Chapter III

Rangelands

Photo credit: U.S. *Department of Agriculture*

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Rangelands

INTRODUCTION

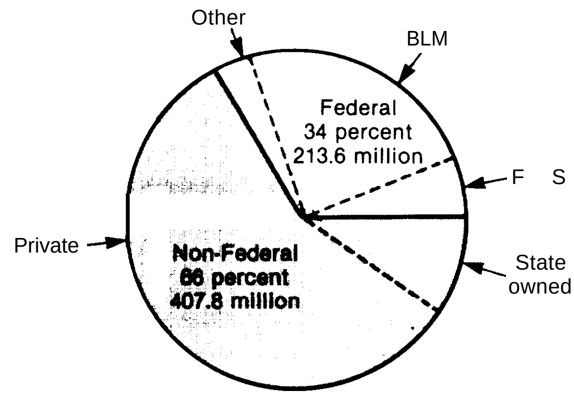
There are about 853 million acres of rangeland in the United States. This includes natural grasslands, savannas, shrublands, most deserts, tundra, coastal marshes, and wet meadows. Typical range vegetation includes grasses, grass-like plants, forbs, and shrubs. (Pastureland, by contrast, is land improved for forage production by intensive management of the soil and vegetation.) In the contiguous United States, over half the rangelands are seriously degraded (USI)A/RPA, 1980).

Excluding Alaska, 97 percent of the Nation's rangelands are located in the Great Plains and the arid and semiarid West. More than half of this land, 66 percent, is privately owned (see fig. 8), These private rangelands generally have the greatest inherent productivity and include most of the highly productive prairie and wet grassland ecosystems,

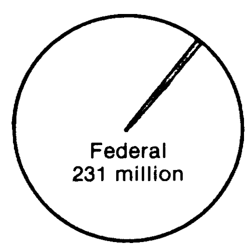
Federal rangeland areas are administered as follows: Bureau of Land Management (BLM), 24 percent; the U.S. Forest Service (USFS], 6 percent; and other Federal agencies (including the Fish and Wildlife Service and the military), 4 percent, Generally BLM lands are drier, less productive, and more fragile than private lands. They include large desert ecosystems with little or no carrying capacity for livestock and extensive shrubland of low productivity, USFS rangeland includes substantial areas of less arid, more productive mountain ecosystems.

Alaska contains 231 million acres of rangeland, much of it (79 percent) in good condition because it has not yet been used for livestock grazing. Information on which agencies administer Alaskan rangelands are imprecise because of landownership changes mandated in the 1980 Alaska lands bill. The 1980 Resource Planning Act report indicates that BLM is the major "owner," managing over half the Alaskan rangelands, When that figure was determined, USFS controlled about one-fifth of the Alaskan rangelands, other Federal agencies had about two-fifths, and only about 2 percent was in private ownership (USDA/RPA, 1980.)

Figure 8.—U.S. Rangelands



Rangeland, excluding Alaska
Total = 621,4 million acres



Alaskan rangeland
Total = 231 million acres

NOTES Federal data are from the Resource Planning Act (RPA) 1979, non-Federal data are from 1977 National Resources Inventory (N RI), State land estimated by Tom Frye USDA, Census of Agriculture statistics on total range are imprecise N RI Indicates 621 million acres (outside Alaska) whereas RPA indicates 588 million acres

Demands for rangeland products and services are expected to increase sharply in the next two decades (US DA/RPA, 1980 and USDA/RCA, 1980], but opportunities for increased production from U.S. rangelands are great. For example, the potential production of herbage and browse from rangelands outside Alaska is estimated at over 700 million pounds per year while the present production is less than half of that (USDA/RPA, 1980). In regions of moderate to high rainfall, water yields from rangeland watersheds could be significantly increased by appropriate vegetation management (Hibbert, 1974), Recreational use, too, can be increased substantially (USDA/RPA, 1980).

In spite of these potentials, most rangeland ecosystems are not resilient when misused because they are typically arid and natural plant growth is slow. The natural forces that tend to degrade ecosystems—i.e., wind, rainfall, and temperature extremes—are also especially powerful in dry areas.

CONDITiON OF U.S. RANGELANDS

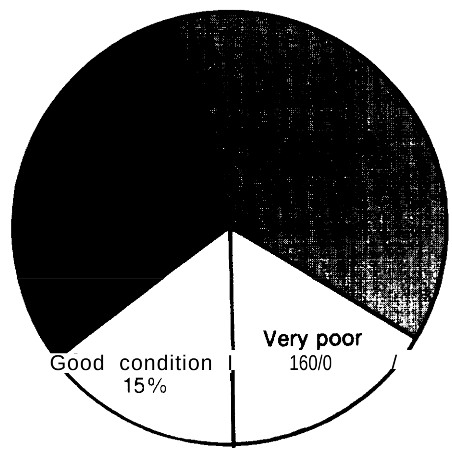
In the contiguous United States, over half the rangelands are seriously degraded and suffer from reduced productivity caused by the ill effects of mismanagement, overgrazing, and erosion. Only 15 percent of the range **is** rated in good condition. Ranges in fair condition **con**stitute another 31 percent of U.S. rangelands; 38 percent **are** rated poor; and 16 percent **are** very poor (see fig. 9) (USDA/RCA, 1980).*

"Range condition" **is a** complex and inexact measure where the present condition of the soils and vegetation **is** compared **to** what **is** thought to be the ecological climax community **as** dictated by the climate, native vegetation, and original (pre-European settlement) soil type **at** the **site.** For rangelands where **exotic vegeta**tion has replaced the natural plant communi**ties, as** in **most** of California, range condition **is** determined by comparing the present soil and vegetation **to** the potential for the **site** with**out** irrigation **or** fertilization.

Overgrazing **causes** great loss of productivity **on** U.S. rangelands. While present trends in range productivity **are** difficult **to** determine, the historical deterioration **is** well documented. Almost all the Western arid and semiarid ranges **were** severely overgrazed in the first **two or** three decades following settlement. For example, the first settler **to** the Salt Lake Valley, Utah, arrived **in** 1847; just 32 years later, the Utah paper, Deseret News, reported:

> The wells are nearly all dried up and have to be dug deeper. At the present time the prospect for next year is a gloomy one for the farmers, and in fact, all, for when the farmer is affected, all feel the effects. The stock raisers here are preparing to drive their stock to where there is something to eat. This country, which was one of the best ranges for stock in the Territory, is now among the poorest; the myriads of sheep that have been herded here for the past few years, have almost destroyed our range (Clegg, 1976).

Figure 9.— Rangeland Condition in the United States



SOURCE USDA 1980, Resources Conservation Act

*For this assessment, range is rated in four categories—good, fair, poor, and very poor, depending on the difference between the land's present vegetation and the ecological potential of the site. Range rated "good" has vegetation between *61* and 100 percent of potential; "fair" range is 41 to 60 percent of potential; "poor" range is 21 to 40 percent of potential; and "very poor" range is 20 percent or less of potential (USDA/RCA, 1980).

The process by which rangelands deteriorate is well understood. Cattle and sheep bite plants for food, consuming much of the aboveground part of the plant before moving to the next plant. In this they are like the enormous herds of bison and other large wild herbivores that once grazed the rangeland. But domestic livestock can cause serious harm to plants, especially grasses, whereas large wild herbivores generally did not (Littlefield, et al., *1980]*. The wild herbivores stayed in herds and moved to other ranges after ''mowing" the forage once. Domestic livestock, on the other hand, scatter over the landscape and stay on the same general site until the rancher moves them. If a rancher overstocks a site and does not move the herd, they are likely to return to a plant again and again, never letting it regain enough green material to maintain its root system or to store energy against periods of drought stress (Savory and Parsons, *1980)*. When the palatable and overstressed perennial grasses die out, substantial changes in the ecology and hydrology of the land commence. Overgrazing removes the grass cover and leads to less plant litter; increased runoff; sheet, rill, gully, and streambank erosion; and less organic matter in the soil. The resulting denuded land is also more susceptible to wind erosion, especially during drought.

