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Manipulative Range Improvements: Summary and Recommendations

Carlton H. Herbel

INTRODUCTION

Largely because of past federal policies, grazing practices, and the climate, most western public rangeland is in a degraded condition. Professional opinion remains divided on whether range condition has improved or deteriorated over the last 50 years; however, there is a consensus that vast areas need immediate attention. Some rangeland is dominated by woody vegetation and undesirable species of annual grasses rather than the perennial grasses and forbs preferred for livestock grazing. However, because the woody plants are long-lived, manipulation of grazing intensity (or cessation of grazing) alone will not restore the rangeland. To increase livestock production on this rangeland, it may be necessary to manipulate the present vegetation by mechanical, chemical, or biological means.

Each manager determines the desired level of productivity of the rangeland on the basis of economic, political, and social factors and the availability of technology. Drastic manipulations of range ecosystems are sometimes required because of invasion by unwanted plants, severe droughts, past abuses by grazing animals, or the desire by the operator to change botanical composition, or productivity, on all or part of the range unit. Such manipulations require the application of many principles inherent in the relationships among climate, soils, plants, and animals. Without proper consideration of these environmental parameters the practices may not produce the desired results. Although the relative costs of these practices are high, the potential benefits may also be great. Control of unwanted plants, revegetation, and/or fertilization can increase forage production 100-1000 percent within 1-3 years. If these risky, costly practices are used, only superior management will reduce the probability of failure and heavy financial losses. To implement revegetation, the following questions should be asked: (1) What is the potential for this site? (2) Are there plant species that may be more productive or better able to meet a particular requirement than the plants growing there now?

Some native plants are poorly adapted for grazing use by animals or for recreational use. In certain areas the vegetation may be manipulated by the introduction of exotic plant species that are superior to native species. In the 1930s, for example, crested wheatgrass (Agropyron desertorum) was introduced to enhance forage in the western areas of Canada and the United States.

Few, if any, managers use only principles that involve intensive practices on a unit of rangeland. Rather, practices employing both extensive (programs whereby broader ecological rather than agronomic goals are emphasized) and intensive (programs predominately aimed to increase forage yield per unit area) principles are used. For increased plant production and soil protection, each unit must be managed to maintain or improve the basic resources. In the Northern Great Plains of Canada and the United States, this may mean seeding part of the range unit with Russian wildrye (Elymus junceus) and crested wheatgrass and using nitrogen fertilizer on both native and introduced species. In portions of the Northern Great Plains, the best practices may include judicious burning of parts of the native rangeland and plowing up the native sod on some of the better sites and seeding wheat (Triticum aestivum) for forage, or for forage and grain. On the semiarid Southern Great Plains and associated grasslands of Mexico and the United States, a useful strategy may include seeding weeping lovegrass (Eragrostis curvula), sideoats grama (Bouteloua curtipendula), wheat, and sudangrass (Sorghum sudanensis). In the arid portions of the southwestern United States and northern Mexico, range productivity could be greatly increased by control of mesquite (Prosopis juliflora) and tarbush (Flourensia cernua) and seeding with Lehmann and Boer lovegrass (E. lehmanniana and E. chloromelas) and fourwing saltbush (Atriplex canescens). On rangeland infested with big sagebrush (Artemisia tridentata), control of the sagebrush and seeding with crested wheatgrass often results in much greater forage productivity and soil stability than would otherwise be obtained. In some instances, composition of plant species may be manipulated to improve wildlife habitat and at the same time maintain or improve livestock production.

The use of various practices is changing with time as dictated by economic, political, and/or social conditions, or as improved technology becomes available. It is important that the range resource is maintained or improved as it is managed to meet multiple objectives. Land managers, and others working with land managers, must be flexible and innovative in their planning. The potential for each range site must be determined before implementation of a treatment program. What will work well on one range unit may not work well on another.

EVOLUTION AND ECOLOGY OF RANGE PLANTS

Factors responsible for vegetation changes include (1) climate, (2) grazing by wild or domestic herbivores, (3) fire, (4) plant adaptations, and (5) governmental policies.

