockwatering and other purposes in very arid regions. Many original water-base grazing permits were given to sheep operations, and often the permitted season of use was yearlong. Most water-base permits still are yearlong, but many have been converted to beef-cattle permits.

Commensurate base-property permits were more commonplace. The private property to which this type of permit was assigned usually consisted of pastures and haylands capable of providing the necessary feed for the permitted number of livestock during that part of the year when they were not grazing federal land. Most commensurate base-property permits were and remain beef-cattle grazing permits.

Because they are attached to private property, grazing permits on adjoining federal land cannot legally be bought by anyone other than the user, usually the owner, of the private property to which the allotment is assigned, who in turn can neither sell nor sublease it. The BLM does allow transfer of the grazing privilege to a lessee if the operator also leases the base property and the livestock. The FS does not. In no event can the permit be separated from the base property and bought and sold as a separate land unit although, with the agency's permission, the permittee may designate an alternative private-land parcel as the base property for the permit. Some illegal selling or leasing of permits does take place.

The complementary nature of private/public-land ownership, which is accounted for by the base-property requirement, characterizes the public-land-dependent western ranching industry. This symbiosis helps explain why cutbacks in permitted allotment animal unit months, increases in grazing fees, new restrictions on herd management practices, increased insecurity of tenure on the part of permittees, and other restrictions undermine public-land ranch property values. Substitution of other land for lost federal grazing land usually is not a viable alternative.

Policy Implications

The FS report (U.S. Department of Agriculture, 1992) projects a decrease of 7.2 million publicly grazed animal unit months by the year 2030 in the western states. At an average size of 650 animal unit months per allotment (Obermiller, 1994), this reduction would equal 11,000 foregone federal grazing permits, or, spread evenly across all allotments, over a one-third reduction in the number of grazing allotments. Many operations, therefore, could remain in business only to the extent that the profitability of private rangeland enhancements increased substantially. But the ecological and the economic potentials of western private rangeland offer little hope for forage increases on this order of magnitude.

The implication is fairly clear. A substantial portion of the commercial beef-cattle industry in the 11 western states is public-land dependent. Public-grazing lands are a necessary addition to private-grazing lands, and one cannot be substituted for the other. In many parts of the semiarid West, most land is in federal ownership and there is not enough private land to substitute for it. In these instances, private ranches retain their livestock production values only so long as they retain their federal grazing permits. Reductions in federal-land grazing to the extent recently projected would result in significant ranch asset devaluation in the western United States. It also could lead to substantive consolidation of western ranch holdings by large corporations instead of by sole proprietors.

The Issue

The federal grazing fee has become a perennial public-policy issue. Perhaps the nation's inability to put the matter to rest stems from the fact that debates focusing on the price of grass continue to cloud the driving issue: the uses of federal lands and their resources.

The fair assignment of value, grazing fee, to something as tangible as domestic livestock forage (per animal unit month used), albeit somewhat complex in an administered federal market, is possible. And lest it be forgotten, in the pursuit of fairness, hunting, fishing, backpacking, and other recreational pursuits are consumptive uses of public-land resources resulting in no return to the federal treasury. Hunting and fishing actually remove products. Backpackers and other campers and boaters are provided with extensive trail systems, campgrounds, boat ramps, and other nonfee or below-cost fee improvements.

Virtually every argument for increasing the federal grazing fee relies on the generally higher rental rates associated with private-pasture and private-rangeland leases. These arguments conclude with a plea to end "subsidized" federal grazing and to charge grazing fees equal to the "fair market value" of private forage. Virtually unaware of the fact that federal-agency personnel set the time and the intensity of public-land grazing independently of the grazing fee, and having concluded that public-land livestock grazing is subsidized, many advocates of fee increases maintain that artificially low fees encourage overgrazing. Others who are aware of agency policy separating the fee and stocking issues may argue, instead, that livestock undermine the ecological health of public lands. Yet federal-land management agencies note steady improvements in public-grazing land condition since the 1930s.

