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RANGELAND

Conservation Needs, Technology, and Policy Alternatives

Range—or more appropriately rangeland-is a kind of land and not a use of land. Rangeland provides or is capable of providing forage for grazing or browsing animals. Range includes grasslands and shrublands and those forest lands that continually or periodically, naturally or through management, support an understory of herbaceous or shrubby vegetation that provides forage. Also included are those lands that have been seeded to non-native plants but are managed like lands that support native vegetation. Lands designated as improved pastures, cropland pasture, and grazed croplands are not classified as rangeland because they are routinely cultivated, seeded, fertilized, and/or irrigated.

Rangeland managment is limited by environmental and economic factors. Many rangelands are dry or precipitation is so erratic that arid land management practices must be followed. However, riparian zones that occur as part of the rangeland ecosystem must be managed according to their particular characteristics. Other environmental characteristics that dictate range management options are steep slopes, short growing seasons, and unfavorable soil conditions. All of these environmental factors lower the productive capacity of the land and limit the amount and reqularity of economic input into management. Cultural improvement practices, such as brush management and seeding, are most useful in attempting to improve deteriorated conditions or in meeting special management objectives. Economically inexpensive and energy efficient range management practices, such as controlled grazing and prescribed burning, can then be used to maintain desired ecological conditions.

Rangeland Use

Rangelands are important to the nation. Thirty-nine percent of the land resource base is classified as rangeland. An additional 20 to 30 percent of the land is managed as range. Over 99 percent of this resource occurs in the 17 contiguous Western States and Alaska, but rangeland must not be thought of as a Western resource. Rangeland is important to all Americans.

Rangeland provides forage, cover, water, and space for domestic livestock and wildlife. Rangeland or lands used as range provide over 200 million animal-unit-months of domestic livestock forage. The sheep and goat industry in particular depends upon rangeland grazing; 80 percent of all sheep and goat products,including lamb, mutton, and goat for human consumption and wool and mohair for clothing, are produced on rangeland. Rangeland is the most important habitat for wildlife in the United States, and healthy wildlife populations depend upon how well we manage these lands.

Water originating from rangeland is an important part of the water supply for the nation.

People use rangeland directly for a variety of recreational opportunities, taking advantage of the clean air, open space, and healthy, natural environment that rangeland provides. The role that these get-away-from-it-all activities play in the social well-being of the nation is unquantified but certainly important.

Rangeland is a source of energy and mineral supply. Coal, oil and gas, oil shale, uranium, and numerous other materials occur on or under rangeland. These materials are being "harvested" to meet our energy and mineral requirements. Lands disturbed for such purposes must be reclaimed to insure their usefulness in meeting future demands of society.

Multiple use is generally practiced on rangeland, but some of the uses may influence management decisions more than others. For instance, an area of range may be used for livestock grazing, wildlife habitat, and water supply, but one of these uses may be of higher priority today because of society's demands or land ownership desires.

Management Objectives

Management objectives for rangeland vary among areas depending upon production capabilities and socioeconomic demands. A primary objective for managing rangeland is to provide a mix of products, services, and values demanded by society today without reducing future production and use options through deterioration of soil and water resources.

Use of rangeland for production of food for human consumption will become increasingly important in the future. A growing population, both in the United States and worldwide, will require that some grain now used to feed livestock be diverted for human consumption. In addition, some grain now fed to livestock may be used for conversion to energy fuels such, as alcohol. Range forage can be converted to human food by the grazing animal without large inputs of costly fossil fuel. Range-fed livestock will become an even more important source of meat for humans. Thus, rangeland will contribute to maintaining a quality diet for Americans.

CURRENT SITUATION

Misuse of western rangeland in the 19th century resulted in a deteriorated ecological condition and reduced forage productivity. Although management of rangeland under federal control improved in the early 1900s with the establishment of national forests, most of the public domain was not brought under management until 1936. Effective management programs really began after World War II when the Grazing Service, responsible for managing these areas, officially became the Bureau of Land Management.

Emphasis on improved management of nonfederal rangeland started in the mid 1930s with creation of the Soil Conservation Service and efforts by the land grant institutions through extension and education programs. Limited data exist describing the condition of nonfederal rangeland at that time. Table 1 contains estimates of range condition by the Soil Conservation Service (SCS) in 1963 and again in 1977. These data indicate that during this 14-year period 20 percent of the nonfederal rangeland in fair or poor condition improved to good or better condition. However, 60 percent of this rangeland still remains in less than good condition (Pendleton, 1979).