In some areas, notably the Great Plains, the evolution of rangeland plant communities was influenced by both climate and native herbivores. In other areas, such as the arid portions of the Southwest and Great Basin, native herbivores had less of an effect, and climate was the most important factor affecting the evolution of vegetation. However, the heavy grazing by domestic livestock during the nineteenth and first third of the twentieth centuries may have exerted pressures with which plant communities were unable to cope. In addition to applying grazing pressure, livestock also disseminate propagules of undesirable plants. Selective grazing may weaken some desirable plants and allow more room for less desirable plants. Decreases in protective plant cover may increase soil erosion. Protection from grazing, however, would be useless in many areas because unwanted, primarily woody, species are established and compete more successfully for the limited resources needed for plant health.

Fire can play a major role in vegetation composition. However, today's arid rangeland generally does not have sufficient fuel to carry a major fire. Furthermore, the distribution of fuel can be patchy, and this prevents a fire from uniformly influencing all vegetation. There is also considerable difference in the effect of fire on various species of range plants.

Many of the plant species in the western United States evolved under conditions that are different from those now extant. Therefore some of these plants are not well adapted to higher grazing pressures, and, in some instances, suppression of fire.

Governmental policies are indirectly responsible for vegetation changes because they affect management and use of rangeland. Prior to the 1930s, public rangeland policy was largely nonexistent. Only recently did the policy of management for grazing dominance give way to active management for multiple uses. This topic is addressed fully in the Workshop on Political and Legal Aspects of Range Management (this volume).

SAGEBRUSH AND SALT DESERT ECOSYSTEMS

The sagebrush-grass and salt desert shrub ranges of the intermountain area of western North America consist of a complex array of plant communities. During the nineteenth century, the sagebrush-grass ranges were altered by the agriculture of the settlers. This ecosystem was not adapted to concentrations of large herbivores (Young et al. this volume). The introduction of livestock and exotic plants along with the resistance of shrubs to grazing led to a rapid increase of shrubby vegetation and some herbaceous plants. A grazing pattern was established that used high-elevation ranges in the summer and sagebrush-grass and salt desert shrub ranges in the fall, winter, and spring.

Weak seedling competition, combined with limited seed production and seed dormancy, makes it difficult to revegetate sagebrush-grass ranges with native plants. However, in the late 1930s it was found that crested wheatgrass was well adapted to these ranges and could be successfully seeded to provide livestock forage. After World War II, it was recognized that 2,4-D would control sagebrush species and thereby lead to increased stands of residual perennial grasses (Young et al. this volume). Picloram is also useful for controlling associated woody plants. Paraquat was used to control cheatgrass (Bromus tectorum) on sites to be seeded because it is deactivated when it strikes the soil. Virtually any range improvement practice requires deferment of grazing for optimum stands of desirable vegetation. Practically no range improvement techniques exist for salt desert ranges.

PINYON-JUNIPER ECOSYSTEMS

Six species each of pinyon pine and juniper trees dominate woodlands occupying approximately 325,000 km^2 (125,482 mi^2) in semiarid portions of the western United States. The extent of these ecosystems is much greater now than when settlers first came to the western United States because livestock grazing has reduced competition from herbaceous plants, and fires have not occurred frequently enough to kill the young trees (West this volume). Reduction of livestock numbers will not reverse or stop these successional changes. The successional pattern for most sites in pinyon-juniper ecosystems indicates that the climatic climax is dominated by pinyon pines and junipers. An active treatment program would be required to return these ecosystems to a grassland-tree savannah. Land managers conducted programs of tree control from the 1940s through the early 1960s to increase herbage production. Recent legislation and increased costs of manipulation have reduced these activities and forced closer scrutiny of the ecological impacts associated with treatment programs (West this volume). Immediate action is required to reduce soil erosion and prevent loss of site potential in these ecosystems.