Moreover, the degraded land can then be invaded by less productive plants, commonly called weeds and brush, Annuals, such as Russian thistle (tumbleweed) and cheatgrass, take hold, and deep-rooted shrubs, such as mesquite, proliferate. In northern regions, sagebrush is the primary invader, Accompanying these vegetation changes are upheavals in wildlife populations, Most species decline, especially the ground-nesting birds, such as quail and grouse, and the herbivores, such as bighorn sheep, pronghorn antelope, and American elk. A few wildlife species, such as the kangaroo rat, jackrabbit, zebra-tailed lizard, and horned lark, prosper in overgrazed areas.

Livestock grazing can be particularly hard on riparian areas near streams, waterholes, and springs. Riparian plants are more appealing to grazing animals and more productive, so are eaten more often. And riparian sites suffer greatly from trampling because animals spend more time in them and because their moist soils are more susceptible to compaction.

Overgrazing also reduces the proportion of rain and snowmelt that soaks into the ground, Ungrazed rangeland on the southern Great Plains, for example, was found to have infiltration rates nearly four times the rates on grazed rangeland of similar character (Brown and Schuster, *1969)*. Rainwater and snowmelt rush off denuded or compacted land instead of being absorbed into the soil. This, in turn, makes streamflows more erratic, tending toward a flood and drought regime. Whole river systems can be changed. The Santa Cruz River in Arizona, for example, was a meandering perennial river that supported an abundance of fish and other wildlife until its watershed and riparian areas were overgrazed. Now it is dry most of the time (Sheridan, *1981)*, Grassland restoration and conservation programs can reverse these effects and improve streamflow significantly (Hibbert, et al., 1974).

The increased runoff associated with overgrazing also increases gullying, or "arroyo-cutting, " as it is called in the Southwest. Combined with the increased sheet erosion caused by overgrazing, gullying carries large amounts of silt into rivers such as the Rio Grande. Indeed, it is estimated that one of the Rio Grande's most overgrazed watersheds—the Rio Puerco Basin in northwest New Mexico—produces over 50 percent of that river's total silt load while supplying only 10 percent of its water (Adams, 1979).

Historically, overgrazing effects have been most severe in arid areas where the land is least resilient. Thus, range conditions are now worst in the Southwestern States. Two-thirds of the rangelands of Texas, New Mexico, Arizona, and California have range condition degraded to 40 percent or less of the original condition, (USDA/RPA, 1980).

The loss of productivity from overgrazing in the Southwest is reinforced by climate changes. Over the past 100 years, the natural vegetation on large parts of the Southwest has undergone changes on a scale usually associated with geologic time, Vegetation zones at different elevations have changed noticeably. At low elevations, vegetation in the desert shrub and cactus communities have become sparser, while the desert grasslands have receded greatly and have been replaced by desert shrubs, cacti, and mesquite. At higher elevations, mesquite has taken over oak woodlands, and the timberline of spruce and fir trees has moved upward (Hastings and Turner, *1972).*

Scientific opinion differs on the cause of these profound changes. Some experts contend that the changes are the result of a change in the region's climate, which apparently has become more arid, with rainfall decreasing about 1 inch every 30 years, Other scientists contend that the prime cause of the vegetation changes was the huge influx of cattle and sheep that occurred in the latter part of the last century. It is likely that climate and livestock combined forces to bring about the most dramatic changes, By weakening the grass cover, domestic grazing animals have reinforced the general tendency toward aridity by contributing to an imbalance between infiltration and runoff in favor of runoff (Hastings and Turner, *1972).*

Average range condition figures for the United States as a whole are not so negative as the figures for the Southwestern States because the climate in other regions gives the land more resiliency, Still, the overall condition is not good. Excluding Alaska, over half (54 percent) of the U.S. rangelands have range condition degraded by 60 percent or more, In Alaska, four-fifths of the rangeland still has over 80 percent of its original productivity—most of it is still virgin. Less than 2 percent—just over 4 million acres—has been degraded to 40 percent or less of the original condition.

CURRENT TRENDS

Experts do not agree on whether the overall trend in rangeland productivity is improving, remaining static in its degraded condition, or continuing to degrade, and there are inadequate data to resolve the question, Nationwide studies of range condition were done in **1936, 1968, 1972, and 1976. Unfortunately, these do** not comprise a time series that can be examined to discern the national trend. The studies from 1976 and 1972 use much of the same data as the 1968 study. Comparing the 1936 data to the 1968 data is not useful because the methods for measuring range condition have changed and because the earlier study measured conditions under an uncharacteristic drought while the later study measured conditions in a more normal period.

Trends in range condition can be estimated without time series data by using indicators such as species reproduction, plant vigor, plant litter, and surface soil condition. BLM, in the process of making environmental impact assessments for its range management plans, is now investigating range condition trend indicators rigorously, Most of their assessments indicate that stocking rates (grazing pressure) must be lowered *20* **to 75** percent to avoid further deterioration (Young and Evans, 1980),

In general, range experts report that forage production on non-Federal land has gradually improved over the past 30 years, but that these lands are still degraded from their ecological potential, The Federal rangelands are apparently either static in their degraded condition or are continuing to deteriorate, There are some exceptional sites where atypical levels of management are improving Federal range condition.

Available data indicate that the area of rangelands has been declining in recent decades. By 2030, the total area of rangeland is projected to decline 7 percent, The acreage lost will come primarily from private lands as range is converted to cropland or pasture or developed for residential areas, highways, airports, and mines (USDA/RPA, 1980).

MONITORING PRODUCTITIVITY

One factor that seriously complicates the evacuation of rangeland productivity trends is the highly variable weather characteristic of the Western States, Rangeland plant production can fluctuate more than 300 percent from one year to the next as a result of a variation in precipitation (Box, 1980). Ideally, a large sample of sites in each rangeland region and subregion should be monitored regularly through several drought cycles to determine trends in rangeland productivity, Eventually, the Resource Planning Act and Resource Conservation Act processes of planning and assessment might include such a monitoring program.

Meanwhile, however, improved monitoring is needed to help manage local sites. Estimates of factors such as species composition, forage output, degree of ground cover, and symptoms of erosion—on which rangeland trend assessments have traditionally been based—would be more useful if they were augmented by systematic monitoring of the rangeland's other vital signs, including:

- the reproduction rate of various species in order to determine whether the plant community succession is advancing or regressing;
- the rate of soil loss by water and wind erosion;
- the soil's water infiltration rate, organic content, and degree of compaction and capping; *
- the water quantity and quality of aquifers and their hydologic interaction with streams; and
- the population dynamics of native animals (including fish) which depend on the rangeland habitat for food, water, and cover.

*''Capping' refers to the formation of a thin crust on the soil surface. It occurs in the more arid types of rangelands, caused mainly by the action of raindrops striking the soil surface and by the chemical-physical dynamics of soil drying. It leads to increased runoff and decreased infiltration of rain and snowmelt.

PRODUCTIVITY-SUSTAINING TECHNOLOGIES FOR RANGELANDS

A variety of management technologies has been developed to improve deteriorated rangeland. These may be broadly categorized as:

- adjusting livestock numbers;
- controlling animal use with grazing systems;
- promoting desired plant species;
- controlling noxious plant species; and
- controlling noxious animal species.

