

Range Research to Meet New Challenges and Goals

JAMES P. BLAISDELL, VINSON L. DUVAL, ROBERT W. HARRIS,
R. DUANE LLOYD, AND ELBERT H. REID¹

Assistant Directors, USDA Forest Service, Forest and Range Experiment Stations: Ogden, Utah; New Orleans, Louisiana; Portland, Oregon; and Ft. Collins, Colorado, respectively.

Highlight

The state of range management knowledge in relation to goals of society was considered by a Forest Service committee, and an enlarged concept of "range" was developed to include both ecological characteristics and land use. Range can contribute to better living conditions by providing stability to rural communities and regional economies and a high-quality environment, with optimum fish, wildlife, and recreational opportunities. Important range research needs are to: analyze ecosystems, inventory range resources, coordinate management and use, improve resources, maintain and improve environmental quality, and analyze social and economic aspects of resource use.

It is worthwhile in most any endeavor to pause occasionally and examine the status quo—to consider carefully what has been accomplished and what needs to be done. Accordingly, the state of range management knowledge in relation to the goals of society was considered by a Forest Service committee, and a position statement is being developed to guide future range research. Since many questions have recently been raised about range, objectives of range management, and the role of the American Society of Range Management itself, it was felt that philosophies and conclusions of this committee might be of interest to others. The authors wish to acknowledge the assistance of many colleagues who contributed to the development of ideas presented herein, particularly Richard J. Mc-

Connen, Kenneth W. Parker, and Robert S. Rummell.

What is Range?

The term "range," as originated in the United States, traditionally carries a strong connotation of land used primarily for livestock grazing. Range is extensive and extremely diverse with wide variations in elevation, topography, soil, climate, and vegetation. It is viewed by some as a residual that was left after more productive and valuable areas were converted to higher economic uses (Upchurch, 1963). Consequently, range cannot be easily defined so an enlarged concept seems necessary to properly include both ecological characteristics and use:

Ranges are uncultivated areas that support herbaceous or shrubby vegetation. The range complex (ecosystem) includes not only the soil and vegetation but also the associated atmosphere, water, and animal life. Some areas are both range and forest: the tree overstory may be sparse or the trees may have been harvested or burned, allowing growth of herbs or shrubs. Most ranges are covered with native plants, but extensive areas have been seeded to exotics. Although ranges are usually used by livestock and wildlife, some may not be ecologically or economically suitable and may not actually be grazed.

Often, an area is range because its ecological nature, economic conditions, or lack of irrigation makes it unsuitable for cultivation. Most

native rangelands that are suitable for cultivation were converted to crop production or permanent pasture; some have reverted to non-cultivated status because of errors in selection, diminishing productivity, or economic changes.

Land use is constantly changing among ranges, forests, and croplands (Fig. 1). Some lands are concurrently used as range and forest. Croplands, rangelands, and forest lands have been and will continue to be transferred to urban and industrial uses as population increases.

Reliable information on the current extent of the Nation's rangelands is unavailable, but estimates based on land-use concepts rather than resource characteristics indicate that livestock graze 865 million acres (38 percent of the Nation's land area) in addition to cropland pastures. Not all rangeland is grazed, however, and it is estimated that half of the contiguous 48 States is rangeland. Of the total 908 million acres, grasses and shrubs characterize 653 million acres and 255 million acres are forested ranges.

Most rangelands are in the West, and most western ranges are publicly owned; but substantial acreage, especially in the plains and the South, is privately owned. Grazing by wildlife and livestock has been the most commonly recognized use of range resources; however, society is becoming more concerned about its total environment, and is looking at rangelands from new points of view.

It should be emphasized that the broadened definition of range is not for the purpose of preempting research and management responsibilities on additional lands but rather to assure that certain lands that will undoubtedly have more and more uses and values in the future are not ignored or mismanaged. The desert area of the Southwest is a case in point.

¹Retired. Present address: Fort Collins, Colorado. Formerly Assistant Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins.