SOUTHWESTERN DESERT ECOSYSTEMS

The land resources of the Southwest include plateaus, plains, basins, and isolated mountain ranges. The three ecosystems discussed are the southwestern shrub-steppe, desert shrub, and desert grasslands of Arizona, New Mexico, and Texas. The average annual precipitation over most of this area ranges from 200 to 300 mm (7.9-11.8 in.). The growing season precipitation occurs during the summer, and the spring period is normally very dry and occasionally windy. The three major arid ecosystems in the Southwest occupy a total of 36.2 million ha (89 million acres) and currently have a stocking level of nearly 6 million animal unit months (AUMs). If the potential of these ecosystems could be realized, present stocking rates could increase dramatically (Herbel this volume).

Species composition of many plant communities has been altered. Woody plants, such as mesquite, creosotebush (Larrea tridentata), and tarbush, along with certain other plant species, cannot be controlled by improved grazing practices alone (Herbel this volume). Mesquite is considered detrimental throughout the semidesert range area. Mesquite invasion is associated with decreased density and herbage yield of grasses and increased sheet and gully erosion. Creosotebush has no grazing value, and forage production in moderate to dense stands of creosotebush is negligible. Tarbush is a deciduous plant that grows primarily on medium to heavy textured soils and its presence results in a dramatic decrease in the production of herbaceous plants.

ECONOMIC EVALUATION OF RANGE IMPROVEMENT PRACTICES

A range improvement project must have a specific goal, otherwise progress will be difficult to measure. There are several criteria for making decisions on range improvements: (1) least-cost approach (the cheapest way of achieving a range improvement goal); (2) worst-first approach (improve the site in poorest condition regardless of cost); and (3) net benefit approach (choosing the treatment that has the highest net benefits) (Nielsen this volume, Gray this volume).

For optimum allocation of limited funds, the net benefit criterion should be used at all levels of decision making. This criterion places the emphasis on sites and practices with the greatest potential for increases in net benefits (benefits minus costs). Each range site should be classified as to which range improvement, if any, should be made and what the potential of the site is for various uses. Some of the costs of range improvements to consider are (1) land treatment costs; (2) structural developments (e.g., fences, water developments); (3) nonuse of grazing animals; and (4) administrative costs (Nielsen this volume). Some of the benefits are (1) increased livestock numbers; (2) increased livestock performance; and (3) improved multiple-use options. Three criteria have been used to determine the economic feasibility of range improvement alternatives and to rank them: (1) internal rate of return; (2) current net worth; and (3) benefit-cost ratio. (These criteria are discussed fully in the Workshop on Applying Socioeconomic Techniques to Range Management Decision Making, this volume.)

ROLE OF LAND TREATMENTS ON PUBLIC AND PRIVATE LANDS

Economically feasible land treatments are easier to implement on privately owned land, where the major limitation is the economic status of the landowner. On private land, the treatment is most often applied for a single use or a few uses. On public land, treatments can be made only after extensive public involvement, and they are more likely to be applied for several uses. Treatment of public and private lands must be coordinated because of the interdependence of the properties. Although many treatments are available, none offers a panacea. Each technique is site specific and will succeed only if the needs of the site are known (Box this volume).

RECOMMENDATIONS

General

1. Range management strategies should be based on an understanding of the biological requirements and limitations of range ecosystems.
2. The selective pressures of arid and semiarid grazing lands affect the success of range improvement practices and the probable costs of the different managerial approaches. Approaches that take biological selective history into account are most likely to succeed.

3. Improvement practices that use ecological principles should be recommended on a site-specific basis.

4. Proper management of range improvement practices is critical if they are to be successful.

5. Managers should be realistic in their expectations and approach to land treatment. The plan should establish a precise and measurable goal and recommend methods that have a high probability for success.

6. Two or more technologies, e.g., mechanical brush control followed by fire and improved grazing management, should be used if they are superior to a single treatment.

7. Treatments on private and public lands should be coordinated to enhance their overall value. Modifications of vegetation on public lands to increase grazing capacity must take into account the requirements of these animals in total rather than only for the time they are on public lands.

8. Managers should consider the use of domestic livestock and wildlife species in various combinations to optimize forage utilization.

9. All planning for range improvements and subsequent management should be integrated, and total benefits and costs--to wildlife, livestock, watersheds, ecological integrity, and reçreation--should be assessed.

10. Positive steps should be taken to reduce stands of unwanted woody plants on rangeland. Reducing livestock numbers, or removing them from a unit of rangeland, is not a solution.