Congress has legislated objectives for use of Federal rangelands. These are stated in the Classification and Multiple Use Act of 1964, the Forest and Rangeland Renewable Resources Planning Act of 1974, the Federal Land Policy and Management Act (FLPMA) of 1976, and the Public Rangeland Improvement Act of **1978.** Generally, these laws state that multiple resource values are the management objectives for public land. The laws establish resource-inventory and land-use planning mechanisms for "the harmonious and coordinated management of the various resources without permanent impairment of the productivity of the land . . . ." (FLPMA, sec. 103 (c)). Translating general multiple-use, sustained-yield objectives from laws into achievable management objectives is extremely difficult, especially when two or more legitimate uses of the land are in conflict. FLPMA specifically states that multiple-use management should consider the relative values of the resources and not necessarily the combination of uses that will give the greatest economic return or the greatest unit output.

In theory, rangeland management strategies should include explicit statements of achievable objectives, management programs to apply technologies, monitoring programs to measure progress toward the objectives, analysis methods to indicate how the management could be changed to enhance progress, and a mechanism to implement the changes indicated by the analyses, In practice, however, there are often no statements of achievable objectives, no rigorous monitoring programs, no replicable analysis methods, and no feedback mechanisms to facilitate adjustment of the technologies,

Most range management technologies are designed to foster livestock production. However, some technologies exist that have other utilities as their major objective. These include game and fish management techniques, erosion control to decrease sedimentation of streams and reservoirs, and vegetation manipulation to increase watershed yields. These technologies are not well developed, however. Scientists and resource managers working with rangelands seem most concerned with livestock production technologies. Because livestock management considerations dominate rangeland use, managers seeking to enhance wildlife or other values would probably be most effective if they focused on influencing the choice of livestock production techniques. This traditional focus on livestock and the paucity of technologies directed at other values may explain in part why livestock considerations continue to dominate Federal rangeland management decisions, even on ranges where livestock is not the dominant objective (e.g., on wildlife refuges) (Littlefield, et al., 1980),

This discussion begins with an overview of technologies appropriate for sustaining range resources and concludes with more detailed descriptions of three promising new approaches: integrated brush management systems, short duration grazing, and grazing potentials in eastern woodlands.

c *Adjusting livestock numbers* is the most widely used range management technique. First, the carrying capacity of the range site is estimated to determine the numbers and types of grazing animals and the seasons they are to graze, Then grazing occurs with the indicated livestock in the indicated seasons. After one or more years of grazing, the range conditions need to be carefully reassessed. If the range shows indications of overgrazing or underglazing, the intensity and timing of grazing are adjusted accordingly. The process can be repeated to fine-tune the carrying capacity estimate.

Adjusting stock rates to the land's carrying capacity sounds relatively simple, but in practice there are severe difficulties. First, the initial carrying capacity can only be estimated. In theory, the range manager calculates carrying capacity by measuring the site's total annual forage production. Then he subtracts the forage that must remain ungrazed to protect the health of plants and soil quality. The remainder is available for grazing, but the range manager must also consider that some forage is likely to be eaten by wild herbivores. (In some cases this sharing of the forage between wild and domestic animals is adjusted by reducing the wild animal numbers to decrease their share, or by manipulating the number or timing of domestic animals' grazing to increase the forage for wildlife.) When the total pounds of forage available for livestock are known, that weight is divided by the ration needed per animal per time unit. (Rations per animal can vary with the character of the site.)

The estimation of carrying capacity is complicated by the vagaries of precipitation in the arid and semiarid West, Since range managers cannot foretell precipitation rates when planning stocking rates, they need to determine if the year that produced the forage crop measured was typical and then discount that to allow for drier years, At this stage, the carrying capacity estimate changes from science to art, and the value of estimates of factors such as the wildlife share of the forage becomes doubtful.

Rather than do such precise analyses, managers commonly measure total forage production and estimate that 50 percent of it is available for livestock grazing (Menke, 1981). Although the continuous reevaluation of range condition, trend, stocking records, and the adjustment of animal numbers and timing are critically important, this reevaluation and readjustment is often not practiced. As a result, the rangeland is overgrazed, especially during drought, and sometimes undergrazed during wetter periods (Box, 1980),

Another difficulty with adjusting animal numbers is that ranching operations often are not flexible and cannot accommodate changes in animal numbers or adjust seasonal grazing. If reduced grazing pressure is necessary at a time when livestock prices are low, the rancher might incur a substantial loss. To avoid this loss, some ranchers choose to overgraze the range, hoping the drought will pass quickly. This is possible if the rancher controls range use by right of ownership or tenure, or if his lease is based on a carrying capacity estimate that did not foresee the drought. Obviously, this method can damage the long-term productivity of the range. Other ranchers may stockpile or purchase alternative sources of forage to feed livestock through drought, Losses incurred by selling part of the herd in stressful times can be minimized if the age and sex ratio of the herd are designed for economic flexibility (Scifres, 1980).

Yet another problem in range management is related to the issue of animal types. The carrying capacity of most range ecosystems can be greater for a variety than for any one type of animal (Box, 1980). If a single species such as cattle is stocked, the overall productivity of the rangeland can be less and overgrazing more likely than if a variety, such as cattle with bison, sheep, or goats, could be used. It is also possible to achieve higher productivity by using a combination of domestic and wild animals with different food preferences. In prac-

Photo credit U S Department of Agricul,ture

The grass is always greener on the other side, These young heifers look longingly at a fenced-off fescue seed patch that was set aside for recovery tice, however, most range sites are managed for single species, usually cattle or sheep.

There are several reasons for the lack of multiple-species management. One is a lack of information on techniques and economics, but this lack of information is probably the result of a more powerful constraint—the conservative attitudes of the ranchers, and of the institutions that support them, toward untried techniques that may affect their profits.

- *Grazing systems* are technologies based on intensely managing how animals use range sites, The aim is to schedule systematically recurring periods of grazing and nongrazing for subunits of the site on the premise that periodically removing the animals from the range gives the palatable plants a chance to recover before being bitten again (Scifres, 1980). Some grazing systems strive to distribute livestock by season of use whereas others work to achieve more even spatial distribution of livestock by fencing, water development, or other means.

For the objective of increasing livestock production, grazing systems sometimes have not proven superior to continuous, year-long grazing at moderate stocking rates (Scifres, 1980; Box, 1980). However, even when livestock production is not increased in the short term, the range is often improved so that, in the long term, increased livestock production, as well as increased overall productivity, can result (Scifres, 1980). While grazing systems offer opportunities for improving rangelands, they are site specific and no one system should be considered a panacea for the problems of range degradation.

One of the more simple systems is rotation grazing. This involves subdividing the range and grazing one unit, then another, in regular succession, Another type of grazing system is called deferred grazing. This means delaying grazing in an area for a particular purpose, such as allowing old plants to gain vigor or new plants to become established. These two concepts have been combined into a system called deferred-rotation grazing. In this system, different parts of the range are deferred in rotation so that in the series all units will benefit from the deferment.

BLM reportedly is relying heavily on variations of the rotation systems and considerable controversy has been generated. Critics say that if stock reductions do not accompany rotation grazing, harmful impacts on riparian areas and regional hydrology will be amplified by periodically concentrating animals on particular sites. Fences to restrict livestock access to riparian lands can be part of the grazing system, but some critics object to the increased physical injuries that fences can inflict on wildlife (Littlefield, et al. 1980). Others who are concerned about the profitability of ranching object to the high cost of fences and to livestock being excluded from highly productive riparian sites,

- *Rangeland vegetation can be manipulated* to increase the abundance and vigor of desired plant species and thus accelerate range rehabilitation. Under natural plant succession, degraded productivity can recover, though at varying rates. On high mountain sites with deep soil that receive 40 to 50 inches of rainfall a year, recovery may occur in a few years. But on lands that receive only 20 or less inches of rain, it may take plant communities centuries to recover from the severely degraded conditions (Box, 1980). Rehabilitation techniques to speed up the recovery process range from "interseeding'—introducing desired plant species without removing the existing plant community—to intensive site preparation, reseeding, and sometimes temporary inputs of water or fertilizers to help desired plants become established. (If the intensive vegetation management is a continuing process, the site is no longer rangeland, but pasture.)