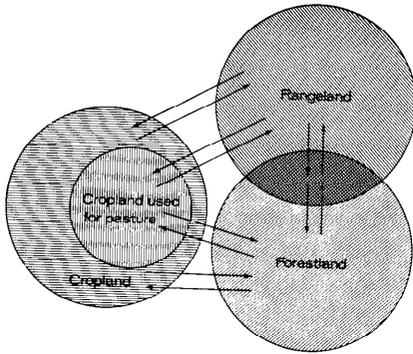


FIG. 1. Uses of ranges, forests, and croplands are constantly changing. The arrows indicate some of the shifts in use that occur.

The Range Ecosystem

Range is composed of communities of plants and animals in their natural environment. Variable and complex, it has innumerable combinations of organisms, soils, climate, and topography. These components function as an "ecosystem," which includes flow of energy and transformation, circulation, and accumulation of matter by living organisms.

Ecosystem is a term proposed by Tansley (1935) to include both the living organisms of a community and the associated nonliving environment. Past attention has been focused on vegetation, but plants are merely part of the larger system, and vegetal response must be interpreted in terms of other components of the system and their interrelations (Fig. 2). These components are closely interrelated; any influence on one affects all others (Ellison et al., 1951).

Components

Although the range ecosystem has an endless number of components, they may be conveniently grouped into a few major categories.

Vegetation is the aggregate of plants, including fungi, algae, mosses, forbs, grasses, shrubs, and trees. Range vegetation is characteristically variable and a small plot may contain numerous species. Hence, many different degrees of tolerance to other factors of the

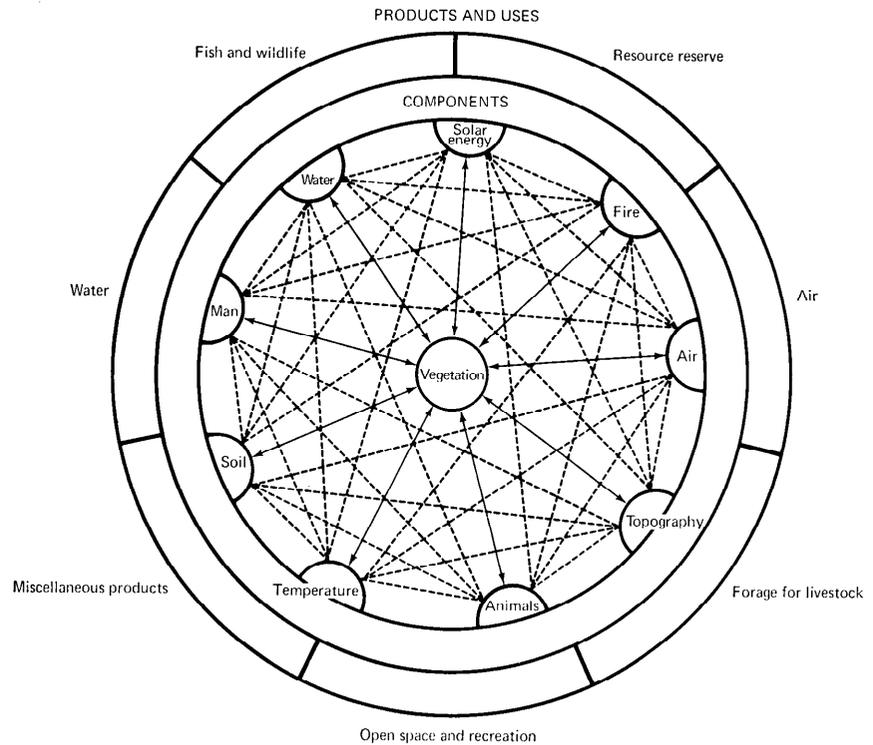


FIG. 2. The range ecosystem (adapted from Billings, 1952) and its many products and uses.

environment are represented as well as many different patterns of growth form and reproductive development.

