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HANDBOOK ON RANGE MANAGEMENT

NEAR EAST — SOUTH ASIA

COMPILED 1957

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ACKNOWLEDGMENTS

This Handbook is a revision of the original ICA—Regional Range Management Course book of 1955 for the Near East—South Asia Area. The material included is primarily from technical papers presented by instructors and participants during Range Leadership Courses in Iran (1955 and 1956) and Iraq (1957). A complete listing is included in the Appendix. In the process of assembly there has been some consolidation, extension and rearrangement of data to make the publication of maximum usefulness to larger numbers of agricultural leaders, especially in the Near East and South Asia Region.

Reflected is the thought and effort of many people in the participating countries including the agricultural staffs, and particularly the technical advisors on range improvement and management of the USOM's in those countries, who have made such significant contributions to the work. Special note is also taken of Range Course leadership by B.W. Allred (1955) and Leslie Albee (1956) in Iran and Clarke A. Anderson (1957) in Iraq. The editor of the 1955 handbook, B.W. Allred, as a reviewer of the present book has contributed many helpful suggestions. The coordinating editor of this revised edition is Clarke A. Anderson.

Appreciation is due as well to members of the ICA/W Technical Advisory Committee on Range Improvement which has forwarded a sound approach to range management since inception of the Committee in 1953. This informal committee has included staff members of the Washington Office of the International Cooperation Administration with senior range officers from the Soil Conservation Service, the Forest Service, and the Agricultural Research Service of the U.S. Department of Agriculture and of the Bureau of Land Management and the Indian Service of the U.S. Department of the Interior.

Leaders of the countries of the Near East and South Asia area, many of whom have helped to make possible this book, are confronted with a real challenge in extending the ideas of the benefits and obligations of sound range management to the millions who are affected by the use of this most valuable resource. The sponsors of this book trust that this assistance will be of great value to those leaders in their task.

PREFACE

Range Management is a particularly complex subject throughout the Near East and Southern Asia. Involved are not only soils, plants, animals and people but an unusually intricate interrelationship heightened by extremes in climate, complications in land ownership and use as well as by difficulties arising from very old and established customs and traditions. Great possibilities exist for (1) better land and water use; (2) improvement in natural pastures (ranges); (3) extension of seeded pastures; (4) increased forage and fodder production and (5) more productive livestock. Prerequisite to a full realization of these possibilities are trained men; public understanding; and adequate support, both locally and nationally.

The purpose of this handbook is threefold: *first*, to aid in the teaching and training of range managers; *second*, to further public understanding of the proper use and management of soils, plants and animals, and *third*, to aid in obtaining the support of livestock people and government officials in the action required to bring about and maintain optimum management of water, soils, plants and animals. The material included is the result of many years' experience in practical range management. The 1955 handbook was so widely distributed and used throughout the Near East and South Asian countries that this revision is considered to be fully justified.

The primary aim has been to include the most recent information and, also, to organize the text material to serve essentially as a complete guide for a course in Range Management. For convenience in organization, the subject matter is presented under seven subdivisions:

PART I. "Soil, Plant and Animal Science" treats the elements of these three basic segments within the broad field of Range Management. Also, their inter-relationships one with another in the production of forage, feed, animals and animal products.

PART II. "Fundamentals of Range Management" deals with the basic principles of range management, as well as with plant ecology; range watersheds and erosion; range sites; land tenure and ownership; grazing laws, regulations and policies; and range economics and extension.

PART III. "Feeds and Feeding" stresses the need for supplementary forage and feeds where range forage is inadequate; the feed requirements of livestock; the importance of a 12-month supply of feed and methods of forage production and preservation.

PART IV. "Application of Range Management" presents various range problems with possible solutions including a treatment of the beneficial effects of conservation management of ranges on both livestock and forage.

PART V. "Range Improvements" covers, in brief, the field of range engineering including range water developments; fencing; driveways; waterspreading; pitting and contour furrowing; rodent and insect control and range reseeding.

PART VI. "Range Studies" emphasizes the need and importance of this essential phase of range work with suggested procedures for range inventories; forage production and grazing capacity determinations; range condition and trend evaluations; etc.

PART VII. "Appendix" includes additional important facts for livestock operators; a glossary of range management terms and a listing of 1955, 1956 and 1957 Regional Range Management Course students and instructors.

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HANDBOOK ON RANGE MANAGEMENT

PART I

SOIL, PLANT AND ANIMAL SCIENCE

INTRODUCTION

Range is normally considered to be any naturally vegetated, and usually unfenced, lands in low rainfall areas grazed by domestic livestock and game animals. *Pasture*, on the other hand, normally refers to improved and often irrigated, fertilized and fenced grazing lands in more favorable precipitation zones which are seeded to domesticated forage plants. *Forage* or pasturage refers to all vegetation upon which grazing animals subsist—grasses and grasslike plants; forbs or "weeds"; palatable woody portions of trees and shrubs or "browse" and berries, acorns and other nuts falling to the ground or "mast." *Herbage* refers to all vegetation, both palatable ("forage") and unpalatable ("non-forage").

Range Management is the science or art of securing maximum sustained use of natural forage crops with grazing animals without serious damage to other resources or uses of the land. In range management, the *soil* is the most basic resource. It produces the *plants* that are converted by *animals* into products for human consumption, and use.

Closely allied with range management are many other fields as: climatology; geology; agronomy; plant physiology; ecology and systematic botany; animal husbandry and general economics.

Treated in the chapters which follow are various elements of soil, plant and animal science as related to range management.

CHAPTER I

ELEMENTS OF SOIL SCIENCE

GENERAL.—The soils that mantle the earth are of many different kinds and classifications due to the number and wide variety of factors affecting soil formation. Moreover, soils are constantly changing so that certain phases of their dynamic cycles are very complex and, therefore, extremely difficult to observe and study.

Soil science is young and has, in fact, only in recent years evolved into a distinct science apart from applied physics, chemistry, geology and biology. There are two branches of soil science: (1) the study of the soil as a natural body (pedology) and (2) the study of the soil with particular consideration to plant relationships and agriculture (edaphology). It is with this second branch of soil science that we, as range managers, are primarily concerned.

SOIL AND ITS ORIGIN.—Soil as herein defined is considered to be the upper bio-chemically weathered portion of the regolith or outer mantle of unconsolidated material lying over the earth above bedrock.

Mineral soils which, by volume, constitute most of the important agricultural soils of the earth are made up of about 45% mineral matter or rock residues, 5% organic matter or plant residues and about 50% pore-space. This pore-space is, of course, occupied by air and water with the percentage of each fluctuating considerably from one time to another.

Organic soils are those in which organic matter content greatly exceeds the mineral matter content. These soils develop in local areas under conditions of high rainfall and temperate climate. They are generally not extensively distributed.

Soil formation, as conceived today, is merely the result of parent material, climate, vegetation and physical geography all operated on and affected by time.

In soil evolution and development all of these factors have been operative in different ways to account for the many different kinds of soils and the variable soil profiles of the earth.

BROAD CLASSIFICATION.—In a general way all of the soils of the world can be classified either as (a) pedocals or (b) pedalfers depending upon whether they are basic or acid in nature. In other words, whether they have been developed under conditions of low rainfall or of high rainfall involving a leaching down of calcium and other bases. Pursuing such a supposition, soils may be classified according to their variable profiles or layers of development into many different series and types, which again fall into three major groups designated as (1) zonal—when profiles are normal and well-developed, (2) intrazonal—where salts or other outside influences have interfered with normal development and (3) azonal—when the soils are of alluvial origin and too young to have normal, well-defined profile development.

When we consider the effect of each factor more closely we recognize that perhaps none can be considered entirely independently. All are closely related and the effect of any one factor is strongly influenced by the operation of others.

From a paper by: J. Glenn Morrill, Agronomist, USOM/Iran.

PARENT MATERIAL.—Parent material is the raw substance of variable character from which soils have been formed. It is the broken-down product of rocks which have resulted from the various weathering processes. The very nature of parent material is more or less determined by the original composition of the rock masses and the particular weathering processes operative in their derivation.

Soil formation and development, of course, begins with the breaking-down and dividing of rock fragments and particles from original or parent rock to form the unconsolidated materials from which the soil is actually derived. The process by which this is accomplished is known as weathering, either physical or chemical.

PHYSICAL DECOMPOSITION.—It results when rock fragments are produced by purely natural or mechanical means. Examples include: the trampling of animals, the leverage action of growing trees and plants, the expansion of freezing water, and the breaking-down of rock minerals as a result of differential expansion and contraction due to changes in temperature. These are all physical means by which rock masses are reduced. Another age-old example of physical decomposition is the movement of glacial ice. Moving glaciers laden with boulders and rocks carry these abrasive materials along in their ice masses. Rocks grinding together and against the rocks they pass over as the ice mass moves along, produces ground-up fragments of rock known as "rock flour." Similar results also occur as streams carry rocks and boulders along their courses, rolling and grinding them together.

Most rocks are aggregates of several simple minerals each having different rates of expansion and contraction with changes in temperature. Scarcely any two expand to exactly the same extent when heated by the sun's rays, especially if their colors differ. Moreover, most minerals expand and contract at different rates along all three of their cleavage planes. Therefore, with changes in temperature there is a tendency for the formation of fissures and cracks. As the process continues and is repeated, there is a "peeling" or breaking-off of rock fragments known as "exfoliation." This process materially assists in the breaking-down and disintegration of rock and mineral masses. Accordingly, all physical forces, great and small, working together provide a very important means by which rock masses are broken down and soil is formed.

The second or *chemical decomposition* of rocks results primarily from the action of various elements and compounds of the atmosphere, which by volume, approximate 78 percent nitrogen, 21 percent oxygen, .03-.04 percent carbon dioxide, and about 1 to 4 millionths parts of ammonia along with variable amounts of lesser elements and water vapor. Chemical changes in rocks which contribute to soil formation are brought about largely by the action of water, carbonic acid, ammonia and oxygen.

Few substances, particularly among those forming rocks, are totally insoluble even in pure water and some, as gypsum ($CaS\ 04$), are readily soluble. Therefore, as rain falls, snow melts and rivers or bodies of water play upon rock masses; water, in itself, becomes an important agent aiding the chemical breakdown of rocks and minerals. Water readily enters into chemical combination with minerals forming various hydroxides. It usually, also, increases the amount of exposed rock surface.

Owing to the universal presence of water ($H2O$) and carbon dioxide ($CO2$) in the air as well as in soils and rock masses, carbonic acid ($H2CO3$) is readily formed and plays a prominent part in the chemical breakdown of rocks. This acid, however weak, is the acidulous ingredient of all effervescent waters; abounds extensively in nature and has seven times the solvent power of pure water. Carbon dioxide is produced in nature by decay of organic residues; by the respiration of plants and animals; in the burning of limestone; by the slow or rapid combustion of vegetal and animal substances including wood, charcoal and other fuels; and in various similar ways.

The presence of carbon dioxide is, therefore, quite general. It exists in the air and comprises about .03 of 1 percent of total atmospheric volume; although, locally, it may be present to a much greater degree because of proximity to sources of formation and because of its greater density than air (about 10 to 1). Soil-air by volume contains a lower percentage of oxygen and a much higher percentage —possibly 100 times as much—of carbon dioxide. Moreover, since it is readily soluble in water..to the extent of equal volumes at ordinary temperatures—it is found in all water and especially in water percolating through the soil.

Waters laden with carbon dioxide may be considered as an almost universal solvent for rock. Limestone is, of course, most susceptible but of all rocks and minerals, only quartzite is unaffected.

Granite and related rocks are rather quickly acted upon because of their soda, potash, lime and aluminum bases.

The solvent ability of carbonated water is increased by the inclusion of ammonia (ammonic carbonate) which always exists to some degree in atmospheric water and plays a prominent part in the processes of chemical weathering. A common example is the etching of windows in barns and stables where strong accumulations of ammonia result from decay and accumulation of animal offal.

The effect of atmospheric oxygen is naturally confined to those rocks containing substances which permit oxidation. Its effectiveness is most pronounced in the case of rocks having ferrous (iron monoxides) and ferroso-ferric oxides. By taking up more oxygen, these minerals—usually distinguishable by their bottle green, bluish or black tints—are susceptible to further oxidation and are converted into ferric oxide or rust, and their colors change to brick red (hematite) or yellow (limonite) depending on whether the hydrous or anhydrous ferric oxide is formed. In both cases, the bulk of the resulting minerals is increased causing zones of weakness and an increase in total surface exposed to further attack.

Soil Horizons.—When a mineral soil becomes developed to the point where it is more or less in adjustment with the climax vegetation of an area, which is again controlled by climate, it exhibits a definite set of characteristics. For example, if we dig a vertical section through a soil or examine the side of a railroad cut or a road embankment, we notice three layers, more or less, sharply separated from one another. What is oftentimes called the "A" horizon is on top and usually contains plant litter and humus which makes it dark. Underneath this "A" horizon is a soil layer which is lighter in color, typically varying from shades of gray and light brown to even a chocolate brown in certain areas. This soil which is usually termed the "B" horizon has relatively little organic material as compared to the "A" horizon yet it is enormously important, because it contains large quantities of minerals. Below this second layer there is a layer which is generally called the "C" horizon consisting of coarse to solid rock material little affected as yet by the processes of either physical or other weathering.

Such an exposed vertical section of soil is called a soil profile. Profiles for various soil types under different kinds of vegetation are quite different as are the relationships between their "A," "B" and "C" horizons. For example, profiles in hardwood forest areas will be quite different from those in coniferous forests and both will be entirely different from grasslands. Even within grasslands, we find that just as there are variations in climate which have resulted in the tall-grass prairie, the mixed prairie and the shortgrass plains, so too, there are companion adjustments which the soils have made under these variations in climate resulting in different soil profiles.

Biological Conditioning.—Obviously, vegetation plays a most important part not only in the original decomposition of soils, but in their subsequent conditioning for higher production and the support of climax vegetation. The first plants to find support on rocks are the lichens. In humid climates we find these crust-like plants growing on practically all rock surfaces. Sometimes we can observe them in the form of a solid mantle that can be peeled off in wet weather revealing the corroded rock surface and the beginning of soil clusterings amid the root fibrils beneath. Following the lichens, common mosses eventually shade out the crusts of the lichens and advance the process of soil formation one step further. Eventually, the mosses are themselves partially or wholly displaced by hardier species; first the ferns and finally by higher flowering plants such as the stonecrops, saxifrages, heather and many other shallow-rooted plants which gradually take possession of the site. The roots of all plants secrete carbonic acid and many of them secrete stronger vegetable acids such as the oxalic and citric acids. Plant roots growing over the surfaces of rocks show clearly the solvent effect of these acids and their importance in the further processes of rock decomposition and soil development.

To this direct action of the higher plants is always added that of innumerable bacteria and molds whose secretory enzyme action materially assists the process of soil formation and conditioning. As the higher plants grow and die, myriads of the lower plant and animal forms—workers in the soil—stand ready to devour these various organic residues and incorporate them into growing plants. These "workers in the soil" include: (1) microscopic plant forms known as bacteria, (2) numerous fungi of which bread molds and other organic molds are typical, (3) protozoa and algae, and (4) numerous earthworms and burrowing rodents. Indeed, the magnitude and complexity of this soil population can hardly be appreciated but it may be helpful to know that according to the best estimates of soil

biologists a gram of good topsoil may contain well over 50 million soil bacteria. Moreover, this soil population is constantly changing—it is hardly the same for a single hour of the day—as the numbers and kinds of organisms fluctuate greatly with even slight changes in temperature, soil moisture and other factors.

The various steps in the process of soil development can be summarized as follows: (a) rock fragments are broken down and accumulated through the processes of physical and chemical weathering; (b) along with these processes and assisting them, simple plants such as the lichens, mosses and ferns obtain a foothold and begin to grow; (c) as the soil develops, higher plants become established and their organic residues are incorporated into the soil by bacteria and other organisms;(d) the acidic secretions of organisms working in the soil further condition and eventually evolve it to a point where certain rather uniform characteristics for a given soil can be noted.

The concept which should be developed is that the substance we speak of as soil—a body of rock fragments and organic residues developed to the point where it becomes a medium of favorable substratum for the growth of plants—has been more conditioned and influenced by biological activity than it has by the nature of the original parent rock material. In other words, while physical and chemical weathering are of great importance in the reduction of rock masses to varying degrees and stages of subdivision, it is the biological weathering of the soil and the chemical processes accompanying it which really determines the types of soil that will be developed.

Remedial Range Practices.—The popular old adage that "an ounce of prevention is worth a pound of cure" is, indeed, nowhere more fitting than in the case of grassland management. Once grassland has been mismanaged and the grass has disappeared, the soil usually erodes and soil-moisture relationships become so poor that it is very difficult, if not impossible, to restore the range and soil to its former productivity. However, and in most cases over long periods of time, the situation is not completely impossible. Frequently, considering that soil forms very slowly, say at the rate of one inch in a hundred or a thousand years, some improvement can be made in a comparatively short period of time. Just what can be done depends, first, on how serious the damage has been and, second, on how intensive a program of range improvement can be undertaken to bring about the restoration. Usually, rangeland economics will not permit too great an expenditure for this purpose and the best policy is generally to inaugurate sound range management programs which, in time, will permit the native range species to re-establish themselves. In other instances, and if land economics will permit, range reseeding and other range improvement practices may be desirable, providing a sound range management program is inaugurated along with these practices. Contour furrowing and construction of water-spreading structures are practices which may be feasible for range improvement either where range is being reseeded or where it is important to encourage the natural recovery of native vegetation. In no case, however, should such costly practices be adopted until a sound range management program has been adopted—sound management is the number one key to good range use and positive range improvement.

CHAPTER II

ELEMENTS OF PLANT SCIENCE

MAN AND PLANTS.—Since earliest time man has been intimately affected by vegetation. Plants, and the use to which they were put, determined largely the mode of life he followed. In forested areas, he cleared and tilled the soil, using the products of his clearing to build shelter and goods usable to other men. His tilling produced food and fiber for his needs. In grassland areas he usually became a livestock producer and lived off the animals which in turn used the vegetation for their food. In deserts, he became nomadic, following the seasonal production of vegetation for his animals and his crops.

In any one lifetime, vegetation changed, but slowly, so that man was generally little concerned about the vegetation as such. It was accepted as something to harvest, to use for his needs, or to destroy for his convenience. As a result, little knowledge was gained of the vegetation and how its use was affecting man's pattern of living except as it was studied for beneficial herbs and for various medicinal and functional uses.

Here in the Middle East, which is generally considered the birthplace of man and the cradle of civilization, many empires have risen, fallen and been lost to all but the archeologist. That the vegetation itself may have greatly influenced the rise and fall of these civilizations has only recently been understood.

Vegetation, through its reaction to man's use, either supplied or denied him the necessity for survival and advancement. Recently, plant ecologists have attempted to tie cause and effect together —to determine how man in his relation to environment affects his pattern of life and to establish basic rules of plant use so that the one might be beneficial to the other.

The basis of such rules is an understanding of the individual plant; how it grows, how it porpogates, and how it reacts to use. We are, of course, primarily inetrested in the vegetation as it is related to grazing and in the basic rules for its management.

THE INDIVIDUAL PLANT.—Plants can be classified in many ways as: (1) by growth habit—annuals, biennials, perennials, (2) by structure—lichens, mosses, forbs, grasses and grass-like species, shrubs and trees; or (3) by moisture requirements—hydrophytic (moisture loving), zerophytic (drought loving) or mesophytic (neither moisture nor drought loving).

Moreover, a great deal of very intensive study has been devoted to grasses, one of the most important forage groups and also one of the largest families of flowering plants. There are more than 500 genera of grasses throughout the world, and in any one rangeland area from 75 to over 200 species are not uncommon.

It is not necessary for the range manager to be able to identify all of the grasses and other forage plants in his area, but he should be familiar with the ones which provide most of the forage or are otherwise important. Usually, not over 12 to 15 species of grasses will be in this category on a given range. In addition, there may be 20 to 30 other important forage plants.

From papers by: B.W. Allred, Leader, 1955 Regional Range Management Course (Iran) and Don Davis, Soil Conservation and Range Management Advisor USOM/Libya.

Grasses, like other plants, can be classified in a number of ways to better help the range manager. Groupings can be made according to size, growth-habits, forage or soil conservation values and other important considerations. Some of the grass classifications which have been fairly well defined in the United States follow (less is known of some of the Middle East grasses):

Tall-grasses vary in height from 150 to 250 centimeters. They are most abundant in wet valleys and along stream-edges in the plains and mountains or in forest openings. Some of the tall-grasses of America are *Andropogon* furcatus, *Sorghastrum* nutans, *Panicum* virgatum, *Calamovilfa* gigantea and *Stipa* robusta in central and eastern United States; *Sporobolus* wrighti in the Southeast and *Elymus* canadensis on plateaus in the central and northern Rocky Mountains. In the Middle East, *Arundo* donax and various species of *Bambusa* classify as tall-grasses.

Mid-grasses vary from 60 to 120 centimeters in height. These were once the most abundant of all native grasses on primeval or climax grasslands. Belonging to this group are *Agropyron* smithi, *Dactylis* glomerata, *Hordeum* bulbosum, *Phalaris* canariensis, *Lygeum* spartium, *Festuca* sp. and most members of the genus *Stipa*.

Short-grasses comprise the low-growing and often mat-forming types that are generally under 45 centimeters in height. Many are particularly useful for grazing and for lawns, parks, airports, and fairways as well as putting greens on golf courses. Some of the best known are *Cynodon* dactylon, *Poa* pratenses and *Poa* bulbosa, all of which occur in the Middle East.

Cool-season grasses are those that grow in the winter, early spring or late fall. They have special economic significance because they provide a cheap source of protein and carotene during the fall and early spring periods when such feeds are at a premium for livestock. In extremely cold climates even the cool-season grasses are forced into dormancy by cold winter weather from the mid-latitudes on north. However, winter growing tendencies increase in southern latitudes when moisture and other conditions are also favorable. To this important group belong the *Agropyrons*, *Elymus*, *Horedums* and *Avenas* as well as *Festucas*, *Phalaris*, *Poas*, *Dactylis*, *Stipas* and *Bromus*. These grasses are distributed throughout the cool temperate regions of the globe.

With *warm-season* grasses, a notable characteristic is their tendency to bloom and mature seed before or shortly after mid-summer. Hence, they provide better summer grazing because they grow when the cool-season grasses are usually dormant, tough, and low in protein and carotene. *Cynodon* dactylon is the most important warm-season grass in the Middle East where it is a key forage plant. Some other important warm-season grasses are *Sporobolus*, *Bouteloua*, *Andropogon*, *Panicum*, *Chloris*, *Eragrostis*, *Zea* and *Setaria*.

In snowless, southern latitudes many warm-season grasses assume cool season habits. For example, the crown leaves of *Cynodon* dactylon remain green in the southern Mediterranean region wherever winter moisture is adequate.

Bunch-grasses grow upright, increase from seed, and spread at the base from crown tillers, much like stooling wheat. The *Festucas*, *Stipas*, *Agropyron cristatum* and most of the *Aristidas* are bunch-grasses. In the United States *Andropogon* scoparius tends to assume bunch-grass characteristics, both on Northern Plains hardlands and in the semi-arid southwest, but produces extensive subsurface shoots in the Gulf Coast regions of Texas and Louisiana.

Sod-forming grasses are equipped to reproduce from seed and from surface runners or stolons, or from subsurface shoots called rhizomes or underground stems (root-stalks). Some that have stolons are *Cynodon* dactylon and *Aeluropus* sp. A few that propogate subsurface shoots are *Agropyron* smithi, *Agropyron* junceum, *Spartina* sp., *Poa* pratensis and several of the sedges or so-called "grass-like" plants. Studies indicate that, other things being equal, both stolons and rhizomes are most abundant where soil moisture conditions and plant nutrition are best. For example, subsurface shoots from *Calamovilfa* in South Dakota (USA) sandhills were 32 per cent greater than those of the same grass in adjacent and more droughty shale beds. Under drought conditions in 1947 at Rapid City, South Dakota, only 10 per cent of the *Buchloe* dactyloides plants in 20-plots produced stolons and the stolons averaged only two inches in length. Under improved rainfall conditions, three years later, 95 percent of the same plants produced stolons and the stolons averaged six inches in length. Twenty *Bromus* inermis plants from a valley site east of Colorado Springs, Colorado (USA) yielded five times more

subsurface shoots by dry weight than did twenty plants taken from the drier ridge immediately adjacent. Yield of forage was determined to be four times greater in the valley than from the ridge top.

Annual-grasses pass through the dry and cold periods in seed form—there is no living-over or accumulation of aerial parts as they live only one year. The annual *Lolium* and *Phalaris* are important forage grasses of the Mediterranean region. Some annuals like *Bromus* catharicus, *Bromus* tectorum and *Hordeum* murinum begin growth in fall, live over winter and produce seeds and die the next spring. These are called "winter annuals." When there is no fall moisture to germinate the seed, they may still grow in the spring if conditions are right. Spring-sown cereal grains are annuals but become winter annuals when fall-sown. *Sorghum* halapensis is an annual in the northern latitudes and a perennial in the southern latitudes.

Perennial-grasses begin life each year from rootstalks or crownbuds that remain alive in the soil. Of course, the original plants come from seed or sprout from stolons or subsurface shoots. These self-perpetuating types give the most dependable grazing. A rangeman having access to them is free of the cost, risk and delay that is associated with sowing annual-grasses for grazing. Some of the tame perennial-grasses are *Phleum* pratense. *Chloris* gayana, *Phalaris* tuberosa, *Dactylis* glomerata, *Bromus* inermis, *Paspalum* dilatatum and *Sorghum* halepense. Examples of wild perennial-grasses are *Hordeum* bulbosum, *Agropyron* cristatum and *Phalaris* tuberosa.

Mechanically injurious grasses are those with sharp awns or processes that puncture the skin, eyes, and mouth of animals. The spear-pointed seeds of many *Stipas* do thousands of dollars worth of damage to sheep pelts and carcasses each year. The seeds of these grasses, along with those of *Aristida*, *Bromus*, *Cenchrus*, *Avena* and *Hordeum*, foul the fleeces of sheep and lower their sale value. The spines of *Hordum* lacerate the mouths of horses, cattle, and sheep. Wads of it may also lodge between the teeth and jowl, often festering the internal mouth tissues and eroding the jaw bone.

Poisonous grasses include several of the *Sorghums* and others like *Holcus* lanatus which, under certain conditions, produce enough prussic acid or similar toxicity to kill livestock. Many are apparently most poisonous when partially dried stalks are cut for feed during drought. *Holcus* is sometimes poisonous either fresh or wilted.

However classified, all plants are basically and functionally similar. All have two parts: (1) that below ground—roots; and (2) that above ground—stems or shoots. The principal parts of a grass are shown in Figure 1.

The basic function of the below-ground portion is to extract, gather, and transmit to the shoots the water and soil minerals necessary for the production of plant food. In perennial plants, the root is also used as storage for food during dormant periods.

The shoot or aerial portion produces the food necessary for plant growth. This production of food is termed the "Photosynthetic" process or the production of simple sugars from the combination of carbon dioxide and water in the presence of sunlight and chlorophyll (the green matter in plants). These simple sugars form the basic food for all animal life. Chemically, the photosynehetic formula is written as follows:

$$6CO_2 \quad \text{plus } 6H_2O \quad \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \quad C_6H_{12}O_6 \quad \text{plus} \quad 6O_2$$

(carbon Dioxide) (Water) (Sugar) (Oxygen)

In photosynthesis, the carbon dioxide ($6CO_2$) is obtained from the air and taken into the plant through small stomatal openings in the leaves. The water ($6H_2O$) is absorbed from the soil through a process called "osmosis" (the passing of a solution from a weaker to a stronger solution through a membrane). Osmosis is a root function and in the process of water-absorption, essential minerals are also absorbed from the soil and transported in solution to the aerial portion of the plant. Sunlight is the source of photosynthetic energy. See Figure 2—How Grass obtains elements to Manufacture Food.