Reseeding and interseeding are widespread practices on private rangeland, Usually the objective of seeding is to increase forage during a season when native ranges do not provide enough or are particularly susceptible to grazing pressures. For example, in the mountain and intermountain regions, there is usually a shortage of early spring forage, Native bunchgrass should not be grazed because that will stunt future growth, so extensive areas are seeded with introduced species such as crested wheatgrass, which produces heavily during the spring season and is more tolerant of spring grazing (Box, 1980),

There are drawbacks to this "monoculture" technique. The introduced grass can so dominate the ecosystem that other species, productive at other seasons, are crowded out. Crested wheatgrass, for example, has low nutritional value for fall or winter grazing livestock or wildlife. To compensate, other species that can compete with wheatgrass can be introduced—e.g., four-wing saltbush and other forage shrubs. These provide the protein and carotene that the grasses lack in the fall grazing season (McKell, 1980). Another disadvantage of reseeding programs where one or a few species are introduced is that the resulting ecosystem has fewer niches for animal life. Less diverse plant and animal communities also may be more susceptible to insect or disease damage (Littlefield, et a]., 1980).

Inadequate nitrogen is often a limiting factor on rangeland productivity, so interseeding legume species may be beneficial. In the United States, alfalfa has been used this way; in Australia and parts of Asia, interseeding with the legume Townsville Stilo is reported to be very successful. Legume shrubs and trees are important sources of nitrogen for rangelands in Africa (Felker, 1981). There is little information available on the positive or negative impacts of legume interseeding on U.S. rangelands, but it is known that forage can be significantly increased (Lewis and Engle, 1980].

For sites where multiple-use management is the objective, and if economics allow, reseeding or interseeding can introduce mixtures of grasses, herbs, and browse plants and can rely more on native species so that the resulting ecosystem is more complex. Presumably this would be the method used on Federal rangelands. In recent years there has been considerable research on methods to enhance, improve, and reseed or interseed vegetation for wild animal use (Box, *1980).* However, for several reasons, such technology is as yet underused on the Federal rangelands. One problem is a lack of reasonably priced seed, but this constraint might be resolved by willing entrepreneurs, A more intractable reason for underuse of seeding to accelerate recovery of diverse native communities is the chronic lack of funding for Federal rangeland improvements. Congress recognized the need for accelerated rehabilitation of range condition when it passed the Rangelands Improvement Act of 1978. However, the act remains unfunded,

- *Controlling noxious plants: excessive* cover of woody plants, the "brush" characteristic of degraded ranges, is one of the primary deterrents to increased forage production. There are three major approaches to brush control: chemical, mechanical, and fire, *Chemical control* has certain advantages: it is effective, various chemicals may be selected that are specific to certain types of plants, and it is relatively cheap compared to other controls. Major disadvantages are that some chemicals, improperly applied, may cause crop damage or health hazards. Current environmental concerns and regulations have largely prohibited chemical use on Western Federal rangelands.

Mechanical control methods vary from hand-clearing or chopping individual plants to using big machines that plow or drag plants from the ground. These methods are advantageous in that the plants are removed immediately while the residue remains on the ground as organic matter. The disadvantages are that costs are generally high and considerable soil disturbance occurs with most mechanical methods.

Fire is a natural factor on all of Western rangelands and it is gaining acceptance as a major brush control technique. To its advantage, it is fairly inexpensive and can be quite effective against nonsprouting species. It has disadvantages, however. Brush areas often cannot support a fire, and since the burned land is denuded for a short period of time, there is an increase in the erosion potential,

Conventional vegetation control techniques have been criticized for being used without regard to their effect on values other than forage production for livestock. The effect of brush control on wildlife depends on the technique used. When large areas of brush are removed, the effect on the wildlife species adapted to brush is detrimental. But when alternate cleared and uncleared strips are left, populations of wildlife species, such as deer, increase (Littlefield, et al., 1980). In general, burning seems to find most favor with the champions of wildlife. A newer approach, integrated brush management, offers improved opportunities for enhancement of broad-scale productivity. That approach is described later in this chapter.

- *Programs to control noxious animals* are used to achieve three range management objectives: 1) to protect livestock, 2) to reduce the numbers of herbivores that compete with livestock for available forage, and 3) to protect the range from overgrazing and subsequent damage to productivity. The techniques used sometimes serve one objective while detracting from another.

Predators, particularly high populations of coyotes, can decrease range productivity by killing sheep or other livestock (Box, 1980; Young and Evans, 1980), On the other hand, when predator numbers are too low, they may kill too few rodents and other wild herbivores, so that grazing pressures increase and range conditions deteriorate (Dwyer, 1980; Box, 1980). Thus, the purpose of modern predator control programs is to optimize, rather than minimize, predator populations.

In the past two decades, Government agencies responsible for predator control have been studying new techniques for estimating predator populations, judging what constitutes optimum predator population levels for particular sites, manipulating the populations or, in some cases, the behavior of the animals, and monitoring the effects of the actions. The overall state of the art for these techniques is primitive and their development is not well supported (Lewis and Engle, 1980). The integrated pest management approach, assessed in another OTA report (U.S. Congress, 1979), seems to be one way to resolve conflicts among the objectives of noxious animal control programs in rangeland ecosystems.

Wild horses and burros represent a particular nuisance and controversy on Federal rangelands. Without effective predators, they are capable of rapid increases in population and can inflict heavy damage on range ecosystems. Capturing and moving these animals is only a temporary control measure, since the population will quickly rebuild. Treating them with fertility-controlling drugs seems to be effective, but very expensive. Selective killing of the animals is simple and effective, but some stockmen and others killed horses and burros with unnecessary cruelty before the animals were protected on public lands by the Wild Horse and Burro Act of 1974. As a consequence there are now strong social and political constraints to killing large numbers of these animals. A report from the National Academy of Sciences will review the state of the art in managing these animals and will indicate what further research is needed. It will not defuse the political controversy, however (Dwyer, 1980; Box, 1980; Meiners, 1981).

With the correct application of management technologies, there is a great potential to improve productivity on many of the severely degraded rangelands. Rangeland management techniques, however, are very site specific and there is a potential for long-lasting harm to productivity when technologies are misapplied. With degraded plant cover and compacted soils, overgrazed rangelands are exposed to powerful erosion and further degradation, Thus, careful monitoring of the soil and vegetation is necessary so that management technologies can be adjusted when needed. Congress, as the manager of policy for the Federal rangelands, recognized the need for information on soil and vegetation changes with the Resource Planning Act and other legislation. The data available are still inadequate, however, to determine whether present policies will suffice to achieve the multiple-use objectives that Congress has mandated for Federal rangelands, In theory, the primary objective of multiple-use management is to sustain or enhance the overall productivity of the resource base. Production of livestock and other specific benefits are secondary objectives. The rationale of such an approach is that managing for productivity will, in the long run, give the greatest production of all the multiple-use values. In practice, livestock production is usually the dominant objective for management plans on both Federal and non-Federal rangelands. The plans to produce livestock are then adjusted to provide for maintenance or enhancement of some nonlivestock values such as wildlife, fisheries, or water quality.