Box (1978) reported the percentage of all federal land in three condition classes and for three dates starting with data from Senate Document 199 (U.S. Senate, 1936). Marked change in condition was apparent between 1936 and 1966, but little change occurred between 1966 and 1972.

Although data from various sources may differ from the trends in Tables 1 and 2, there appears to be general agreement that the trends are representative of changes taking place on Western rangelands since the 1930s.

Table 3 summarizes, by major ecosystems, the condition classes as well as the present and potential stocking rates on both public and private land in the 17 Western states. The present stocking rate of 195 million animal-unit-months (AUM's) could be increased to 620 million AUM's if

Table 1. Range conditions, 1963 and 1967.

Date	Range condition (percentage of area)			
	Excellent	Good	Fair	Poor
1963	5	15	40	40
1977	12	28	42	18

Source: SCS, USDA

Table 2. Range conditions, 1936, 1966, and 1972.

Date	Range condition (percentage of area)		
	Good or excellent	Fair	Poor or very poor
1936	16	26	58
1966	18	49	33
1972	18	50	32

Source: Box (1978)

all the land were in good condition. Interestingly, the data indicate that 15 percent of the range is in good condition; 31 percent in fair; with the remaining 54 percent being in poor or very poor condition.

Frequent drought, coupled with encroachment of unwanted plants and past management practices, has resulted in the deterioration of much western rangeland. Brush has replaced much of the grass and other forage on 200 million acres of rangeland in the Southwestern alone (NACD, 1979). This leads to reduced livestock grazing capacity, inefficient use of precipitation, increased soil erosion, and deterioration of wildlife habitat. Seventy-seven percent of all nonfederal rangeland needs some kind of conservation treatment.

Sheet and rill erosion on rangeland ranged from 0.5 to 8 tons per acre per year in 1977. The average soil loss was 2.8 tons. Rangeland erosion is a severe problem (over 5 tons/acre/year) in two range states, a major problem (3 to 4.9 tons/acre/year) in one state, and a moderate problem (2 to 2.9 tons/acre/year) in seven states. Average rangeland erosion is less than 2 tons per acre in seven of the 17 Western states.

Because many rangeland soils are shallow and have considerable slope and climatic limitations, erosion occurs readily where land is misused. Wind erosion in excess of 2 tons per acre per year occurs on 27 million acres of rangeland in the 11 Great Plains states. This represents about 9 percent of that regions rangeland. Sheet and rill erosion on rangeland in excess of 2 tons per acre occurs on 124 million acres or 30 percent of all nonfederal rangeland, excluding Alaska. States with severe sheet and rill erosion problems on rangeland include Arkansas, California, Colorado, and Mississippi. Texas also has a major sheet and rill erosion problem with over three tons per acre loss. Moderate sheet and rill erosion is found in Kansas, Nebraska, Nevada, New Mexico, Oklahoma, Utah, and Wyoming. Most other range states have only slight erosion problems (USDA, 1980b, c). Wind erosion is a problem in New Mexico and Texas.

The reduced carrying capacity of range in less than excellent condition represents a loss of 30 to 40 million AUM's of grazing, or a loss of

Table 3. Rangeland types, areas, condition, and stocking in the 17 Western States.†