A very close relationship exists between root and shoot. Each must function to the benefit of the other and what affects one affects the other. Another basic function of individual plants is reproduction by seed and, in many, by rhizomes, stolons, or tillaring. Plant life in general and individual plants, in particular, are always in competition with one another for the soil-water necessary to growth. There is also strong competition for sunlight, particularly in denser stands of vegetation.

PRINCIPAL PARTS OF A GRASS

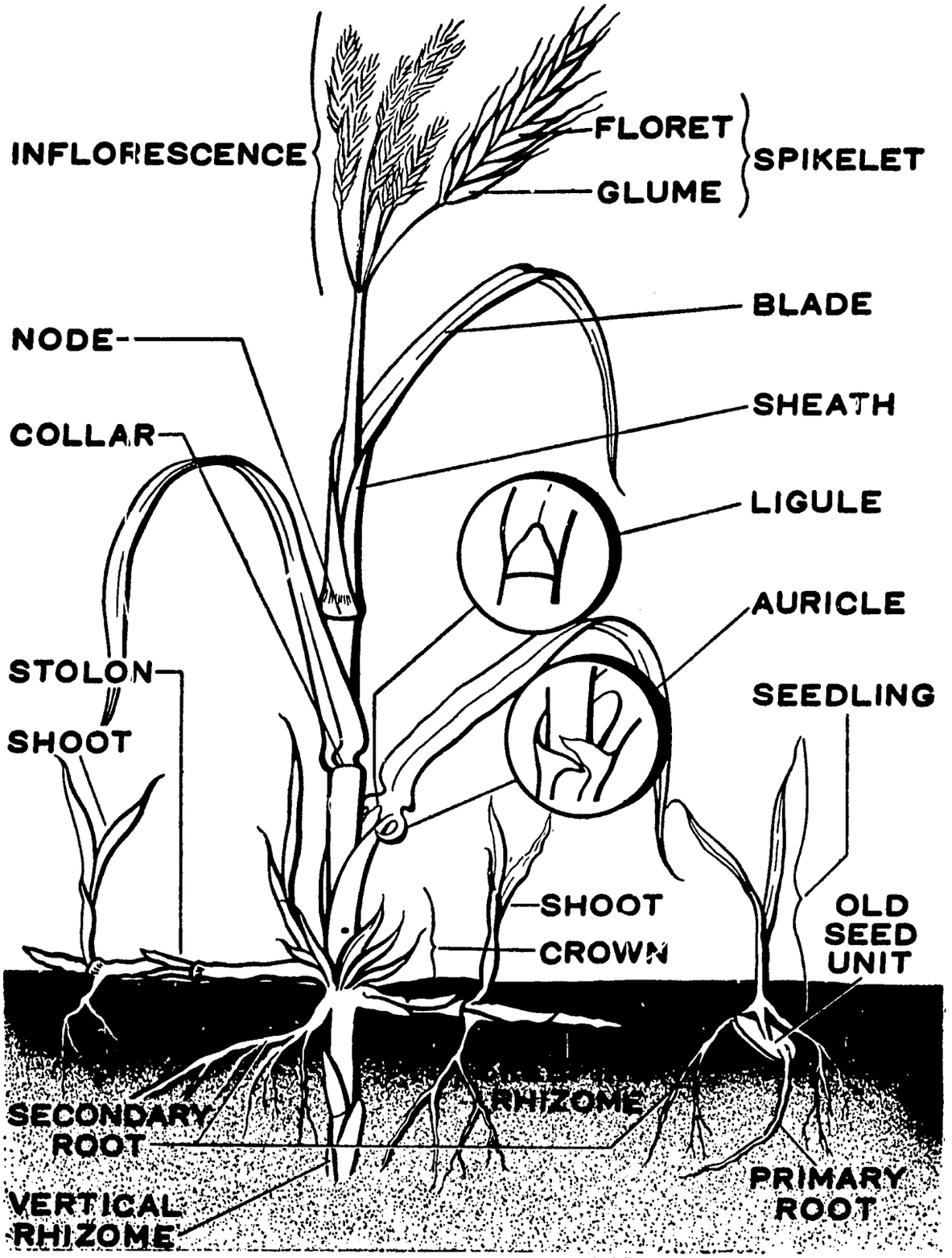

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FIGURE 1

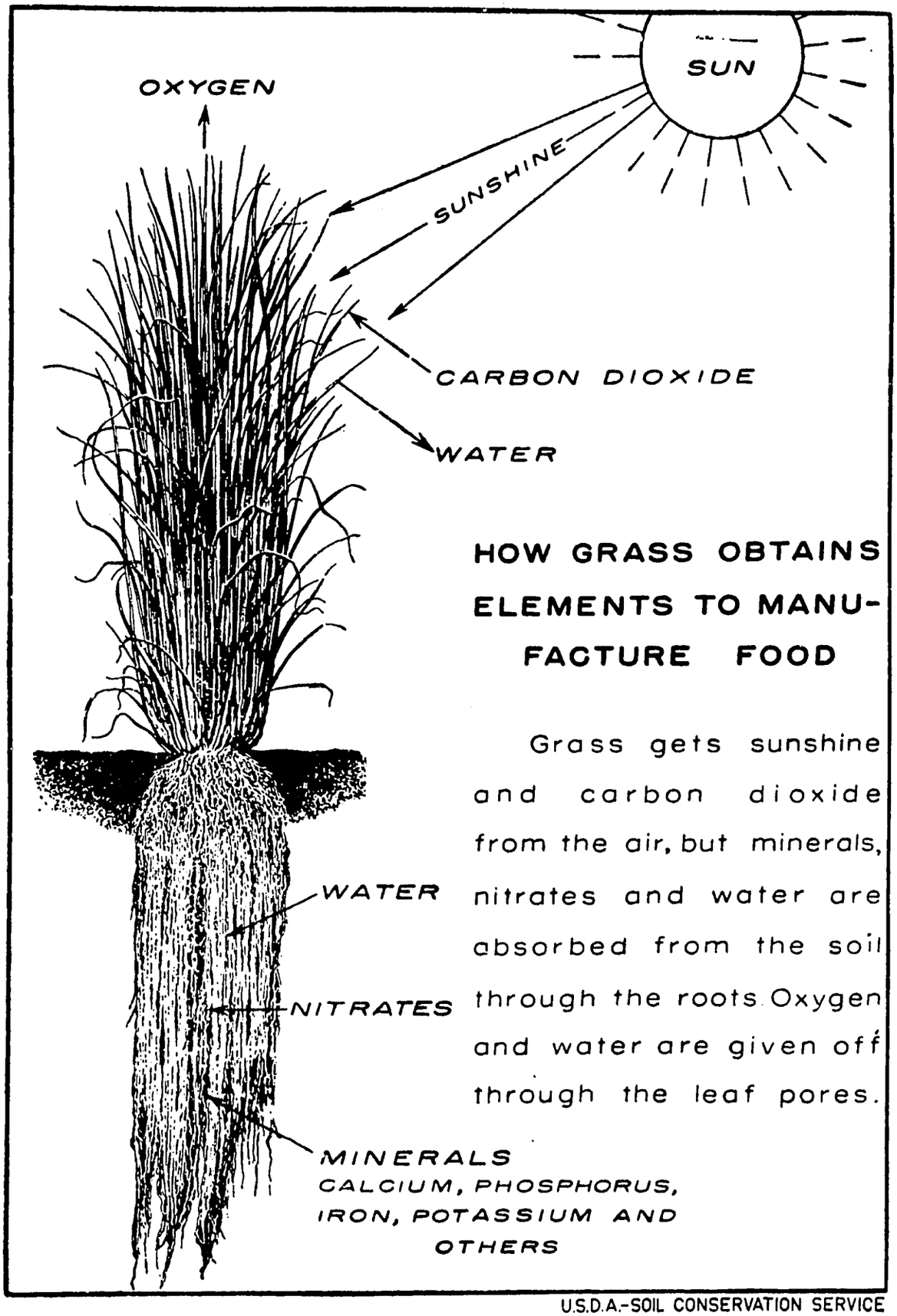

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FIGURE 2

EFFECTS OF GRAZING.—What is the effect of grazing on the individual plant? The first, and most important effect is that of reducing the leaf surface or food-producing portion of the plant. This is followed by a weakening of the root due to a reduction in the food being produced by the shoot. Thus, if the removal of the aerial portion is often enough and severe enough, the root may eventually starve and the plant will die. Here, then, we come to a very basic rule of grazing management—"starve the root and you kill the shoot." Perennial grasses are ideally designed for grazing as nature provides a generous portion for removal and still allow for normal root functions. Latest experimental results show that approximately half the shoot can be removed with little damage to the plant. However, more than this degree of grazing use usually results in eventual death of the individual plant. Here, then, we come to another basic rule of grazing management—"take half and leave half." The effect of over-use is shown in Figure 3.

THE PLANT COMMUNITY.—The plant community is made up of many individual plants. A community is initially controlled by the environment—climate and soil. In deserts, we find zerophytic plants, adapted to periods of drought and with special provisions for retaining moisture such as very small stomatal openings and small leaf surfaces. When moisture conditions are favorable, we also find other plants which are able to grow quickly, produce seed, and then go dormant within short periods of time. In areas of heavy moisture, we have hydrophytic plants able to grow even in standing water as the rushes and sedges. Between these extremes, we find the normal—or mesophytic (neither wet nor dry)—conditions. In each environment, nature has over thousands of years, adapted the vegetation to the soil and climate to produce a community of plants in balance with the site. On the other hand, man with his grazing animals and his plow has not always allowed nature to reach or maintain this balance. He has allowed animals to take more of the shoot than proper, the root has starved and the more desirable plants have died and been replaced by other and usually less desirable plants—those better able to withstand grazing. An entire plant community may therefore change. Thus, we find zerophytes on mesophytic sites, annuals where we should find perennials, shrubs in place of trees, and want instead of plenty.

THE ROLE OF THE RANGE MANAGER.—There are other aspects of plant-growth important to the range manager. We hear much about the nutritional value of certain plants as compared with others. Actually, in case of grasses and legumes—with very few exceptions—nutritional value like palability, depends upon the stage of plant growth. Crude protein content is always highest when plants are growing the fastest. At this same time, plants are also highest in water content and hence more palatable.

When growth first starts, the plant is drawing on stored energy from the roots, if a perennial, or the seed, if an annual. As growth progresses, an exchange of food between the shoot and root takes place with the shoot feeding the root. Moreover, and at this stage of growth, the plant is still using much of its food to produce seed. After seed is produced, the perennial plant's energy is turned toward storing food in the root for another season's growth. The annual plant completes its life cycle when seed is produced and thus stores its energy in the form of seed for the next season's growth.

All these facts are important to the range manager. He needs to know the season of growth for various groups of plants so that he can manage to protect the most desirable during their critical periods. In managing perennials, there are two very critical periods or stages: (1) when growth first starts and prior to the time the shoots are furnishing food to the roots and (2) the period after seed maturity when the plant is storing food for another season's growth. Even light grazing during these periods is harmful. Part of the problem of management is to find ways of protecting the more valuable plants during these growth stages.

Another little-known, but important, factor in management is the time of the year when perennial plants reach their various stages of growth. It has been all too commonly accepted by herdsmen that growth is dependent upon and coincides with seasonal moisture. This is not true. In actual fact, a given perennial will reach identical stages of growth—start of growth, doughstage, seed maturity, etc.—within a ten-day leeway, year after year. It has further been found that length of day is the important, controlling factor rather than other more seasonal climatic factors. Thus, a knowledge of the growth habits of each important plant is very useful. In fact, the more we know about the growth habits and basic functions of individual plants and how these processes relate to the plant community, the better will be the range management we are able to practice.

OVERGRAZING CAUSED THIS PLANT DETERIORATION

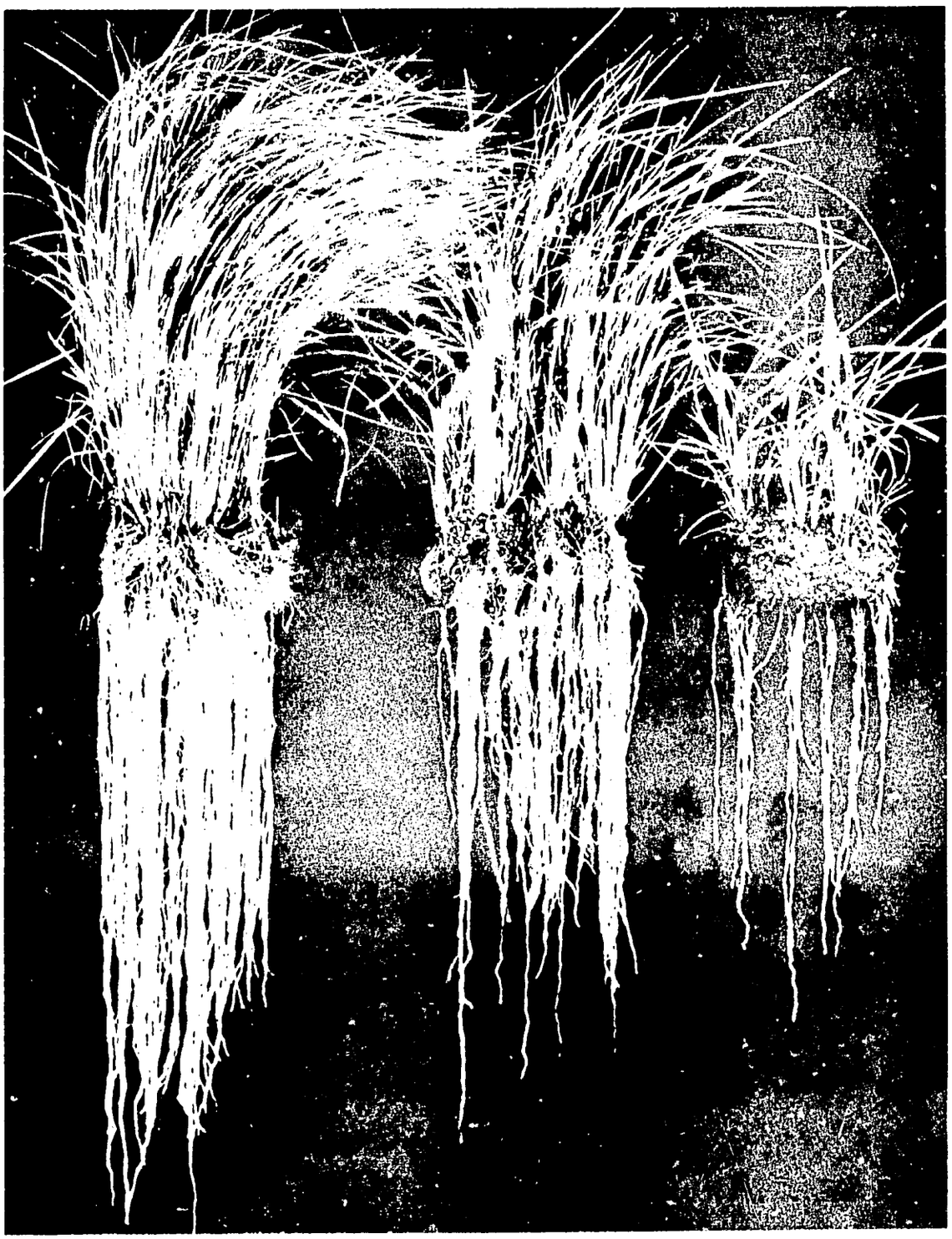

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FIGURE 3

CHAPTER III

ELEMENTS OF ANIMAL SCIENCE

INTRODUCTORY.—The elements of animal science are the factors that make for life itself, together with everything that affects the economics of livestock production. Both are extremely interesting, if we but allow ourselves to be interested in them.

Animals are living creatures. That is a very simple statement of a very obvious fact. Moreover, animals give us the chance to study life and learn much about it which includes ourselves. We know that animals are reproduced in a very orderly manner. This is the key to much of our success or failure in producing the kind of animals we want.

ANIMAL LIFE.—An animal comes into being as the result of two very small germ cells uniting. One of these germ cells, known as the sperm, comes from the father, and the other, known as the ovum, or egg, comes from the mother. These germ cells are very small. The male germ cell is much smaller than the female germ cell, yet they are of equal influence in their effects on the animal produced. These germ cells are all either parent can contribute to the future animal. Here is the key to the breeding of superior livestock. We must understand the functions of these germ cells.

GROWTH.—Growth is the second fundamental and starts as soon as the two germ cells join in fertilization. A great deal of growth takes place before the animal is born. Proportionately, it is much greater than growth after birth. A calf or a lamb will increase in size from 15 to 20 times after birth, but between fertilization to birth it will increase in size several million times. Moreover, it changes from a spherical object, so small it cannot be seen with the naked eye, into a living animal with a skeleton and muscle structure, circulating system, digestive tract, respiratory tract, reproduction organs, a highly developed nervous system and an outer or skin covering. This process is one of the wonders of the world, and over and over again we fail to appreciate what we see, or should see.

An increase in size is growth, but more than that, it is the development of all the complicated system mentioned. These systems are built of matter. The matter is not just material, but many well differentiated materials which must be proportioned properly. This proportion is achieved through nutrition.

Animals, then, may be likened to factories. From a simple beginning and with the utilization of raw materials, valuable end products result. The cow is a particularly good example of what might be termed a "farm factory" as illustrated in Figure 4.

GENERAL BIOLOGY.—The biological world is divided between animals and plants. Each of these, in turn, has many subdivisions. In range management we are interested only in the domestic animals and really in only a small segment of that group. The pig, the chicken, and the dog have little or no place in range management. The dairy cow has no major place on the range. The really important animals are sheep, goats, cattle, horses and donkeys, and camels.

From papers by: Dr. Lawrence M. Winters Livestock Advisor—USOM/Iraq
and F.A. Ralston, Livestock Specialist—USOM/Iraq.

The Farm Factory

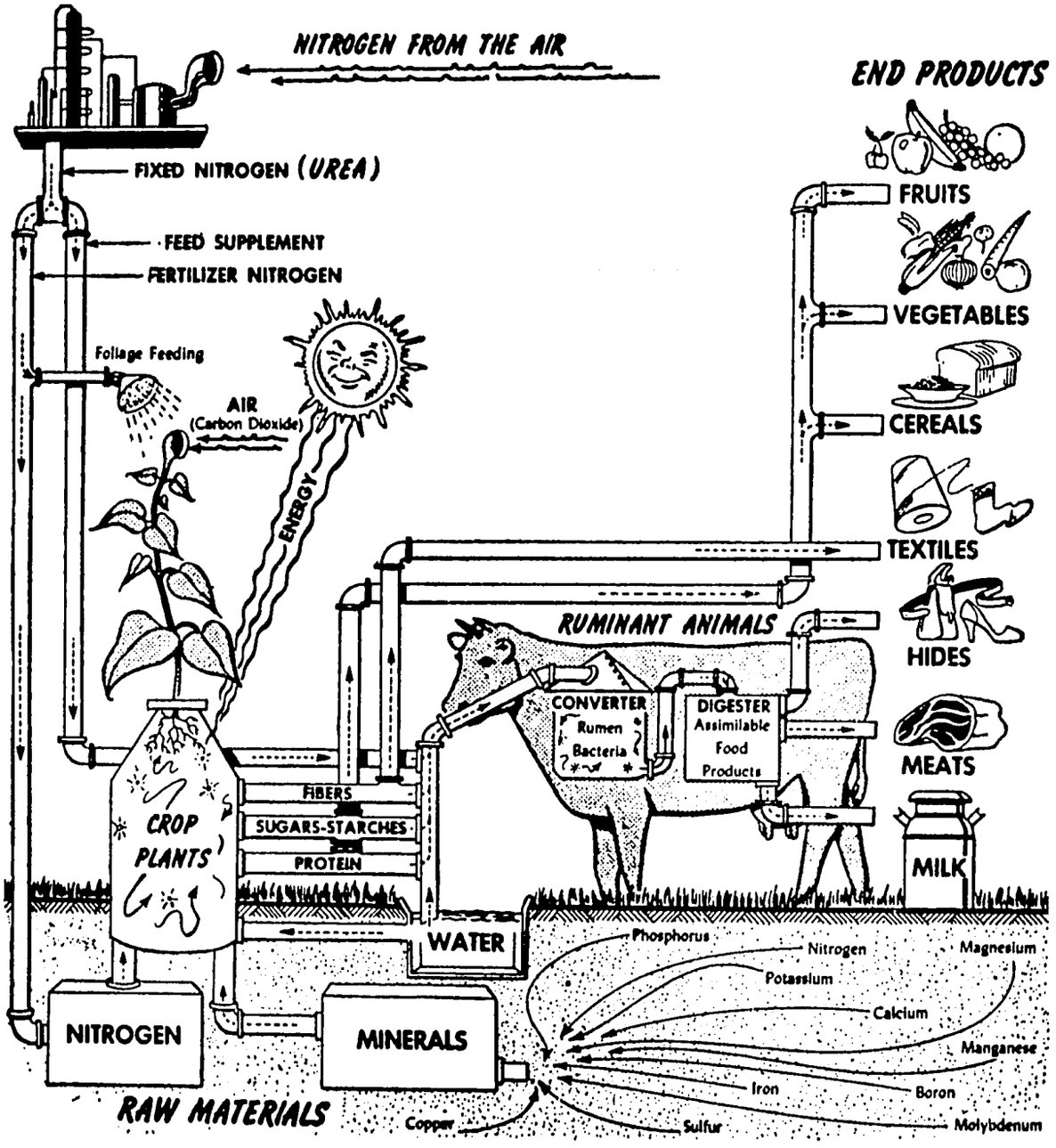

FIGURE 4

SHEEP.—Sheep are the leading range animal in this part of the world. They are quite different from sheep in the western world. Main differences are in temperament, in body form, in milk production, in type of fleece, and in hardiness. They are more thoroughly domesticated—they certainly obey the shepherd and follow him. Their temperament is also very different from that of sheep in Western Europe and England. There is one exception, the East Friesian sheep of Germany has much in common with local sheep, but they are a soft sheep and they do not have fat tails.

Local sheep also differ from Western European sheep in body form.They have less well developed muscles along the back and fat is deposited, for the most part, in the tail. In Western European sheep, fat is deposited over the body and interspersed within the muscles. Again, the East Friesian is built much like local sheep except that they lack the fat tail.

In milking ability, local sheep also have a similarity to the East Friesian. The range, however, is a poor place to produce and properly care for milk. Range operations are better suited to the production of meat and wool.

Sheep production, even on the range, must be well organized. Most areas have their summer and winter ranges and many have times during the year when it is profitable to bring sheep to farming areas and graze them on irrigated fields or feed them on crops harvested and preserved during the growing season.

In most Near East and South Asian countries, sheep produce light weight, short fiber fleeces and this condition needs improvement. They should clip more and have a higher quality of fleece. The factors affecting quality are: length, fineness, luster, freedom from weak spots, and crimp. Also, a white fleece has more value than a colored fleece.

GOATS.—Goats are closely related to sheep, but in general they are less valuable. They will live on coarser vegetation and unfortunately, are generally introduced when the range is too poor to support sheep. Some countries have banned goats from the range because of the damage they do both to herbaceous vegetation and to trees. Goat meat is of lower quality than sheep meat and the fleece clip is less valuable. Goats are however, better milk animals than sheep and some breeds have been well developed as milk producers. They are the poor man's animal—and they are very useful for just that purpose.

CATTLE.—Cattle are divided into various classes on the basis of the uses made of them. Around population centers, cattle are kept almost entirely for milking. The dairy industry is not suited to the range. The beef industry is suited to the range but beef is not locally as appreciated as it is in other parts of the world. One reason is that superior beef is not common. Ranges should be developed locally to carry larger numbers of beef-type cattle. Cattle require a better range than sheep and do not eat grass quite as short, whereas goats eat grass even closer than sheep. It is also necessary to provide more extra feed for beef cattle than for sheep during the off-season for grass. There is a big opportunity in this area for the running of large herds of beef cattle on the range when there is feed and then bringing them into the farming country for feeding when the grass gets short or when the cattle are ready to be finished for market.

HORSES AND DONKEYS.—Horses and donkeys fall in the same general grouping as work animals. They graze range forage closer than cattle and about the same as sheep. They can, however, travel farther and faster than sheep, so can be raised where water-holes are more distantly spaced. In general, horses and donkeys are declining in economic importance.

CAMELS.—Camels are the principal users of the more arid range areas. They will graze and browse on forbs, shrubs, and trees that are not palatable to other animals or on which other animals cannot survive. They frequently graze or browse in areas where only very scant vegetative cover remains and, accordingly, hinder the beginning of range management programs designed to revegetate such areas. Since they provide the main source of food and transportation for people living in these areas they create problems of range management which are difficult to solve.

BREEDING, CULLING AND SELECTION.—Good animals do not just happen. Better strains or breeds of livestock do not come naturally. They are the result of specific breeding programs and long and careful selection. In the case of some breeds of livestock the best animals are the result of selections for a thousand years or more. That means that for a hundred or more generations the breeders of that kind of livestock have been selecting and breeding the best animals in an effort to establish a type or breed with the characteristics wanted. To do this it has been necessary to discard and slaughter more animals for meat than were kept for breeding. Examples of this kind of breeding program can be cited in any of the major breeds of livestock and in dairy breeds such as Jersey, Guernsey and Brown Swiss. The original cows in all of these breeds were low producers but by selecting the best of both male and female the final result has been high producers. Behind the beef breeds such as Shorthorns, Angus and Herefords, there are many generations of careful breeding, also with many animals having been discarded along the way. In sheep, the same thing has happened until there are many breeds of sheep which have specific characteristics as to color, size, conformation and the amount and quality of wool they will produce.

STABILILY.—There are many reasons for improvement programs on livestock, but the most important are probably "stabilizing a product" and economy of production. Where agricultural commodities are in a competitive position with each other and with other commodities, quality and price are the factors which determine sale volume. To illustrate stabilization, when we say a "registered" Hereford beef animal we know that the animal had to meet certain standards as to pedigree, color markings, and so forth in order to be registered. The same is true for other beef breeds. In the dairy industry, in addition to breed standards, there are production standards, such as the number of kilos of milk or butter-fat produced. From experimentation it is known that certain characteristics are inherited and that if the ancestors of a dairy animal were high producers most of the offspring will be high producers. The net result is that these breeds and types are stabilized and have reached certain standards which are characteristic of that breed or type.

YIELD AND ADAPTABILITY.—Production in livestock is just as important as in industry. This is the reason certain types or breeds have been established in various countries, as the Brown Swiss breed of cattle in Switzerland, the Holstein in Holland, the Merino sheep in Australia and the Sante Gertrudis beef cattle in Texas (USA). They are adapted to the conditions in the particular area and give a high return for the investment made in them. It has been observed that in many Middle East countries, wealth is based on numbers of animals, regardless of quality. This was also true in the United States for many years and was made possible because of the free use of range land. However, as land becomes more thickly settled, as less free range is available and as more equitable taxes are established, quality and economy of production becomes more and more important. Local examples include carpets, and workmanship on silver, brass and copper. In considering improvement of ranges, one of the basic factors is control of numbers of livestock on the range. Laws and regulations will be necessary, but the kind of livestock is also important. If ten units of improved livestock will produce the same amount of milk, meat, or wool as twenty units of poor quality livestock the problem of feeding is reduced by almost half.

THE ROLE OF THE RANGE MANAGER.—It is possible to develop a better kind and quality of livestock in the Middle East. They could be imported, but importing the numbers needed to stock these countries would be very expensive and losses would certainly occur due to change of environmental conditions, climate and feed. Some importations may, however, be necessary and desirable. In a number of countries, importations have already been made which may constitute a nucleus for a breeding program in upgrading local animals. On the other hand, cross breeding may not be the most important part of an improvement program as indigenous animals in all countries have an inherent advantage over imported animals. Good native animals, through culling and selection, can usually produce the improved quality of animals needed. It is probable that sheep originated somewhere here in the Middle East and that such animals were the foundations for all breeds today. Climate, feed, selection and breeding have developed strains in specific areas which are now thoroughly adapted to those

areas. There are some very good breeds or strains of cattle and sheep in this part of the world. In Iran, for example, the Raini goat in the vicinity of Kerman produces a very fine mohair similar to Kashmir. The sheep from the Mogan area is a very good meat animal. The Golpaygan and Sarab cows are probably among the best native milk producers. There are, of course, many other breeds and strains in Middle East countries which have been or can be built up to superior qualities by selecting the best animals year after year in a careful breeding program merely through culling and disposing of the inferior ones.