Integrated Brush Management Systems

Introdrution

Excessive cover of woody plants, commonly referred to as brush,* can constrain forage production on rangelands. The concepts underpinning brush management have changed drastically during the past 30 to 35 years. Initially, the goal of most brush management was to eradicate undesirable species. But as it became obvious that eradication was not possible, the emphasis shifted to "brush control."

Various brush control methods have been developed that can be effective in specific situations or for particular purposes, but each also has characteristic drawbacks. Brush can be physically removed, for example, but that is labor and energy intensive and thus expensive. Chemical treatments, too, are increasingly expensive and sometimes restricted.

Looking for the most effective controls, ranchers began using certain of these treatments in combination—e.g., spraying and then physically removing (chaining) unwanted species. During the past 5 years, researchers have begun studying the most effective overall management schemes to combat brush problems and have developed a new approach called integrated brush management systems (IBMS).

*Brush is a growth of shrubs or small trees usually of a type undesirable to livestock or timber management, but which are sometimes useful or can be managed for wildlife—e.g., mesquite, pinyon, juniper, chaparral, sagebrush, etc.

Basic IBMS principles include:

- reducing dependence on any one method, such as repeated herbicide treatments, in favor of coordinating techniques;
- using available techniques in a complementary sequence to take advantage of synergistic effects;
- patterning the application of selected treatment sequences to enhance livestock production and habitat diversity for wildlife simultaneously;
- developing treatment sequence alternatives to make systems flexible for adaptation to particular site circumstances and the producer's operating constraints;
- integrating actions with other management strategies, such as grazing systems, for maximum utility; and
- enhancing economic returns from brush management investments by increasing effective treatment life and optimizing output of products.

IBMS incorporate existing and new technologies to take advantage of the unique strengths of each method while minimizing the inherent drawbacks. The systems are designed to consider multiple uses of the resource (e. g., forage production, wildlife, watershed, etc.) so that overall production is optimized rather than maximizing returns from one use to the detriment of others (Scifres, 1980).

IBMS can be applied most effectively when they are orchestrated with other key practices, particularly grazing management. Brush management is futile when the range is overgrazed. In fact, brush management without grazing management may be more detrimental than beneficial in the long run by opening up more land to repeated overuse (Welch and Scifres, 1980),

A planned, orderly sequence of treatments is important in IBMS results, For example, suppose a range livestock producer using a four-pasture, three-herd grazing system* has determined certain brush species are limiting production. The chosen control procedures and rationale might include (Scifres, 1980):

1. An aerial spray, used to reduce the competitive advantage of a weed species, considering:
   - Herbicides should be applied in the fall when potential for spray drift damage to susceptible nontarget species is minimized.
   - The pastures should be treated in turn as they are scheduled for deferment from grazing in the fall, thus spreading the investment over 4 years and taking advantage of regularly scheduled deferments to maximize forage response. This also allows the producer to increase his livestock herd gradually in response to the rate of improvement.
   - The herbicide should be applied in patterns to retain some brush for white-tailed deer habitat and reduce total land area sprayed.
2. The area should be burned 18 to 24 months after spraying to remove standing woody debris, reinstate valuable broadleaves damaged or removed by the spray, improve botanical composition of the forage standby favoring the more productive grasses, suppress brush regrowth that survived the spray, and improve the browse value of large, decadent, unsprayed brush.
3. Repeat burning at 2- to 3-year intervals, depending on weather, unless brush regrowth becomes excessive, in which case individual plant treatments with herbicides or treatment of local areas may be advisable.

Potential Scale of Application

IBMS should be applicable on almost any site now treated by single methods. It has been estimated that an average of 1.5 million acres of Texas rangeland were treated for brush control annually from 1956 through 1977 (Scifres, et al., 1980). Junipers, mesquite, and sagebrush alone infest some 242 million acres of U.S. rangeland* (Klingman, 1962).

To be successful, IBMS require relatively long planning horizons. For example, whereas the expected treatment life of a given herbicide spray for mesquite control may be 7 years or less, brush management systems are designed to span 15 or 20 years (Scifres, 1980). For the next 10 years, IBMS are expected to receive most attention in States such as Oklahoma, Texas, and New Mexico where the brush problem is a priority concern among both Government land managers and private ranchers.

Much of the impetus for developing IBMS lies in recent Federal scrutiny of herbicides and the rising costs of conventional range improvement methods. If these factors continue to be important, the rate of adoption of IBMS will probably increase rapidly during the next decade.

Potential Impacts

The primary goal of IBMS technology is to optimize range products on a sustained basis. By expanding forage opportunities, IBMS may have the potential to double livestock carrying capacities of many range sites (Thomas, 1970). For example, combining use of a pelleted herbicide with prescribed burning for whitebrush-infested rangeland in Texas increased the livestock carrying capacity from 1 animal unit (AU)** per 35 to 40 acres to 1 AU per 12 to 15 acres in three growing seasons (Scifres, 1980). Other, similar increases have been reported. These levels of productivity, discounting weather fluctuations, are expected to hold as long as the systems are operative and livestock management is maintained at a high level.

*Although a four-~ asture, three-herd grazing system was used to relate 1 BMS procedures, other grazing management systems can be used effectively. Short duration grazing (SDG) appears to be especially amenable to IBMS. However, there is no available research or field experience to support a discussion of the integration of IBMS into SDG.

"Another OTA assessment, "Water-Related Technologies for Sustaining Agriculture in U.S. Arid and Semiarid Lands," is exploring potential innovative uses for these and other range species.

* *An animal unit is the forage required to support a cow and a calf for 1 year,

The primary biological processes affected by IBMS relate to vegetational change, Wildlife habitat quality is improved by developing a mosaic of vegetation types rather than total suppression of brush. Increasing the ground area covered by perennial native grasses decreases sheet erosion during wet periods and the mulch cover increases water infiltration. This increases the amount of forage produced per increment of precipitation received (Scifres, et al., 1977a).

The impacts of the herbicides used in IBMS are uncertain, Residual patterns of newer herbicides, such as tebuthiuron, have not been established over a wide range of conditions, and add it ional research is needed. At application rates used in IBMS, herbicides such as 2,4,5-rr (2,4,5 -trichlorophenozy acetic acid) are dissipated in the growing season of application, and picloram [4-amino-3,5,6 -trichloropicolinic acid) should not be expected to carry over into the second growing season (Scifres, et al., 1977 b). However, just what happens to the dissipated chemicals is not clear.

The effects of fire on rangeland soils are as follows:

1. *Erosion potential:* The greatest erosion occurs on steep slopes when a high intensity storm follows a burn. This is of special concern with soils that seal readily and promote overland flow. However, erosion can be reduced by limiting burning to gentle slopes (no greater than 5 percent] and to Iate winter or early spring to promote early regrowth and rapid development of cover.
2. *Water relationships:* The greatest difference in water dynamics of burned v. unburned rangeland is that lush new growth consumes more water, This extra demand typically exists only through the first growing season after burning,
3. Nutrient *status:* Minor amounts of nitrogen, sulfur, and phosphorus are volatilized by range fires, organic matter may be decreased somewhat depending on conditions of the burn, and soluble salts [calcium, potassium, etc.) are returned to the soil in the ash.

The net impacts of IBMS burns on rangeland soil have not proven detrimental, perhaps because prescribed burns are generally less intense than wildfires.

Conclusions

The costs of IBMS are the sum of the costs of each step in the treatment sequence and are therefore highly variable. Indirect costs, too, should be considered. For example, risks of herbicide drift and the possibility of a prescribed burn getting out of control are indirect costs, There are also indirect benefits. Improving vegetation of one management unit within the ranch should relieve stress on adjacent units and encourage their improvement. Other potential effects, such as increasing or reinstating streamflow, benefit users removed from the actual site of brush management.