Total stocking ecosystem‡	Area	Condition				Grazed	Stocking rate	Present	Potential
		Good	Fair	Poor	Very poor				
	million acres	%					AUM/a	1,000 AUM's	
Sagebrush	129.9	12.3	36.1	35.0	16.6	89	0.182	24,641	77,770
Desert shrub	81.2	17.4	36.4	31.5	14.7	70	0.041	2,809	8,070
Southwestern shrubsteppe	43.2	10.5	14.8	41.5	33.2	92	0.084	3,775	17,140
Chapparral-mountain shrub	15.5	11.8	24.0	37.9	26.3	95	0.125	1,612	8,300
Pinyon-juniper	47.3	9.1	28.6	44.4	17.9	88	0.073	2,393	12,040
Mountain grasslands	26.9	17.5	36.2	31.2	15.1	97	0.319	16,597	29,020
Mountain meadows	3.3	32.4	38.8	21.1	7.7	79	0.613	822	4,220
Desert grasslands	24.7	8.4	24.7	50.5	16.4	93	0.091	2,998	8,220
Annual grasslands	10.2	13.2	5.0	36.7	45.1	96	1.095	10,649	64,010
Alpine	6.8	42.8	27.1	28.7	1.4	70	0.045	216	460
Shinnery	4.7	16.5	27.7	40.5	15.3	97	0.406	1,848	6,780
Texas savanna	28.4	16.4	23.5	45.9	14.2	99	0.428	16,493	43,660
Plains grasslands	175.2	14.7	34.2	39.6	11.5	98	0.294	54,325	168,560
Prairie	41.0	14.0	34.2	38.1	13.7	95	1.090	45,145	148,680
Douglas-fir	38.5	--	--	--	--	52	0.049	1,000	2,000
Ponderosa pine	33.7	--	--	--	--	74	0.059	1,617	3,230
Western white pine	0.6	--	--	--	--	48	0.234	50	100
Fir-spruce	113.4	--	--	--	--	51	0.028	418	840
Hemlock-Sitka spruce	19.8	--	--	--	--	0	0.000	173	350
Larch	2.8	--	--	--	--	41	0.147	178	360
Lodgepole pine	21.2	--	--	--	--	56	0.011	527	1,050
Redwood	0.8	--	--	--	--	55	0.063	28	60
Hardwoods	39.8	--	--	--	--	56	0.059	1,222	2,440
Longleaf-slash pine	0.3	--	--	--	--	96	0.200	55	110
Loblolly-shortleaf pine	5.4	--	--	--	--	37	0.011	22	40
Oak-pine	3.3	--	--	--	--	48	0.105	147	290
Oak-hickory	7.6	--	--	--	--	28	0.253	531	1,060
Oak-gum-cypress	2.8	--	--	--	--	3	2.490	191	380
Elm-ash-cottonwood	1.6	--	--	--	--	10	0.213	51	100
Wet grasslands	3.5	17.0	27.6	20.7	34.7	79	0.663	4,304	8,610
Desert	7.5	76.6	11.6	6.5	5.4	45	0.001	3	10
Total	940.9							194,840	617,960

† Partially obtained from and based on "An Assessment of the Forest and Range Land Situation in the United States" (Forest Service FS-345, 1980).

‡ Potential stocking was calculated by assuming that good, fair, poor, and very poor range conditions produced 80, 50, 30, and 10% respectively, of potential. Based on the ecosystems for which we had condition data, we assumed that the potential stocking for the remaining ecosystems could be approximately doubled.

almost one billion pounds of red meat and significant amounts of wool, mohair, leather, tallow, insulin, and many other by-products. With the increase in demand for red meat and animal products by the year 2030, demand for range grazing is expected to increase 140 percent over what it was in 1976 (USDA, 1980b, c).

A 1973 inventory of brush encroachment problems showed 277 million acres of brush on nonfederal rangeland and pasture. Twenty-two areas were identified as having major brush problems. In these areas brush was so dense it dominated the plant community, seriously suppressed the growth of more useful plants, severely restricted land use, and left soil vulnerable to erosion. These areas contained 223 different kinds of brush. In the 17 Western States severe brush problems were found in Oklahoma, Oregon, Utah, and Texas. Five range states had major problems, four states had moderate brush problems, and four had only slight brush problems.

Land use conversion will continue to reduce the rangeland base. The 1975 Potential Cropland Study (USDA, 1977) indicated that from 1967 to 1975 just over 4 million acres of rangeland and pasture were converted to urban, built-up, and water areas. This equals one-half million acres per year. These figures are not great nationally, but locally they are significant. Future losses in the rangeland base will occur chiefly through conversion to urban, built-up, and cropland uses. The SCS Potential Cropland Study shows that about 40 million acres of rangeland has medium potential for conversion to cropland, while 9 million acres has high potential. The RPA assessment projects a 57 million acre loss to all uses by the year 2030.

In the 1980 update of the Forest Service RPA document livestock grazing use in the National Forest Systemis projected to increase from the current 9.9 million AUM's to 15.5 million AUM's by the year 2025. This increase will be made possible by improving coordination with other resource uses. Two key elements in achieving this goal are (1) grazing in timber stands for 10 to 20 years after harvesting and (2) concentrating grazing on the most productive lands.

STATEMENT OF THE PROBLEMS

The Problems

The nation is faced with an almost continual reminder of the need for increased levels of production and quality of food, fiber, and environmental amenities. Recently, this plea has been muted by the supreme dominance of energy over our economy, politics and society. Concomitant with the concern about energy is an increasing concern for natural resources, namely, soil, water, and air. This situation emphasizes that we are finally in a resource-oriented era.