One problem with both the arguments for increasing federal grazing fees and for eliminating grazing on public lands is that federal and private grazing leases are not analogous. Although similar in that they are arrangements for exchanging forage, the arguments are not equivalent exchange mechanisms and do not have comparable values. Most federal land is extensive, steep, or otherwise difficult land for managing livestock. Most such land remained in the federal domain largely because homesteaders found other areas more attractive. Private land, even rangeland, usually is more productive and manageable.

Additionally, the terms and conditions of private leases and of federal permits differ greatly. The amount of private rent or of public fee paid the landowner depends, therefore, as much on the terms and conditions of the exchange agreement as on the quality and quantity of forage exchanged. So although private grazing leases and federal grazing permits are contractual business arrangements and in both instances, the landowner, i.e., a private individual or the public, agrees to allow someone else restricted use of his or her land for grazing purposes, here the similarity ends.

If the restrictions imposed on an exchange agreement cause the lessee's or permittee's cost of harvesting forage, referred to as *nonfee cost*, to increase, then the net return to the harvested forage, and thus the appropriate rate of return to the landowner, diminishes. The restrictions imposed on federal grazing permits are much more severe than those typically imposed on private grazing leases. Federal grazing permits include commensurate base-property requirements, multiple-use restrictions on time and pattern of livestock grazing, forage limitations and withdrawals for watershed and wildlife habitat purposes, construction and/or maintenance of improvements by the permittee, and ever-increasing overhead costs due to, among other things, the ever-increasing demands of federal-land management agency personnel and public-interest groups. The result is a level of nonfee costs for federal grazing much in excess of nonrent costs for private grazing leases (Table 5.2).

In short, private- and public-forage exchange agreements are not directly comparable because the restrictions imposed on these otherwise similar business arrangements are quite distinctive. If the agreements were to be compared, all restrictions imposed only on federal grazing permits, e.g., restrictions to ensure multiple-use management, recreational access, and environmental protection, would need to be relaxed. This preposterous suggestion underscores the fact that as long as public lands are managed for many current uses and aggressively protected for future

Table 5.2. Forage use costs per AUM[a] on public versus private rangelands: 1966 costs price updated to 1990 (Bartlett et al., 1993)

Operation	Federal grazing permits	Private leases
Lost animals	$ 1.83	$1.26
Association fees	.25	0
Veterinary	.53	.60
Moving livestock to and from	1.51	1.50
Herding within operation	3.03	1.84
Salt and feed	2.25	3.04
Travel to and from operation	1.80	1.46
Water (production items)	.33	.28
Horse	.37	.22
Fence maintenance	.87	.95
Water maintenance	.71	.57
Development depreciation	.37	.10
Other	.57	.55
Totals	$14.42	$12.37
Federal grazing fee (1990)	1.92	0
Private forage value (includes lessor's overhead and risk) (1990)	0	4.73
Total operating costs/AUM	$16.34	$17.10
Capitalized cost of grazing permit	3.25	0
Total costs	$19.59	$17.18

[a]AUM = animal unit month.

public uses, federal grazing fees must remain at levels below private grazing lease rates.

The federal grazing fee is set by formula to keep total per-animal unit month costs of grazing on private and on public rangelands equivalent on average. The formula is based on the 1966 *Western Livestock Grazing Survey*, which demonstrated that when all rent, nonrent, and nonfee costs were taken into account and the costs of buying a grazing permit excluded, a grazing fee of $1.23 per animal unit month would cause total fee-plus-nonfee grazing costs on federal rangelands to equal total (rent-plus-nonrent) grazing costs on private, nonirrigated rangelands in the 11 western states. Since 1966, this $1.23 per animal unit month "base fee" has been multiplied by indices reflecting changes in private-grazing rental rate, livestock price, and livestock production cost. The main purpose of these three indices is to allow the grazing fee to reflect changes in both short- and long-term market conditions.