The primary constraints to implementation of IBMS are economic, environmental, and technical. The major economic constraint is the capital required to initiate the first [and usually most costly) step in the sequence. Federal cost sharing through agencies such as the Agricultural Stabilization and Conservation Service (ASCS) is of increasing importance, especially for smaller ranches (Whit son and Scifres, 1980).

Technical constraints to wider use of IBMS technology are significant because research is still in the formative stage and the rate of testing treatment-sequence variations cannot exceed the pace of natural seasons, For example, prescribed burning must be explored in more depth to capitalize on its full potential. Herbicide use must be refined through new application techniques for registered compounds and development of improved compounds. Low-energy mechanical methods for brush management should be developed and refined. The economic factors that affect IBMS adoption must be identified and various tradeoffs analyzed to determine optimum system designs for various types of ecosystems and management objectives.

Short Duration Grazing

Considerable interest exists among both livestock producers and range scientists in short duration grazing (SDG) systems. Such grazing systems may as much as double the carrying capacity of certain ranges (Scifres, 1980).

SDG systems concentrate a relatively large number of animals on a given area, but for much shorter times than in more conventional deferred grazing systems. SDG also has shorter rest periods and other differences from traditional grazing management,

Rangelands and their management needs vary widely, not only in a geographic sense from the arid and semiarid West to humid Southeast, and from the cool North to the mild South, but also among specific sites within geographical regions, Any discussion of range management, including SDG, must recognize the site-specific nature of range improvements.

Most modern grazing management espouses the idea that periods of rest (removal of all grazing animals) are necessary to prevent overuse and allow plants to recover vigor, The typical SDG system rotates herds through a series of pastures several times (six or more) per year. Grazing periods are short (7 days or less), and rest periods generally are not longer than 60 days. This concentration of relatively large numbers of animals on a given area for a short time followed by long rest periods is designed to simulate the grazing activities of the wild herbivores under which the range ecosystem evolved. Consequently, SDG is sometimes considered to be the most "natural" grazing method available.

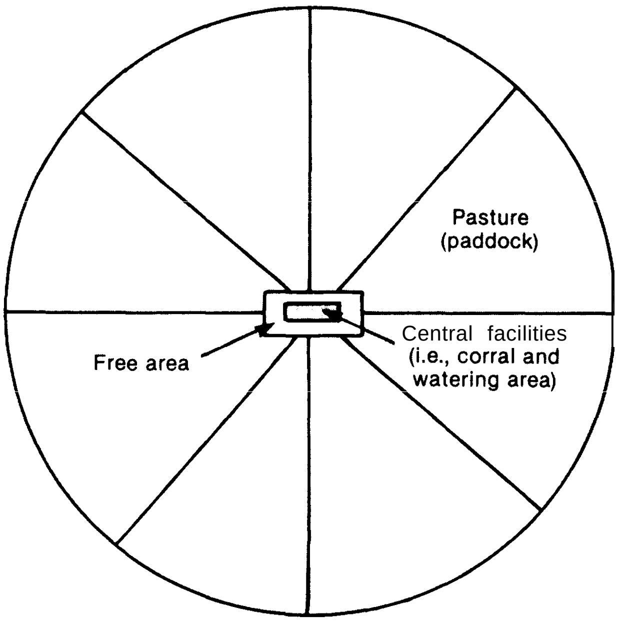
Because SDG entails frequent movement of stock and high stocking rates, ranchers must take precautions to minimize animal stress. Livestock under stress can suffer low conception rates, nutritional difficulties with weaning, and poor summer weight gains. One way to reduce stress is to reward the livestock for moving between sites. In a Pavlovian approach, the cattle can be trained to associate extra food with some stimuli, such as a horn or call, that occurs before changing cells, Eventually the livestock will lose their apprehension and will move without the extra reward,

The SDG systems might be most attractive to larger ranches with the reserve capital necessary to invest in adequate fencing and facilities. Larger operations, too, would be able to absorb the short-term reductions in sales that might come with the transition to higher stocking rates, This transition period can take several years, depending on the size of the system and characteristics of the ranch.

Proponents of the technology claim that the increase in livestock carrying capacity can occur without harming the range ecosystems, either plantlife or wildlife. Unfortunately, there is a paucity of research data to allow an objective assessment of these management strategies. There is some concern that high stocking rates could damage certain soils during wet periods. If excessive compaction does occur in those situations, this negative impact should be weighed against the previously mentioned claims of beneficial impacts from trampling.

In terms of technology diffusion, SDG is in the early stage of adoption in this country. One type of SDG, the Savory grazing method (SGM), for example, was only introduced to the United States 3 years ago, although it has been used abroad for a decade. SGM, sometimes called the "cell system, " arranges pastures in a cartwheel design, with watering and handling facilities in the hub (see fig. 10), Livestock are herded through the various cells according to a management plan that accommodates site variables in each cell. In preparing a SGM plan, the rancher notes his particular needs (e.g., pastures for breeding, birthing, weaning, etc.) and notes which cells will be unavailable at any time for any reason, For instance, the rancher may want to avoid having his heifers in close proximity to a neighbor's bull or too near recently planted crops, Or he may wish to keep

Figure 10.—Cartwheel Pasture Arrangement Used in the Savory Grazing Method



SOURCE Off Ice of Technology Assessment

livestock out of certain cells when they are expected to harbor poisonous plants or during breeding season for ground-nesting birds.

The SGM system purports not only to protect the land but actually to enhance it. According to proponents, the physical impact of livestock hooves has two interrelated beneficial effects, if properly managed. First, livestock hooves churning the soil surface can break up any crust formed by the impact of raindrops and runoff, This reduces erosion. Also, as more rainfall penetrates the soil, more moisture is available for plant roots and for replenishing ground water supplies.

This method, developed in East Africa, is beginning to receive relatively rapid acceptance among U.S. ranchers. However, American range scientists are only just beginning to investigate the system's constraints and potentials. Thus, many questions about the method's impacts, both good and bad, remain to be answered. The following discussion answers some of these questions from the view of the developer of SGM (Savory, 1981).

1. Who can use SGM? Theoretically, any rancher could apply this method on his own without assistance. But in practice, SGM differs greatly from conventional range management and is also, because of its flexibility, quite complex. Accordingly, many who have tried it without prior training have had considerable difficulty. Under the guidance of private range consultants, increasing numbers of U.S. ranchers are succeeding with the methods. The agricultural educational community could be trained to provide this instruction. In fact, together with inadequate data on its effective use, the lack of a trained cadre of instructors is the major barrier to the system's adoption.
2. Are some soils unsuited to SGM? Certain soils may be particularly susceptible to compaction when wet. Other than this possible limitation, SGM has been used on many soil types without ill effects. To avoid compaction, ranchers must plan, insofar as possible, to use pastures only when they are relatively dry.