The worldwide population increase is projected at 1.7 percent annually. At this rate there will be 3 to 6 billion more people by the year 2030. In the United States an increase from about 230 to 300 million is expected during the same period. The rate of increase in food and fiber production has been about 1 percent a year. Much has been written about whether the world will have an adequate food supply in the future when 15 million people already die annually from starvation.

Among the constraints facing the United States and the world are the following:

1. Shortage of fossil fuel energy.
2. Scarcity of water.
3. Insufficient knowledge and technology reserve.
4. Failure to apply existing technology.
5. Increasing competitive uses for resources.

As the demand for goods and services from rangelands increases, these constraints make future range management qualitatively different from that practiced in the past.

By its very nature, rangeland is managed for a variety of products. This attribute is the basis for conflict among several segments of American society, and in some cases it has polarized opinion to the detriment of rangeland management for any of the products.

The dominant or primary use of rangeland resources in the past 100 years on public and private rangelands has been the production of domestic livestock for meat, wool, and mohair. Current users of these rangeland resources are now more numerous, affluent, environmentally concerned, and have other values than pre-World War II society. Water, hunting and fishing, nonconsumptive recreational pursuits, oil, gas, hard rock minerals, timber for wood and fuel, and even scientific and aesthetic values are among those valuable products that can be produced and are being requested by Americans. These products have value in the marketplace.

Research is needed to find ways of integrating management for as many rangeland products as possible. In some land forms, where terrain, remoteness, climate, and soil and water resources limit production and/or uses of several products, a single use may be an essential management goal. On most range sites, however, more than one product can be produced without compromising or reducing the production of others. Indeed, many extensive rangelands, grazing by domestic livestock is the most effective tool for producing vegetative conditions favorable to other uses.

Society's demands may require single use or multiple use. These decisions, nonetheless, should have the guidance of scientific information.

Although progress has been significant in improving the productiveness of rangeland in the past three decades, much remains to be done. Several problems are unique to rangeland and its proper management. They include:

1. Range management decisions are difficult because of the lack of

knowledge about the interdependence among the multiple uses of range ecosystems and lack of climatic and economic data and analysis.

2. Competing biologic components reduce productivity.

3. Water shortages limit productivity.

4. Knowledge of nutrient cycling in relation to soil-plant interactions, soil fertility, water supply, and animal performance and production is inadequate.

5. Knowledge of optimum livestock breeds and cross breeds, and wildlife species for various ecosystems and management systems is lacking.

In the future most cropland suitable for feed and fiber crops will likely be used to produce food and other products for human consumption. Moreover, energy shortages call for better management of our natural resources.

Demands for recreation, watershed protection, and fossil fuel mining further increase the need for research. Also, range improvements enhance wildlife habitat and promote soil and water conservation. The needed conservation treatment of water developments, fencing, brush and noxious plant control, vegetation type conversion, and revegetation of ranges in poor condition requires time and money.

The Solutions

Problems facing range in the next three decades can be partially met by application of known technologies. Much can be done if what is known can be applied through education and extension. However, the knowledge base is not complete, and basic information is needed on an array of problems before the nation's ranges will be able to meet the demands put on them by 2030.

The decade of the 1970s brought out many projections of range research needs. These reports identify an array of researchable problems. Invariably, some generally inclusive research needs emerge:

I. Improvement, maintenance, and use of rangelands for efficient utilization of soil and water resources

Previous use and management of rangeland, along with climatic, soil, and other environmental conditions, have resulted in losses and damage to rangeland soils. Water quality, and quantity and timing of water yields have also been affected adversely. Rangeland now produces forage at less than half its potential. Frequent drought, rodents, insects, and brush encroachment are major causes and indications of deteriorated conditions. Major gains can be realized from research aimed at rehabilitating deteriorated rangeland. Restoration of range ecosystems to correspond more closely with their ecological potential should improve stability of all range resource values as well as increase forage supplies.

A. Range Improvement Practices

1. Brush Management. Brush is a problem on much of the

approximately 940 million acres of land grazed in the United States. Brush on rangeland induces losses by decreasing forage production, water yield from watersheds, and recreational activity (hunting, fishing, picnicking, etc.). Dense stands of poisonous, thorny, and pollen-producing brush species also increase the cost of handling livestock and losses of livestock through death and injury. Human allergies are aggravated as well.