Stockmen alone cannot do this job; neither can the range specialist, nor the banker. It requires the combined efforts of all these, plus an educational program to establish an understanding of the needs, and with that, projects and programs to satisfy these needs.

CHAPTER IV

SOIL-PLANT-ANIMAL RELATIONSHIPS

GENERAL.—While plant-animal relationships are basic in range management, other elements of the site and the bio-community must not be overlooked. For any locality, these elements are the base rock, or parent material; the topography, or the shape of the land; the climate; the soil, the vegetation; and the animals. Each of these may affect or modify the others. To limit our observation to any one or two may lead to error, particularly if the possible effect of the others is overlooked. Our first impressions of any condition or situation should be checked by measurements and experiment to make sure that our observations do not overlook important facts.

The livestock-man may be inclined to regard his animals as the most important resource because they are the immediate source of wealth—food, fiber, and related commodities. Livestock, however, cannot exist without plants, the source of their food. The abundance and kinds of plants may determine the number and quality of animals. Plants must have good soil, which in turn may be modified or limited by other plants, by climate, by topography, and by the parent material. The parts of an environment intermesh and react so that all parts must be considered in any evaluation.

LAND USES.—Range management is often regarded as concerning itself solely with the production of animals on natural pastures. This view, however, does not go deep enough. The basic wealth of any people is the land. To meet the enlarged demands of increasing human population, some of the land is cultivated in order to increase the products from the more productive and limited areas. Other lands, unsuitable for cultivation, yield products under natural conditions. In the lower rainfall areas, these products are usually the forage plants and, in the high rainfall sections, the forests. The range manager, then, becomes a land manager where the small vegetation—the grasses and forbs and shrubs—predominates. As such, his first concern and responsibility is not the production of livestock but the control of land-use so that this part of his nation's land can contribute maximum benefits to the people. Involved may be the grazing of livestock on some or most of the area. Also involved, may be *not* grazing livestock on some of the area in order to protect the land and reduce wind or water erosion and flood runoff. Other areas may need to be reserved for use by important wildlife species.

Wherever land areas are small in proportion to population, there will be a demand to cultivate marginal lands where rainfall is low or where slopes are steep. All of these uses need to be reconciled in the interest of good land-use in order to make all the lands most valuable to the people. The range will then consist of those lands which the combinations of soils, climate, and topography dictate should remain under a cover of permanent vegetation, much of which may be grazed by livestock.

PLANTS.—Plants tend to form communities in which they can successfully adapt themselves. These communities undergo continuing change as the soil develops until, finally, a degree of stability results and the plants and soils more or less reach the limits set by the climate. When grazing animals enter this community, the balance may be disturbed. There is a certain amount of disturbance when animals reduce the seed crop, the leafage, or when they compact the soil. If the animals are few in number, this disturbance is usually slight and the plant community readily adjusts itself. If grazing

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From a paper by: H.E. Schwan, Range Specialist, USOM/Iraq.

is heavy, the first effects may be on the plant community itself. The animals tend to graze first the plants which they like best. These plants may be grazed very closely and gradually disappear. The grazing then turns to the less preferred plants. This process sometimes continues until all that remains are a very few major species which animals dislike, which are resistant to grazing and yet adapted to the site. If heavy grazing is long continued and if the site is suitable, most or all perennials may disappear and be replaced by annuals. As an example—in the steppe area of northern Iraq, *Poa* bulbosa is now the dominant grass but in protected places it grows in company with a variety of legumes and other broadleaved herbs. If grazed heavily, the *Poa* appears to be in pure stands, although a few low weeds also remain. At a still lower stage, the annual *Stipa* tortilus invades. This grass is normally most abundant in desert wadis. At this stage, harmal (*Peganum* harmala), worthless for grazing, may become established. In the Western Desert of Iraq, the preferred shrub, *Salsola* rigida, usually disappears first. *Artemisia* herbaalba and *Achillea* sp. often increase and later decline. Finally, in very severely grazed places as near wells, the only vegetation left may be a stand of *Stipa* tortilus, which forms a lush vegetation for a few weeks in the spring. In oak (*Quercus*) forests in the mountains of Iraq there are frequently no shrubs except widely scattered, weak individuals. Yet, with a few years protection, other shrubs—(*Cratacgus*, *Pyrus*, etc.—appear in increasing abundance. It can be said, then, that some of the effects of excessive grazing are: (1) a change in the species which make up the plant community; (2) a decrease and gradual disappearance of the species which are preferred by livestock; (3) a change toward the least preferred or disliked species and those which are more drought-resistant or more resistant to grazing and (4) a change on many areas, from perennial species to annuals. There may also be a reduction in the density of the ground cover. Very often, however, the plants which are disliked may maintain the cover or the annuals may be very abundant for a short time each year.

SOIL.—When large numbers of animals move back and forth, the soil becomes compacted and changed. On heavily-grazed areas, the organic matter content declines. This condition favors runoff of water and a decrease in water intake. Tests commonly show that on loamy-mountain soils, an ungrazed plot will take-in a given quantity of water up to ten or more times faster than the adjacent, heavily grazed area. As a result of heavy grazing, then, there is less moisture in the soil and an adjustment in the vegetation with long tap-rooted broad-leaf herbs frequently replacing the fibrous-rooted grasses.

With the reduction in ground cover plus close grazing, less organic matter accumulates on the soil surface. A greater amount of the surface is also exposed to the impact of falling raindrops. Such impacts stir up the surface material and tend to form a crust which forces water to flow across a slope, thereby reducing water intake by the soil. The soil surface, unprotected by plants or plant material, is exposed both to the sun and to air movements and therefore dries out very quickly. Evaporation is increased, although recent experiments indicate that the loss of moisture through evaporation is probably not greater than that transpired by the original plant cover. But water lost by evaporation does not help produce useful plants. Where the height and density of vegetation is reduced, the soil surface is increasingly exposed to wind, evaporation, and rapid-drying. This often results in lower germination rates of seeds and greater death-loss of small seedlings. On the other hand, conditions may be more favorable for the germination of seeds from drought-resistant plants. Generally, however, the daily extremes of temperature are much greater on exposed soil-surfaces, which results in more rapid loss of organic matter and a reduction in survival rates of seedlings.

In winter climates, exposed soil cannot hold wind-driven snow. If there is a good cover of plants, wind movement is reduced and quantities of snow are trapped by the vegetation to add to the soil-moisture. Where there is a good cover of live and dead plant material, this also tends to act as an insulating layer which reduces the rate at which snow melts. In plots protected against grazing, a heavy layer of snow often remains while on nearby denuded ranges the surface is free of snow. In the protected plot, the snow melts more slowly and there is a greater opportunity for the water to sink into the ground while the moisture from the rapidly-melting snow on denuded areas flows over the surface and adds to flood runoff.

All of these changes in the microclimate—that is, the climate near the surface of the soil—tend to make the site less productive, and drier. The environment shifts from forests toward grassland

or brush, or from grassland toward the desert. The vegetation shifts from grasses toward tap-rooted plants, or from perennials toward annuals

On the other hand, the change to undesirable plants may compensate, to some extent, for the reduced soil protection as a result of deterioration of the original cover. For example, in desert areas in Iraq, shrubs trap wind-driven sand and improve the surface conditions for reestablishment of grasses and other vegetation. Spiney or unpalatable shrubs often shelter a few remaining grasses which can re-invade when grazing pressure is reduced. In areas protected against grazing in North Africa, range recovery is rapid if *Zizyphus* spina-christi is present. This large, spiney shrub shelters a few parent plants which can re-invade. Where *Zizyphus* is absent, recovery is usually very disappointing because there is little protection or no source of seed of the really desirable species. Even those plants which are never grazed, like *Rhaza* stricta, in Saudi Arabia, serve a useful function is stabilizing sand. In the Iraq desert, the common trend resulting from overgrazing is a reduction in shrubs because these are often preferred as feed by camels and goats. Such vegetative change increases the difficulties of keeping livestock through the long, hot summers as shrubs retain high protein content and are nutritious even while dormant at the time grasses either disappear or have very low nutritive values. Obviously, these and similar situations should be analyzed by the range manager before he undertakes chemical control of unpalatable plants.

ANIMALS.—Some changes in vegetation may produce interesting secondary effects on the native animals. As an example, the increase in *Artemisia* tridentata, as a result of overgrazing on ranges in the Western United States, often improves the winter ranges of the native wild deer. The *Artemisia* is not grazed by livestock in summer, but is an important food plant for deer in winter. Many other similar situations exist. The American prairie dog (*Cynomys* sp.), a rather large, burrowing rodent, lives in big colonies and is destructive to vegetation. Investigation has shown that when ranges in the state of Oklahoma (USA) were protected against livestock grazing, the increase in tall-grasses made conditions unfavorable for this animal. The prairie dogs then moved to more favorable areas where the grass stand had been reduced by grazing. It has also been shown in the state of Arizona (USA) that the change from grasses to broad-leaf herbs, as a result of overgrazing, resulted in an increase in jack-rabbits (*Lepus* sp.) which found the herbs a more favorable food. Moreover, an eminent American ecologist has said that "the best way to stop a grasshopper plague is with a barb-wire fence." What he meant was that by fencing out livestock and increasing the vegetation, the resulting conditions were less favorable for a grasshopper increase. In one instance, complaints were received that grasshoppers were destroying the range in the state of Wyoming (USA). Investigation showed that experiments had been conducted with two species of grasshoppers which were abundant. Feeding grasshoppers in cages with the better grasses resulted in shorter life-spans, reduced egg-laying, and in general, a reduction in numbers through several generations. But the insects thrived and increased when fed certain broadleaf herbs, like dandelion (*Taraxacum* officinale). Such herbs are most common on areas which are overgrazed by cattle and the experiment suggested that overgrazing appeared to improve conditions for some species of grasshoppers.

SUMMARY.—The foregoing illustrates that the relationships between soils, plants, and animals are often complex. Also, that simple observations are not always reliable. Observations should be checked with measurements, studies, and careful analysis. Disturbance and animal use of the plant community may start reactions which affect other plants, the soil microclimate and other related elements. As range managers, our job is to recognize and appreciate these inter-relationships. Also, to manage ranges and livestock to the best advantage possible at all times.

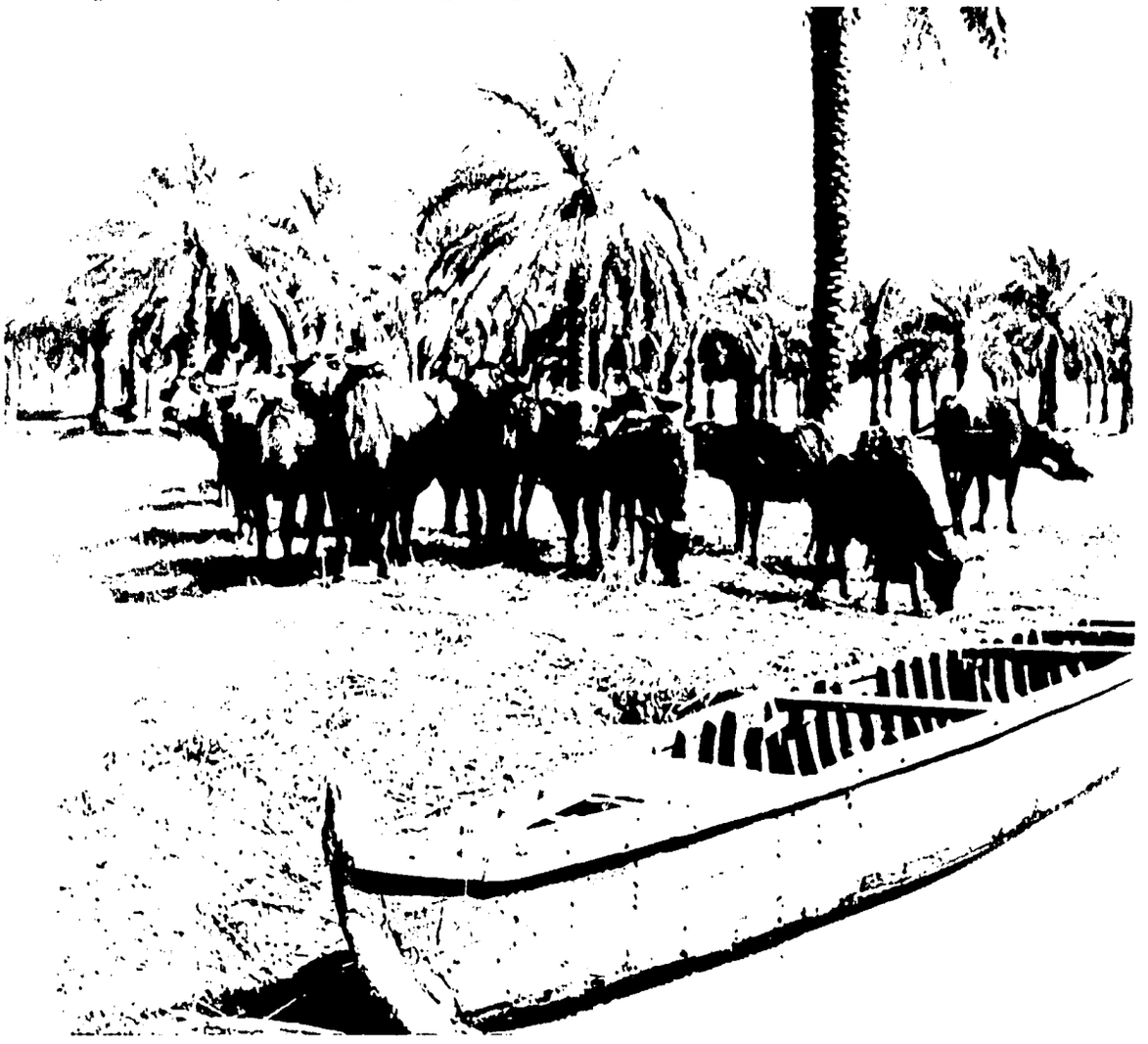
FIELD TRIP PHOTOS (IRAQ)

Students and Course Leaders at Salahuddin in Northern Iraq — 1957

Range Inspection Trip near Salahuddin in Northern Iraq — 1957

FIGURE 5

Range Students Study Silage-making at Agricultural Experiment Station — Abu-Ghraib, Iraq



Water Buffalo in Swamp Area near Basra, Iraq

PART II

FUNDAMENTALS OF RANGE MENAGEMENT

CHAPTER V

ELEMENTS OF RANGE MANAGEMENT

INTRODUCTORY.—Range management has been defined as the science or art of securing maximum sustained use of the forage crop without real damage to other resources and uses of the land. This implies controlled grazing use.

The use of land for growing useful products may be conveniently divided into two parts: (1) farm lands, which can be planted and cultivated, and (2) wildlands or those which are dependent upon nature to grow crops. Another great subdivision of agriculture, animal industry or the production of meat, milk, wool and other animal products, overlaps both farm lands and wildlands. Hay production and irrigated pastures are on one side and range lands are on the other side of this dividing line.

The crops from wildlands are trees, grass, shrubs, forbs, and animals, both wild and domestic. These wildlands, known as ranges or forests, are usually unsuited to agriculture because of low rainfall or because they are steep and mountainous. Many cultivated lands as in the Elburz Mountains of Iran, for example, are on very steep slopes and are properly range or forest lands, not farm lands.

Each piece of land has three things which cannot be greatly changed by man: (1) the parent rock, (2) the climate, and(3) the topography or land forms. These three elements influence the character of the soil and determine the kind of plant and animal life that can exist in any given place. They are the fixed elements which make up the site and the ones upon which are superimposed several others which can be changed or modified as soils, plants, animals, and man.

If the parent rock is limestone, the soils and usually the plants are different than if the rock is granite or shale. The climate may determine whether the plants are tropical or desert-vegetation or forests. The topography results in different plants on north and south slopes and on the high mountains as opposed to plains and valleys. The rock and climate and plants produce a particular kind of soil. These various factors, but particularly the plants, determine the kind of local animals most suited to a range.

Three elements—rock, climate, and topography—largely determine the use which should be made of the land or, more properly, they may limit its use. Created may be conditions favorable for forests with the land best suited for growing trees or the conditions may result in open lands which may be grazed but cannot be safely farmed. On farmlands, man can make some changes in soils but on vast areas of range or forest, he has very little direct control over the soil. However, a great deal can be done to change the amount and kind of vegetation. If man reduces the amount of vegetation or changes its character, the result may be a loss of soil fertility or compaction with a decrease in soil moisture or even erosion and loss of soil. Improvement of plant cover, in turn, will improve the soil.

GRAZING MANAGEMENT.—On vast expanses of range, great and extensive changes in the plant cover may result only with changes in grazing use. Overgrazing has caused deterioration of the plant cover on large areas in the Middle East and elsewhere in the world. One result has been extensive

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From a paper by: H.E. Schwan, Range Specialist, USOM/Iraq.

loss of top soil. By controlling grazing use, man can improve deteriorated plant cover and, in this way, improve the soil. This fact is the basis for range management.

If too many livestock graze the range for too long a time, the choicest plants are used to the point where they neither maintain vigor nor reproduce. Less desirable plants usually increase and when they are grazed too closely, give way to still more inferior species. This process of deterioration may be traced through a series of steps or stages wherein the occurrence of certain species in abundance indicates each successive stage. If grazing pressure is removed or reduced, an improving trend will develop. Similar stages, each indicated by a particular group of plants, represent improvement. The stages of improvement, however, may not be identical with the stages of deterioration. By carefully studying the range and by correlating the kinds of plants which are present with the condition of the soil, the relative condition of the range itself can be determined from excellent or good, through fair and poor or very poor. This determination is often referred to as "reading the range" and to become proficient, every range technician must be familiar with the several stages of plant succession, on the various types of vegetation in his area.

Range Improvement.—Man can do certain things directly to the plant cover as reseeding or waterspreading. However, neither are practical except on very limited areas and on certain sites. Reseeding is primarily a repair job and other "farming practices" such as contour trenching have the same limitations. For this reason, on the extensive areas of deteriorated ranges in Middle East countries and elsewhere, one big, outstanding job is to obtain proper management by controlling the kind and numbers of livestock and the time at which they graze the range.

Great changes in the range vegetation can be brought about merely by the way livestock are managed or controlled. As range managers, we do not usually try to control thousands of livestock ourselves. These animals are generally owned by many people. We must attempt to obtain livestock control through the individual livestock owner, the farmer and the herdsmen. Our job then, becomes primarily one of dealing with people.

Regulation or Education.—We have two ways of doing our job. One is by enforcing proper management through law and by the uses of police power. Such action is necessary in many places and situations. In the long run, however, the only really effective and permanent way is to educate the livestock people and convince them that good management is in their interest and in the interest of future generations. To create such interest we, as range managers, must be well qualified. We must know what needs to be done, how it should be done and then create the desire in the people themselves to take the necessary action. We must create the will to protect and improve the plant cover and soil and to pass these resources on to future generations in better condition than they are today.

Forest Grazing.—There are other uses of wildlands besides the grazing of livestock. Conditions in some areas may result in a forest site. This immediately brings up the question: "Should the forest be grazed?" If so, what type of management is required? Throughout the Middle East, in particular, wood and timber are so valuable that forests must generally be perpetuated and made more productive. In many forest areas it will be necessary to eliminate grazing in the forest. Light grazing, carefully controlled, may be permissible in some areas. Range men should, therefore, become familiar with the basic principles of forestry. They should cooperate with foresters and both should reach agreement regarding grazing use and control in the forests.

Water.—Water is life itself in the Middle East. All of the forest and range lands are watersheds and the source of many important streams, especially in the higher mountains. Severe erosion, siltation and irregular stream flow are everywhere evident. The range manager should recognize that the protection of plant cover and soil and watersheds on range lands is his responsiblity. He should understand what needs to be done and be prepared to take proper and prompt action.

Cultivation.—There are many cultivated areas on steep slopes and in areas of low precipitation. These lands usually yield only poor crops and often pass out of cultivation after a few years. They are usually also a menace because of erosion. Such lands should be converted back to range as quickly as possible and are, therefore, a part of the range manager's responsibility.

WILDLIFE.—Many range areas are the homes of wildlife such as the gazelle, mountain sheep, ibex and other species which require vegetation for food and shelter. In order to preserve wildlife in reasonable numbers, adjustments in grazing use may be necessary. Perhaps some limited areas are so important to wildlife that domestic livestock grazing should be much restricted or eliminated. The range manager should try to determine the needs of wildlife or work closely with wildlife technicians and provide for the valuable species to the extent necessary.

OTHER USES.—There are, of course, other resources and land uses of the range. As range men, we must appraise all resource possibilities and determine how maximum benefit for all the people can be obtained from combination uses. This we sometimes call "multiple-use" management.

SUMMARY.—The aim or objective of range management, simply stated, is to produce from rangelands the greatest possible benefits for people. This means, that as range managers, we must first improve each area of the range to the point where it supports the best possible cover of the choicest plants. To do so requires that the soil be improved along with the vegetation. We may also find that in providing for other resources such as forests, water or wildlife, it may be necessary to eliminate or restrict grazing on special areas. Moreover, when we have reached a point of maximum production, then, we must so manage the range that this production will be forever maintained.

CHAPTER VI

PRINCIPLES OF RANGE MANAGEMENT

INTRODUCTORY.—A most basic principle in range management is adjusting grazing use to forage production. Involved is (1) an inventory of existing and potential forage resources and (2) adjusting and maintaining grazing use in balance with these resources.

As range managers, we must look closely at the land and study it, not on the basis of how it is used now, but how it should be used to make it most valuable to the country and the people. To start, we should look at the condition of the watershed and the soil. Is there stability? Will the present use cause flood runoff and soil erosion which will endanger cities and farm lands and irrigation works? Which lands are suitable and safe for cultivation? Which lands are best left in forest? Which lands are most suitable for range? Where should grazing be limited or prohibited to protect beauty spots for outdoor recreation, or areas which are of great importance for wildlife as gazelle, ibex or mountain sheep? In other words, we must classify the land, area by area, to determine what its best or highest use should be. This may mean taking certain lands out of cultivation, closing some areas to grazing, and restoring other sites through range reseeding or the planting of trees. When this land classification job is completed, we will know which lands are or should be used as natural pastures. We must then bring these data to the attention of the government in such a way as to result in passage of suitable laws directed toward an ideal pattern of land use and management.

After range men know the location and area of range and its condition, a first step in management is to control and maintain proper grazing use. This involves four basic principles: (1) the kind of animals grazed should be suited to the range; (2) they should graze at the proper season and for a proper length of time; (3) their numbers should be in balance with forage production, and (4) they should be properly distributed over the range.

KIND OF ANIMALS.—On most ranges, certain livestock as sheep, goats or cattle are being grazed and a pattern of use has already been established. However, many ranges are best suited for one particular kind of livestock and if changes can be made, better use of the range will result.

Cattle generally prefer grassy ranges but will take considerable amounts of browse, especially when grass is dry. They do best on flat or rolling ranges, require easy access to water and are not well suited to using dry desert areas or ranges at very high altitudes. Sheep prefer ranges with an abundance of forbs. During dry periods they can subsist on shrubs, taking the new growth which retains a high percentage of protein. Sheep will avoid coarse grasses as well as dry grass until they are forced by hunger to graze on such plants. They also can use very rough mountain areas and ranges that do not have a good distribution of water. Goats can use very rough, rocky ranges and thrive in both deserts and mountains. They seem to prefer browse where it is available but will eat nearly any kind of forage. Goats are very destructive to young trees and shrubs.

The kind of animals which the people have will, of course, determine the immediate demand for range. Where it is possible to make changes, sheep can use weedy ranges as old cultivations or

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From a paper by: H.E. Schwan, Range Specialist, USOM/Iraq.

fallow crop-lands. Similarly, if ranges are grassy, with few weeds, relatively flat and well watered, a change to cattle may be desirable. On desert ranges, goats often destroy shrubs which are needed to carry sheep and other animals through the long, dry periods when herbs and grasses have dried or disappeared.

In determining the kind of livestock to graze on a range, three main factors should be considered: (1) the local demand for grazing a certain kind of livestock; (2) the kind of animals for which the range is most suitable, and (3) benefits to the range by changing to another kind of livestock.

SEASON OF USE.—Generally speaking, in Middle East countries, the ranges used by nomads are in better condition than the ranges around settled villages. The nomadic stockmen move from one area to another or from low country to high country and back again. Each part of the range is grazed and then, as a rule, rested as the animals move on. Village herds, however, use the range near settlements year-long and the range usually receives no rest.

Forage normally benefits if animals are not held too long in any one place and if they are moved on before the range becomes dormant during the dry season. Range plants, particularly perennial grasses and shrubs, should not be grazed before they have made considerable growth. It is harmful to graze some bunchgrasses before they are 6 to 8 inches (15 to 20 cm) high. Sodgrasses can be grazed somewhat sooner. However, if grasses are closely grazed early in the spring, they will produce far less forage throughout the growing season than if they are first grazed when they have made most of their growth. Forage plants must be allowed to produce seed and very early grazing may prevent plant growth from reaching the point where seed is formed.

A number of management devices may be used to prevent damage to forage plants from too-early grazing. Where livestock migrate from the desert to the mountains in spring, much range damage can be prevented if the herds can be slowed or held back until forage has made considerable growth and some seed production is assured. Around villages it will be necessary to develop pastures or sources of green or dried fodder which can be fed for at least part of the year, particularly in the spring, to allow the range plants to develop and reproduce properly.

In Iraq, short periods of protection in the spring indicate that some form of rotation-grazing may be effective. A simple system whereby one part of a desert range is used before April 1 to 15, while the balance of the range is used after this date would allow plants to develop and furnish much more feed on the area used later. The following year, the use should be reversed on the two areas. This same system of use might be followed with livestock migrating into the mountains. One route might be followed in spring and another in fall. The next year the use could be switched.

NUMBERS OF ANIMALS.—The numbers of animals which are grazed on any range largely determines how closely the forage is utilized. If plants are grazed too closely year after year, they will gradually die out. The better forage plants will leave first, converting the range to types with less desirable species. Finally, the hungry animals will graze these less desirable species and a barren range may result. As the plant cover is destroyed, the unprotected soil is washed away and the usefulness of the range is completely lost. The number of animals should always be balanced with the amount of forage which may be safely removed.

Short-grasses should generally not be grazed closer than 2 inches (5 cm.) and bunch-grasses not closer than 3 to 6 inches (7 to 15 cm.), depending on species. The short-grasses are able to produce leaves which lie flat against the ground and thus escape killing out, even though forage production is much reduced. Bunch-grasses, if grazed too closely may have nothing but stems remaining.

Aside from the direct effect on individual plants, close grazing may also change the site. If part of the plant growth is allowed to remain on the ground, it will tend to reduce summer soil-temperatures, lessen evaporation and increase infiltration of water. Plants will continue to grow later in spring or early summer. Erosion will be reduced and conditions will be more favorable for new seedlings.

On badly deteriorated ranges it will be necessary to close the area to grazing until recovery is made, or else grazing must be so light that plants can increase in vigor and produce seed.