   Some desert margin soils may also have problems under SGM. Even brief periods of livestock trampling seem to promote the growth of undesirable runner grass communities in small areas—typically 20 to 30 yards in diameter—where the soil is most disturbed,
3. Can SGM be used on steep terrain? Adapting SGM to steep terrain may call for special layouts and fence arrangements. The usual rule of thumb, however, is that if other range management methods can be used on the mountainous land in question, so can SGM,
4. What are typical installation costs for an SGM grazing system? It is impossible to generalize because construction costs are site specific. As an example, the cost of a grazing cell system, installed as part of a whole ranch development near Midland, Tex., was $4.80 an acre, including expenses for water, fencing, and labor, In the 2 years since the system began operating, its stocking rate has more than doubled and survived the 1980 drought at that increased rate.
5. Does SGM require a great deal of paperwork? These systems require more advance

planning and recordkeeping, but the paperwork burden is reduced as the ranchers become practiced in the use of the special recordkeeping systems,
6. When a grazing system has only one watering point and that point is a natural stream, pond, river, or lake, is there danger of serious riparian damage? Although more work needs to be done on this question, proponents of SGM maintain that riparian damage can be avoided by designing the system so that cattle use only part of the watering source at a time, and then for just a limited period.
7. Is the fencing necessitated by a full-blown application of SGM detrimental to wildlife? Fencing in any range management scheme can be detrimental to wildlife, but these effects can usually be limited by using simple three-strand fences that allow most wild species to jump over or crawl under them without injury, In addition, game gates sited on SGM fence lines may be left open when domestic stock are not in the paddocks served by the gates. This facilitates wildlife movements. These systems count good wildlife management as an asset to the rancher because it can have economic as well as esthetic benefits.

razing **Potential** for Eastern **Woodlands***

Introduction

If properly managed, Eastern forests could provide substantial increases in economically and environmentally sound livestock grazing. The 310 million acres of forests in the East could support as much as 20 million AUs of forage (an AU is the forage required to support a cow and a calf for 1 year) if the land were intensively* managed for multiple purposes (Byington, 1980). Under less rigorous, extensive* * management, potential forage is only about 1 million AUs (tables 8 and 9). However, the technologies for intensive multiple-use management have not been developed and demonstrated for most Eastern forest communities, so the potential remains untapped,

Farmers have grazed livestock in Eastern woodlands to varying degrees since first settlement. But most such grazing is environmentally destructive because of overgrazing, erosion, compaction, and other damage to forest growth and reproduction. Further, most of this unmanaged forest grazing is uneconomical,

Only limited progress is being made in developing appropriate technologies for Eastern grazing management because of the commonly held attitude that native forages on Eastern forests simply cannot be produced and grazed in an economically and environmentally sound way.

Current Use

The Eastern United States is blessed with abundant rainfall, adequate growing seasons, and good soils needed to produce abundant vegetation. Most forage in the East comes from intensive crop and pasture management on cleared land, either from growing forage crops as part of a crop rotation or from allowing livestock to graze on residues and stubble left after harvest. Native grazing lands, those forests and grasslands with naturally occurring vegetation suitable for livestock grazing, are of secondary importance.

It is difficult to judge the current extent of grazing in Eastern forests because of problems

*The Eastern United States is defined here as that area east of the 97th meridian. This basically excludes the Great Plains States but includes the forests in Oklahoma and Texas.

*"Intensive management" makes investments in technologies and practices to maximize production, quality, and use of native forages while maintaining the forest for wood products, wildlife, and recreation.

* *"Extensive management" controls livestock numbers with little effort to achieve planned distribution of livestock or to increase carrying capacity through alterations of the forest canopy. Management investments are made only to protect the land from damage.

Table 8.—Estimated Potential of Major Forest Communities to Produce Livestock Forage Under Extensive and Intensive Management—Northern Region

		Average potential proctuction (total AU)		
Potential natural community	Total grazable acres (000's)	Extensive management	Intensive management	States in which community is primarily located
Great Lake spruce-fir.	5,503	7,673	91,581	Minnesota, Wisconsin
Great Lake pine.	5,660	13,217	112,426	Michigan, Minnesota, Wisconsin
Northeastern spruce-fir.	11,934	31,838	646,478	Maine, New Hampshire, New York, Vermont
Northern floodplain.	2,518	32,029	158,547	Minnesota
Maple-basswood.	1,690	0	122,693	Illinois, lowa, Minnesota, Wisconsin
Oak-hickory.	14,310	146,536	890,662	lowa, Illinois, Indiana, Michigan, Montana, Ohio
Elm-ash.	18,556	0	1,650,284	Indiana, New York, Ohio, Pennsylvania
Beech-maple.	*1,448*	1,206	125,452	Michigan, Ohio
Mixed mesophytic.	*5,039*	0	132,520	Ohio, West Virginia
Appalachian oak.	15,309	0	424.419	Connecticut, Massachusetts, Maryland, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, West Virginia
Northern hardwoods.	***38,665***	***34,921***	2,596,887	Massachusetts, Maine, Michigan, New Hampshire, New York, Pennsylvania, Vermont, Wisconsin, West Virginia
Northern hardwoods-fir.	7,891	0	511,218	Michigan, Wisconsin
Northern hardwoods-spruce.	10,421	43,370	334,452	Maine, New Hampshire, New York, Vermont
Northeastern oak-pine.	1,471	31,209	88,817	Massachusetts, New Jersey, New York
Oak-hickory-pine.	3,587	8,528	305,214	Delaware, Maryland, Montana, West Virginia

SOURCE Evert K Byington, "Livestock Grazing on the Forested Lands of the Eastern United States."' OTA background paper, 1980

Table 9.—Estimated Potential of Major Forest Communities to Produce Livestock Forage Under Extensive and Intensive Management—Southern Region

		Average potential production (total AU)		
Potential natural community	Total grazable acres (000's)	Extensive management	Intensive management	States in which community is primarily located
Oak-hickory.	32,113	294,369	1,846,497	Alabama, Arkansas, Kentucky, Mississippi, Oklahoma, Tennessee, Texas
Mixed mesophytic.	5,203	0	169,097	Alabama, Kentucky, Tennessee
Appalachian oak.	20,788	0	415,760	Georgia, North Carolina, South Carolina, Tennessee, Virginia
Oak-hickory-pine.	71,069	59,224	6,573,882	Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, *Tennessee,* Texas, Virginia
Southern mixed.	24,801[a]	413,350	1,972,360	Alabama, Florida, Georgia, Louisiana, Mississippi, Texas
Southern floodplain.	25,607	21,339	832,227	Arkansas, Louisiana, Mississippi, Tennessee

a About milllon acres of total are not suitable for intensive mamaefnent

SOURCE Evert K Byington, "Livestock Grazing on the Forested Lands of the Eastern United States, " OTA background paper, 1980 of definition and classification of land use and land type among the three primary agencies that collect such information. The Forest Service, Soil Conservation Service, and Department of Commerce conduct some inventories of livestock grazing in Eastern forests, but the information is limited and inconsistent. Estimates vary from the Forest Service's high figure of 100 million acres of grazed Eastern forest to Census of Agriculture statistics that indicate only 26 million grazed forest acres. The inconsistency is partly because the latter estimate considers only a certain class of forest owners.

Ownership is an important factor in the use of forests for livestock grazing, Generally, four classes of ownership are considered: public, forest industry, farmer, and other. Farmers throughout the East graze livestock in a higher percentage of their forests than other classes of owners (Byington, 1980).

Overall, forest grazing has declined in recent years. The Soil Conservation Service's conservation needs inventory of 1967 estimated that over 80 million acres of forest in the East were being grazed. The 1977 National Resource Inventories by the same agency estimated that only 36 million acres were then being grazed. The decline, however, is not because of any increasing unwillingness among farmers to graze their woodlands; it is, in large part, caused by the changing pattern of landownership. During the past 25 years, the area of forests owned by farmers dropped 35 percent, though the total area of forest in the East remained relatively stable (table 10). Nearly 55 million acres of forests passed from farmers' hands, much of it into other private holdings less amenable to grazing (Byington, 1980).

History

Throughout the East, native grazing lands played an important role in settlement. The forests and prairies provided inexpensive forage to support livestock used for food, transportation, and animal power for tillage. However, there are major ecological and cultural differences between the northern and southern halves of the Eastern United States that have affected the acceptance of woodland grazing.