Animals include not only man, domestic livestock, and wildlife but the entire fauna above and below ground. Undoubtedly, domestic livestock have had the greatest effect on rangelands in recent times, but pressures of native wild animals have also been severe in many situations. Influences of grazing animals are mainly exerted through herbage removal, trampling, and dissemination of seed. Also, insect and rodent pests may have tremendous effects on range vegetation. Man is both a part and a manipulator of range ecosystems (Van Dyne, 1966), but in reaching production goals he has often upset the ecological balance with disastrous results.

Soil is the natural body of organic and mineral material supporting plant life. It varies with parent material from which it developed and with the associated

climatic, topographic, and biotic factors. It is the source of water and nutrients that support vegetation and, therefore, is the basic range resource that must be maintained in a productive condition.

Topography includes variations in elevation as well as degree and direction of slope of the land surface. It modifies the local climate and, consequently, the character of the vegetation. It has a very important influence on the distribution of animals.

Climate is a combination of atmospheric factors: radiation, precipitation, temperature, air, wind, and humidity. It dictates, to a large extent, the type of vegetation and soil on a particular area. Variations in climatic factors make different kinds of weather, which greatly influences annual production of herbage.

Fire is considered as a separate component of the range ecosystem because of its unique effects. Starting from either climatic or biotic causes, it has played an important

part in shaping major biotic communities, particularly through the destruction of woody plants, thus allowing development of predominantly herbaceous vegetation. Fire can be an important tool in vegetation management.

Despite recognition that the system functions as a whole, the maze of interrelations between the various biotic and abiotic factors has long discouraged attempts at complete ecosystem studies. Nevertheless, studies dealing with a few factors have made real contributions to our understanding of certain ecosystems. Recent developments in modeling concepts, mathematics, and computer technology have opened the way to more complete analyses.

Products and Uses

In the minds of many, range has been associated merely with livestock production and in recent years it has become increasingly evident that the range has a rather low capability to profitably absorb inputs for livestock production alone. However, it is becoming recognized more and more that livestock is but one of many outputs from the range, and that all outputs—present and potential—and their interrelations must be studied and evaluated.

Water

Water is probably the most important single product. Not only is it directly essential to human life, but it is vital to the life and production of vegetation that may be harvested for man's use. Agriculture, transportation, power generation, manufacturing, and waste disposal need water produced by the range ecosystem.

In terms of supply it is estimated that total water withdrawals in the contiguous 48 states in 1980 will amount to 50 percent of renewable surface ground water supplies, as contrasted to 21 percent in 1960. It should be recognized, however, that present uses already approach or exceed the limit of available

supplies in many localities of the East (U.S. Dep. Agr., 1962). Since range comprises roughly one-half the land surface of the United States, it provides a substantial part of the total water supply. It is extremely important, therefore, that the range be properly managed for optimum production of quality water.

Air

Air—the mixture of gas, liquid, and solid particles that envelops our earth—is vital to man directly, essential for plants and animals, and necessary for man's domestic, community, industrial, and agricultural activities. Physical properties of air—temperature, water density, and air movement—affect the growth and development of plant and animal life, and limit man's use of the land. Chemical properties—oxygen, carbon dioxide, water vapor, and, increasingly, pollutants—directly affect man and his well-being (Middleton, 1966).

Rangelands provide a source of unpolluted air as well as an immense capacity to receive, transport, and discard pollutants from urban and industrial areas. Air quality is directly influenced by wind erosion resulting from depleted vegetal cover, smoke from burning organic matter and, of course, by carbon dioxide-oxygen exchange processes of the vegetation. With continually increasing problems of air pollution, knowledge of the air environment becomes more and more important as a basis for regional "airshed" management.

Fish and Wildlife

The Nation's rangelands and associated waters are the habitat for millions of big game and countless numbers of other wildlife including songbirds, upland game birds, waterfowl, and fish. These wildlife resources provide recreation and income for a broad spectrum of our population. For example, some 40 million of us—about one in four—

spend about \$5 billion annually to go hunting and fishing. In addition, great numbers of people simply like to observe, photograph, or study wildlife, and thereby enjoy the legacy of our lands and waters. Fish and wildlife, then, contribute substantially to our national economy, and are particularly important to many farm and rural community residents.