Methods of controlling many brush species on rangeland are ineffective, inadequate, or not economical. Chemical application, a common practice, provides temporary control. Treatments must be repeated in subsequent years. Mechanical treatments, such as dozing and root-plowing, may effectively control brush, but they require large energy inputs, sometimes destroy the grass stand, and expose the soil to wind and water erosion. Other mechanical treatments, such as mowing, chaining, and roller chopping, require less energy input and soil disturbance but usually provide only temporary control.

Methods to determine accurately the losses caused by a given infestation of brush would provide a useful indicator of when control is economically justified. Accurate data on brush control costs and environmental effects of each control method would provide a basis to judge the value and feasibility of alternative methods.

The research objectives are to develop new and improved methods of brush control that are safe, effective, and economical for the major problem species on rangeland.

2. Revegetation. Millions of acres of rangeland in the United States have been and are being disturbed by plowing, mining, road construction, drought, and poorly managed grazing. After severe disturbances, annual plant species are first to re-colonize the site. Then come pioneering perennial species that, in turn, may be followed by the perennial dominant species. Unfortunately, the procession of species sometimes requires an unbearably long time and is sometimes prevented entirely by soil losses or other irreversible changes in the ecosystem.

For this reason, an urgent research need is the development of technology required to obtain prompt revegetation of disturbed areas for conservation of soil resources and livestock production. Methods of revegetation can be defined simply as sodding or seeding; however, the technology must be based on knowledge of soils, climate, range sites, plant species adapted to those sites, mechanical and chemical methods of seedbed preparation, sodding methods and equipment, methods and seasons of seeding, methods of conserving soil moisture, seed and seedling characteristics and requirements, and management requirements after seeding.

The real challenge is to define the combination of treatments and methods that minimize effort and cost on each range site. Some results transfer from one site to another, but the limitations of methods and techniques can be defined only by repetition on many different sites. Such repetition must not be misconstrued as needless duplication of research effort.

The major objective of this research is to develop knowledge of species, soils, microclimates, and revegetation techniques that, when properly combined, will establish useful plants on depleted ranges. The species should promote conservation of soil and water resources.

B. Grazing Systems Research

Grazing management is the most important single practice in ranch and range management. It brings together the elements of range improvement into an overall system for production of meat, wool, and mohair. It applies to every acre of grazed land. All other range improvement practices fail if grazing management fails. However, without seeding, brush control, insect and rodent control, and other practices where and when they are needed, grazing management alone could never bring a range to its maximum value to society.

Effective use of diverse range resources will require development of management systems compatible with many complex biological factors. Native range responds to grazing intensity, season of grazing, length of grazing season, and the interaction of grazing management, soil, and climatic factors. At the same time, animal productivity changes as the grazing animal matures and responds to environmental factors, including quantity and quality of forage. Intensive research is needed to provide basic information on the response of each plant and animal species to intraspecies and interspecies competition and to provide guides to the interaction of the biological systems involved in the soil-plant-animal complex. With this basic information, years can be saved in developing and testing grazing systems.

The research objective is to develop improved production systems for converting range forage to livestock products, consistent with conservation of soil and water resources.

C. Improved Plants and Animals for Efficient Use of Soil and Water Resources

Improvements in the genetic ability of range plants to produce quality forage is basic to improving rangeland productivity. Plant breeders can improve the genetic ability of a species to produce a useable product only if genetic variability exists within the species. Germplasm of native and introduced range plants must be collected, evaluated, and preserved in genetic banks for range plant breeders.

Range plants include many diverse species with unique reproductive systems and complex cytology. Often they have minute flowers that discourage emasculation and hybridization. Apomixis, cleistogamy, polyploidy, chromosomal irregularities, and taxonomic problems are common and limit the use of conventional breeding methods in many valuable range species. Cytogenetic and cytotaxonomic studies are needed to solve reproductive problems, establish species relationships, and develop breeding techniques.

Breeding of cultivars for specific sites and special uses, such as wildlife habitat, conservation, reclamation, and enhancement of environmental quality, is also needed.

The research objective is to produce genetically superior forage plants for livestock production, wildlife uses, and specialized purposes on major range sites and localized problem sites.

The feed efficiency in beef cattle, sheep, and other animals is enhanced by their ability to use roughages as a source of energy and non-protein nitrogen as the major source of dietary protein. These attributes have not been fully realized.

Increased reproductive efficiency per animal unit would greatly improve the production of meat per acre of rangeland. Average reproductive efficiency in American beef herds and sheep flocks has been increasing. However, progress is much slower than what could be realized through increased research on those factors affecting the reproductive performance of range livestock and wildlife.