Many ranges in the Middle East have been and are being severely overgrazed. A reduction in season of use or number of animals or both is necessary to prevent further destruction. The question naturally arises as to how the people will produce adequate supplies of meat, milk and other animal

products. There are several possiblities, including (a) *pastures*... in most areas, dryland and irrigated pastures can be established. Good forage plants are adapted to many different conditions. Bermudagrass (*Cynodon* dactylon) pastures can be successfully developed at lower elevations where rainfall is adequate or some irrigation is possible. Alfalfa (*Medicago* sp.) and grass mixtures are very productive under irrigation. Pastures are especially needed near most towns and villages; (b) *Crep rotations*... in cereal producing areas, annual legumes such as *Vicia*, *Lathyrus* and others can be seeded into the stubble. Light discing usually increases the stand. This practice provides good pasture from early spring to summer. Part of the crop may also be stored as hay or silage for use in late summer and fall. On longer rotations, alfalfa and perennial grasses may be grown in rotation if soil and moisture conditions are suitable and (c) *better animals*. Throughout the Middle East much grass is wasted. Good grass goes into unproductive animals or animals which later die. Herds and flocks frequently contain an excess number of male animals. Because of these factors and because of poor nutrition, calf and lamb crops are usually low. Many animals die because of poor nutrition and disease or because adequate provision is not made for periods of forage shortage. Also, the type and grade of animals is often such that meat, wool and milk production is very low.

DISTRIBUTION.—Animals should be evenly distributed over the range in order to avoid overgrazing in some areas and light or no use in others. One of the principal reasons for uneven grazing-use on Middle Eastern ranges is lack of water. This situation is being corrected in several countries by the drilling of wells. However, water development creates additional problems because without control new water may result in additional livestock use rather than in relieving grazing pressure on heavily-grazed areas. It has been suggested that all new wells constructed in desert areas should be equipped so that they can be locked or otherwise closed. By alternately opening and closing wells or by opening some wells late in the spring, it should be possible to develop good systems of both deferred and rotation grazing. Distribution can also be greatly improved by fences. However, because of the high cost of fencing and the low forage production on most areas in the Middle East, fences will probably not be extensively used except, perhaps, for crossfencing in improving Bermudagrass (*Cynodon*) or irrigated pastures through rotation of grazing so that parts of each pasture have periods of use and rest.

PROBLEMS.—There are, of course, many problems in range management on Middle East forage areas. Some of the more universal and important include destruction of shrubs for fuel, uncontrolled grazing, low income from livestock and excessive grazing use.

In desert areas, in particular, grazing-shrubs such as *Haloxylon* salicornicum and others are widely used for fuel. Often in the vicinity of wells or camp sites, all shrubs have been destroyed even though they are a most important part of desert-range vegetation. In some areas, certain shrubs which are very resistant to grazing have been planted or occur naturally. In Iraq, *Tamarix* articulata has been very successfully established on limited areas and is becoming an important source of fuel. It has been grown from cuttings watered for only one year on dune-sand in 3 inch (7.6 cm.) rainfall areas. *Prosopis* Stephaniana which occurs naturally, is also a very important source of fuel. Moreover, it withstands repeated cutting. Obviously, there must be other trees and shrubs which could and should be introduced to supply fuel and reduce the demand on better grazing shrubs.

Uncontrolled grazing is very common. The prevailing rule among livestock people is that forage belongs to whoever takes it. Under such conditions, it is impractical for anyone to reserve forage or to graze ranges properly. Some system must, therefore, be developed which will assure that whoever improves a range will reap the benefits.

Low earnings from meat and other animal products appears to limit the development of improved pastures. Improvement of animals and other means of assuring a better income for the producer should place pasture returns in a better position and encourage pasture development. Better meat grading and marketing practices might also help assure better meat prices.

Excessive grazing use is also far too common. In Iraq, village or farm sheep are taken to the desert in spring where they compete with the sheep of the Bedouin. This creates an excessive grazing load in many areas. The development of pastures or crop rotations with forage plants should be encouraged to provide a source of feed for such sheep.

THE ROLE OF THE RANGE MANAGER.—A knowledge of range management is of no use unless it is applied. Since grazing animals greatly affect the vegetation, it is by managing livestock that vegetation

can be most effectively changed. As range men, we must work with the people who own the livestock. Much of our work will, therefore, be in dealing with people.

We know that there are two major ways in which range managers can best deal with the men who own or graze livestock. The most important is thorough education—by teaching the reasons for and the benefits from improved ranges and by demonstrations. The other is by law enforcement and prerequisite are suitable laws directed toward sound programs in range management. To be effective, laws must be enforceable and have public support. Range managers, therefore, have a definite responsibility in the formulation of fair and workable range policies, laws, and regulations.

The range manager, particularly in government service, is part of an organization or team. He may be in charge of such an organization or he may be a unit or area manager. As such, it will be necessary for him to see that he and those under his direction work as a team so that each job will be done within his country's range policy and toward the goal of productive ranges and good watersheds. Simply stated, he must be a good administrator and must get many people to work with him toward a common goal.

In order to accomplish the many activities necessary in range management the range manager must also train others. This does not merely mean telling them, it means being able to do each job himself so as to be able to show them. Quite often, the range manager must work with his hands—driving or repairing machinery, building fence, and doing similar jobs. Unless he knows how the work should be done he will have difficulty, both in training others and in inspecting the completed job to determine whether it is satisfactory. Some system of planting is necessary so that jobs will be done at the right period and that time will be used effectively. For example, if the range manager forgets about a seed collection project and starts work two weeks late, the seed may be gone and an entire year will be lost.

Range management is out-door work. The range man will not succeed unless he is at home out-of-doors on the range, and understands the plants and animals with which his work deals. It is often uncomfortable and hard work. In government, in particular, most salaries are low, yet there can be great satisfaction in public service. The real reward comes in the form of better land; improved watersheds, ranges and livestock; and a better living for many people. The mere conviction that the future is a little more secure because of his work will give most range managers great satisfaction.

CHAPTER VII

RANGE ECOLOGY

INTRODUCTORY.—The word "Ecology" is derived from two Greek words: oikos, meaning home or habitat and loges, meaning science or discourse—in other words, all human relationships or the science of plant, animal and human communities. In terms of organisms, this means the relationship of all organisms to their complete environment.

All land surface, with few exceptions, is covered by some kind of plant cover or vegetation depending upon the prevailing climate. Natural vegetation ranges from scanty desert cover to luxuriant tropical forests. Life on earth is a continuous, engulfing layer called biosphere.

The type of vegetation in any location is determined by the prevailing climate and soil. The climate of any area is the relatively stable conditions prevailing in that region over a long period of time. Weather changes from day to day and year to year, but the climatic pattern stays constant over thousands of years. In the Persian language there is only one word for both of these concepts. This word is "abo hava." Literally translated it means water and atmosphere. Actually, a desert climate will support only a desert vegetation and the possibility of higher growth and development of vegetation both in quality and quantity is, therefore, limited by climate.

As far as the development of vegetation in any location is concerned it should be realized that only areas deeply covered by water, the barren mountains, some saline spots and a few other places are devoid of vegetation. Even so and as water areas fill up with soil and site conditions improve with rocks breaking down due to weathering, the possibility of encroachment of plant life greatly increases. The eventual result is the highest form of vegetation which the area will support.

PLANT SUCCESSION.—Of course, the highest expression of climate in any region in terms of vegetation does not come about overnight. Different kinds of life-forms invade these areas and, after some time, give way to other life-forms more suited to the region until a stable community of plants—the fullest expression of nature and the most suited vegetation for the climate—develops. This is called "climax vegetation" and the process through which it comes about is known as "primary succession." The climax vegetation of any natural land is, of course, the least costly, and most productive natural plant cover for the site.

Unfortunately, many rangelands throughout the world have lost their climax vegetation due to heavy grazing and subsequent weakening and eventual death of the better plants. Closing overgrazed ranges to grazing, temporarily or for longer periods, particularly when a source of seed of climax species *is* available in nearby protected areas or regions too high or too rough for livestock, should bring back that vegetation in a short period of time. This, however, is not universally true as many areas have not only lost their original plant cover but also the proper soil necessary for the support of climax vegetation. This process of destruction is called "site deterioration." The original vegetation may never come back into these areas, but under rest or moderate and light grazing any community

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From papers by: Dr. Mohamad J. Meimandi-Nejad, Iran
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of plants on deteriorated sites will evolve a higher, more productive plant cover. This process is called "secondary succession."

The so-called "plant succession" concept has probably had more to do with the development of range management principles in the handling of vegetation than any other single factor.

Two typical successions include the type of succession which occurs in a 100 percent water environment, such as in a shallow pond, lake or reservoir, and that which occurs in an extremely dry situation as on a rock slide. To illustrate, assume that we have a pond area in a valley and rock cliff with blocks of broken-rock of various sizes facing the west, where the exposure to sunlight brings intense temperatures and high evaporation rates during the major portion of the day, particularly during the growing season. Initially, bare areas such as these have probably been upon the earth's surface over millions of years in various places. Since we have always had mountain formation and erosion and degradation, we probably have taking place here the things that have taken place over millions of years in the development of vegetation and soil.

In the case of the pond, we start with the succession which occurs in water and which is oftentimes called a hydrosere (literally—a succession in water). If we go from the deeper waters of the pond toward the shore line, we have a shallowing of the depths as we reach the shore and a formation of vegetation around the edges of the pond with which we all have some familiarity. We may not, however, have tried to associate the various types of vegetation found in belts or zones with the conditions which determine the placement of that vegetation.

On the other hand, most of us have been in boats out where the water is perhaps 3 to 5 meters deep and looked down to see a very rich Bed of vegetation including various species of *Potamogetons* which are famous as shelter spots for fish as well as food for wild fowl. There is also another water plant which is called *Elodea*, and stoneworts, such as *Chara* which form dense beds below the surface of the water. Almost never does this vegetation come within 30 cm. of the surface, yet it is very dense and very productive. This "submerged stage" is the one which is found in deeper waters—not in the very deepest waters because they will not support even this type of development. During the winter season, this bed of vegetation dies down. Eventually, there is an accumulation of plant debris of one kind or another and with spring freshets some clay and silt washes in. Gradually, the water depth is decreased as organic matter and clays and silt accumulate until the depth might be only 3 meters. At depths of somewhere between 2 and 3 meters we begin to note changed conditions and find such forms as the water lily with its great root-like stems anchored in the mud, but with long leaf-petioles and leaves which float on top of the water. We also have the water smartweed which is a highly desirable food for waterfowl and we have again some *Potamogetons* which have floating leaves. This is known as the "floating stage."

When the accumulation of organic matter, the bringing in of silt and clays, builds up the bottom to within 1 to 2 meters of the water's surface we have an ideal medium for the great bulrush and the cattail to take hold and develop along with associated forms. This is called the "reed-swamp stage." Next, the accumulation of washed-in silts and sands and clays brings about a very quick change and we have a saturated soil with a grasslike plant which is not a grass at all but a *Carex* (sedge) coming in and anchoring these saturated muds. This is the "sedge-meadow stage."

Now if the pond is in an area surrounded by bunchgrasses, gradually these sedges will, along with washed-in soils and materials, build this shallow soil up to a point where there is less water and more air resulting in a favorable place for some of the moisture-loving meadow grasses to come in —some of the blue grasses (*Poa* sp.) some of the fescues (*Festuca* sp.) and similar plants. These may be there for quite a long time until the soil finally becomes too dry for them, when they will be replaced by the typical native-grasses characteristically developed under the existing climate.

Thus we have hastily traced a succession of plant forms, which during their development have completely changed the character of a soil and its relation to moisture, air and to organic material. We have gone from a submerged stage, to the floating stage, to the reed-meadow, to a sedge-meadow stage with saturated mud, to the meadow and finally to native grassland. If, however, the pond is located in a forest at mid-elevations, instead of going to meadow grasses and bunchgrass we may have our succession passing into willow (*Salix*), alders (*Alnus*) and birches (*Betula*) thence gradually into the forest type characteristic of the area. The important point is that this plant succession proceeds until the highest type of vegetation which a particular climate can support is finally attained.

Succession in the case of dry areas oftentimes called "zerosere" (literally—a dry-succession) is just as interesting but much slower. Here we have as the first colonizers on bare rock surfaces, small crusty plant-growths which the ordinary person usually disregards. They may be variously colored—gray, yellow, brown, green, etc. Many people think of them as mineral encrustations. Sometimes, rocks do have mineral encrustations but ordinarily the crusts we see are living plants—a plant form called "lichen," which is one of the most interesting plants in the world. It is not a single plant but an organization of two plants living together—a "fungus," somewhat like a mold, made up of numerous packed threads within which are held captive "algae"—little green plants which are capable of manufacturing food. The fungus cannot manufacture food but gets its sustenance from the algae it has captured. The algae could not possibly grow on such dry habitats alone but the fungus absorbs water which the algae cells use.

The lichen is beautifully adjusted to the extreme changes of temperature and drought which occur on rock slides. With the absorption of moisture from the evening air, the coming of the sun each morning brings about a period of photo-synthetic activity when the algae manufactures food. Perhaps the lichen is active for only two or three hours, if the day is hot, since by 9:00 or 10:00 o'clock the atmosphere will have become so arid that the lichen is dried out and both the fungus and the algae go into a period of dormancy like that of plant-seeds during winter. This activity remains until evening when the saturated atmosphere once more gives the fungus a chance to extract moisture from the air. Again each morning, there is a period of food manufacture, a period of growth and perhaps reproduction and then a rest period during the heat of the day when the temperature on rock surfaces may become as high as 140 or 150 F (60 to 65 C). These are the characteristic pioneers of the dry, rock-surface under the trying conditions found throughout the world.

Lichens have several forms. First, the crustose-form which, through the accumulation of organic matter and wind-blown dust, gives just a thin beginning of soil upon the surface of the rock; then a higher type of lichen comes in which is more leaf-like. Being vigorous in growth, it could not come in first because the substratum was not sufficiently developed to provide it with the necessary moisture and minerals. This leaf-like form of lichen produces more organic material and between the leaf-like folds there is more room for the accumulation of wind-blown dust resulting in the development of a thicker layer of soil and,eventually, conditions favorable for the development of some of the mosses. The mosses, although typically moisture-loving, are in some cases adapted to dry conditions.

With the advent of mosses, succession begins to move much more rapidly. Not only is there a faster accumulation of organic matter but there is also a more rapid accumulation of windblown soil and eventually a soil layer, perhaps 5 or 6 cm. deep.

Such a soil-medium is adequate for some of the forbs or weedy plants to take hold. They may be such species as yarrow (*Achillea*) or five fingers (*Potentilla*) or beard tongue (*Penstemon*) or some of the weed-type grasses which have short life cycles. Gradually this "herbaceous weed" stage, as it is called, increases the depth of the substratum with dead leaves, roots, stems and the accumulation of still more soil, to the point where it is deep enough to allow still higher types of vegetation to come in.

If the rock slide is located in the grassland zone, gradually the soil becomes deep enough and helds moisture well enough to allow the climax grasses to come in as the highest type of vegetation which the climate will support in that particular area. However, if the rock slide is in a forested area, it will pass from the herbaceous weed stage to shrubs such as *Prunus*, *Rubus* and others which further help to build up the soil until trees can establish themselves and eventually develop a forest.

Notice that in each case we started with one extreme, either that of 100 percent water or with the other extreme of a rock slide, one of the driest situations on earth, but as the stages of succession proceed we arrives at the same end—the highest type of vegetation which the climate in the particular area is capable of supporting—the climax vegetation.

PLANT TYPES.—Throughout the world, there has been developed many different patterns of soil and vegetation coinciding with various climates. Generally, these are broken into formations or plant groups. Plant formations in different parts of the world are composed of many different species yet the characteristics of the plants within a group or type are the same wherever found. Broad plant formations arranged in ascending order from driest to wettest climates might be listed as follows:

True Desert	Desert Shrub	Short-Grass	Mid-Grass
0 to 125 mm. rainfall	125 - 250 mm.	250 - 375 mm.	375 - 500 mm.
Tall-Grass	Savannah	Forest - Tropical Forest	
500 - 625 mm.	625 - 750 mm.	750 mm.	

Such a classification is, of course, greatly affected by changes in altitude and temperature and humidity also plays a part. As a general rule, however, each 1,000 meters of altitude or each 15 of latitude measured north or south from the equator at the same elevation would, in any one rainfall group, place the vegetation in the next higher plant grouping within temperature zones and elevation limits up to 4,000 meters.

As with any general rule there will be exceptions. However, this classification gives the general pattern of vegetation to be expected in any one area with the given prevailing climate.

It is in the 125 mm. to 500 mm. rainfall zones that most of the world's rangelands or natural pastures are found. This is also the area in which the bulk of natural pasture or range management work is centered. Zones with 500 to 750 mm. of rainfall also contain natural pastures which respond well to natural ecological laws. However, because of population pressures and the demand for directly converted foodstuffs—cereals, vegetables, etc.—these zones should usually be classified and treated as arable lands, except where too steep or where other important physical limitations are present. True deserts—0 to 175 mm. zone—will respond to management, but the rewards are often quite meager. The forests—750 + mm. zone—are properly and more economically suited to the production of wood-crops or for use as arable lands than as grazing lands.

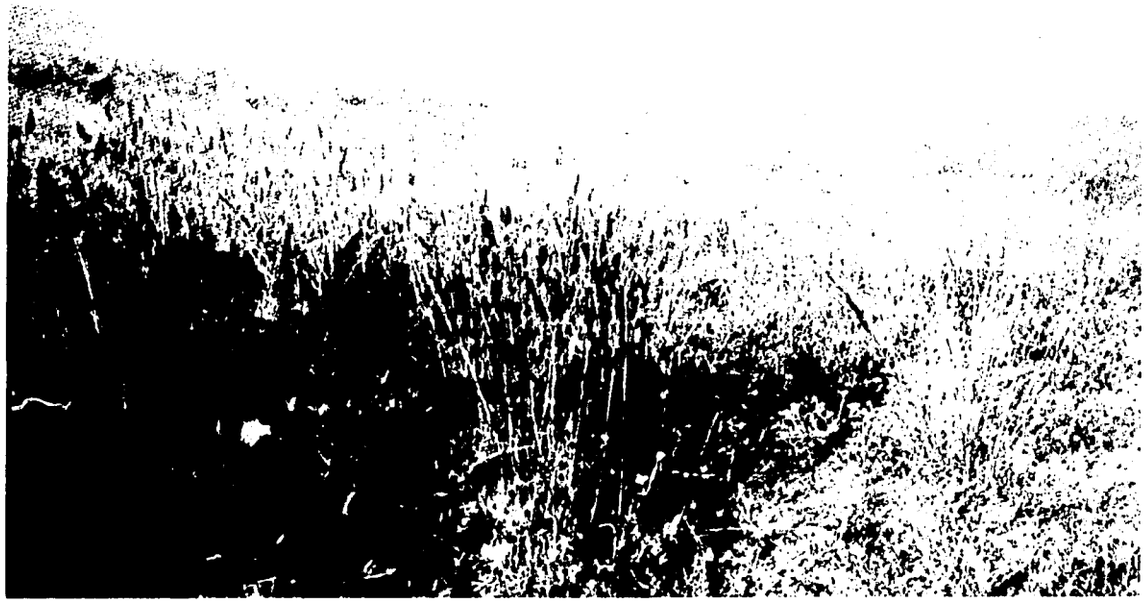
THE ROLE OF THE RANGE MANAGER.—All rangelands will respond and improve under proper grazing management. They will also maintain themselves in top condition indefinitely if properly used. This is true because natural vegetation responds to natural laws, the most important of which is the law of plant succession. This law, simply stated, is that "Nature will develop and maintain or try to put back on to a soil under a given climate, the kind of vegetation that is optimum for the site."

This means, for example, that if we clear a forest and plant it to pasture, we must repeatably keep clearing the woody species that nature will try to put back. Such a condition is not bad. In fact, pasture on cleared forest land is a good alternate-land use. The land manager must remember, however, that this pasture will have to be renewed at regular intervals, perhaps fertilized, and otherwise treated as any other tame crop if he is to secure highest yields.

We should remember, also, that a range in top condition, with a good protective cover of both living and dead vegetation will normally hold all the water that nature furnishes. It is well protected against erosion and will supply for livestock grazing, up to four times the amount of forage provided by most present-day depleted ranges. This alone should prove incentive enough to the stockman to practice range management using ecological principles as a guide.

FIELD TRIP PHOTOS (IRAN)

Oxen grazing depleted native intermediate wheatgrass range northwest of Hamadan. An unpalatable weed, Peganum harmala, is the most common plant.



Good condition native range northwest of Hamadan. The important grasses are crested wheatgrass, intermediate wheatgrass and Stipa lessigiana.

Cattle on denuded range west of Hamadan, Iran.

FIGURE 6

Nomad stockmen striking camp in the Caspian area.

Hay for livestock and weedy plants to be used as fuel are piled near villages for winter use. This Village is west of Hamadan.

CHAPTER VIII

WETERSHEDS AND EROSION

INTRODUCTORY.—An integral part of range management is the handling of land resources so as not to impair the fullest production of usable water nor bring about the loss of top soil. All plant and animal life is dependent upon water. The soil is the greatest source of stored water. Watershed management and the control of erosion are, therefore, important phases of the range managers' job.

WATERSHEDS.—A watershed is usually defined as any area supplying water (a drainage basin). Watersheds may be large or they may be small. They may be timbered or covered with shrubs, forbs or grass and, in some places, they may have no plant cover at all.

Forests will catch less snow than grasslands, yet hold it longer. Frost occurence is reduced in forests. There is also less wind movement and evaporation. On the other hand, transpiration is greater but moisture transpired to the air above cools it and leads to increased frequency and more regular distribution of rainfall.

Unforested areas have lower average winter and higher average summer soil temperatures. Their range in temperature is often three times as great as forest soils. Grass cover intercepts much less precipitation. Evaporation is greater but since transpiration rates are lower, grassland is an equally or more satisfactory watershed where water yield is of greater importance than timber production.

Bare areas, of course, are the least desirable as their soil is easily displaced by the action of wind, water and gravity. Average annual soil losses per acre (2/5 hectare) from denuded watersheds in recent studies were measured at 12 tons (1090 kilos) as against only 2 pounds (less than 1 kilo) from adjacent vegetated areas. Other similar studies have shown that in heavy, rain-storms less than 5 percent ran off normal plant and litter covered areas whereas 80 percent ran off adjacent deteriorated sites. Soils on deteriorated sites very definitely have a much lower infiltration rate than soils with undisturbed plant cover.

Run-off is yielded either as (1) seepage flow or (2) overland flow. Seepage flow leaves the soil slowly and in a clear, filtered condition—such water is very good. Overland flow does not go into the ground and is, therefore, usually undesirable and often dangerous—it robs the soil of moisture and causes soil washing and floods. In arid areas, sparsely covered with plants, overland flow may be the only type of run-off. Seepage flow can occur only when the soil is wet in excess of its capacity to hold water against the force of gravity. It is only slightly manageable as by (a) varying the height and density of plant cover to vary interception losses or (b) favoring deeply or shallowly-rooted plants to adjust depth from which transpiration losses occur. However, overland flow is largely manageable as much can be done to increase the capacity of the land to absorb, store and slowly release water.

Agreements and unwritten laws have long governed navigation and, more recently, the agricultural and industrial uses of waterways. Unfortunately, too little and in many places no action has yet been

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From a paper by: Clarke A. Anderson, Forestry and Range Management Advisor, USOM/Lebanon and Leader 1957 Regional Range Management Couse/Iraq.

taken to secure wiser use and conservation of the land resource. This, even though plant-soil-water relationships have been recognized for thousands of years and scientifically proven for nearly a century.

EROSION.—Erosion is usually defined as the wearing away of the earth's surface by winds, water and gravity. If the process is slow and usually unnoticeable, it is termed "normal" or geologic erosion. This type of change in the land surface is almost always beneficial. Usually nothing needs to be done to control normal erosion nor is control practical in most situations.

When normal erosion is speeded up, the land manager becomes concerned. This speeded up or so-called "accelerated erosion" is almost always a result of man's abuse of the land.

The amount and severity of erosion varies with slope, plant density and accessibility of the area. Soils are most stable and erosion least on northerly slopes. Areas with deep, organic soils have little erosion as contrasted with shallow, compact soils supporting sparse plant cover which is easily overgrazed and depleted. Even with moderate use, such critical areas tend to erode easily. They need careful management and, if badly eroded may require lighter or no grazing use if deterioration is to be arrested and improvement realized.

Erosion may also result from the cultivation of submarginal lands, and especially when not plowing or seeding on a contour; from marginal forest cutting operations; from improperly located and poorly drained roads and trails; and from range and forest fires. Unfortunately, the destruction of plant cover and subsequent loss of the soil are largely confined to man's use of wildlands and the result is always that of converting plant cover to a more desert type. Some desert areas lie in regions of ample rainfall.

Erosion factors include (1) ease of detachment and transport of soil particles; (2) kind, amount and density of vegetation; (3) precipitation density; (4) wind velocity and (5) steepness of slope. Erosion is usually further classified as (a) sheet erosion and (b) gully erosion. We have all seen and are familiar with both types.

Some indicators of accelerated erosion include (1) muddy water and water-borne deposits of soil and debris; (2) clouds of dust and wind displaced soil; (3) accumulations of sliding soil, particularly sand and gravel; (4) undercut streambanks; (5) rills and raw gullies; (6) soil remnants, rock pavement, lichen lines and exposed bedrock and (7) exposed plant roots and pedestled plants. Stable soil has undisturbed litter, clear stream channels and smooth land surfaces with top layers intact.

The importance of watersheds cannot be disputed. All life is dependent on soil and water. Neglect of land within any watershed has far-reaching effects on both up-stream and downstream users—people, industry, animals and agriculture.

History records the rise and reign of many peoples in lands which today cannot support a fraction of their onetime population. The answer usually lies in their failure to use wisely and conserve fully their soil and water resources.

IMPORTANCE OF WATERSHEDS... Future development in many areas will not be possible unless soil stability is obtained and unless irrigation systems, water supplies and all lands, crop and otherwise, are adequately protected from erosion, floods and siltation.

WATERSHED MANAGEMENT.—Watershed management is a science which usually causes some confusion among land managers as well as the general public, at least regarding overall objectives and potentialities. In brief, desirable management is simply the handling of land resources within a drainage area for the production of maximum usable runoff to streams and ground or surface water basins. Attained, should be (a) the greatest volume of clean water; (b) the least possible number and size of damaging floods and (c) adequate usable water when, where, and as needed.

DESIRABLE WATERSHED MANAGEMENT PRACTICES.—Some of the more important and most desirable watershed management practices include: (1) light to moderate grazing use of range lands with adequate protection of steeper, shallow-soiled, thinly vegetated areas; (2) cultivation only on suitable sites and with contour plowing and planting; (3) careful harvest of forest products using lightest practical equipment and short logging trails away from drainageways and across, not up and down, slopes; (4) locating roads on gradual grades, providing frequent and adequate drainage plus sloping, mulching and revegetation of banks (stock-pile top-soil during construction for this purpose) and

(5) preventing or controlling range and forest fires. All of these practices can be applied by land users. The job of the land manager is to assist and, where necessary, require that soil and vegetation be properly used.

Supplemental practices which may often be beneficial and desirable, particularly where soil and plant deterioration is unusually severe, include: (a) waterflow regulation structures as check dams, waterspreading or diversion ditches, contouring or terracing, sedimentation reservoirs and similar mechanical devices; and (b) artificial revegetation including reforestation, range reseeding, shrub planting along eroding drainageways and similar work activities. Such mechanical and artificial treatment is expensive and should generally be undertaken only as a last resort or when fully justified by damages resulting or probable.

THE ROLE OF THE RANGE MANAGER.—The most effective and least expensive watersheds improvement and erosion control practice is good land-use management. Attaining good management is, therefore, the most important justification for our existence as range and land use managers.

CHAPTER IX

RANGE SITES

GENERAL.—Rangelands have been classified by numerous methods since earliest time. Perhaps the oldest classification is simply: good range or poor range. Differences in opinion concerning variations in good and poor range later resulted in further breakdowns as: excellent, very good, good, fair, poor and very poor or depleted. Trend, or the direction in which a range site is moving, is usually classified as: up, if improving, down, if deteriorating; and static or stationary where direction is difficult or impossible to determine.

Many people feel that if vegetation is plentiful a range is good but if the vegetation is sparse the range is poor. Actually, however, poor grazing land might be so classified because of such factors as: over-use, seasonal drought, low production, shortage of water, soil erosion or steepness of slope. Accordingly, a poor range site could be in an excellent condition and a good range site might be in a poor condition.