But why does the livestock grazing industry argue so strongly against fee increases when public-grazing lands contribute only 2 to 4% of aggregate U.S. feed and forage supply? Data indicate that greater than half the commercial beef-cattle herds in the 11 western states are in livestock operations holding grazing permits on either BLM or FS system lands (Table 5.3).

Moreover, many holders of livestock grazing permits consider the movement to increase federal grazing fees a smoke screen obscuring the drive to curtail and, in the extreme, to eliminate public-land livestock grazing. And the public-land-grazing subsidization issue, no matter how gratuitous, has public appeal and even has been divisive within the livestock industry. Few seem to recognize how common subsidization is within American agriculture or indeed within other major segments of the national economy.

The "Cattle Free by '93" and related anti-public-land grazing campaigns do threaten the public-land-dependent western livestock industry. If federal grazing fees are, in fact, increased to the level of prevailing private-land-grazing lease rates, for many operators, grazing on many public lands no longer will be economically feasible. Many public-land-dependent livestock ranchers will go out of business, and the rural communities in which they shop and buy ranch supplies will decline. If western ranchers are priced out of the public-forage market, many may have little choice but to sell their cattle, to subdivide their private-land holdings, and to contribute to the parcelization of western resource lands and to sprawl on the rural/urban fringe. As previously discussed, this scenario clearly would destabilize wildlife habitat and populations (Williamson, 1992).

Table 5.3. Forest Service and Bureau of Land Management Grazing Permits and AUM[a] Authorizations in the 11 Western States (U.S. Department of Agriculture, 1990; U.S. Department of the Interior, 1990a)

Agency and type of permit	No. of permits	No. of AUMs (000)
Forest Service		
(National Forests)	9,698	8,069
Bureau of Land Management		
Section 3 Grazing Districts	12,153	12,034
Section 15 Grazing Leases	7,101	1,520
Total BLM Permits	19,254	13,554
Total Federal Permits	28,952	21,623

[a]AUM = animal unit month.

6 Conclusions and Recommendations

Effects of Removal of Livestock from Public Lands

If livestock were removed from public land either by outright banning or by increasing grazing fees such that few ranchers could afford them, economic and ecological consequences to individual ranchers, local communities, and states would be widespread. Ranchers only minimally dependent on public-land grazing and not heavily in debt might be able to stay in business by intensifying management of their own land. Those ranchers wholly or primarily dependent on public-land grazing to round out their operations probably would go out of business, and their private lands would be sold. Even if their lands were brought by a neighboring rancher, the local community would lose part of its tax base, for lost federal animal unit months of livestock forage would mean fewer livestock and less sales revenue.

In resort or popular recreation areas, private land put on the market by forced sale might be bought by speculators or developers and subsequently converted to 40-a. "ranchettes" or otherwise developed (Williamson, 1992). If the converted land was critical big-game winter range, the new use probably would result in lost winter habitat base. Other wildlife species also could be affected adversely, even on ranches that stayed in business. Intensifying livestock operations on private land also could diminish the value of that land as winter range for big game and as habitat for other wildlife species. Because winter range often is the habitat most critical for maintaining populations, either scenario could lead to smaller big-game populations after the removal of livestock from public land. Some game populations also would decrease because of the lost symbiotic habitat relationship with livestock (Anderson and Scherzinger, 1975).

Resource Degradation

Recent claims (Ehrlich, 1990; Wuerthner, 1990) have implicated livestock grazing on public land as the primary cause of diminished biodiversity, impaired range condition and desertification, damaged watersheds, soil erosion, depleted wildlife habitat and populations, and numerous other environmental problems. But scientific evidence and other information indicate that although public rangelands are being degraded in localized areas, current livestock-grazing practices are not degrading public rangelands on a large scale (Vavra et al., 1994). In fact, with a few exceptions, U.S. rangelands are in their best condition this century. In most instances, public rangelands are in a sustainable condition meeting management objectives for the multiple uses of specific areas.