Vegetation manipulation through such practices as livestock grazing, timber harvesting, complete type conversion, selective plant control, and introduction of new species through seeding and planting can greatly influence habitat quality and, consequently, wildlife populations. Full consideration must be given to interrelations between terrestrial range uses and associated fish habitats. Improper land use in some areas has resulted in excessive stream siltation, unstable channels, and exposed banks. Improved fish and wildlife outputs will come about only through an understanding of the ecosystem and fully coordinated land management practices.

Forage for Livestock

Although some rangelands are not high producers, essentially all are integral parts of the operations of thousands of ranch families whose livelihood depends upon sustained yield of forage and livestock products. Range forage is used in combination with hay and grain produced on local agricultural lands and allows profitable utilization of such feeds that might otherwise be difficult or uneconomical to market. This is particularly true of some of the sparsely populated areas of the West. At the same time, these rangelands are a source of beef cattle and lambs that are finished in the large commercial feedlots prior to slaughter.

Regardless of economic and social factors, public and private rangelands have a long history of grazing use. Such use will undoubtedly continue in the foreseeable future.

Therefore, it is important that they be managed in such a way as to maintain or improve the basic resource while providing maximum returns to the ranch families as well as to the communities and states of which they are a part.

Open Space and Recreation

Rangelands provide innumerable recreation opportunities in addition to those directly associated with fish and wildlife. Abundance of surface water, wide open spaces, and interesting and beautiful landscapes are attracting more and more people into range areas for camping, picnicking, rock hunting, and other kinds of outdoor recreation activities.

Colorful rocks, unique geological formations, and a wide variety of plant communities make an endless array of interesting and beautiful scenery for the viewer. Wildlife is also a source of interest and beauty. To some people the ultimate in enjoyment of the outdoors is seeing deer or elk in their native habitat or hearing the song of an unseen bird. Pastoral scenes can also add much to the landscape. Cattle and sheep, cowboys and shearers, rustic cabins, corrals, or even sheep-camp wagons contribute to enjoyment of the range landscape—especially if a good job of land and livestock husbandry is evident. Not the least of rangeland attributes is simply the broad expanse of open space where one's eyes and thoughts can roam to distant horizons.

With increasing recreational use, knowledge of range ecosystems is essential to maintenance of quality opportunities and wise integration of recreation with other uses and values of this extensive resource.

Miscellaneous Products

Products from the range vary as much as its sites, climate, and vegetation. Ranges produce edible nuts and berries, chemical compounds with present and potential medicinal or industrial uses, and wood

products. New uses constantly stream from our Nation's laboratories. Since livestock grazing and other land management practices affect the vegetation and its various uses, management plans should account for all product possibilities from the range. Knowledge of the operation of various biotic communities is essential to proper evaluation of the many resource values and to wise management decisions.

Resource Reserve

As an output of the range ecosystem, the resource reserve is an important national asset maintained in a readiness condition available to support our economic and social culture (U.S. Dept. Agr., 1968). It is much more than a source of agricultural production and must be preserved as a viable, flexible system that can respond to future needs. This range resource reserve has particular significance in view of today's rapidly changing society generated by a highly developed, progressive technology. As our growing population places more and more demands on our total environment, this resource reserve will be available to satisfy presently unforeseeable needs. We need to learn how to manage the range ecosystem for efficient production at the present time without causing serious damage or irreversible changes in the basic resource.

Range in Relation to Goals of Society

The vast rangeland areas of the Nation are becoming increasingly valuable to society. Economic progress, changes in society's needs, and varying roles among regions are influencing the relative importance of the Nation's rangeland uses and products.