Range sites are merely range habitats. In any locality, vegetation may differ widely in one habitat as compared with another. These differences might be in plant composition, growth or appearance. In addition, there may be real differences in soils and climate. As a result of such variations, different grazing use and management practices are usually required to maintain or improve vegetation on various range sites.

Broad classifications can result in many differences of opinion which may lead to excessively detailed site break-downs. To overcome such differences and tendencies, more adequate but very simple, site classifications are often used.

SITE CLASSIFICATION.—Studies show that, other things being equal, climate controls the amount and kind of vegetation produced from area to area. Moreover, variations occur under similar climate largely because of differences in soil-moisture-plant relationships or in the amount of moisture available to the vegetation. Hence, in any given climate, there are at least three major site classifications commonly called (1) "normal" sites, (2) "run-in" sites and (3) "run-off" sites. All sites can be related to these basic separations.

Normal sites are those whose soils can hold and make available for plant growth all the moisture that nature furnishes. These sites have the vegetation that is normal for the climate and when managed and protected, they are stable and dependable. They usually occur on nearly level to rolling upland locations. However, erosion and misuse can degrade them to pre-climax sites and this deterioration has occurred over much of the range land in the Middle East.

Run-in sites are those that receive moisture in excess of that furnished by nature. They are generally in lowland or bottomland locations and have naturally deep, well-developed soils. Such sites receive the moisture lost by adjacent poorer sites and reflect this additional moisture by producing vegetation similar to that of a climate with as much as 125 mm. more precipitation. They are relatively stable,

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From a paper by: Wayne Wenburg, Grasslands and Range Management Advisor, USOM/Turkey.

resist erosion and will withstand grazing use better than other range sites. Generally, however, if such areas have over 300 mm. of precipitation they are utilized for cultivated crops.

Run-off sites are those whose soils cannot hold and make available to plant growth all the moisture that the climate furnishes. Soils may be too shallow to allow the moisture to be contained where it falls, and overland flow or run-off occurs. The soil is often too coarse to hold the moisture supplied, and water loss may occur due to gravity through deep percolation. Run-off areas will have a plant growth in the amount and composition of climax normal sites in a drier climate. Generally, the vegetation will be similar to that found on the normal site in a climate furnishing approximately 125 mm. less precipitation. Such sites are called "pre-climax." They may occur on level land, but generally they occur on steeper slopes and are quite subject to erosion. The destruction of vegetation through unwise use and the resultant and accompanying erosion has caused many normal soils or sites to degenerate and become equivalent to run-off or pre-climax sites.

SITE VARIATIONS.—There are many variations within basic site classifications. Major differences may be caused by soil tecture, parent material, slope, exposure, salinity or alkalinity and similar factors. The more important are sometimes further classified and listed as: (a) *Wetlands*—subirrigated lands with an over-surface water table during part of the growing season making them too wet for cultivated crops but highly productive under natural cover. (Not open water marshes.)

(b) *Subirrigated*—lands with a water table only rarely over the surface during the growing season but subirrigated most of the period. This site class is quite common in sandhill areas and along permanent streams. It is normally indicated by low, flat relief with a dark humic upper soil.

(c) *Overflow*—areas regularly receiving more than normal soil moisture because of run-in from higher land. Examples include stream overflow, run-in from higher slopes and areas with water spreading systems. (Not subirrigated or wet land.)

(d) *Saline Lowland*—overflow or subirrigated land where salt accumulations are evident and influence the kind of native vegetation.

(e) *Savannah*—uplands on which grass cover with isolated trees is normal. This site is common along the margin of forest climates but it also occurs deep in grassland climates if soil moisture conditions especially favor tree growth. (Soils with a high intake at the surface and a slowly permeable layer several feet below may normally produce savannah cover even though in a grassland climate. Such cover may also occur in a grassland climate where exposure to sun and wind is reduced as on north slopes due to more economical use of moisture). Bedrock near the surface is not characteristic as on very shallow sites. Heavy grazing or absence of fire has caused some savannah sites to be occupied by woodlands with a 40 percent plus canopy of stunted trees and brush but these should be regarded as range sites rather than as forest sites. Likewise, deteriorated open grasslands may be invaded by savannah types but should not, therefore, be regarded as savannah sites.

(f) *Sands*—deep, loose, coarse-textured, predominantly sand-soil on nearly level to gentle slopes. Included are all textures of sands except loamy, very-fine sands.

(g) *Choppy Sandhills*—deep, loose, coarse-textured, predominantly sand-soil with abruptly irregular slopes, often in excess of 20 percent.

(i) *Silty*—very fine sandy-loams, silt-loams, and silts.

(j) *Clayey*—relatively pervious clays, and clay-loams.

(k) *Dense Clay*—relatively impervious clays and soils underlain by clays at depths of 10 inches (25 cm.) or less.

(l) *Shallow*—all shallowly developed soils typical for the climate, excepting sands and loess. Also, soils underlain with base rock or clean gravel at depths between 10 and 20 inches (25-50 cm.) and all thin, very-gravely or very-stony immature soils.

(m) *Panspots*—areas where shallow depressions occupy 20 to 25 percent of the site with hard clays or other impervious materials lying close to or at the surface.

(n) *Thin Loess*—shallowly developed or thin loess soils on slopes of 30 percent or more.

(o) *Thin Breaks*—poorly developed, mixed-soils derived from different parent materials that outcrop at different levels forming irregular slopes of from 20 to 65 percent. Trees may occur locally above outcrops. (Breaks with generally calcareous surface soils may be differentiated from others.)

(p) *Gravel*—uplands where rock fragments or gravel up to the size of small stones occur in and on the soil. Coarse materials greatly reduce moisture retention and affect the kind of native vegetation. A sharp-pointed spade cannot be forced into the soil. (Included are some river terraces and outwash deltas.)

(q) *Very Shallow*—areas where few roots can penetrate deeper than 10 inches (25 cm.). Exposure of bedrock is characteristic but rock-seams and joints develop deep soil-pockets usually marked by tall-grasses, shrubs, or stunted trees.

(r) *Saline Upland*—upland soils with an excessive accumulation of salts influencing the kind of native vegetation. Common only in arid climates.

(s) *Shale*—uplands where raw, easily-puddled shales are exposed at the surface and little, if any, soil profile development is evident. (For deeply factured slaty shales, refer to the "Savannah" site description. For shales showing some soil development, refer to the "Shallow" site).

(t) *Badlands*—nearly barren lands broken by drainages which are dry most of the year. The intermingled grazable areas are usually too small or too narrow to justify separate mapping.

RANGE CONDITION AND TREND.—Range condition may be defined as "range health." The condition or health of a range is commonly determined on the basis of the percentage of the present vegetation that is climax for a range site. Accurate determinations require a knowledge of the "site potential" or the plant cover that the site is capable of producing and supporting under the best possible range management.

Site potential, then, is a basis for classifying range condition. For all practical purposes, if 75 to 100 percent of the vegetation present on an area is climax for the site the range is in excellent condition; with 50-75 percent, the range is good; it is fair with 25-50 percent, and poor with less than 25 percent.

Range trend is the direction in which the range health or condition is moving. An upward trend in range condition means that better range plants are maintaining themselves or increasing in quantity and vigor; volume of natural mulch is building up; erosion scars, if any, are healing and soil is improving. If these signs are lacking, the trend is probably down or, at least, the range is not improving.

THE ROLE OF THE RANGE MANAGER.—In order to prevent the rapid run-off of rainfall on ranges, sites must be managed to insure sufficient vegetation to hold the soil in place. This can best be done by the fibrous-rooted grasses and better plants which occur on climax sites. Careful management is a profitable enterprise resulting in more water, livestock feed, meat, timber and similar products. Plants are the most vital living things on earth. They must, however, have water. The soil is the reservoir for water and, in good condition, it has great holding capacity, thereby providing the medium for plant growth. With satisfactory plant cover, water "walks" off instead of "runs" off the land.

The ability to recognize range sites, range condition and range trend is basic to good range management. Variations in these factors are the only true basis for the different grazing-uses and management practices necessary to maintain or improve range lands.

CHAPTER X

LAND TENURE AND OWNERSHIP

GENERAL.—A very important factor which has a real influence on all phases of range management is man's control of grazing lands. Sometimes, this control is good but more often it is bad.

Since earliest times, then, efforts to encourage improvements on the land and increase its productivity have remained dependent on control—on the rights and obligations of the land user. Appreciable development has never occurred except under systems of land use which guarantee reasonable permanence to land occupants plus a fair and just share of production and relative freedom in the transfer of their financial and labor outlay. In other words, history has repeatedly demonstrated that of all land users the resident land owner, with an economically-sized operation, obtains greatest productivity with minimum damage to land resources.

Present ownership patterns and land-uses in the Middle East are very complicated. Generally, there is a great need for future land tenure and ownership policies which will insure maximum livestock production while maintaining and improving plant, soil and water resources.

LAND TENURE.—The manner or period for which real estate is held and used is ordinarily termed "land tenure."

Originally, the world was generously endowed with a rich and varied supply of land resources. The first peoples were semi-nomadic. As they and their numbers of livestock increased, so did pressure on the land. Initially, the problem was not insurmountable; the people merely moved into new areas. Eventually, people divided into two groups—those who settled permanently on a specific tract of land and those who became fully nomadic and traveled greater distances each year in rounding out their existence. Eventually other groups as merchants and industrialists, came onto the scene.

The history of the two land-use groups has been quite similar the world over. As population pressures mounted so did land deterioration. Naturally, the settler was the first to be forced to employ conservation measures in his use of the land; he normally lacked opportunities for increasing his land base. On the other hand, neither group has been able to retain an economic livelihood and remain in business without wise use of plant, soil and water resources.

Improper land tenure has resulted in numerous and varied situations. Perhaps the most far-reaching has been the increase in number of submarginal operations and the eventual decrease in number of individual land owners. In other words, tenancy increases with land deterioaration and the standard of living decreases.

A most important question is, "What can be done to improve land tenure?" Basic is the fact that the impetus for change never comes from those who are benefiting from an existing situation regardless of how harmful it may actually be to the general welfare. Economically, land resources are important only when viewed in terms of satisfying the demands of people. Moreover, changes in land-use and tenure are desired only when people either do not like existing conditions or when they are able to visualize better use and tenure of such resources. Obviously, the first step is education. Fol-

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From papers by: Clarke A. Anderson, Forestry and Range Management Advisor, USOM/Iraq and Leader 1957 Regional Range Management Course (Iraq) and Hoy C. Connelley, Range Management Advisor, USOM/Pakistan.

lowing education, man is able to (a) determine major land problems (b) establish broad objectives and (c) develop alternatives for future action. This entire process is really land reform; the recognition and correction of improper land uses.

OWNERSHIP.—A lawful claim or title is termed "ownership." Actually, however, there are many ramifications in land proprietorship. Originally, land was owned by either the Church or the Central Government. Later by gift, decree, or settlement, ownership of certain areas passed in whole or in part to individuals, family groups or tribes. To further complicate the situation, ownership of land is seldom static; usually it is constantly changing. Eventually many claims may come to exist on a specific area. Ownership may be taxed, and usually is; although in some parts of the world it is subsidized.

Another question, then, is "What needs to be done in improving the land ownership pattern to guarantee the best type of land tenure and insure maximum livestock production?" The problem is not local; it is worldwide.

History has repeatedly demonstrated that pride of ownership is the prime motivating force for proper care and use of any item or commodity. Second, perhaps, is leasing or tenancy which will insure resonable permanence and just returns for labor and monetary investments by land occupants. Again, as with land tenure, the first step is education. With education, desirable and needed reform is not insurmountable. An outstanding example is Denmark where just over 100 years ago the King ordered his lords to distribute their land to Danish tenants. Today, Denmark has extremely high production and excellent standards of living along with a high population density. Another, and more recent, example is Mexico where land reform was inaugurated only 4 decades ago. During the last decade, farm population decreased 10% but agriculture conributed 3% more of the total national income. Moreover, agricultural income increased 5.7 times whereas national income increased only 4.8 times.

THE ROLE OF THE RANGE MANAGER.—Today, the greatest fallacy throughout most of the world is evaluating livestock production on the basis of numbers of animals rather than actual production per animal unit. Here again, the answer is education. With education will come selective breeding and better strains of animals as well as improved and adequate feed and forage resources.

Improvement in land tenure and ownership will result in better livestock production. Conversely, improvement in livestock production should automatically bring about better land tenure and more equitable ownership of land resources.

Reforms in any land tenure pattern should be brought about without exploiting the people. Corrective measures should be sponsored by all levels of society. This means that reforms, and particularly those affecting arid grazing lands, will be slow in materializing. Therefore, and in most cases, it will be necessary and desirable to plan range and pasture development programs or schemes that will be effective under present land tenure and ownership problems. Examples include, in particular, instances of such problemes as unregulated public ranges, improper use of private range lands, and nomadic graziers.

The majority of the natural pastures, or range lands, throughout the Middle East are not privately owned or controlled. Accordingly, the individual grazier lacks the incentive to improve or conserve range lands—the land is "underpriced and overgrazed," free to everyone and no one's responsibity. The result is apparent everywhere in such conditions as floods, erosion, and low standards of living. The problem is one that we cannot alleviate other than by keeping ourselves informed and by continually seeking the attention of those in government who can do something to help.

In many cases and particularly where individuals, families, villages, or tribes have ownership or control of land, the responsibilities which accompany ownership and control are not fully appreciated. People too often think of range lands as indestructible. They do not know the possibilities and advantages of proper use. The problem is a real one which we, as range technicians, can do something about. It can be solved through education.

Nomadic graziers normally present many problems. In areas where individuals or groups have permanent control of grazing lands, the solution, is again education. When the land owner realizes the benefit to be derived from proper use, he will not allow his range to be misused. It has been said that, "the family and the home are the twin evangels of civilization—the basic units of every well-ordered society wherein every living thing wants a place to stay." If this philosophy is correct, then perhaps the nomad can be settled if he can be shown that it will be to his advantage. In other words, all range problems can usually be solved through education. In this, the range management technician has a very important role. In fact, and in most instances, he must be the educator.

CHAPTER XI

GRAZING LAWS REGULATIONS AND POLICIES

GENERAL.—We probably all agree that soil, water and plants are basic resources and that without them there could be no life. Accordingly, their wise use and conservation is mandatory. On the other hand, the basic law of survival and self-preservation, particularly in heavily populated areas with deteriorated natural resources, is too often in conflict with proper land-use policies. For these reasons, direction in the use of land is needed whether such use is for immediate personal gain or continuous and long-time public benefits.

Regulated land use always becomes more necessary as productivity falls below economic standards and the land is not improved or no new land exists onto which the land user can move. Initially, this directed use was provided by the individual; the head of a family or the chief of a tribe. Subsequently, both Church and Government invoked land use policies, laws and regulations. Such centralized control, of course, has been most effective when other people or the country itself were being adversely affected by the use an individual made of his land. Originally, such direction was verbal, today it is generally written.

Almost without exception the control of land use, both public and private, follows a well-defined pattern of (1) policy, (2) law and (3) regulation. These terms in themselves denote change as established procedure. In many countries, rural economy is based solely on "the rights of the user"—principally the inhabitants of the immediate area. Therefore, regulated land use usually operates against deeply-rooted traditions and customs. Even where this condition does not exist, people resent change, at least initially. They particularly oppose mandatory adjustments in their private land operations. Accordingly, legislation must be introduced with caution and, insofar as possible, in conformity with existing social and political conditions. Obviously, the most urgent needs should receive first priority and attention. Law is satisfactory only if a majority of the people understand its aims, recognize its importance and appreciate the necessity of its enactment. An educational approach is generally indicated, particularly since countries with high illiteracy usually have the poorest land management.

POLICY.—Land policy is, of course, merely the basis established for land use. This is true whether the land be properly used or, as is too often the case, wastefully exploited. Regardless, the starting point in land management is "policy" and having a sound policy in the form of preambles to laws is advantageous to prevent the enactment of unwise legislation. Land policies, and particularly range-land policy, should be national in scope; not for the few, but for all the people. It should also coordinate with the country's agricultural, economic, industrial, commercial and social policies since as wild-land production increases there is need to utilize and market this increase. Moreover, coordination with the policy of other countries is essential to determine trends and maintain a balance between supply and demand. Land policy must certainly include sound principles of sustained yield.

From a paper by: Clarke A. Anderson, Forestry and Range Management Advisor, USOM/L and Leader 1957 Regional Range Management Course (Iraq).

LAW.—Land laws and grazing laws merely give effect to land policy. A primary requisite is harmony with the principles which are the foundation for all national legislation—the coun: : general and administrative laws. Other requisites include (a) definition and classification of land over which operative, (b) nature and extent of property rights, and (c) responsibilities of land owners. A prerequisite, of course, is education—legislation to be really enforceable must have the support of an enlightened public.

Physical, economic or social differences between regions in the same country may make the uniform application of law difficult. For this reason, laws (and land and grazing laws in particular) should be broad. They should then be justly interpreted and vigorously enforced by means of enabling regulations. Legislation is, of course, easier in countries with a strong central government than where legislative power is divided between central and local subdivisions. On the other hand, and as in the United States and Switzerland, subdivisions can have and effectively apply local policy within the framework of broad central laws. As laws have the character of permanence they should certainly follow stable patterns conforming to the country's broad and fixed national policy.

REGULATIONS.—Throughout history, effective control is dependent on sound policies and education along with laws and regulations, as necessary, for fullest acceptance and observance by the people.

THE ROLE OF THE RANGE MANAGER.—As land managers, our primary responsibility is to formulate or assist in developing sound policies of range and land usage. Another responsibility is help secure the laws and regulations to properly implement such over-all policies. As an example, some countries do not have such laws; others may have inadequate or unfair laws that need revision; supplementary legislation may oftentimes be necessary. All of these represent jobs in which range managers should and must participate.

CHAPTER XII

ECONOMICS AND EXTENSION IN RANGE MANAGEMENT

ECONOMICS.—Economics is the science that deals with the production, distribution and consumption of wealth. Therefore, range economics might be defined as "the science dealing with the production, distribution and consumption of range forage and of livestock, the product of the range."

Production requires a combination of what economics call "factors of production"—land (including water and other natural resources), labor, and capital. An added factor is management. For example, in the production of range products the land factor would be the range or pasture. Labor would be the herdsman or caretaker of the animals and capital would be the livestock. Management is supplied by the owner or operator. Production, however, is more than meat or wool on the range. These products are of little or no value until they are consumed. First they must be converted into a type of commodity that consumers will purchase. For example, an animal must be slaughtered before it can be consumed as meat—it must be made into a form that can be used. This, we call "form utility." Production also includes "place utility" or transporting the animal or product to the location where it can be consumed and "time utility" or having the product or animal available at the time it is wanted by the consumer. The man who owns and bears the risk of ownership creates still another service called "ownership utility."

Hence, processing and marketing are forms of production and should be so considered in the initial treatment of the basic or raw material. The demands of the consumer, of course, greatly affect basic production and along with the available supply (in a free economy) determine price received for the sale of goods.

In producing goods, the basic factors of production can be joined in almost any combination and proportion. As an example, we would have meat and wool to sell if we had a thousand hectares of range, one-hundred head of sheep and forty herdsmen. We would likely still have some meat and wool to sell if we had one hundred hectares of range, a thousand sheep and one herdsman. Neither, however, would be economical or profitable.

To be economical and profitable, range operations must be based on a more efficient "input-output" relationship where minimum costs will produce maximum returns. The discovery of this correct relationship, particularly in range management, is not easy. In fact, there is no single answer, even for a given problem. Ordinarily, the rangeland is a fixed item, although range forage is usually extremely variable, particularly in relation to other range and livestock factors. The important questions of how many animals to place on a range, what kind and breeds, and how to manage both range and livestock are only some of the many combinations which are possible. Such information is necessary, however, in making correct management decisions for greatest "output" from minimum "input."

Other important factors include such items as: use of credit; market locations and marketing methods; consumer's demands; utilization of by-products; and optimum herd size to obtain maximum calf and lamb crops and lowest death losses with existing range-forage and supplementary feeds.

From papers by: Dean W. Hubbard, Agricultural Economist, USOM/Iran and
David Sharp, Extension Advisor, USOM/Iran.

We should remember that any practice which increases the number of animals born and raised is economically advisable. Experiments have shown that flocks and herds properly managed will give a much higher calf and lamb crop than flocks and herds on poorly-managed range. An important factor in these experiments is the number of head of livestock per grazing unit since over-stocked and over-grazed ranges gave far less lambs and calves than properly used ranges. In other words, calf and lamb crops were increased by actually decreasing the breeding stock on given grazing areas. Other factors involved were health of the female at breeding time, an adequate number of male animals, breeding females at proper age, and controlled breeding without free-running sires. Obviously, unproductive breeding stock should not be retained in a herd.

Similarly, proper range management gives greatest weight gains and production per animal with reduced death losses. Starvation is a direct result of poor range and insufficient forage. Poorly-fed animals are, of course, more susceptible to disease, parasites and death than animals in good condition. Also and even though poisonous plants exist, they are not nearly so dangerous on good ranges where livestock have adequate feed. Generally, supplementary feeding is profitable during periods when range forage is inadequate, lacking in mineral-elements, or unavailable during adverse climatic conditions.

The quality of livestock is also very important. A poorly bred and poor-quality animal will eat as much or more than a well-bred and good quality animal. Moreover, better-quality animals bring better market prices per kilo and per animal.

In summation, proper range management and sound range conservation practices are necessary not only to improve ranges but to return maximum sustained earnings and profits to livestock producers.

EXTENSION.—Extension is defined in most dictionaries as "the act of reaching out." In the field of range management, "Extension" or reaching the people, particularly livestockmen, is very important. The need for proper range use, good livestock husbandry, efficient utilization of forage and feeds and economy in operation is extremely great and generally not adequately understood by those who should be most concerned. A real educational job is necessary and Range Extension is a most effective medium in the dissemination of range and livestock information. Certainly, no other method can reach so many people in as short a time and with more effectiveness than a well-organized extension effort.

We are all acquainted with some of the many so-called "tools of extension"—the extension agent; field tests, demonstrations and "show-me" trips; bulletins, leaflets and press releases; radio and television programs; moving pictures and slides; conferences, meetings and discussions; and charts, posters and diagrams.

In most Middle East countries the Ministry of Agriculture is deeply interested in range management. This is encouraging after so many centuries of overgrazing. Also encouraging, is the interest demonstrated in sending representatives to conferences for work and study in ways of handling ranges so as to obtain maximum feed while protecting land resources for future use.

Much of the new world, a relatively young country, has had considerable experience with poor range management. In many cases, the trend in range condition was downward until Government recognized the problem and along with the farmers and the range-men, set about to correct land abuses. There is still a long way to go, but the direction is right. The Middle East, too, has a long way to go, but the job can be done.

In the Ministry of Agriculture, extension is the educational arm. The Extension Service should be interested in any phase of agriculture and rural living that will help farmers and livestockmen to a better way of life. Many extension agents are not trained in range management. Part of the range manager's job is to educate extension agents in the simple, fundamental factors of improving and protecting rangeland. We, as Range Managers, can multiply ourselves many times by having extension agents carry the message of good range management to the rural people. If possible, each agent should have at least one demontration on range management in his area. A start could be made in so many different ways. A very simple accomplishment would be to develop a cheap stove and arrange for cheap fuel. This might seem a long way from range management; yet if done, the result would be to save the brush that checks erosion and the manure, that is being burned for fuel instead of being

used to add humus to the land. Both, in turn, would produce more forage which could be used to hold livestock off the range until vegetation is ready for grazing and the tender grass has had a chance to make a good start in the spring.

Culling out unproductive livestock is another practice that would save feed for more profitable animals and reduce over-use of ranges. Better feed will produce more milk, meat and fleece per animal. Even more important is the conservation of water, which is the life blood of the Middle East, and the conservation of soil, without which there could be no range plants or livestock.

In summary, Extension is a most effective means of furthering proper range management. It is a means of doing the job that we, as range managers, must accomplish. An important quality is faith —faith in the country and faith that rangelands can be improved. We have this faith or we would not be range managers and if we can instill that faith in enough other people in the Middle East nothing can stop progress in range management in this part of the world.

PART III

FEEDS AND FEEDING

CHAPTER XIII

IMPORTANCE OF FORAGE AND OTHER FEED RESERVES

GENERAL.—As a motor can be shut off when its feed reserves (fuel) runs low, some plants have the ability to pass into a state of dormancy when adverse climate or moisture restrictions make their required nutrients inaccessible. Livestock, however, must continue to eat if they are to stay alive. As a matter of fact, if livestock are to live, flourish and maintain production, they not only require feed continuously at fairly regular intervals, but their feed must also be provided on a suitable nutritional level. About 60 percent of the food an animal is able to eat is required for such functions as body maintenance, metabolism, circulation of blood, respiration and reproduction. Livestock gains and profits for the owner, are dependent upon the feed an animal has available and is able to eat over and above the amount required for maintenance purposes. This being true, it immediately become evident that profitable returns from livestock are directly dependent upon good feeding.

In order to do well, livestock require adequate supplies of carbohydrates, proteins, vitamins, various minerals and water. These can be partially provided from various sources and kinds of feeds. However, the bulk of the requirements of an animal's diet can be most economically supplied in the form of forage which can be grazed directly by the animal. In instances where seasonal, climatic or other limitations make this impractical, nutriants must necessarily be provided from other sources; either by providing hay and dry roughages, silages, and crop by-products or through various concentrated feeds. The important thing to keep in mind is that livestock cannot stop eating. Feed must be constantly provided.

Since drought, hot weather, insect pests and other factors make feed production of range lands very hazardous and uncertain, it is desirable to produce and maintain good feed reserves. This practice is important, first, in order to provide at all times for the nutritional requirements of the animal and, second, to avoid overtaxing and overgrazing the ranges in times of low production. Moreover, whenever good supplies of range forage are available there is less inclination for livestock to graze on poisonous plants and other undesirable species which invade over-grazed ranges. In addition, high levels of nutrition tend to protect the vigor and health of livestock and less difficulty is encountered from disease, parasites and other problems which result in high death losses.

By maintaining high forage reserves, there is also a better chance of keeping animals growing and thriving. This results in fullest economy of production. There cannot be good economy where the condition of animals fluctuates to an appreciable extent as they are being grown and fattened for market. Good feed makes a high quality product which will generally bring a better price on the market and provide a greater profit for the producer. In other words, it is possible to starve the profit out of an animal. It is good business to feed well.

KINDS OF FEED RESERVES.—When we speak of animal feeds, we usually think of five general sources or types including: (1) native ranges, (2) artificially reseeded (dryland) pastures, (3) irrigated pastures, (4) roughages, such as hay and silage, and (5) concentrates. Of these, native range is the one

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From a paper by: J. Glenn Morrill, Agronomist, USOM/Iran.

that nomadic animals are almost exclusively dependent upon. Moreover, most village flocks in the Middle East derive their main sustenance from this source. Because man neither plants nor harvets the feed, native-range forage is the least costly of all animal feeds, but it does have its limitations. Continued heavy grazing results in production that is far below the potential for the site, both in quality and in quantity. Moreover, the size of the crop fluctuates with weather and growing conditions and may, at times, be insufficient for current needs. In some areas, it may even be made unavailable by winter snows. In addition, and perhaps most important of all, serious losses of nutrients takes place during the long period following the cessation of plant growth. The result is that, during an appreciable portion of the year, range forage may be little better than straw in supplying the essential nutrients for normal growth and reproduction of livestock.

Artificially reseeded dryland pastures are costly since they are man-made, although like native pastures they are harvested by animals. Seeded pastures may, however, produce greater yields of high quality forage than native ranges since many of the undesirable species present on most sites are destroyed or materially reduced in the process of preparing the seedbed. Even so, many of the shortcomings of native ranges are likewise apparent in artificially reseeded dryland pastures.