Following are conclusions concerning the condition of the public-rangeland resource:

1. **Sustainability:** Heavy, prolonged, or continuous livestock grazing can cause significant resource degradation. But appropriately managed livestock grazing, now the norm on most public rangelands, usually is sustainable and can modify or improve many rangelands for other purposes, e.g., wildlife habitat.
2. **Range Condition:** Heavy grazing of public rangelands occurred in the last half of the nineteenth and in the early part of the twentieth century. Greatly refined grazing-management techniques since the formation of the National Forests and the passage of the Taylor Grazing Act have resulted in the substantially improved condition of most upland public-rangelands. Continued improvements in range condition are hindered in many areas by successional limitations, but not in most instances as a result of current livestock-grazing practice.
3. **Watershed and Riparian Conditions:** Because livestock, especially cattle, tend to concentrate in riparian areas, conditions there have not improved as noticeably as on upland areas. However, both the FS and the BLM are focusing efforts on improving the management of riparian areas. These efforts generally are succeeding although many riparian areas still need to be improved. It also must be remembered that the importance of riparian zones was not recognized widely until the mid-1970s.

4. **Desertification:** Claims that much of the western United States is moderately to severely desertified are based on incorrect assumptions.
5. **Biodiversity:** Heavy, prolonged livestock grazing can decrease biodiversity, especially if vegetative structural diversity is limited. For most rangelands, greater biodiversity occurs at the midseral stage, that is, under high "fair" to low "good" range conditions. Both ungrazed and heavily grazed areas probably are less biodiverse than moderately grazed rangelands. Thus, the biodiversity of public rangelands is now probably as great as ever, even taking into account the era before livestock introduction. Elimination of proper range management likely would diminish biodiversity in many if not most areas.
6. **Wildlife Habitat and Populations:** Wildlife habitat was damaged greatly during the period of heavy, uncontrolled grazing. Concurrently, biggame populations decreased significantly in the absence of legislative protection. But wildlife habitat condition generally has improved alongside range condition, and the populations of most biggame species are more robust than at any time this century. Grazing has both negative and positive effects on nongame species, but many of these effects on many species are not well understood by researchers.

Grazing Fees and "Subsidization"

In addition to resource degradation, increased public-land grazing fees are at issue. The arguments for increased fees are that (1) private-land lease rates are higher than federal grazing fees, and (2) present fees do not cover the cost of administration and therefore cloak a subsidy. But because they do not take into account the concomitant costs of grazing on public rangelands, simple comparisons of public- and private-lease rates cannot suggest fair market value for federal grazing permits.

One problem with the arguments for increasing federal grazing fees or for eliminating grazing on public lands is that federal and private grazing leases are not analogous. Although both are arrangements for exchanging forage, they are not equivalent exchange mechanisms and do not have comparable values. Most federal land is extensive, steep, or otherwise difficult land on which to manage livestock; indeed, most such land remained in the federal domain largely because homesteaders found other areas more attractive. Private land, even rangeland, usually is more productive and manageable.

This issue should be resolved through improved cooperation among all parties and organizations, and the result should be healthy and properly functioning rangeland ecosystems on public lands that allow and will continue to allow room for the multiple uses appropriate to specific areas.

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Appendix A: Acronyms and Symbols

a.	acre
BLM	Bureau of Land Management
CAST	Council for Agricultural Science and Technology
CRC	Committee on Rangeland Classification
FS	Forest Service
ha	hectare
k	kilometer
LU	Land Utilization
NRC	National Research Council
NRCS	Natural Resources Conservation Service
PLLRC	Public Land Law Review Commission
PRIA	Public Rangeland Improvement Act
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior

Appendix B: Glossary

Acquired land. Land acquired by the government through exchange of timber or of original public-domain land.

Channel entrenchment. Condition in which floods are unable to spread over a floodplain.

Climax. End point, or optimal plant-community, resulting from vegetative succession.