Important goals for natural resource management in the United States during the 1970's are to:

- (1) strengthen rural communities,
- (2) maintain environmental quality,

and (3) provide fish, wildlife, and recreational opportunities.

Range can contribute to better living for present and future generations by providing security and stability to regional economies and rural communities. It also can provide a high-quality environment, recreational opportunities, fish, wildlife, water, forage, etc. These uses must be balanced within the constraints of the stewardship responsibility.

Strengthen Rural Communities

Livestock products are valuable income sources for rural populations and regional economies. The social and economic viability of rural communities can be strengthened if farm and ranch incomes can be increased to provide adequate returns to the operators, and rural slum situations can be relieved. Correcting these factors will help reduce the flow of rural people to urban areas in search of employment.

Rangeland is a major component of the income base for many farms and ranches, large and small, throughout the West, South, and the Ozarks. Rangeland use and management in these regions should be directed to provide adequate incomes and to maintain and strengthen the competitive position of families whose incomes and living standards are based on range livestock production. Opportunities exist for more efficient land use, better balance of resource combinations, improved efficiency of livestock production, increased volume of business, and lower costs of production for many range livestock producers.

Although livestock production always has been an economic mainstay of rangeland areas, some localities are experiencing new diversification. Recreational, fishing, and hunting opportunities are relatively new sources of income for many rural communities. Benefits of these income sources can be increased through understanding the

ecosystem and coordinated management.

In much of the West, local and regional economies are highly dependent on the range livestock industry, and many year-round ranch operations are based wholly on use of range forage. In the Ozarks and in the South, most small-acreage farmers depend upon grazing their livestock on forest ranges to augment their incomes. The amount and quality of forage, the balance of seasonal ranges, and the management efficiency of the ranch operation govern the incomes of ranchers and of their communities.

A hypothetical case demonstrates the importance of rangeland to a western rural economy. If grazing were reduced 20 percent (222,876 animal-unit-months) on Federal lands in Grant County, eastern Oregon, annual ranch income would decrease 11 percent (\$405,000), and total county income would drop \$624,000 per year (Bromley et al., 1968). Comparable increases might be realized if range productivity were improved.

Situations exist where effective management and use of the range resources would permit rural families to remain self-employed and independent in their home communities, earn adequate incomes, and contribute to their local economy rather than move to a city where their presence might add to an urban crisis. Improved management and use of the 163 million acres of forested range in the South can strengthen and maintain rural families and communities.

Maintain Environmental Quality

The concern of society for environmental quality has prompted an examination of past uses and abuses of rangelands. Certainly, lack of harmony between man and his environment has been demonstrated, but dearth of knowledge about operation of the ecosystem prevented him from taking the action necessary to avoid serious problems. For example:

—When livestock grazed the western ranges during the late 1890's, the early settlers did not realize that too many cattle could severely damage the rangeland vegetation and create soil erosion.

—When 18 million acres of mixed prairie in the Great Plains were plowed within a 10-year period, no one visualized the duststorms that were to follow.

—When chemicals were sprayed on millions of acres to control insects and noxious plants, the possible effects on wildlife, birds, fish, or man were not anticipated.

—When water tables under some rangelands were lowered through gully erosion, no one could predict the seriousness of vegetation changes that would follow.

The science of range management was developed under a philosophy of stewardship, on the premise that vegetation can be used perpetually for grazing while simultaneously providing society with high-quality air and water, open space, and recreation. Proper exercise of stewardship responsibilities will protect the ecosystem and its basic components from irrevocable damage. The total environment must be preserved, restored, or improved, as an obligation to future generations.

Plant cover greatly affects amount, timing, and quality of water produced. Insect and disease infestations, wildfire, livestock and wildlife overuse, and severe droughts can seriously damage vegetation, reduce soil stability, and adversely affect water quantity and quality. On the other hand, man can manage the system to produce desired changes in vegetation with corresponding improvement in water quality and/or yield.