Irrigated pastures are a valuable supplement to native ranges, particularly during the summer and autumn months when the latter may be dry. Since irrigated pastures are generally green throughout the season of grazing use, they furnish many of the essential nutrients and vitamins needed by livestock They are also especially well suited to the needs of the dairyman and, properly integrated with other feeds, will often prove a more profitable use of land and water than the production of any other crop.

In addition to reserves of range grasses, a certain amount of other forage reserves should be maintained. These may include such feeds as alfalfa hay, cereal straw, corn silage, beet silage, and various fodder crops. Hay, silage, and similar roughages must be grown and harvested and are, therefore, more costly than most other types of animal feed. They are, however, essential to improved livestock production for all types of livestock enterprises except the nomadic type and even nomads could use some hay to very good advantage. When the weather is cold and particularly where there is a great deal of snowfall, hay, silage and other forage reserves should always be available.

Concentrates, such as cottonseed cake, cereals, corn or mineral supplements are, of course, the most costly of all animal feeds. For this reason, they are best suited to complement other types and their judicious use is a profitable means of increasing animal productivity.

The kinds of forage reserves which are most desirable will depend upon a number of factors. Generally, however, all forage reserves should and must be planned and provided in keeping with sound economic principles. If possible, reserve forage should be produced by the livestock operator and the kind of feed grown will normally depend upon the types of feed that can be harvested on the operators land.

Where the weather is suitable for curing and soil, water and other factors are suitable for production a good source of livestock feed is alfalfa or clover and grass hay. Legumes, in particular, produce good quality hay where soils are high in lime. However, where rainfall is high and moisture conditions are unfavorable, legume and grass silage are often preferable to dry and cured hay. Corn silage is also a good supplementary feed source. In other areas corn fodder, sudan-grass and other annual crops may have to be relied upon as the best source of reserve forage. Cereal straw can be used to provide feed for livestock but because of its very low protein value and low vitamin content it should never be depended upon as a sole source of feed. However, straw will sustain life and in emergencies, mature animals can be successfully brought through the winter on rations containing a large amount of straw.

In areas where beet pulp, peavines, cottonseeds and other crop by-products are available, their full use as livestock feed should, obviously, be encouraged. However, and as is true with straw, they should be used primarily as supplementary sources of feed and should not be depended upon to provide the balance necessary in a livestock ration. As an example, dried beet pulp, which is often available in the Middle East, has a nutritive value almost as high as barley with a somewhat lower percent of protein which gives it a wider nutritive ratio. Wet beet pulp or beet-pulp silage is also very good feed for livestock as it is highly succulent and is particularly desirable when fed with alfalfa-hay or other dry roughages. On the other hand, the protein content of beet pulp is so low that livestock rations usually need to be reinforced with protein concentrates such as cottonseed cake or soybean-oil meal.

GRASS-LEGUME ROTATIONS.—In most areas, an important source of livestock feed is provided by means of forage and other crop rotations. The practice involves merely a regular and planned rotation of crops on agricultural land. Grass and legume crop-rotation systems are those in which grasses and legumes are used as one of the crops. The production of grasses and legumes in agriculture can be justified in many ways. Moreover, their production in rotation with other agricultural crops is generally well-accepted in modern farming, largely because of their important contribution to range management and particularly to livestock production.

Alfalfa hay, clover and grass hay as well as irrigated and improved pastures containing a mixture of the better grasses and legumes are nearly perfect livestock feeds. When pastured, legumes as well as grasses, are substantially higher in total digestable nutrients and especially in protein and vitamins. In addition, when they are properly cured, dried and stored, their feeding value is surprisingly high. For example, alfalfa at 1/10 bloom stage contains as much as 22 percent protein yet in its dry condition the total percentage of protein may be well above 10 percent and its total digestible nutrients over 50 percent. Clovers and grasses, in both a green and dried state, are only slightly lower than alfalfa in protein, vitamins and T.D.N. From the standpoint of reserve forage, legumes and grasses are of great importance both for their feeeding value and in the ease with which they can be handled, processed and stored.

Another principal advantage of growing grasses and legumes in rotation with other crops is that they beneficially affect the soil. Legumes, although taking nutrients from the soil, represent the only type of plants which add nitrogen to the soil. This is largely because of the characteristic nodules on their roots which provide sustenance to soil organisms in taking nitrogen out of the soil and air into their bodies and in this way increasing the total available soil nitrogen for succeeding crops. Moreover, all grasses and legumes by virtue of their growth habits and the nature of their root systems, hold soil in place, prevent erosion and, under proper use, actually contribute both to the organic content and to improved physical condition of the soil. Many of the better and most productive sites with highest organic matter are basically grassland soils. Also, where grasses and legumes are grown in rotation with other crops a better balance of nutrients is maintained in the soil. Various crops feed heavily upon different elements and when planned crop rotations are practiced, there is less tendency for essential nutrients to become critically short in the soil.

An additional benefit is that where grasses and legumes are grown in rotation with other crops, the problem of controlling weeds is usually reduced. This is particularly true where crops like alfalfa are grown for hay and mowed regularly or in irrigated pastures when well fertilized, clipped occasionally and otherwise properly managed. Still another benefit is that where grasses and legumes are grown as a planned part of a regular crop-rotation system they are generally effective in the control of many insect pests. Numerous crop diseases can also be more effectively controlled if crop-rotations are followed and if the land is not continually used to grow one or two specific crops. Crop rotations tend to upset the developmental cycles of insects and also aid in the control of certain viruses and other diseases by eliminating from the field the host plants or food supply. For this reason, a well planned and carefully followed crop-rotation system, in addition to numerous other agricultural benefits, makes a definite contribution to the control of insect pests and plant diseases.

CHAPTER XIV

FORAGE PRESERVATION

GENERAL.—Four principal ways to harvest forage crops are (1) grazing directly from the field, (2) cutting and chopping of forage and feeding it directly to enclosed livestock, (3) making dry hay and (4) making silage.

When forage can be grazed, no problem of preservation is encountered. Making hay or silage is the common way to preserve forage for the use of animals when range forage is not available or when animals are kept at some distance from forage producing areas.

Hay is dried forage. As such, it is what you make it—hay can be excellent feed on which animals thrive and produce good economical returns or it can be poor and supply little more than body maintenance and heat. Musty or extremely dusty hay may have harmful effects upon the animals to which it is fed.

An encouraging fact in making hay is that it is easier to make good hay than poor hay. The first step in making good hay is to have a standing crop of forage plants, free from weeds and trash or debris and undamaged by insects. Combinations of companionable crops are usually superior to stands of a single species because they normally result in better weed control, more palatable feed, greater yields per unit area and more support for each other with better utilization of plant nutrients and water from the soil.

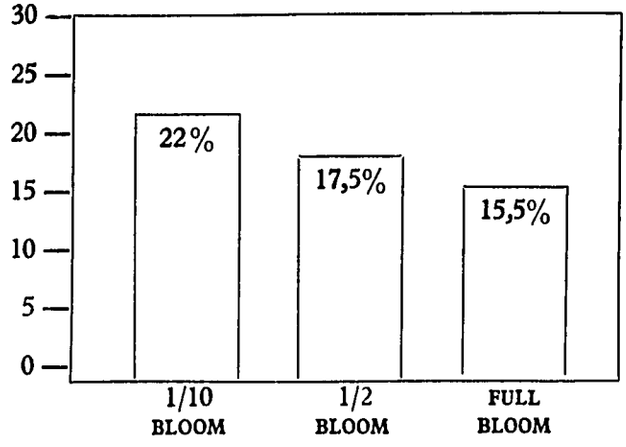
In order of importance, the more common hay mixtures in the United States are (1) alfalfa hay in the west and southwest, (2) timothy and clover hay in the northeast and (3) wild or prairie hay in the plains. In Middle East countries, hays are produced principally from alfalfa or other leguminous plants.

ALFALFA HAY.—The essential characteristics of a high grade alfalfa hay are purity, a high percentage of clinging leaves, green color and pliable stems. Leafiness is the most important single factor because two-thirds of a plants' protein is carried in the leaves. Generally, hay that has the leaves attached has had proper care. Bad management usually results in loss of leaves. Stemmy hay is normally lower in protein and has poorer color. Usually, it has been cut too late and the leaves have started to "brown-off" near the base of the plants or been lost.

Time to cut is important in the quality of alfalfa hay. The greatest percentage of leaves to stems by weight is evident at one tenth bloom. Leaves contain 70 percent of the protein and 90 percent of the vitamins and are also 40 percent more digestible than the stems (see chart).

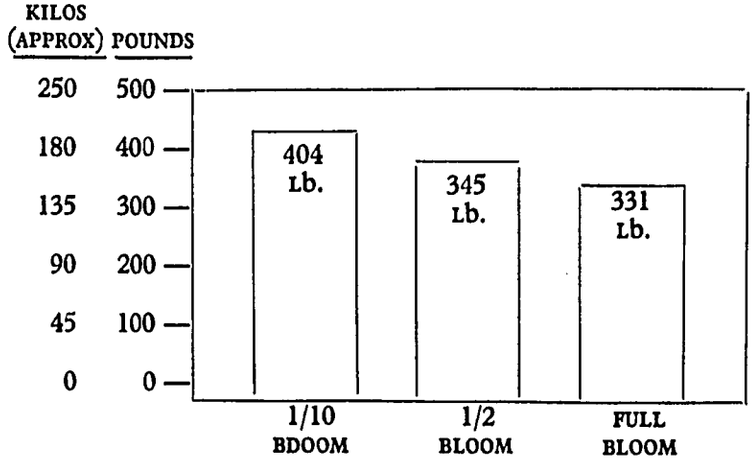
From a paper by: James H. Wood, Irrigation and Crops Specialist, USAC Contract—USOM/Iran.

APROXIMATE PROTEIN CONTENT OF ALFALFA HAY CUT AT DIFFERENT STAGES OF MATURITY



The superiority of high protein hay over low protein hay is shown by the per acre (.4 hectare) production as represented in the butterfat produced when such hay is fed to good dairy cows.

POUNDS OF BUTTERFAT PRODUCED FROM HAY HARVESTED ON ONE ACRE (.4 HECTARE) AT VARIOUS STAGES OF MATURITY



Green color in hay means a high feeding value. Black or brown hay is low in feeding value. Green hay has vitamin A and carotene retained for the benefit of the livestock. Very dark hays have lost much of their vitamin A and carotene. Light brown hay has lost some vitamins. Fineness of the stems is also an important indication of good hay of low fibre content. Fineness is acquired by having dense, healthy stands and cutting at early stages of bloom.

If difficulty is experienced in determining when to cut alfalfa by the bloom, other guides include the growth of the basal shoots, coarseness of the stems, color of the lower leaves, and the general appearance of the field. If alfalfa is grown as a major crop in a hay mixture, cutting should be at the right stage for the alfalfa regardless of the other species in the mixture. In addition, cutting alfalfa hay too close to the ground retards recovery thus delaying subsequent crops and increasing the percentage of stems and browned or yellowed leaves. Accordingly, alfalfa should be cut about 3 to 4 inches (8 to 10 centimeters) from the ground.

Hay should be allowed to wilt but not become dry before raking into windrows. Wilted hay can be moved to the windrow without loss of leaves. The side delivery rake and the new horizontal action rakes put the hay into a windrow with the basal stem ends exposed and the leafy upper stems rolled to the inside. Leaves, being very thin, dry faster than stems so it is important to expose them to less sun and wind than the stems. When hay will twist a few times without breaking but be dry enough that the bark on the stem cannot be rubbed off with the thumbnail, it is ready to stack or bale. For field-chopping it must be slightly drier. Baling when hay is too dry, as it often becomes on a hot afternoon, results in the loss of leaves. Under such conditions, baling should be done only in the morning, at night or in the evening when the hay has softened up from water vapor in the cooling air.

The cheapest way to handle hay from the field to the animal, according to latest studies, is to mow, rake and chop the hay with a field pick-up chopper. Such machines also blow the hay into wagons for hauling to barns or stacks where it can be unloaded and stacked mechanically. Field chopping has many advantages over baling, or stacking. Stacking hay by hand requires a minimum of equipment but the hay is difficult to feed and bulky to transport. Field baling is desirable if the hay is to be transported but it is expensive and does not improve the quality of the hay.

A new type baler has been developed which compresses wilted hay into cylindrical pellets about the size of a small ink-bottle. This process eliminates the need for wire and twine, reduces storage space and allows hay to be pressed the same day it is mowed. With other methods, however, artificial drying of hay (if properly done) is desirable so it will retain all of the carotene, vitamins and minerals.

In summary, there are many guides to making good hay. Some of the most important include: (a) grow adapted, companionable, nutritious grasses and legumes in simple combinations; (b) use fields of high fertility with ample mineral elements needed by plants and animals; (c) keep hayfields free of weeds and trash; (d) cut hay at proper stages of maturity, then cure and store it as quickly as possible (alfalfa, which is superior to all other species for hay should be cut at 1/10 to 1/4 bloom stage; timothy should be cut from early bloom to full bloom but not be allowed to over-mature; clover hay should be cut at 1/2 to 3/4 bloom); (e) legume hay yields are higher if cutting is delayed to full bloom but the feeding value of the hay is lower; (f) rake legume hay into small, loose windrows as soon as it has wilted so curing can be completed as quickly as possible to avoid loss of leaves and color—preservation of leaves in alfalfa and all legume hays is most important as the leaves contain most of the protein, vitamins and minerals; (g) green color in all hay is a reliable indication of good carotene and vitamin A content and (h) special artificial curing practices are adaptable to some areas but are not essential to making good hay in the dry, arid climates common to most Middle Eastern countries.

SILAGE.—Silage is a moist, succulent feed made by storing fresh green or slightly wilted forage crops in a silo, pit or stack in such a manner as to exclude air. The outstanding characteristics of silage are palatability, consumption without waste, and usually high carotene content. Moreover, crops may be utilized which might otherwise be lost as excessive rain or drought does not prevent the making of silage. In addition, some low quality forage crops are consumed as silage much more readily and make better feed as silage than in any other form.

Silages made from the grasses—corn, sorghum and small grains—contain insufficient proteins and minerals for good growth and milk production in livestock. Accordingly, they must be supplemented with feed which will remedy these deficiencies. Silage made from legumes is high in protein and minerals.

Some of the advantages of silage over other forages include (a) their succulence as green roughage for feed at any season; (b) their higher feeding value than hay since about 80 to 85 percent of the feeding value of a green crop is preserved in silage as compared with 70 to 75 percent in hay; (c) the higher protein content of the same crop in silage than when cured as hay; (d) the higher carotene

and vitamin content imparted to milk; (e) the use which can be made of weedy crops that would not make good hay, except that good, green-forage makes good silage and poor forage makes poor silage; and (f) the savings in space and reduction in fire hazard although requiring about the same labor as in hay making.

Any plant that makes a good grazing crop makes good silage. Corn is a very popular silage crop. Sorghum used alone or with peas makes good silage and could be used advantageously in most Middle East countries. Sweet clover and alfalfa make high quality silage if the moisture content is controlled and grasses and small grains, when cut green, also make good silage but are better if used in combination with legumes.

In classifying silage it is examined for odor, mold or rot, uniformity and animal acceptance. The odor should be clean and not rancid. There should be no mold or soft mushy rot and the original plant tissue or leaves should still be discernible. The color should be uniformly green or brownish-green. Dark brown color indicates excessive heating or too high a water content. Black silage is usually rancid or spoiled. If animals will eat the silage in large quantities, it can usually be considered to be good silage.

The upright silo is a cylindrical wood, metal, or cement structure which can be filled through the top and emptied through doors which open at the bottom and down the side. More temporary silos can be made easily and cheaply. Stack or fence silos can be made above ground with wire and paper. Trench silos can be dug in the ground and used successfully if the sides taper in at the bottom and the trench is not too wide. The size should be such that the entire exposed front is cut back at least 2 inches (5 cm.) every 2 days. Trench silos can be lined with stones or cement and made more permanent.

CAPACITIES OF TRENCH SILOS

Depth (feet)*	Bottom Width (feet)	Top Width (feet)	Cross Section in sq. feet	Weight in pounds** per Lineal foot
4	5	7	24	840
4	6	9	30	1,020
4	7	10 1/2	33	1,155
6	6	9	45	1,575
6	8	13	63	2,205
8	6	10	64	2,240
10	6	11	85	2,975
10	10	18 1/2	142	4,970

* 1 foot-0.305 meters
** 2.2 pounds = 1 kilo

To make good silage, forage should be cut early, chopped fine and packed tightly into the silo to exclude air. The addition of preservatives or, at times, other feedstuffs may be necessary to reduce water content. Cutting early means before maturity and, in making silage harvesting is normally earlier than at the stage which makes the best hay. A general guide is to cut alfalfa at 1/10 to 1/2 bloom in the first cutting and at 1/2 to 3/4 bloom in later cuttings; ladino clover should be cut when 8 to 10 inches (12-25 cm.) tall; sweetclover at very early bloom or as soon as there is a good sizeable growth, as about 1 meter (2 to 4 feet); red and other clovers, before 1/2 bloom; vetch, when seeds in the pods on the lower plants are half developed; cereals, when grain is in the "milkstage"; grasses, as soon as the heads form or in early bloom; corn, when the kernels have finished "denting" and while all but one or two of the lowest leaves are still green; and sorghum, after the seeds reach the "dough-stage."

The moisture content of the forage at the time of siloing is also important. If it is too wet, it will produce strong and sometimes rotten silage; if it is too dry, it may heat and char. A moisture content of 65 to 70 percent is desirable. A simple test is to squeeze a handful of the cut and chopped forage. If water drips from the hand after squeezing, it is too wet. If the material remains in a hard compact ball, it is still too wet. If the handful of squeezed material is compact but slowly springs apart, then it is just right (65 to 70 percent moisture). When chopping, it is desirable to chop fine with sharp knives. Pieces should be cut at about 1/2 inch (1.3 cm.) lengths for best results.

DRY MATTER CONTENT

Crop	*Stage of Maturity*	*Per Cent Dry Matter at Cutting*	*Hours of Wilting Before Ensiling*
Alfalfa	1/4 bloom	22-27	2-3
Red clover	1/2 to full bloom	23-28	2-3
Korean lespedeza	1/2 to full bloom	30-35	0-1
Soy beans	Pods 3/4 filled	23-28	2-3
Cowpeas	First pods filled	16-21	3-4
Sweetclover	1/2 bloom	20-25	3-4
Blue grass	Before bloom	25-30	0-1
Timothy	Before bloom	25-30	1-2
Cereals	Early milk stage	22-27	2-3

The normal and desirable chemical changes which take place in the silo are the conversion of the sugars in the plant material to acids—mainly latic acid. Light packing to exclude air helps these changes take place.

Corn and sorghums have a high sugar content and a low protein content. They are easily converted through fermentation and are natural silage crops. Wet grasses and legumes which contain high protein and low sugar content do not pass naturally through the proper fermentation changes and usually require some aids or controls. It is, therefore, advisable to allow the forage to (a) wilt to the right moisture content or (b) add some conditioner or (c) blend the forage materials with other feedstuffs which have a drying effect. Wilting in the field before chopping is the best procedure as it is easiest and cheapest.

MOLASSES AS A CONDITIONER

Crop	*Molasses Used Per Ton* *
Grasses or cereals	40 Lbs. (3 1/2 gallons)
Mixed grasses and legumes	60 Lbs. (5 gallons)
Alfalfa or clovers	80 Lbs. (7 gallons)
Soy beans	100 Lbs. (8 1/2 gallons)

* 1 Ton = 0.9072 metric tons; 2.2 pounds = 1 Kilogram

Ground grain, as: barley, wheat or corn may be used at the rate of 70 to 90 kilos per ton of forage. They not only aid as drying agents and conditioners but also increase the feed value of the silage.

The only unavoidable spoilage in a silo is a small layer at the top where air cannot be excluded. On trench silos that have a relatively large surface it is necessary to cover the entire silo with straw and earth or with earth and pack it down tightly. Tight sides and careful sealing of doors is, of course, important in tower-type (upright) silos.

In summary, a number of factors merit consideration in silage-making including:

(1) The silo is a means of conserving quantities of forage that might otherwise be lost. Silage can be made under conditions unfavorable for the curing of dry fodder and hay, saving a larger percentage of leaves, green color and total nutrients for feeding.

(2) Silage has greater palatability, a higher carotene content, and is less wasteful in feeding than any other form of forage preserved on the farm.

(3) A variaty of forage crops can be made into nutritious silage.

(4) Silage is made in permanent and temporary tower silos, and in trench and pit silos. Permanent tower silos are made of wood, steel, concrete and tile; temporary types of paper-lined or wood-slat fencing. Trench and pit silos are sometimes lined with concrete but are often unlined. All silos should be carefully constructed on well drained land and should have bottom drains that function.

(5) Silo capacity on the farm should be related to the production or availability of crops and the potential utilization of silage by feeding. Such factors as the number of animals to be fed, quantity fed per day, weight of silage per cubic unit and the number of days in the feeding period should all be considered.

(6) Corn is the principal silage crop in corn producing sections. It is a carbohydrate crop, low in proteins and minerals with yields ranging from 5 to 20 tons per acre (0.4 hectare) with an average of about 7 tons. Corn is usually harvested for silage about 10 days before it would be cut green and shocked or no later than when 90 percent of the kernels are dented and 75 percent are so hardened that milk cannot be squeezed from them.

(7) Sorghums are often used for silage and sometimes out-yield corn. All varieties are suitable and they are usually cut for silage when the seed is in the dough stage.

(8) High-yielding legume and grass hay and pasture plants are important silage crops. Legumes or a combination of legumes and grasses make a better silage than grasses ensiled alone. They are higher in protein, carotene and minerals than corn or sorghums and produce the best silage when cut at or slightly before the best stage for haymaking. This stage is usually after heads emerge but before bloom for grasses and during early bloom for legumes.

(9) Silage will keep almost indefinitely without molding or rotting if it is properly packed in the silo so that oxygen is quickly used by fermentation and no more air gains access. Acids develop in silage during fermentation, the kinds produced affecting both flavor and palatability.

(10) The quality of the silage produced and losses occurring during storage are affected by the moisture content of the crop when it is ensiled. The quality will be best, the silage will be the most palatable and nutritious and the losses during storage will be least when the crop is ensiled with a moisture content above 60 but not exceeding 70 percent. In silage (properly stored, packed and sealed) the loss of dry matter over a 3 to 7 month storage period may not exceed 10 percent but if improperly stored, losses may be much higher.

(11) Non-leguminous crops such as corn, sorghums or the grasses cut after heading when ensiled alone (or with less or an equal part of legumes) will produce enough of the right kind of acids to make good silage. Legume crops and immature grasses which are high in protein and low in fermentable carbohydrates should be wilted or have acid, molasses or ground dry grains added as a conditioner. Fine cutting, firm packing and a moisture content of not more than 68 percent are the requisites for the production of good wilted silage from high protein legumes and immature grasses.

(12) The making of silage from a crop does not increase its inherent palatability or feeding value. The composition of silage is usually similar to that of the crop from which the silage was made. The quantity of nutrients depends upon the dry matter content. Forage that is palatable and nutritious when put in the silo will be the same when removed. Forage which is unpalatable and low in nutritive value when ensiled will not be improved in these respects by ensiling.

CHAPTER XV

CALCULATING FEED REQUIREMENTS

GENERAL.—Most successful livestock producers figure the feed needs for their animals a long time in advance. They carefully estimate the number of cattle, sheep, goats, horses and other kinds of livestock they expect to have each month of the year. Then they compute the hay, pasturage and forage required for the livestock they plan to keep. They also know the grain mixtures they intend to feed and the amount of each ingredient necessary. Most good livestock farmers plan their needs at least a year ahead. Many figure pasture, hay and forage requirements several years in advance and arrange their crop rotation systems accordingly.

There are many advantages in this kind of planning. A principal one is that if a livestock man has to buy feed he knows how much of each kind he should purchase and can buy at the time of year when such feeds are the least expensive. Moreover, one feed can often be substituted for another with equally good results. By figuring ahead, the livestock man can usually substitute a cheaper for a higher priced feed whereas by waiting he may be forced to buy a higher priced product because the cheaper one is not available when needed. Similarly, he can determine which feeds are cheaper to buy and which he can raise for less than purchase cost.

Another very important reason is that with advance planning a livestock man is always prepared to properly care for his livestock. Unless animals are well fed they cannot be profitable. Livestock producers must, therefore, always have the right kinds of feed to make the most profits from feeding or, if feed is to be in short supply, they should have time to figure the best time of year to sell their least profitable animals. Similarly, if a livestock man is going to have more feed than he needs, he can, with careful planning, either sell some of the extra feed when prices are highest or watch for chances to buy additional good livestock at reasonable prices to utilize the extra feed. Good management, therefore, affords an opportunity to balance the numbers of livestock with the feeds available. As a rule, no farmer should keep more livestock than his land can provide with all the forage, silage, hay and pasture the animals require. Usually it is well for him to grow at least part of his grain needs. When the livestock producer has to buy and transport hay or forage he usually loses money. Moreover, it is good practice to plan for about 10 percent more feed than will be needed to allow for unfavorable crop producing seasons. The carbohydrates, proteins, vitamins, minerals and water that livestock require can, of course, be provided from various sources and kinds of feeds including range, irrigated or improved pastures, silages, dry hay or other roughages and concentrates.

ANIMAL UNIT EQUIVALENTS.—In planning the use of grazing lands, estimating their degree of utilization, and calculating hay and other feed requirements, livestock are normally considered on the basis of what is generally termed an "Animal Unit." Such a unit is usually considered as equivalent to a mature cow, with or without an unweaned calf. The various equivalents in most common use as animal unit ratings for the various kinds of livestock are approximately as follows:

From papers by: E.M. Hormon, Livestock Specialist, USOM/Iran and Glenn Morrill, Agronomist, USOM/Iran.

CATTLE	
Weaned calves and yearlings	.06 Animal Unit
Mature cows and steers (cows with o without unweaned calf)	1.00 Animal Unit
Bulls, 2 or more years old	1.30 Animal Unit
HORSES	
Yearlings	.75 Animal Unit
Two-year-olds	1.00 Animal Unit
Three or more years old	1.25 Animal Unit
SHEEP, GOATS AND DEER	
5 weaned lambs, kids, or yearlings	.60 Animal Unit
5 ewes or does, (with or without unweaned lambs or kids)	1.00 Animal Unit
5 rams or bucks	1.30 Animal Unit
5 deer	1.00 Animal Unit

Animal unit equivalents are, of course, very useful in planning. Because of differences in animal preference for various range forages, however, equivalents should not generally be used to convert grazing capacity estimates, particularly from sheep and goats to cattle and horses without additional study. If possible, field trials should be made to determine grazing capacity on the basis of the value of forage on ranges for each kind of livestock.

FORAGE VALUE EQUIVALENTS.—A cow month is generally defined on the basis of the amount of grazing or other feed required to feed a 900 pound cow for one month. For example, 12 cow months of grazing would be required to graze a cow for one year, whereas 10 cow months of forage would be sufficient to feed 5 cows for a two-month period. Animal units then, multiplied by feeding period in months represents the total animal unit months of feed required.

Table Showing Comparative Rating of Forage Crops for a 900-pound Range Cow on a Maintenance Ration

Feed	*Pounds* Per Month (Airdry)*
Hays:	
Smooth brome hay	600
Native hay	600
Alfalfa hay	600
Sweetclover hay	650
Cereal grain hay	600
Grain and Cotton-seed Cake:	
Corn	216
Barley	225
Wheat	216
Oats	216
Rye	216
Cotton-seed cake (43%)	138
Succulents:	
Corn silage	1200
Sunflower silage	1275
Wet beet pulp	2000
Potatoes	1380
Beet tops	990

Feed	*Pounds* Per Month (Airdry)*
Dry Roughages:	
Whole corn fodder	600
Corn stover	1200
Sudangrass or Johnsongrass hay	640
Millet hay	640
Cane fodder	640
Kafir corn	640
Bean straw	640
Pea vines	675
Oat straw	1000
Barley straw	1350
Wheat straw	1500
Russian-thistle hay	750
Peanut hay	600

* 2.2 pounds = 1 kilogram

With minor exceptions, few foods are maintenance rations when fed alone. Barley, wheat, rye, or oat straw are not maintenance rations but are satisfactory for wintering beef cattle if 1 to 1 1/2 lbs. of cottonseed cake is added. On the other hand, this combination is not correct for breeding cattle and if fed alone, there is danger of abortion and milk shortage. Accordingly, hay should be added to the ration a month before calving to counter such dangers.