The necessary methods and systems for increasing biological efficiency in animals maintained chiefly on rangeland could be identified and perfected through integrated, interdisciplinary research.

Research objectives are to develop livestock with high biological efficiency for meat production and to use range animals as a means of maximizing efficient use of rangeland resources with minimal use of fossil energy.

II. Develop an inventory classification system applicable to rangeland for maintaining and improving the use of soil and water resources

A. Research is needed to determine the relationship between soil and water losses from rangelands and the continued productivity of the range resource.

Many attempts to apply present technology to improve productivity are complicated by the extreme variability of factors affecting these fragile sites. Nevertheless, a national uniform system of resource inventory and classification is needed that will permit documentation or evaluation of the impacts of methods to improve range condition. Such a system would relate chemical and physical properties of soil to infiltration, plant growth, soil moisture, evapotranspiration, and erosion.

B. Allowable soil loss values (T) need to be developed for rangelands

Information does not exist that allows the evaluation of soil erosion effects on changes in productivity. Soil loss from rangeland is highly variable because of climatic, physiographic, and edaphic characteristics. With an already restricted soil profile, any erosion losses may be intolerable. Research is needed to define tolerable soil loss. The rate of soil formation from parent geologic material offsets the erosion loss, and the sum must ensure long term soil productivity. Existing, limited information suggests that the natural soil-forming processes are much slower under semiarid conditions than under more humid conditions. Low T-values are much more critical on shallow soils than on deep soils. Such fundamental research must include plant nutritional and water requirements, consideration of fundamental erosion mechanics from both wind and water, and the consequences of erosion for on-site fertility and downstream water quantity and quality.

C. Uniform range inventory procedures, including use, suitability, and classification of range potential, are needed.

These procedures would allow more precise application of the best management practices required by legislation for the conservation of soil and water resources. Such programs are also needed to ensure the quality of downstream water resources.

SUMMARY

Range includes grasslands, savannas, shrublands, and forests that can be used by grazing or browsing animals. Economic and environmental factors such as low productivity, little precipitation, steep slopes, and shallow soils limit how rangeland can be managed.

Nearly two-thirds of the land in the United States is used as range. This land is a source of forage, cover, water, and space for domestic livestock and wildlife. Rangeland provides more than 200 million animal-unit-months of grazing for livestock. It also represents some of the most important wildlife habitat in the nation. Rangeland provides a variety of other commodities, and uses as well, including recreation, water supply, and energy and mineral resources.

Although the idea of multiple use generally applies to rangeland, some uses may influence management decisions more than others. A primary objective of range management is to provide the best mix of products, uses, and values demanded by people today without reducing future production and possible uses through land deterioration.

Because of competition from other uses for grains now fed to livestock and because of conversion of crop and pasture land to other uses, we expect more of the nation's meat supply to be produced on rangeland. The ability of grazing animals to convert range forage to human food means that rangeland will help maintain a quality diet for Americans.

Researchers, users, and policymakers must find ways to improve any rangeland whose potential to meet future demands is threatened because of inadequate management. Two problem areas deserve research if we are to conserve soil and water resources on the nation's rangeland:

1. Rehabilitation and Management of Rangeland for Efficient Use of Soil and Water Resources

a. Learning how to rehabilitate deteriorated rangeland should permit restoration efforts that will reduce soil loss, improve water use, and increase productivity. Better and more efficient methods of brush and weed control, revegetation, management of insects, and improved cultural techniques are needed.

b. Grazing systems must be developed that enable livestock to more efficiently use rangeland forage while improving or maintaining soil, water, and vegetation resources.

c. Range plants and animals with greater biological efficiency must be selected and bred. Measures of efficiency include fixation of atmospheric nitrogen, resistance to pests, photosynthetic rate, and the conversion of plant material to animal products with less water use and soil loss.

2. Inventory and Classification of Rangeland for Monitoring Soil and Water Resources

a. We need to learn how to evaluate the effects of soil erosion and water loss on range productivity. This information is needed to make better decisions about range management.

b. We must learn how much soil erosion rangeland can endure before its productivity is adversely affected. Without this information, range managers cannot identify those sites where soil is being lost at a rate that threatens the future use of those sites.

c. Uniform procedures are needed to make inventories of range use, suitability, condition, and trends; and better procedures are needed to classify range potential. These procedures would permit more precise application of the best management practices to conserve soil and water resources.

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