Some 4 billion tons of sediment are washed into tributary streams in the United States each year, and

a substantial part of this comes from rangelands. Vegetation is the major deterrent to erosion. For example, amount of live plant and litter cover has been shown to be the most important site factor affecting erosion on rangelands in Utah, Idaho, and Montana (Cope-land, 1965).

Water supply can be seriously impaired by livestock wastes. Domestic animals produce more than 1 billion tons of fecal wastes a year and over 400 million tons of liquid wastes. Waste production by animals in the United States is equivalent to that of a population of 1.9 billion people (Wadleigh, 1968). Manure disposal is difficult, partly because commercial fertilizer is less costly and easier to apply. Keeping livestock dispersed on pastures and ranges is one alternative that may help abate this type of pollution.

Rangelands provide one of the Nation's largest reservoirs of clean air. Vegetation on these vast areas is a vital source of photosynthetic activity. As plants extract carbon dioxide from the atmosphere, they release oxygen as a by-product. This contribution to the oxygen-carbon dioxide balance is basic to life, and may be one of the range's most important—yet most overlooked—effects on man's environment.

An estimated 30 million tons of dust enter earth's atmosphere each year (Wadleigh, 1968). Windblown soil not only pollutes the air, but also lowers the quality of the land and its capacity to produce. Proper management of range ecosystems and repair and improvement of previously damaged rangelands can help alleviate this problem.

Range landscapes are rich in historical, archeological, and esthetic values. In his constant quest for open space and natural beauty, man can find freedom from disturbing noises as well as offensive sights and odors. Under pressures from an expanding population, resource managers are faced with the challenge to maintain and enhance the natural environment.

Understanding ecological relationships among living things makes it possible for the land manager to conserve plant-animal communities and restore or maintain desirable landscapes. In Nicasio Valley, California, for example, environmental designers found that the open grassland character of the landscape could be maintained only when cattle grazed the area (Twiss et al., n.d. [1969]).

Provide Fish, Wildlife, and Recreational Opportunities

Modern society values fish and wildlife even more than the pioneers who used them for food. Today, esthetic qualities for personal observation and photography outrank values for hunting and fishing.

Managers of the range ecosystem must recognize the importance of the habitats for both fish and wildlife. Each species has peculiar food and cover requirements. Interactions among wildlife species as well as interrelations of livestock and wildlife must be considered. Often, livestock grazing is necessary to maintain suitable wildlife habitats.

Streambank vegetation regulates the amount of solar energy received at the stream surface. Water temperatures are critical for many species of fish. If vegetation is damaged, water temperatures may change, and undesirable species of fish may become dominant. Streamside vegetation also influences food production in streams and the chemical content of the water. Condition of nearby watershed areas also influences fish and their habitat. Sediment from roads, improperly used ranges, and barren streambanks can destroy habitats and fish populations.

Recreation on rangeland has expanded from token activities in pioneer times to present-day major use. Clawson (1959) estimated that city and country park-type recreation would quadruple by the year 2000, but resource-based recreation—visits to forests and rangelands—would increase 40 times.

Man, as a recreationist, exerts pressures on rangelands similar to those of grazing animals. Solutions to many recreation problems may be found in principles used for years in range management. Rotation of campground locations is a short step from rotation of grazing use by animals. Damage due to concentrations of people and pack stock on fragile vegetation and soils also is an ecological problem.

Recreational values already are high for some rangelands, especially in the mountains. Those for other areas, such as deserts, are increasing. Generally, there need be no conflict between recreation and grazing if the two uses are properly managed.

Range Ecosystem Research

Public concern over rangeland stewardship and conservation problems fostered the growth of the art and science of range management (Roberts, 1963; Stoddart and Smith, 1955), and a program of research was developed to provide a scientific basis for range management (USDA, Forest Service, Division of Range Research, 1944).

Although range management has usually emphasized "planning and directing range use to obtain sustained maximum animal production" (American Society of Range Management, 1964), range scientists have recognized the multiple values of the range and the complexity of interacting factors within the ecosystem. Consequently, their efforts have been directed at range ecology as well as grazing management and direct range improvement. Because of public alarm over mudflows and flash floods, early range scientists often focused attention on watersheds damaged by unregulated and excessive grazing, as well as on fundamental ecosystem characteristics and biological production.