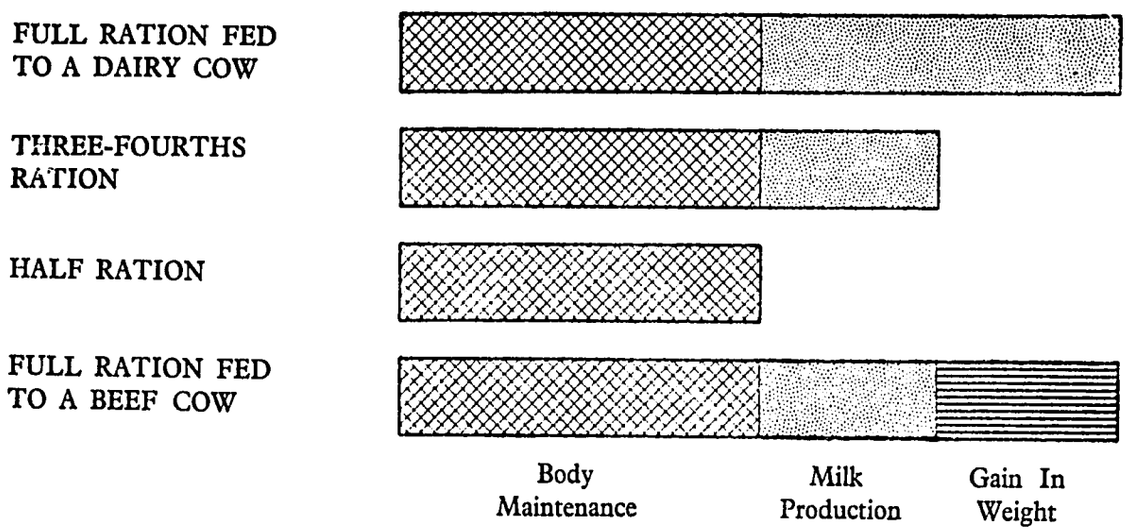
The amount of food necessary and the particular type of food or combinations of food required depends upon the kind of livestock and the purpose for which they are being fed. Production, however, is not possible until maintenance requirements such as digestion, circulation of blood and reproduction have first been satisfied. For example, livestock being fed for the production of meat or milk will require a fuller and more complete ration than those fed merely to maintain body processes. As shown in Figure 7, about half of what an animal is able to eat is required for maintenance and only that which is eaten over this amount can be used for increasing body weight, or for milk and other kinds of production.

THE CALCULATION PROCESS.—In determining how to plan a livestock farm or ranch operation to make maximum profit, the livestockman should first estimate how many livestock he thinks his place will support. He should then compute how much of each different kind of feed he will need. Then he sould study his land and see if he can arrange a cropping system or rotation to produce that much food each year. If the land and water is not sufficient to produce all of the hay, forage and pasture he requires he should reduce his livestock estimates. Planning should always include at least 10 percent more feed than needed. Most livestock producers make the mistake of trying to keep too many animals and then lose much of their profits by under-feeding. If an operator has more crop-land than he needs he may then decide whether to increase livestock numbers or sell some feed but he should never keep more livestock than he can provide with pasture, hay and roughage, preferably from his own land.

In computing feed-needs for native cattle a sound practice is to allow avout 5 kilos of good dry hay a day per grown animal. Alfalfa hay is best. In addition, each cow should have 10 kilos of silage a day or its equivalent in beet pulp, corn fodder, or grass hay. Silage is best and beet pulp, corn or nearly any grass will make good silage. For example, let us assume that a man wants to keep 40 cattle and will have an average of 40 calves and yearlings. The 40 young stock will eat about as much as 20 mature cattle. In other words he will have to feed the equivalent of 60 cattle. This means he needs 60 × 5 or 300 kilos of dry alfalfa hay daily during the feeding season. He will also need 60 × 10 or 600 kilos of silage daily.

Now, if we further assume that he will keep 200 sheep and goats, each grown animal should have one kilo of dry alfalfa hay per day or a daily total of 200 kilos. They should also have at least 2 kilos of silage each year per day or a daily total of 400 kilos of silage. In this example the livestock man

HOW COWS USE FORAGE



CATTLE PRODUCE MOST EFFICIENTLY ON A FULL DIET

WHEN GIVEN A FULL RATION, DAIRY COWS CAN USE ABOUT HALF THEIR FORAGE TO PRODUCE MILK AND BUTTERFAT; BUT WHEN THE COW'S RATION IS CUT TO THREE-FOURTHS, SHE CAN USE ONLY ONE-THIRD OF HER FORAGE FOR MANUFACTURING MILK.

WHEN FED HALF ENOUGH, COWS NEED ALL THEIR FORAGE FOR BODY MAINTENANCE. BEEF CATTLE WHEN FED A FULL RATION WILL CONVERT SOME OF THEIR EXTRA FORAGE TO BODY FAT INNSTEAD OF MILK AND BUTTERFAT.

FIGURE 7

must have 500 kilos of dry alfalfa hay and 1,000 kilos of silage daily if he is to feed his cattle and his sheep and goats so they will be profitable to him. Next he should study his pasture. Pasture may be either irrigated or dry. He should determine how many days a year he can expect pasture to provide the animals all the feed they need to keep in good condition. Let us assume that he finds he can have good pasture 95 days a year. Then he will need to feed silage and hay for 270 days.

By simple computation then, our livestock producer must have 270 × 500 or 135,000 kilos of alfalfa hay. If he gets three cuttings of alfalfa a year averaging 2,000 kilos each or 6,000 kilos of dry alfalfa per hectare yearly, he needs 22 1/2 hectares of alfalfa. Adding a 10 percent safety factor he should have 25 hectares in alfalfa. Then let us suppose he can grow 10,000 kilos of green corn, sorghum or grass per hectare for silage. His needs are 270 × 1000 or 270,000 kilos of silage. This means 27 hectares of silage crops and adding 10 percent as a safety factor he, therefore, needs 30 hectares in silage crops. With dry land alfalfa and only one cutting a year our operator would need three times as much area in alfalfa. The important thing for him to be sure about is the amount of feed and then to adjust the size of his flocks and herds to balance his feed supply.

Grain needs are additional. Sheep should have some grain at breeding and lambing times and all animals should all have a little grain while in milk. If they get all of the pasture, silage and alfalfa-hay they will eat they need about one kilo of grain for every four kilos of milk. Each livestockman must decide for himself the amount of grain needed depending on the production of his animals and the quality of his hay, pasture, and silage. If we assume, in our example, that the livestock operator determines he needs an average of 60 kilos of grain a day for his cattle and 40 kilos a day for his sheep for the year, then 100 × 365 or 36,000 kilos of grain will be required for the year. If he can raise 1,400 kilos of grain per hectare he needs about 26 hectares of grain which with 10 percent added for safety brings his total area for feed-grain to about 30 hectares.

In summing up our example, with the yields discussed, our livestockman would need 25 hectares of alfalfa, 30 hectares of silage crops and 30 hectares of grain for 40 cows, 40 young cattle and 200 sheep and goats. If the land will produce more feed per hectare he may either buy more livestock or sell some feed. But if his land will not produce as indicated, he had better sell some livestock. Many operators lose money trying to keep more livestock than their land will support. This type of reasoning and calculating is what makes successful livestock men. No two will have the same problem. Some will have more and some less livestock. Some will have better alfalfa and some will have poorer alfalfa. Some will have pasture that will give ample feed for their flocks for a longer period and others may have little or no pasture. However, by following sound principles and by always being sure to have plenty of feed, livestock men will measureably increase their profits.

Good livestock poorly fed are not profitable. Poor livestock poorly fed always lose money. Poor livestock well fed are seldom profitable. Good livestock well fed are not only profitable but they are the most important branch of agriculture in all of the more advanced countries of the world. It is the people in the nations which are the most important producers of livestock and the most important consumers of livestock products that lead the world in health, vigor, vitality and longevity. It is the area where livestock is the basis of the agricultural structure that most has been done in developing a sound, profitable and prosperous rural culture. No greater contribution can be made to the health, vitality and economic stability of the countries in the Middle East than that offered by a prosperous, well-bred and well nourished livestock industry. Good breeding plus proper management of the range and forage resources are the keys to the problem.

PART IV

APPLICATION OF RANGE MANAGEMENT

CHAPTER XVI

MANAGEMENT PROBLEMS AND SOLUTIONS

GENERAL.—From time immemorial, the Middle East has been a livestock area. It consists primarily of vast expanses of desert with a few spots of cultivated land where-ever there is a stream or a spring or a "ghanat". In the main, these small spots of cultivated land are mere pin points on the landscape. Here and there, however, are a few larger areas, but all of them together constitute only about 5 to 6 percent of the total land area. The amount under cultivation is actually much less because out of this 5 or 6 percent about half of the area, or in many cases two-thirds, is followed.

A most limiting factor is the supply of water which, in many areas, is only enough to irrigate from a half to a third of the land that is cultivated. It seems unlikely that at any one time more than 3 to 4 percent of the land area will be in crop production. The next year, part of the land in crops will lie idle as fallow, and land that was fallowed will be cropped. This practice has the advantage of adding some fertilizer to the soil and perhaps for a limited time, gives some relief from the effects of insect pests and plant diseases.

Besides such farm land, there are certain other areas that are used for town sites, roads and other developments. All of this land, however, represents only a small area, so that the total which is farmed or used for essential living purposes other than livestock grazing is probably less than 10 percent. This means that somewhere around 90 percent of the total land area must make such contribution as it can make to agriculture by producing native forage plants to be grazed by livestock.

PROBLEMS OF APPLICATION.—Throughout the Middle East, one of the most important problems in a coordinated and well-balanced agricultural program is how to produce with the resources available, maximum sustained yields of animals and animal products—meat, fiber, hides, milk, and power. Basically, there are just two ways of doing this: (1) through improving the germ plasm of the animals, including the care and husbandry thereof; and (2) through improved feeds and feeding. To concentrate on the first of these and neglect the second would be an extremely serious mistake, for without some improvement in the animal's diet, improved germ plasm is incapable of adequately expressing itself. On the other hand, worthwhile and efficient improvement in quality and quantity of animal products cannot be made through feeds alone. The two must go hand in hand.

To illustrate, we need only look at the animal population of the world, both domestic and wild. We find that animals in the various life provinces are remarkably well adapted to their environment, in spite of man. We further find that in Middle Eastern countries, with their long history of civiliza-

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From papers by: L.R. Short, Range Specialist, USOM/Iran;
George Stewart, Acting Chief of Agriculture, USOM/Iran; and
B.W. Alfred, Leader 1955 Regional Range Management Course (Iran) and Conservationist U.S. Soil Conservation Service, Washington D.C.

tion, even the domestic animals are well adapted to the rigors of daily life. Any attempt to change animals without changing their environment, including feed, might well result in serious consequences, including wholesale death of the animals.

Fortunately, the fine work which has been done to date in the Middle East toward livestock improvement, health, and animal husbandry has been centered largely in areas where better-than-average feed conditions prevail, such as at livestock and agricultural experiment stations. It should be emphasized, however, that there is a real danger of such programs coming to naught in the average village area unless fully integrated with a program of feed improvement.

Native range is the most important and, in the Middle East, quite often the most uncertain source of animal feed. There can be no question but that many centuries of heavy grazing use have greatly reduced range forage production. With increasing livestock and human populations the matter of adequate forage goes far beyond the mere improvement of native ranges, important as that may be. Also necessary, is a considerable expansion in artificially seeded pastures and a real increase in the production and use of supplementary feeds such as hay, silage and concentrates.

The purpose in mentioning the various types of animal feeds is simply to focus attention on another grave problem, that of making planned use of such feed. The objective of obtaining maximum sustained yields of animals and animal products can never be satisfactorily attained by a single-practice program. Just as we have seen that animal improvement, health, and sanitation alone will not succeed, so too, we must recognize that it is not enough to manage native ranges, or artificially revegetate them, or plant irrigated pastures, or raise hay and fodder crops, or produce feed concentrates. Neither will such other practices as range waterspreading, contour furrowing, stock-water development, deferred or rotation grazing, closing forest lands to grazing use, or fertilizing pasture lands, in themselves, prove satisfactory. What is required is a coordinated plan involving the right combunation of all needed practices to fit a given situation.

A prime requisite, of course, is a better organization for handling range livestock than there has been in the past. The current practice is to graze off 80 to 90 percent, or in many cases 100 percent, of the plant growth. Under usage as severe as this, plants simply cannot reproduce and approach anything, like vigorous growth. There is a strong tendency, therefore, for plants which animals do not like or which they cannot eat because of thorns or similar appendages to be about the only cover left on the land. It would seem, therefore, that a principal function of range management is to convert villagers, tribes, range owners or other divisions of the population to the necessity of moderate and proper use of range lands.

Throughout the Middle East, grazing is conducted partly in connection with permanent village operations and partly in connection with nomadic tribes-people. In Iran, for example, only about one-fourth of the people are nomads, yet they probably use two-thirds of the grazing lands. Around the settled villages, the pattern of living consists of small areas of irrigated land, a small acreage of farm pasture, and then grazing as far out from the villages as the animals can be driven in the morning and returned in the afternoon. As a result, all grazing areas near the villages are heavily over-grazed in addition to which vegetation is severely trampled by repeated trailing of livestock. Also near the villages, a common practice is for the villagers to gather up woody plants for use as fuel in baking and for heating in cold weather. The land is, therefore, almost bare within 10 to 20 kilometers of most villages. Another reason that fuel gathering is so extremely detrimental to range lands is because most of the better grasses germinate and begin their growth along the edge of woody vegetation where they are shaded from the hot summer sun. Therefore, when the edible vegetation is severely grazed by livestock and the woody vegetation is carried away for fuel, there is little chance for new growth of good plants to become established. One of the principal weeds, all over the Middle East, is another source of fuel besides the woody vegetation remaining on ranges after the more palatable plants have been removed by livestock. Government could make a considerable contribution by providing, at no or very low cost, simple oil stoves for cooking and heating plus arrangements for kerosene to be made available at prices the people can afford. Coupled with this fuel gathering is also the practice of using animal manure for fuel instead of returning it to the land as fertilizer. The remedy for this burning of manure would likewise be providing another source of fuel, such as oil. At first glance, this program might seem difficult, but it is highly important both from the standpoint of cultivated agriculture and range management throughout the area.

SOLUTION TO PROBLEM.—Most important, of course, is effective application of the basic principles of range management—proper numbers and kind of livestock well distributed on the range during the proper grazing season and for a correct length of time.

Also involved, of course, are such factors as improved animal husbandry, rotation and deferred grazing, increased use of supplementary feeds, better land tenure and ownership policies and additional well-trained range managers.

Animals seasonally select the most palatable plants. Generally, these plants are also the most nourishing and when they occur in mixtures, livestock will eat them to the exclusion of less-preferred plants. With continued overuse, these better plants become depleted, yield very little or die. Then the animal turns to the next most desirable species. Plants that survive heavy grazing are usually the least palatable, and often the least productive.

Leaf development, root growth, flower-stalk formation, seed production, forage regrowth and food storage in plant roots take place in the order named. Each growth stage is essential in plant development. Grazing management must allow for these natural growth sequences if maximum forage yields and peak animal production are to be obtained.

The first growth of perennial plants in the spring comes from food stored in the roots the fall before. These stored reserves may produce as much as 10 to 12 percent of the current year's height growth. Once the plant has exhausted food reserves from its roots, it depends on its leaves for current operating nutrients. With little root storage occurring when plants are growing fastest, moderate use of the forage is essential, as enough leaves must remain to manufacture food throughout the growing season. Rest at the beginning of the growing season helps to stimulate vigorous growth and occasional rests made possible by grazing rotations will also help, particularly when the range cannot be rested at the beginning of the growing period.

The various good-quality range plants develop and reach their period of maximum usefulness at different times of the growing season. If they are grazed too soon, the plants are injured and net gains of livestock are lower. If grazed too late—after they mature—the plants may not be injured but animal gains will be less. Some grasses, particularly those in an arid or semi-arid climate, cure on the stalk and yield a higher quality of forage during dormancy than the same plants grown in humid and semi-humid areas. The promotion of the greatest production of livestock with the least range abuse can be accomplished by providing adequate amounts of feed with a proper ratio among the warm-season or summer-growing grazing plants and the cool-season or early spring-growing plants. A reserve of the best species for winter grazing must also be maintained along with adequate supplemental grazing and stored feeds to correct deficiencies at all times. Experience has taught that when the better grasses and herbs are dormant in winter, livestock often try to satisfy their hunger for green forage by eating bitterweed (*Hymenoxys* odorata), loco (*Astragalus* sp.), or other poisonous, winter-growing plants that are often common on run-down ranges. The success of any livestock operation depends primarily on having sufficient forage to meet the year-long needs of the animals.

Plants thrive when moisture is good and degree of use is moderate. They suffer most in dry weather when grazing is excessive. Livestock men cannot control the weather but they can minimize the effect of drought by keeping their ranges in good condition. Overcropping of the better plants on all or part of the pasture is what range managers guard against and plan to avoid at all times.

There are a few general rules which are helpful in deciding when plants have been properly used. About half of the yearly volume growth can safely be grazed. This means, for example, that the average grazed heights of short-grasses should be about 1 1/2 to 2 inches (3.8-5.1 cm.); 4 to 7 inches (10.1-17.8 cm.) for mid-grasses; and from 7 to 10 inches (17.8-25.4 cm.) for tall-grasses. A moderately grazed range will usually not have all grass cropped to these heights but will have plants varying from no utilization to closely grazed. Observations on use can be restricted to the key grasses—those that are to be perpetuated.

On grasslands where the better grasses are thriving, several other marks of improvement will be indicated. Plant vigor and production of plants will be high, litter will be accumulating, good forbs will be increasing, weedy forbs and undesirable grasses will be decreasing, soil-tilth will be improving, and erosion and runoff will be reduced. In addition, there are definite economic incentives for grazing moderately. Studies have shown that yearly income from steers is 50 to 60 percent greater

when they graze only half the forage as compared to steers on ranges where utilization is 75 percent.

There are also a number of safeguards that successful managers use to maintain ranges under fluctuating climate and related conditions. One is to adjust the numbers of livestock in conformance with the forage production. Another is to shift animals to fresh grazing grounds, feed lots, or to market before the plants are seriously hurt and valuable livestock weight-gains lost. Speediest adjustments can be made by those who run stocker and feeder livestock. The animals are readily mobile and merchantable. Livestockmen with breeding herds can also reduce their risks by keeping 50 to 60 percent of their herd as breeding animals and 40 to 50 percent as stocker and feeder animals. During drought and other periods of feed shortages, the stocker and feeder animals can be sold, leaving all of the forage to carry the breeding herd with greater safety and economy. Many operators find this procedure safeguards both grass and livestock. They are not forced to liquidate their total livestock holdings because of forage failures during protracted drought although, at such times, some reductions in livestock may be necessary. Also, some of the better plants may die, but enough are usually left to replenish the range when conditions again become favorable. However, where drought accompanies heavy grazing, better vegetation is usually killed out.

Uniform Distribution of Livestock.—Uniform grazing is often difficult to obtain where sites and range condition vary or watering places are widely separated. Livestock generally prefer to graze low and comparatively flat-lands, leaving steep, broken or rocky ranges to the last. So pronounced is this preference that animals will often trail up a steep hill covered with excellent forage to graze poorer forage on flat benches or table lands.

Most domestic animals avoid wet, muddy or boggy places except when forced to use them by feed shortages elsewhere or to avoid insects. In wet weather, they prefer sandy soils to heavy clays. They like to graze in soft soil that is free of rocks and gravel. Sheep graze steep ranges better than cattle and goats are greater climbers than sheep.

There needs to be sufficient well-spaced water to prevent livestock from utilizing vegetation too closely around watering places. Without a protective cover of vegetation, the soil is blown or washed away. To improve livestock distribution there should be enough well-spaced watering places to encourage animals to spread out over the range, thus avoiding local over-use of forage. Greater caution in spacing of water developments is needed where there are several range sites within a pasture. This is especially true on rough land.

An animal's need for salt can easily be used to the livestockman's advantage. By making salt readily available at the right places he can gain local control over the distribution of livestock on the range and thus secure more uniform use of the available forage. Such distribution of grazing is one of the requirements for the conservation of soil and water on grazing land. Locating salt so it influences the distribution of livestock depends upon variations in range sites and condition. The advantage of using salt to attract animals lies in the fact that livestock can be enticed to areas that otherwise would be lightly used. They can also be drawn away from too-heavily used areas, from areas where soils are highly susceptible to erosion, where forage is easily killed, or where damage to valuable trees may result. To help distribute grazing, salt locations should be changed frequently. There are, of course, situations where salt cannot be used to help with conservation grazing. Livestock frequently cannot find salt when placed on ranges covered with dense brush and thick stands of timber. Under such conditions, satisfactory distribution must be accomplished in some other manner.

On large ranges where site variations cause animals to concentrate on accessible areas, and under-graze less accessible ones, division fences can be built so that each area can be grazed separately and more uniformly. Often, the need for fencing is temporary and fences of cheap construction will serve. Electric fences can also be used where fence boundaries need to be shifted frequently in avoiding concentration or, in other cases, under-use of certain areas. Where small ranges and pastures include several sites; temporary fences, salt, stockwater, or supplemental forage, may be used to draw livestock away from areas of concentration to others where forage is under-used. Livestock graze small pastures more uniformly than large ranges and sometimes large pastures need to be subdivided by fences to obtain more uniform grazing. Irregularly shaped or triangular pastures are usually more difficult to graze uniformly than rectangular ones. Animals graze into the wind and the windward side of the pasture

will be grazed the most. Many ranchmen build their fences to give livestock a wider pasture in the path of prevailing winds to bring about more uniform use of the range.

Sometimes ranges are so mixed up with mountains, canyons and rolling uplands that it is impossible for the animals to graze in such a manner that all sites are maintained in excellent or even in good condition. The goal of management is to obtain the highest range condition for the site that will contribute the greatest net income and effectively control erosion. Provision should be made to prevent destructive use of other sites that may, of necessity, remain in poorer condition.

ROTATION AND DEFERRED GRAZING.—A large acreage of low-condition range needs to be improved. Where condition and vigor of vegetation is poor, improvement of both can be obtained by use of properly timed rests (deferred-grazing). The time to rest plants depends, of course, upon their season of growth and period of seed development. Cool-season grasses need to be rested in spring and early summer and warm-season grasses receive greatest benefit from rests in summer and early fall. Where both cool and warm-season grasses are in the same range or pasture, rest should extend from early spring to late fall and so benefit both types of plants. Rests during the growing season allows plants to produce seed and reproduce by rootstocks and stolons. Germination and growth of seedlings is higher on ranges rested successively for 2 or more years and rate of recovery through vegetative reproduction is better.

On most livestock operations, it is impracticable to keep animals out of all the pastures while the better grasses grow. However, part of the range can be rested during the season while other parts are grazed. Finally, over a period of years, all pastures will thereby benefit from growing season rests. As the better plants increase in number and abundance, their vigor and condition improves and forage yields increase. Obviously, the pastures being grazed must not be overused while the others are rested or the benefits are minimized or lost. Where moderate summer grazing is practical, seedlings and new sprouts from buds of older plants—resulting from rests—have a better chance of developing into vigorous forage producers. During the rest period, however, all livestock should be excluded. A few animals left in a pasture will eat the seed-stalks and flowers of better grasses and leave inferior kinds to increase. In the late summer and early fall when seed is produced, even a few animals concentrating on the seed heads may consume the seed crop. The tender seedstalks and flowers of these better grasses carry more protein, phosphorous and nitrogen and are more succulent than basal leaves and stems; so where seed is needed to thicken the stand, grazing at flowering and seeding time should be avoided.

There is still another benefit from the practice of resting ranges. On large ranches, there is a good deal of labor and expense due to riding, windmill maintenance, worming, shearing, branding and docking. Livestock are confined to fewer pastures on ranches where range resting is practiced. Hence, there are fewer pastures to be serviced at a time and costs for livestock care are reduced. This is especially true on brushy ranges.

Ordinarily, in arid and semi-arid regions, the practice of shifting livestock (rotation-grazing) between pastures after short rests does not increase animal gains or improve range conditions compared with continuous grazing, provided rate of stocking is about the same. However, there are circumstances when animals may be alternated frequently between pastures to further range improvement and aid in livestock management. For example, cattle need to be shifted from ranges where oak (*Quercus* sp.) or other seasonally poisonous or injurious plants are present. Timely grazing of seasonally palatable annuals or low grade perennials at a time when the good perennials are dormant, may also be helpful. Rotating animals between seeded pastures and native range is a good practice which can be used where farming and grazing are carried on together especially now that pasture seeding of former croplands is increasing.

There are many instances where type of vegetation increases the desirability of grazing some areas in winter and others in summer. For example, the best use of tobosa (*Hilaria* mutica) grass is obtained in summer whereas grama (*Bouteloua* sp.) grass ranges make better winter grazing. Summer gains per animal are about the same for both. Therefore, summer grazing of tobosa and winter use of grama ranges is a good combination. Where part of a landowner's pasture is made up of cool-season varieties and part supports warm-season plants, it has proven profitable to graze the cool-season

pastures in winter and the warm-season areas in summer. Ranges with chamise or four-wing-saltbush (*Atriplex* canescens) and guajillo (*Acacia* berlandieri) shrubs that maintain green leaves in winter, can be used for winter grazing.

Some types of operation necessitate shifting of animals between pastures at different times to help with their management. Included are such livestock management practices as: breeding, calving and lambing, branding, dehorning, docking, shearing, spraying, dipping, separating, weaning, and shipping. With mixed operations, several pastures are needed. Many operators maintain a number of pastures to hold different classes of animals such as: bulls, rams, billies, stallions, cows, ewes, nannies, mares, stockers and feeders. Extra fencing is not ordinarily needed to practice rotation-grazing in these situations.

SUPPLEMENTARY FEEDS.—Livestock select range or pasture forage as it develops in natural sequence throughout the year. However, most livestock suffer from hunger for considerable periods, once at least, and usually several times, during their lifetime. Hunger may be due to feed shortages or it may be due to poor forage quality.

The timely use of supplemental feeds and pastures helps stabilize livestock grazing enterprises. Even though the amount of native grass may be adequate, there are times of the year when its quality is too low to satisfactorily maintain livestock. Wise use of farm-grown and commercial feeds that provide the needed elements is warranted to relieve ranges and pastures during seasons of subnormal production or while perennial pastures are being deferred during the critical growing or flowering period. Most ranchmen need feed reserves or emergency feed supplies for use during such seasons. The purpose of the reserve is not to supply feed for additional livestock, but merely to assure maintenance of present livestock in adverse years. Supplemental feed, more especially concentrates, should be used to supply protein, minerals, and vitamins not found in range forage, rather than merely adding to the animal's ration. This practice should not be used, however, to increase range and pasture utilization to the detriment of perennial plants.

Native grass also makes good hay. It is one of the better roughages for cattle, sheep, and horse maintenance. Supplies of native hay or other roughages need to be kept on hand to feed livestock when ranges are grazed-off or fail to grow during drought. Tall and mid-grasses yield more hay than short-grasses, hence meadow management should be directed toward the perpetuation of the taller grasses. In the United States, bluestem (*Andropogon* sp.) meadows mowed about 4 to 6 inches (10.1-15.2 cm.) high and cut in July gave highest yield and greatest feeding values although June cuttings had a higher average protein and phosphorous content.