Evolution and Ecology of Range Plants

1. Managers should recognize that different plant and animal species may respond quite differently to the same managerial approach.

2. Important traits of plant species proposed for introduction to a region (annual-perennial habit, carbon assimilation pathway, sod formation, etc.) should be compared with those of the native dominant species. Although it is not necessary to mimic current dominant plants, there should be good reasons for introducing different plants.

3. Managers should take into consideration plant production as well as the ease of plant establishment (particularly on harsh sites).

4. Use of chemical and mechanical methods for improving range-land should be assessed not only with regard to immediate biological and economic impact, but also with regard to long-term biological effects.

5. More research is needed on the effect of environmental stress on individual plant responses/life cycles.

Sagebrush and Salt Desert Ecosystems

1. Treatment of sagebrush communities, when feasible, should include application of 2,4-D to reduce sagebrush when there is an adequate stand of residual grass plants. If the degraded sagebrush stand lacks sufficient perennial grasses, the improvement practice must include seeding.

2. If weedy annual grasses are not present, the shrubs in the sagebrush community can be controlled with 2,4-D and a mixture of desirable species seeded in the standing dead brush. If weedy annual grasses are present, some form of herbaceous weed control is necessary if seeding is desired.

3. The atrazine fallow method for herbaceous weed control in the sagebrush community can be vertically integrated with brush control to obtain total site conversion.

Pinyon-Juniper Ecosystems

1. Where feasible, the areas treated in the 1950s and 1960s should be re-treated where undesirable shrubs have returned to dominance.

2. Seeding of desirable forage plants onto burned sites should be done promptly. The opportunities provided by wildfires for revegetation and plant control should be acted upon more often, where needed.

3. Prescribed burning of pinyon-juniper should be used more often where tree stands are sparse and understory vegetation is adequate to carry fire and provide sources of propagules. This should be contemplated primarily for sites with less potential for tree growth, mainly the scattered juniper at the upper and lower boundaries of the woodland belt.

4. Additional herbicides should be evaluated for their efficacy in curtailing tree and shrub populations. Before herbicides or prescribed burning is used, the public should have an opportunity to harvest the wood products.

5. Tree harvesting should be integrated into plans to change the size and age class mosaic on entire watersheds. Small patches of trees should be marked for use as fence posts and fuel wood. Such revenues from tree utilization will help defray costs of other treatments. Over time the landscape would develop patches of different aged treatments and would be more

aesthetically pleasing as well as have positive effects on watersheds and wildlife.

Southwestern Desert Ecosystems

1. Because of frequent and prolonged droughts, it is important to sustain a high level of flexibility in management and utilization of rangeland in the Southwest.

2. Control methods should be used on unwanted plants--improved grazing practices will not control woody plants such as mesquite and creosotebush. The proper method of plant control should be selected on the basis of site potential, the target species, and the degree of infestation.

3. Mesquite may be controlled by use of several chemical and mechanical methods. One of the methods used is aerial spraying with 2,4,5-T, 2,4,5-T+ dicamba, or 2,4,5-T+ picloram. Another promising method is the aerial application of tebuthiuron pellets. There is a substantial increase in plant growth with control of dense stands of mesquite on sandy soils.

4. Creosotebush and tarbush may be controlled with an aerial application of tebuthiuron pellets. Sites heavily infested with creosotebush and tarbush may be rootplowed and seeded where there is no residual stand of desirable plants. Tarbush may also be controlled by chaining or railing when the plants are dormant. The following species may be seeded on light- to medium-textured soils: Boer and Lehmann lovegrasses, black grama (Bouteloua eriopoda) and sideoats grama, yellow bluestem (Bothriochola ischaemum), blue panicgrass (Panicum antidotale), and fourwing saltbush. Plants adapted on medium- to heavy-textured soils are alkali sacaton (Sporobolus airoides), sacaton (Sporobolus wrightii), vine mesquitegrass (Panicum obtusum), blue panicgrass, yellow bluestem, and fourwing saltbush.