Today's research problems can be grouped into the following categories: (1) analyze ecosystems, (2) inventory range resources, (3) coordinate management and use, (4) improve resources, (5) maintain and improve environmental quality,

and (6) analyze social and economic aspects of resource use. Several agencies and institutions are conducting research on these problems: the U.S. Departments of Agriculture and Interior, State Agricultural Experiment Stations, and many universities, particularly those affiliated with the International Biological Program.

Although substantial progress has been made, the total research effort is far from adequate. Funds sufficient for a realistic research program, even as contemplated over 30 years ago (USDA Forest Service, 1936), have not been available. Some problems described in 1936 still persist, while new problems emerge. The gap widens between knowledge available and that needed to exercise responsible management and stewardship of the range ecosystem. Basically, the total range research program needs to be expanded and its scope broadened to emphasize society's growing concern for environmental quality and improvement of rural communities.

The most pressing needs are for new information to: (a) help resolve serious problems confronting people and communities that are economically dependent on range resources, (b) facilitate more effective management of rangelands as a major portion of our total environment, and (c) enable us to meet stewardship responsibilities. Range ecosystems should be intensively and comprehensively analyzed, and rangeland resources scientifically inventoried.

Recent range research emphasizing resource improvement, management and use coordination, and ecology of plant communities has provided much usable information and should be continued and expanded. Research in the other categories listed, however, has been severely limited by shortage of funds and societal preferences. An expanded and intensified research program in these areas is imperative.

Productive research on range ecosystems and man's use of them will

require dedicated scientists with thorough and modern training in various disciplines—soil physicists, microbiologists, ecologists, range scientists, zoologists, mathematicians, economists, sociologists, etc.—organized into teams. The traditional single-function research organization cannot cope with today's complex problems.

The needs and opportunities for range research are considered within this general framework.

Analyze Ecosystems

Existing information on range ecosystems is substantial but it is fragmentary. The scientific foundation for management of the huge resource in the 1970's and beyond is inadequate because the ecosystem components vary widely and their interrelations are extremely complex. The first step toward meeting society's goals, especially those for environmental quality and stewardship, is to consolidate our present knowledge and initiate new research to fill gaps in our understanding of ecosystem components and their interactions.

Inventory Resources

The Nation's range resources should be continually inventoried and evaluated as a basis for developing national policies and programs. Such an inventory would provide periodic data on quantity, quality, and productivity of rangeland ecosystems.

Coordinate Management and Use

Satisfactory management, often complicated, is essential to controlling environmental quality and strengthening rural communities. Systems are needed that minimize conflicts between grazing by livestock and wildlife and other uses; complementary uses should be encouraged. Managers responsible for multiple use planning need to know the probable impacts of ecosystem manipulation alternatives on society's goals.

Improve Resources

Many ranges have been depleted because of unwise attempts to cul-

tivate, past mismanagement of livestock, encroachment of undesirable shrubs and trees, and destruction by pests. Low-value plants have invaded more than 300 million acres in the West; intensive treatment is needed on 40 to 80 million acres to protect watersheds, to improve landscape values, and to restore forage productivity.

Maintain and Improve Environmental Quality

Man's use has often impaired the environmental quality of our rangelands. As population and use pressures grow, the threat of further loss of environmental quality increases. Research is needed to monitor undesirable changes imposed by management practices and uses; to determine impacts on soil, water, air, fish, wildlife, recreation, and landscape values; and to find ways to overcome past damage and prevent future losses in environmental quality.

Analyze Social and Economic Aspects of Resource Use

Viable resource use systems develop and operate within constraints imposed by social and economic criteria as well as by ecological criteria (Firey, 1960). A comprehensive range ecosystem research program should include work in the social and economic sciences. Too often, the lack of knowledge and understanding of the social, political, or economic aspects of rangeland use has hampered—or even blocked—full use of sound biological research.