During the late 1800's and early 1900's, timber industries denuded large acreages in the East and conflicts between cattle and lumber interests increased. By the 1920's and early 1930's, the Federal Government became increasingly concerned with land use, particularly on the cutover lands in the South. The National Forest System in the South was established, and research began on the interactions between forestry and livestock.

In the Southern pines region, cattle were seen as an opportunity to bring clearcut forestland back into production. But in the Northern hardwoods, grazing was observed to damage

Table 10.—Area, Including Change Over Time, of Commercial Timberland in the Eastern United States, by Ownership, Region, and Section, and for the years 1952 and 1977

	1952		1977		Percent change in forest area, 1952-77	
Region and section	All ownerships (000's of acres)	Farm ownerships (000's of acres)	All ownerships (000's of acres)	Farm ownerships (000's of acres)	All ownerships	Farm ownerships
Northern region.	167,768	64,567	169,353	44,431	1.0	–31
New England.	30,936	7,842	31,015	2,391	0.3	–70
Middle Atlantic.	42,099	15,114	48,215	10,013	15.0	–34
Lake States.	51,838	14,227	49,356	11,345	–5.0	–20
Central States.	42,895	27,384	40,767	20,682	–5.0	–24
Southern Region.	192,083	91,311	188,433	57,217	–2.0	–37
South Atlantic.	46,963	31,937	47,677	19,016	1.5	–40
East Gulf.	42,104	23,134	40,142	11,006	–5.0	–52
Central Gulf.	49,497	21,198	51,045	18,016	3.0	–15
West Gulf.	53,519	15,042	49,569	9,179	–7.0	–39
Total	359,851	155,878	357,786	101,648	–0.6	–35

SOURCE Adapted from table 2, "Forest Statfstlcs of the U S , 1977, " Forest Service, USDA, 1978 the forest, so research was oriented toward documenting livestock impacts. The results of various experiments and observations led to a near-universal conclusion that grazing was necessarily detrimental to Northern forests and was not economically worthwhile. This split in research approach is still visible.

Conservation in Grazed Forests

Table 11 is a summary of non-Federal acres of forest being grazed and thought to require conservation treatment in 1967 and 1977. Two types of conservation treatments are recommended: 1) to reduce or eliminate livestock grazing, and 2) to maintain grazing but improve forage production. Reducing or eliminating grazing is the most recommended practice in the Northern region, while increasing forage production is more often recommended in the South.

Most of the recommended conservation treatments are directed at reducing erosion by maintaining adequate ground cover. Table 12 contains summaries of erosion by land capability class and land use and by the area being grazed. This indicates that a considerable amount of erosion is caused by livestock grazing in woodlands, particularly on land classes V-VIII.

Technologies for Multiple-Use Management of Forest Grazing

Multiple-use management offers the best opportunity for expanding the production of both wood and forage in Eastern forests. The most basic technology used for grazing lands is the management of grazing animals. The technologies needed to develop the forage/livestock systems in forests include:

- Technologies to manage livestock use of native forages that ensure: 1) livestock health and productivity is adequate, 2) the vigor of the plants is maintained, and 3) other resources are not damaged. These technologies include grazing systems, controlling season of use, managing stocking rates, selection and mix of grazing animals, use of feed supplements, and construction of physical structures (fencing, water development, etc.).
- Technologies to improve forage productivity and quality and to increase output per acre to get adequate economic returns or to restore vegetation on damaged land. Technologies include seeding with improved plant species; fertilization; water development; use of mixtures of cool- and warm-season plant species, as well as shade-tolerant species in forests; and the

Table 11 .—Area of Forestland in the Eastern United States Being Grazed by Livestock, Including Area Requiring Conservation Treatments

	1977 NRI			
		Acres of grazed forest requiring conservation treatment		
Region and section	Acres of forest grazed (000's)	Reduce or eliminate grazing (000's)	Improve forage (000's)	Percent of grazed forestland requiring conservation treatment
Northern region	13,130	8,236	3,533	9 0
New England	231	81	59	61
Middle Atlantic	1,870	1,418	210	87
Lake States	3,264	2,051	753	86
Central	7,765	4,686	2,511	93
Southern Region	22,967	6,081	10,239	71
South Atlantic	2,318	962	553	65
East Gulf,	4,346	824	2,209	70
Central Gulf	5,549	2,283	1,400	66
West Gulf,	10,754	2,012	6,077	75

SOURCE Derived from "Basic Statistics 1977 National Resource Inventories (NRI) revised 1980 "

Table 12.—Average Sheet and Rill Erosion Rates in Crop Production Regions[a] of the Eastern United States in 1977 (non-Federal land only)

	Erosion by land use (ton per acre)					
Region and capability groupings	Ungrazed forest	Grazed forest	Cultivated	Hay	Pasture	Range
Northeast						
Classes I-IV.	0.27	1.42	6.33	0.79	0.96	—
Classes V-VIII	0.54	4.60	11,75	1.27	3.79	—
Lake States						
Classes I-IV.	0.06	1.14	2.81	0.54	0.82	0.05
Classes V-VIII. . . .	0.39	12.42	6.94	2.65	2.74	0.44
Corn Belt						
Classes I-IV.	0.66	5.47	7.56	1.72	2.43	0.37
Classes V-VIII. . . .	1.94	11.42	29.60	4.20	9.18	—
Appalachian						
Classes I-IV.	0.26	2.52	9.12	1.56	1.65	—
Classes V-VIII. . . .	1.90	7.26	46.13	8.06	10.65	—
Southeast						
Classes I-IV.	0.16	0.53	6.95	0.38	0.47	0.27
Classes V-VIII. . . .	0.63	1.41	16.42	0.86	1.30	0.36
Delta						
Classes I-IV.	0.18	1.56	6.86	0.78	1.33	1.90
Classes V-VIII. . . .	0.99	8.54	28.35	5.09	9.20	4.51
Southern Plains						
Classes I-IV.	0.10	0.45	3.41	0.76	0.97	1.00
Classes V-VIII. . . .	0.71	1.62	4,58	0.44	2.15	5.22

Geographic regions and land capability groupings are as defined by the Soil Conservation Service.

SOURCE USDA 1980 "Table 172" in Basic Statistics, 1977 National Resource Inventories, revised 1980

use of livestock, chemicals, fire, and machines to control unwanted plant species.

- Technologies to manage the interactions of forage plants and livestock with other land uses so as to reduce conflicts and maximize overall output of goods and services. Such technologies often involve tradeoffs between uses and depend on the judgment of the land manager. For example, the tree canopy limits light and water flow to the soil, and thus forage production. Opening up the tree canopy will increase forage production but may reduce overall production of wood, Success in selecting a technology to manage such interactions depends on the availability of knowledge about how each resource will respond, so that tradeoffs can be estimated and evaluated.

Conclusions

The grazing potential of the Eastern forest is a resource that has not been considered of sufficient value to develop and manage with appropriate technologies, Forest production in the East is based primarily on a philosophy of single dominant use, and although farmers use their woodlands for grazing, it is at a low level of management which typically is neither economically nor environmentally sound. Because few techniques for intensive management have been developed except in the Southern pine forest, the forest owner has little choice except to manage for wood products, sell the land, or clear the forest to establish pasture.

Over 50 million acres of forested land have passed from farm ownership in the last 30 years, With increasing land values and higher taxes, farmers have often found that they cannot afford to keep forests for either woodland grazing or production of wood products. The future of these lands will depend on how the mix of economic and social factors changes the value that is placed on the various resources these forests can supply. Intensive management of forest lands to produce both wood products and livestock forage may make it profitable for farmers to retain their farm forests.

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