Commensurable base property. Requisite nearby private property on which livestock permitted to graze federal lands during certain seasons are supported during non-permitted seasons.

Commercial beef-cow operation. An operation with an inventory of 100 head or more.

Competitive effects. Strictly speaking, the negative effects of competition on two or more populations; more loosely, unilateral effect only.

Defacto usufructuary rights. The right to enjoy the advantages of another's property, provided that such property is not destroyed or damaged.

Deferment. Withholding of grazing until a predetermined plant phenological stage is achieved—usually seed ripeness of one or more of the key grasses or other species.

Desertification. Permanent degradation of the productive capacity of land. Generally, land use that has become unsustainable.

Disasters. Drastic natural changes to the environment.

Diversity. Richness or evenness of species.

Ecotones. Edges at which vegetation types meet (see *edges*).

Edges. Abrupt boundaries between one vegetation type or structure and another type or structure.

Evenness. Species diversity implying distribution of individuals within species.

Facilitative grazing. The concept implies positive effects of herbivory by one or an assemblage of herbivores on other herbivore species by altering botanical composition, increasing productivity or accessibility of particular forage species, affecting nutritional quality of forage, and increasing habitat diversity by altering its structure.

Federal rangelands. Both lands once available for disposition under homestead laws and lands reserved for a specific public-purpose, such as timber production.

Grazing allotment. A permitting system extended to established operators grazing sheep and cattle on spatially identifiable land parcels located in the Forest Reserves of the western United States.

Grazing fee. Lease paid the government for the opportunity to graze on public land.

Grazing preference. Timing, intensity, and amount of permitted livestock grazing preferred by the owner.

Greenstripping. Planting of strips of less flammable native and other species to break up large areas of highly flammable cheatgrass brome.

Gullying. Incising of stream channels and thus the reduction of overbank flooding and subirrigation effects and the drawing down of high water-tables.

Marginal lands. Lands that could not be given away during the homestead era.

Mosaic. Combined ungrazed, lightly grazed, moderately grazed, and heavily grazed areas, a mix probably maximizing diversity in most landscapes.

Nonfee cost. Lessee's or permittee's cost, above the direct fee paid to the leasor, of harvesting forage.

Overgrazing. Continued heavy grazing that exceeds the recovery capacity of the community and creates a deteriorated range.

Patchiness. Habitat diversity.

Prior Appropriations Doctrine. Preference approach to the allocation of water rights permits.

Public-domain land. Lands, including those withdrawn from the federally owned land base, that are available for disposition and reserved for a specific public-purpose such as timber production.

Range condition. "Present state of vegetation of a range site in relation to the climax (natural potential) plant community for that site" (The Society for Range Management, 1989).

Rangeland health. Another, more recent, term for *range condition*.

Resource partitioning. The concept that all animals are, to a degree, selective foragers having evolved to use—depending on body size, gut morphology, and mouth parts—certain portions of plant-community composition.

Rest. Withholding of grazing for one year.

Riparian area. Banks of a river or other body of water.

Richness. Number of species.

Rotation. Organized movement of animals from one pasture to another.

Secondary succession. Pathway of vegetative change as rangelands improve.

Sustainable livestock grazing. Practice that maintains options in land use for future generations.

Threshold. "A boundary in space and time between two states . . . the initial shift across the boundary is not reversible on a practical time scale without substantial intervention by the range manager" (Friedel, 1991).

Time permits. The standard permit term for 10 years subject to renewal.

Ungulates. Hoofed mammals that are mainly herbivores.

Unsustainable. Diminishing capacity to produce vegetation.

Western federal rangelands. Rangelands owned by the federal government and administered by the Bureau of Land Management (U.S. Department of the Interior) and the U.S. Forest Service (U.S. Department of Agriculture).

Western federal-rangeland states. Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Tennessee, Utah, Washington, and Wyoming.

Western states. Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Xeric vegetation. Adapted to a dry environment.

Index

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