5. Practices such as seeding, control of rodents and rabbits, and fertilization should be used only on limited areas with special needs and with a high potential for production of forage.

6. To a great extent, riparian communities have been damaged irretrievably. They may be partially recovered by seeding willows (Salix spp.), cottonwoods (Populus spp.), blue paloverde (Cercidium floridum), and fourwing saltbush and big saltbush (Atriplex lentiformis). However, grazing will still need to be controlled.

7. Water-spreading schemes substantially increase forage production where sedimentation does not pose a serious problem. The watershed area above the water-spreading site should provide at least one flooding per

year; however, this does not occur in the drier portions of the Southwest.

Economic Evaluation of Range Improvement Practices

1. Management decisions should take into account the uses of the land.
2. Land managers should be certain that the criterion used within the agency to allocate range development funds is the same one used by others to evaluate the success of the program.
3. Variance in yields, costs, and prices in range improvements is high and must be considered in the economic analysis. The simplest way to include risks may be to add a risk premium to the discount rate.
4. High interest rates diminish the value of benefits received in future years; therefore rapid net returns have a higher value than those in the distant future.
5. The net benefit principle should be used as an allocating criterion. This principle emphasizes the selection of sites and practices having the greatest potential for increasing the differences in per acre benefits and costs.
6. In allocating range resources among competing uses, the same type of economic analysis should be made for each use.
7. Policies on required nonuse should be biologically justified, since the managerial policy of nonuse has such a pronounced effect on the economic feasibility of improvement practices.
8. The government should reimburse livestock permittees for the unused portion of private investments in range developments on government land if and when a change in land use eliminates or seriously reduces grazing.

Role of Land Treatments on Public and Private Lands

1. Estimates of productive potential are essential to the design and implementation of land treatments, and these should be developed over two drought periods.
2. Range improvement practices should be monitored continually to assess their overall utility. The length and frequency of monitoring depend on the annual variability in precipitation.
3. The availability of propagules needed to revegetate rangeland should be determined, and more attention should be given to selecting genetically improved plants.

4. Renewable resource management in arid and semi-arid areas depends both on ecological and on agronomic management. Ecological management procedures that will work on agronomically developed grazingland ecosystems are needed.

5. A careful evaluation of the relationship between plant and animal productivity is needed, and it needs to be compared to indices commonly used to depict range condition. A high ecological condition is not always the most productive.

6. The range site or habitat type is the basic unit for management of rangeland. These ecological response units must be identified clearly. It is impractical to research each range improvement practice on each type of unit. Thus response units must be placed on a continuum or otherwise aggregated so that results found in one unit may be extrapolated to others. Also, we must have information on the relationships among response units under various conditions that are managed as a unit.

BIBLIOGRAPHY

Box, T.W. Role of land treatments on public and private lands. In this volume.

Calkin, B. Response to "Role of land treatments on public and private lands." A discussant paper. A paper presented at the workshop on manipulative range improvements, National Research Council, April 7-8, 1981.

Donart, G.B. The history and evolution of western rangelands in relation to woody plant communities. In this volume.

Gray, J.R. Response to "Economic evaluation of treatments that manipulate vegetative succession." In this volume.

Herbel, C.H. Successional patterns and productivity potentials of the range vegetation in the warm, arid portions of the southwestern United States. In this volume.

Jameson, D.A. Response to "Successional patterns and productivity potentials of pinyon-juniper ecosystems." A paper presented at the workshop on manipulative range improvements, National Research Council, April 7-8, 1981.

Low, B.S., and J.A. Berlin. Natural selection and management of rangelands. In this volume.

Michieli, R.A. Role of land treatments on public and private lands: A discussant paper. In this volume.

Nielsen, D.B. Economic evaluation of treatments that manipulate vegetative succession. In this volume.

West, N.E. Successional patterns and productivity potentials of pinyon-juniper ecosystems. In this volume.

Wright, H.A. Response to "Successional patterns and productivity potentials of the range vegetation in the warm, arid portions of the southwestern United States." In this volume.

Young, J.A., R.A. Evans, and R.E. Eckert, Jr. Successional patterns and productivity potentials of the sagebrush and salt desert ecosystems. In this volume.