Research is needed to provide a sound basis for directing ecological studies, and for getting their findings into practice. Social and economic research also is essential to maintain and strengthen rural economies.

Literature Cited

AMERICAN SOCIETY OF RANGE MANAGEMENT, RANGE TERM GLOSSARY COMMITTEE. 1964. A glossary of terms used in range management. Amer. Soc. Range Manage. Portland, Ore. 32 p.

BILLINGS, W. D. 1952. The environ-

mental complex in relation to plant growth and distribution. *Quart. Rev. Biol.* 27:251-265.

BROMLEY, D. W., G. E. BLANCH, AND H. H. STOEVENER. 1968. Effects of selected changes in federal land use on a rural economy. *Oreg. Agr. Exp. Sta. Bull.* 604, 27 p.

CLAWSON, MARION. 1959. Methods of measuring the demand for and value of outdoor recreation. Resources for the Future, Wash., D.C. RFF Reprint 10, 36 p.

COPELAND, OTIS L. 1965. Land use and ecological factors and relation to sediment yields. *In Fed. Interagency Sedimentation Conf. Proc.*, Pap. 11. U.S. Dep. Agr. Misc. Pub. 970, p. 72-84.

ELLISON, LINCOLN, A. R. CROFT, AND REED W. BAILEY. 1951. Indicators of condition and trend on high range-watersheds of the Intermountain region. U.S. Dep. Agr., *Agr. Handb.* 19, 66 p.

FIREY, WALTER. 1960. Man, mind and land—a theory of resource use. Free Press, Glencoe, Ill. 256 p.

MIDDLETON, JOHN T. 1966. Control of environment. *In Environmental Improvement (Air, Water, and Soil)*, p. 53-71, U.S. Dep. Agr. Grad. Sch., Wash., D.C.

ROBERTS, PAUL H. 1963. Hoof prints on forest ranges—the early years of national forest range administration. Naylor Co., San Antonio, Tex. 151 p.

STODDART, L. A., AND ARTHUR D. SMITH. 1955. Range management. Ed. 2, McGraw-Hill Book Co., New York. 433 p.

TANSLEY, A. G. 1935. The use and abuse of vegetational concepts and terms. *Ecology* 16:284-307.

TWISS, ROBERT, DAVID STREATFIELD, EUGENE KOJAN, AND ARTHUR W. MAGILL. n.d. [1969.] Nicasio—hidden valley in transition. Marin County Planning Dep., and others, San Rafael, Calif. 50 p.

U.S. DEP. OF AGR. 1962. Land and water resources—a policy guide. Govt. Print. Off., Wash., D.C. 73 p.

U.S. DEP. OF AGR. 1968. USDA resource conservation mission—a response to the Bureau of the Budget issue on agricultural production capacity, Sept. 27, 1968. Resources in Action. *Agr./2000*, 25 p. Wash., D.C.

U.S. DEP. OF AGR. FOREST SERVICE. 1936. The western range. 74th U.S. Cong., 2d Sess., Doc. 199, 620 p.

U.S. DEP. OF AGR. FOREST SERVICE,
DIVISION OF RANGE RESEARCH. 1944.
The history of western research. Agr.
Hist. 18:127-143.

UPCHURCH, M. L. 1963. Public graz-
ing lands in the economy of the

West. *In* AAAS Symp., Denver, Colo.,
Dec. 27-29, 1961. Amer. Advance
Sci. Pub. 73:83-98.

VAN DYNE, GEORGE M. 1966. Eco-
systems, systems ecology, and systems
ecologists. ORNL-3957, UC-48, illus.

Oak Ridge Nat. Lab., Oak Ridge,
Tenn. 40 p.

WADLEIGH, CECIL H. 1968. Wastes in
relation to agriculture and forestry.
U.S. Dep. Agr. Misc. Pub. 1065,
112 p.