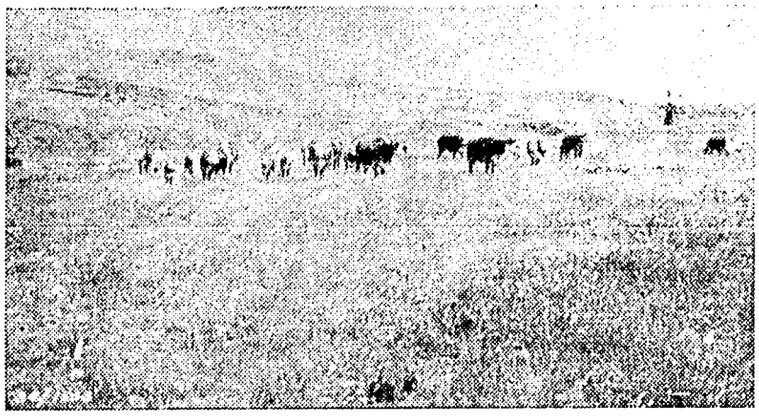
LAND TENURE AND OWNERSHIP.—Complicated land tenure and ownership patterns may increase the difficulty of carrying out a coordinated plan of range and livestock management, but the problem is man-made and as such can be overcome by an enlightened people. Reasoning to the effect that if one shepherd does not use all available forage another will is no justification for Mismanagement.

In many areas, a primary responsibility of the range manager will be to further, in every way posssible, a better land tenure and ownership structure. Custom, tradition and even superstition may confront him in this task. He should, however, keep in mind the fact that unsound range and land-use policies have been corrected in many places throughout the world. With sound policies, just laws, and workable regulations he will have a real foundation for proper range management.

TRAINED PERSONNEL.—Intelligent solution of the many and diverse problems of range management requires leadership and understanding of the interrelationships, both within and outside the field of range management. It requires a strong, healthy organization, staffed by trained men of considerable experience. It requires resource and land classification surveys, maps, and data as a basis for a coordinated plan. And it requires research, demonstration, extension, and education for all of the major problems under important sets of physical conditions. Stress must be placed on the quality of the product, rather than on the number of animals that can barely exist—a short-coming that is widely prevalent throughout livestock producing areas in many parts of the world.

Most Middle East countries now have some trained range managers. Generally, however, their number is inadequate for the enormous job that remains to be done in range management. A most important requisite to proper range management is, therefore, additional trained personnel. We can and should all help in this training. In addition, we can devise instructions checklists, forms and similar media to aid not only in training but in accomplishing the job that needs to be done. An example is illustrated in Figure 8—a Conservation Job Sheet on the "Management of Native Pastures" in Nebraska as developed by the United States Soil Conservation Service—as follows.

MANAGEMENT OF NATIVE PASTURES



IT TAKES GRASS TO MAKE GRASS. LEAVE HALF AND TAKE A BIGGER HALF NEXT YEAR.

NATIVE PASTURES are permanent pasture mixtures of naturally adapted grasses such as: switchgrass, big bluestem, Indiangrass, little bluestem, sideoats grama, western wheatgrass, buffalo, blue grama, and other. Native pastures will maintain themselves, and improve in quality and production naturally if YOU will manage them. Kentucky bluegrass IS NOT a native grass.

TO GET TOP PRODUCTION FROM NATIVE GRASS PASTURES you will need to:

1. STOCK PROPERLY — by grazing only half of the top growth and leave half. The half that is left is not lost--it provides leaves to manufacture food for a vigorous plant and high production of forage. Secondly, it makes a mulch to reduce runoff and erosion which puts more moisture into the soil to grow more grass.
2. REST NATIVE PASTURES — that are in a fair or poor condition to improve the quality and quantity of forage. Remove ALL livestock during season of desirable grasses to permit natural reseeding. Resting two or more consecutive grazing seasons brings rapid improvement. Some poor pastures may be restored faster by seeding.
3. DISTRIBUTE GRAZING UNIFORMLY — by proper location of stockwater wells and ponds, by salting in lightly grazed areas, by fencing, and by mowing.
4. GRAZE IN PROPER SEASON — Graze each pasture during a definite season according to the needs for livestock forage and for pasture improvement or maintenance. Avoid grazing too early — give the grass a chance.
5. USE OF TAME GRASSES — as brome or wheat grasses or temporary pasture of rye or sudan for early spring and late fall grazing season.
6. GROOVE OR PIT — run-down pastures on the contour, on medium and heavy textured soils with fairly uniforme slopes. This will reduce runoff and when used with proper stocking will increase the stand of taller grasses that spread by under-ground stems.
7. CONTROL WEEDS AND BRUSH — A vigorous stand of native grasses is the best method of control. You can help the best grasses crowd out weeds by mowing or spraying.

(*Specific recommendations are shown on the back of this sheet*)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

NEBRASKA

5, L-13, 455

FIGURE 8

GRAZING SCHEDULE

Field No.	Kind of Pasture	Acres	Condition	Recommended Degree of Use	PLANNED ANIMAL UNIT MONTHS	DISTRIBUTION OF GRAZING (Animal Unit Months)									
						Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

REMARKS _____

WEED AND BRUSH ERADICATION

Annual Weeds

1. Mow prior to seed set.
2. Spray broadleaf annuals prior to seed set with 1/2 pound per acre of ester form of 2,4-D in water in May or June.

(Hemp is poisonous and spraying makes it more attractive to livestock.)

Perennial Weeds

1. Spray with 1 pound per acre of ester form of 2,4-D in water.
2. Spray each year until weeds are killed. May take 3 consecutive years.
3. Spray on optimum dates for eradication which are:

Buckbrush ------ May 7-21
Blue vervain)
Ironweed) --- June 7-21
Others)

CHAPTER XVII

BENEFICIAL EFFECTS OF CONSERVATIVE MANAGEMENT ON LIVESTOCK

GENERAL... There is a great deal of general information but only a few items of specific application on the effect of good range management in relation to livestock production. General figures over many years have shown that calf crops may be as high as 80 to 85 percent under good range management, but drop to 30 percent or below on heavily-grazed, poorly managed ranges. In the case of sheep, though the actual figures are a little different, the trend is similar. Under good management a number of sheep ranchers obtain lamb crops of from 105 to 120 percent because of the frequency of twin lambs. The tendency, however, under range-grazing conditions has been to produce about 85 to 90 percent lamb crops on good range, but only around 65 to 70 percent on deteriorated ranges, and 60 percent or less on poorly managed areas. Such differences in calf and lamb crops, resulting from the beneficial effects of good range and good management, make the difference between a reasonably sound profit and an extremely risky business.

One of the recent studies, most applicable to the Middle East, on the beneficial effects of conservative management on range livestock is probably the Desert Range Study near Milford, Utah (USA). Other, although perhaps less applicable, U.S. studies include those at the Range Livestock Experiment Station in Montana, at the Central Plains Station in Colorado and in the Vernon Reseeded Pasture in Utah. Additional valuable sources of information in the United States are the experiences of cooperating land operators in Soil Conservation Districts.

In the Middle East there are such studies as the Native Pasture Experiment at Bhamburda, India. Other local studies are desirable.

DESERT RANGE STUDY.—In the Utah desert study, sheep were grazed over a period of 13-years in 20 pastures in which 30 to 60 sheep were kept separate from those in other pastures. Adjacent were four large pastures where full bands (2500-3000 head of sheep) were grazed in comparison with a similar band on the surrounding unfenced and uncontrolled range. Three stocking intensities were used—light, moderate and heavy. The grazing season was divided into three equal periods of about 50 days each—early winter (November 15-January 3); middle winter (January 4-February 23) and late winter (February 24-April 10).

Sheep were allowed to graze freely without herding and had access to snow or water every day. When snow was not readily available, water was hauled to the range and placed in troughs. The sheep were bedded in different locations from time to time and the troughs were frequently moved to aid in obtaining uniform utilization within the pastures. During cold weather it was often necessary to break and remove ice from the troughs so the sheep could drink.

From papers by: Dr. George Stewart, Supervisor USAC Contract, USOM/Iran and W.M. Nixon, Soil Conservation Advisor, TCM/India.

Average changes in body weight of ewes throughout the winter season on lightly or moderately grazed ranges showed a net gain in each of the three winter grazing periods for six years of the study. The gains under moderate grazing in the first two periods exceeded those made on lightly grazed range but in the late winter period, ewes under light grazing gained slightly more than those on moderately grazed ranges. Total net gain for ewes under moderate grazing of 11.4 pounds (5.2 kilos) was well above that for ewes under light grazing—8.5 pounds (3.8 kilos). Ewes in the heavily grazed pastures lost weight during the early and midwinter periods but gained about 2 pounds (nearly 1 kilo) per head in the late winter period when early green growth of the forage plants became available. The gain during the late winter period under heavy grazing was less than half the gains made under light and moderate grazing, and was insufficient to offset earlier losses.

The kind and amount of forage produced on the range areas influenced sheep weights considerably. Ewes in the lightly grazed range pastures where vegetation was primarily sand dropseed (*Sporobolus* cryptandrus) and shadscale (*Atriplex* confertifolia) with very small amounts of winterfat (*Eurotia* lanata) showed approximately 2 to 3 pounds (about 1 kilo) less gain than those in other moderately or lightly grazed pastures. Greatest gains were made on areas where winterfat, Indian ricegrass (*Oryzopsis* hymenoides) and bud sagebrush (*Artemesia* spinescens) produced 30 percent or more of the forage.

Total averaged gain for the light grazing treatment was 8.4 pounds (3.8 kilos) per ewe—3.2, 1.4 and 3.8 pounds per head respectively for the early, middle, and late winter periods. The average total gain for moderate grazing was 13.0 pounds (nearly 6 kilos) per head. In contrast, sheep in heavily grazed pasture failed to gain. These results are quite similar to those reported for other sheep in the pastures. Ewes that were on moderately or lightly grazed range for two or more of the winter periods gained two to three times as much as those on heavily grazed range for two or more periods. Sheep that remained vigorous and in good condition through one period of heavy grazing frequently gained rapidly the following period if they were placed on moderately or lightly grazed ranges. An example is a pair of ewes that were on moderately grazed pasture in early winter, on heavily grazed pasture for the middle winter period, and on moderately grazed pasture again in late winter. Although they lost an average of nearly two pounds during the middle period, they made an average gain of nine pounds during the late period.

Sheep under moderate grazing often gained more than those in the lightly grazed pastures probably because herbage production and plant composition in the various pastures differed, as well as because the sheep in smaller groups using the lightly grazed areas were more restless and discontented than the larger groups of sheep in other range pastures.

On the unfenced range, sheep were managed according to pratcices customarily used on most of the winter ranges in the locality. The entire range area was grazed repeatedly as a single unit; sheep were bedded on established bedgrounds, often for several nights in succession and often after trailing as much as three miles to reach a particular site; trailing and movement were seldom checked by the herders; and animals were primarily dependent on snow or reservoir supplies for water, and sometimes had to be trailed as much as four miles to obtain water during dry periods in early and late winter.

Sheep on the moderately grazed range under good management showed an average seasonal gain of 9.3 pounds (4.2 kilos) per head for the entire period of study, whereas those on heavily grazed range with poor management gained only 1.1 pounds per head for the entire period of study. The 8.2 pounds (3.7 kilos) difference between the two herds was nearly the same as that recorded for sheep in the moderately and the heavily grazed fenced pastures where treatment and management were uniform. There were great fluctuations in weight changes from year to year, primarily because of differences in forage production and weather conditions. Notwithstanding this fact, the sheep on moderately grazed range remained in good condition and showed gains in all winters. Ewes on moderately grazed range made greater gains in every year than those on the heavily grazed range. In three years, with rather severe winter conditions, sheep on heavily grazed range showed net losses in weight.

Fleece weights of all sheep wintered on the experimental allotments were obtained after spring shearing. Average fleece weights were greater in every year for the herds that grazed at moderate level. Weights on a "grease" or "dirt" basis before the fleeces were washed, showed differences from a low of 0.24 pounds per head to a high of 1.97 pounds and averaged 0.95 pounds for the 8-year period that such observations were made.

The greater fleece weight of the sheep on the moderately grazed areas is attributable to the larger amounts of nutritious forage they consumed. An earlier study in New Mexico presented evidence that the plane of nutrition has a marked influence on wool yield, and that well-fed sheep produce more wool than underfed sheep.

Observations on winter death-losses were also made on herds during the period of study. Death losses among the sheep on the moderately grazed range averaged 3.1 percent, of which about 2 percent were killed by coyotes and the remaining died from unknown causes. Death losses of sheep on heavily grazed range were more than double with an average of 8.1 percent, of which a little more than half was due to causes incident to malnutrition and the rest to coyotes and unknown causes. After winters with very short feed—especially when weather was cold and the snow deep—sheep on the heavily grazed range became very weak by spring and losses were extremely high, as much as 10 to 20 percent being common on heavily grazed ranges in the vicinity of the experimental range. Some herds suffered losses as high as 50 percent.

Lamb crops of herds wintered in the moderately grazed allotments and on heavily grazed range were also recorded with lambs being counted at docking time. The herd on moderately grazed winter range produced, on the average, 11 percent more lambs than the herd that wintered on heavily grazed range. Lambs at market time were also slightly heavier.

During the 13-year study period, sheep within the moderately grazed experimental allotment wintered in good condition without any supplemental feed, even in severe winters. Sheep on the heavily grazed range were fed some supplements for short periods during a few of the severe winters but the usual practice was to feed only the poorer sheep. Although receiving this supplemental feed, many of the animals still lost weight and death losses were heavy. Several other herds on adjacent, heavily-grazed range were fed considerable amounts of cottonseed cake or corn 5 different years to help carry the sheep through periods when range forage was inadequate. In one fairly severe winter, these herds were fed cottonseed cake during a period of 4 to 6 weeks, but even so, many of the ewes remained in poor condition and death losses were high.

Costs of operations and prices received are those that prevailed during the study period. Wool sales were not uniform for the two herds. In some years the wool was old; in other years, one or more of the operators shipped it on consignment. To eliminate the difference in sale methods and prices obtained for wool, $0.35 per pound was used to compute the income for wool for the two flocks. This is approximately the average sale price of wool prevailing during the study. Higher prices and operational costs now prevailing would no doubt affect the total income. However, the comparisons between moderate and heavy grazing would be proportionate to the value given.

Average net return from the herds on moderately grazed range was slightly more than twice as great as that from the herds on heavily grazed range. Annual net income per head from moderate grazing was 3.45 as compared with 1.69 per head for heavy grazing.

The greater net return on the moderately grazed range areas was directly attributable to a generally better conditions of the sheep. Death losses were lower, fewer lambs were needed for replacement, and a greater number could be sold. The herds on moderately grazed range also had a larger number of breeding ewes. Because of these interrelated factors these herds produced for market 31 percent more lamb, 43 percent more mutton, and 14 percent more wool. In addition; lambs, being approximately 5 pounds heavier, sold on the average for one-half cent more per pound.

Costs of operation during the period of study were greater in all years for the herds that grazed at heavy intensity. This was primarily because of increased expenditures for ewes in poor condition, including hauling and feeding costs. The greater replacement costs after heavier death losses formed another item of expense which reduced the net income from the herds on heavily grazed ranges.

RANGE LIVESTOCK STATION.—In a 12-year study in eastern Montana (USA), ranges stocked at approximately their proper grazing capacity, produced a calf crop 7 percent larger and calf weight per cow 43 pounds (nearly 20 kilos) greater, on the average, than comparable range pastures stocked 25 percent heavier over the years. The cows on the over-stocked ranges required practically double the expense for supplemental hay feeding as those on ranges properly stocked. Ranges stocked about 25 percent below grazing capacity produced a slightly greater calf weight per cow and required less

supplemental feeding. However, these advantages were not sufficient to offset the greater land costs.

CENTRAL PLAINS STATION.—Similarly, in the last year of a 7-year (1940-1946) cooperative study at the Central Plains Experimental Range in Colorado, (USA), yearling Herefords gained an average of 252 pounds (115 kilos) on short-grass range stocked at 40 head per section (291 hectares) for a 6-month season. This degree of use approximated the grazing capacity of the range. On comparable range, over-stocked at 60 head per section (291 hectares), the average gain was only 174 pounds (80 kilos). The better developed animals on the properly grazed land sold for 1.25 more per hundredweight (45.5 kilos). Comparable profit amounted to 1,807 per section (291 hectares) for the range stocked at approximate grazing capacity and 1,345 for the overgrazed range, even though the latter produced slightly more beef. For the entire study period, the difference in favor of moderate stocking was 43.13 per section (291 hectares) annually. The heavy stocking also resulted in cumulative soil and forage deterioration.

VERNON RESEEDED PASTURE.—Near Vernon, Utah (USA) on an area reseeded to crested wheat grass (*Agropyron* cristatum) and used as an experimental grazing pasture, the production of beef per acre (.4 hectare) is from 9 to 11 times as great as is the production of beef on similar unmanaged range that has not been seeded. Individual cattle on the re-seeded range, during a six year study, gained from 2.7 to 3.2 pounds (1 to 1.5 kilos) per head per day. Those on unseeded range either did not gain or gained less than 1 pound (about 1/2 kilo) per day and yet required five to eight times as much range area per animal. This study points out the value of reseeding in such areas.

BHAMBURDA EXPERIMENTAL PASTURE.—At Bhamburda, near Poona, India, where the rainfall varies from 15 to 20 inches (380 to 500 mm.) annually, an area of 40 acres (16 hectares) of typical kuran (native grass pasture) is being used for experimental and improvement purposes. The area, which is bounded with small contour embankment largely constructed with small stones scattered across its surface, was divided into four equal blocks for the purpose of demonstrating improved methods of range management. Twenty-cattle graze these blocks in rotation. Each year, one block is deferred so natural reseeding can take place while the remaining three blocks are rotationally grazed.

Block III, containing a very coarse, tussocky grass, was opened first for grazing while Block IV, the most inferior, was grazed last. This permitted the vegetation to become properly rooted to withstand trampling and grazing early in the season. Block I was closed to grazing until seed had dropped, and hay had been cut and stored. Only second growth was, thereby, available for grazing from December 16th to January 15th. After four yeors, at the close of one complete rotation, the number of plants had increased almost threefold, and the tussocks or clumps of grass had grown to three times their original size. The original, poor-grazing land rapidly improved with better quality vegetation including a higher percentage of legumes. Increased growth of trees and brush also occured. The result was to change a barren and scandily covered slope into a well-covered, useful pasture, whiche support more cattle than before and provides them with a larger quantity of more nutritious feed.

Following this original experiment, another was begun with 500 acres (202 hectars) on Mangdara kuran, near Poona. All small gullies were blocked with plugs (dams) or embarkments and the area was divided into four equal blocks. One block was closed to grazing each year, while the remaining three were grazed in rotation. Shifting of cattle from block to block dependend on the condition of vegetation withim a block and did not conform to any predetermined order of rotation. No fencing was required but three herdsmen were engaged to keep the 250 cattle used in the study confined to the block being grazed at any one time. The average live-weight of the cattle was 448 pounds (200 kilos) each. Natural objects such as trees and boulders marked the bouldaries between blocks. Unfortunately, no similar area was continuously grazed during the same period for direct comparison. However, after seven years of this large-scale trial, it was evident that village herdsmen can effectively utilize a system of deferred and rotational grazing. There is nothing extraordinary about the system and it can be used with good results on every grazing area of the province, if the villagers can be induced to adopt and willingly carry out similar programs of controlled grazing. The measures advocated are inexpensive, but the results can be profitable as four acres (1.6 hectares) of grazing land which at present barely provides feed for one animal can be developed to provide for two animals including a large quantity of cut grass or hay for use when range forage is insufficient.

ACTUAL EXPERIENCES OF LIVESTOCK OPERATORS (USA).—In the United States, as much or perhaps more than anywhere in the world, the need for research in the conservative management of range-lands is widely appreciated and resulting data are rather fully utilized. However, it is not research or study results that are most useful in obtaining a wider acceptance and application of range conservation. An even more important factor is the experience of the land operator.

Typical of such actual experiences in day-to-day operation of range lands are the following as related by livestockmen in Texas (USA): *Lee and Bill Reed* of Sterling City, Texas, improved the grass on their 50-section ranch about 25 percent in the four years they have cooperated with the North Concho Soil Conservation District. The Reeds accomplished this by providing more area for their cattle and sheep to graze, by dividing some of their large pastures into smaller ones, and by building water diversions and earthen water-spreading structures.

Four years ago their pastures were brilliant in spring and early summer with the yellow bloom of poisonous bitterweed (*Hymenoxys* odorata). There were as many as 1,200 plants an acre (.4 hectare). Now all but a four-section (1164 hectare) pasture is practically free from this harmful weed. Once, poison losses were considerable, now there are practically none. Also, fifteen percent of the threeawn (*Aristida* sp.) grasses on the Reed range have been killed out by better plants as by buffalograss (*Buchloe* dactyloides) which has increased 15 to 20 percent and sideoats grama (*Bouteloua* curtipendula) which has increased two or three-fold. It is estimated that plant litter has doubled or trebled. Moreover, good plants have become more vigorous in the four years since the Reeds began their conservation program.

In May, 1941, *H.O. Prideaux and his son, R.O. Prideaux,* signed a cooperative agreement with the Upper West Fork Soil Conservation District to undertake a coordinated conservation program on their 11,000-acre (440 hectare) ranch in the corner of Young, Jack, and Archer Counties, Texas. Soil Conservation Service technicians assigned to the district learned, in preparing a ranch plan with the owners, that only a 60 percent calf crop was being obtained and that 10 percent of the breeding cows and their calves were being lost. This condition was largely due to the lack of sufficient suitable pasture vegetation to nourish the animals with a resulting large percent of calves from heifers being lost because of malnutrition.

Under the conservation plan, the Prideaux's reduced their stocking rates 50 percent, built stock pounds to distribute grazing more evenly in the different pastures, and erected cross-fences so that they could practice deferred and rotation grazing. The plan was designed to give good vegetation a chance to recover and develop. Originally settled in 1874 by Dr. R.O. Prideaux, first of three generations of Prideaux to own the property, the ranch had been over-grazed to such an extent that the original tall-prairie grasses had vanished almost completely and their place on the range had been taken by less beneficial vegetation and invadors such as mesquite (*Posopis* juliflora).

In four years, the conservation plan brought these results: Hereford breeding cows averaged more than 1,000 pounds (455 kilos) as against 625 pounds (289 kilos), the low weight reached between 1930 and 1934; the calf crop averaged 90 percent as compared with a former crop of only 60 percent; and calves weighed 460 pounds (210 kilos) at marketing time instead of the 350 pounds (160 kilos) they averaged prior to 1941. Moreover, none of the heifers were being lost at calving time and no cows or calves were being lost because of malnutrition. Also, and despite the 50 percent reduction made in stocking rates, 32,300 more pounds (14,681 kilos) of calves were produced than before.

H. B. Holmes, of the Highland Soil Conservation District, Marfa, Texas, is convinced that good range conservation pays on his ranch. Says Mr. Holmes: "When I asked for assistance from our district five years ago, Soil Conservation Service technicians helped me make a thorough analysis of the grass, soil and water on my ranch. When we finished I decided to reduce my breeding herd of 230 cows which I was running on my eight-section (2,327 hectares) ranch to about 180 head. At first, I doubted if my calf weights would increase because I was already selling 420 pounds (191 kilos) calves. However, I sold 30 cows the first year and the next calf crop I sold averaged 480 pounds (218 kilos). This encouraged me, and the third year I reduced my herd more than had been recommended. When I got through selling that fall, I had only 160 breeding cows left. The next year I did not creep-feed any, a practice which I had been following for several years, and my calves averaged about 530 pounds (241 kilos). I don't mean that was just the heavy end either; that was the entire calf crop. These results convinced me that good range conservation pays."

OTHER FINDINGS (USA).—Reports from the Santa Rita experimental range in Arizona, are that a calf crop of 82.7 percent was secured over an eleven year period. Operators on the surrounding ranges, for the same period, secured a calf crop of 55 percent.

Nine-year studies in South Dakota, involved grazing of mixed-prarie vegetation to obtain utilizations of 63, 46 and 37 percent. Calf crops weaned were 55, 60, and 85 percent respectively.

Unsupplemented cows on California annual grass ranges, produced calf crops of 60, 77.8, and 72.5 percent under heavy, medium, and light grazing intensities, respectively.

On Montana short-grass ranges, calf crops of 79, 85, and 85 percent were secured under heavy, medium, and light grazing, respectively.

In a part of New Mexico, the normal lamb crop was 57 percent but on a demonstrational range improvement site in the same area it was found possible to secure a lamb crop of 106 percent.

SUMMARY.—In summary, conservative management of rangelands pays big dividends to the livestock operator. Not only are calf and lamb crops increased but indi-weight gains per animal and quality-prices received for such animals and animal products, along with reduced operating expenses, results in greater profit per unit of land area.

In addition to more income to individual livestockmen, conservatively managed ranges are better ranges. They not only improve in quantity and quality of forage but result in greater soil protection and better water yields.

As range managers, one of our most important activities is to show and convince livestock people of the many benefits to be gained from proper range management. We can use research results from other comparable areas where similar data are not locally available. However, we should make every effort to obtain such information locally and as rapidly as possible—particularly cost-benefit data

CHAPTER XVIII

BENEFICIAL EFFECTS OF CONSERVATIVE MANAGEMENT ON FORAGE

GENERAL.—A great deal of information is available throughout the world on the beneficial effects of good range management in sustaining and improving both quantity and quality of forage. It is, therefore, regrettable that poor and even destructive range use is still continuing in so many areas.

Generally speaking, most range lands under good conservative management—particularly where moisture is not too much of a limiting factor—would easily produce from two to four times as much forage as they are now producing. Moreover, this increased forage-yield would be of higher quality and composed of more succulent and palatable plants with greater protein content. In addition to greater yields of better forage, conservative range management results in many other benefits including increased production of livestock and animal products; improved soil conditions; less erosion; and more usable water when, where, and as needed.

A number of research studies on ranges comparable, in many respects, with range lands in the Middle East can be used as guides until local research projects are undertaken and completed. One such study is on desert range in the United States near Milford, Utah. Another is on arid range at Grand Prairie near Fort Worth, Texas (U.S.A.).

DESERT RANGE STUDY.—Around Milford, Utah (U.S.A.) native ranges had been severely overgrazed since the advent of domestic livestock about 100 years ago. In the Middle East such conditions have generally existed for thousands of years. Even so, forage production, when studies began at Milford, were estimated at only 20 percent of their potential. To evaluate the effects of grazing intensity on herbage yields, data were obtained from three sources: (1) sixteen 320-acre and four 240-acre experimental range pastures grazed at three intensities—light, moderate and heavy; (2) adjoining unfenced range areas—generally very heavily grazed and (3) protected enclosures—ungrazed.

Within the experimental pastures (located on valley, alluvial-fans) vegetation consisted chiefly of shadscale-winterfat-grass subtypes. These are among the most extensive plant subtypes on the winter range but they are not the most productive. During the period of study (1935-47), five species —winterfat (*Eurotia* lanata), shadscale (*Atriplex* confertifolia), Indian ricegrass (*Oryzopsis* hymenoides), sand dropseed (*Sporobolus* cryptandrus) and galleta (*Hilaria* sp.) produced 80 percent of the herbage and furnished 88 percent of the forage in moderately grazed pastures. Winterfat alone contributed 35 percent of the forage, almost twice as much as any other plant.

Utilization of forage plants was influenced primarily by their level of palatability but other factors such as relative abundance, stage of maturity and weather conditions also had considerable influence on the kind of forage eaten by livestock. Winterfat, Indian ricegrass, sand dropseed and galleta were utilized more heavily in pastures where they were relatively scarce than where they made up larger proportions of the herbage.

From papers by: Dr. George Stewart, Supervisor USAC Contract, USOM/Iran and W.M. Nixon, Soil Conservation Advisor, TCM/India.

Total herbage production of the subtypes within the pasture area was closely associated with precipitation received during the preceding 12-months. With an average 12-month precipitation of 6.68 inches (16.9 cm.), herbage production was only 219 pounds (99.5 kilos) per acre (.4 hectare). A maximum of 468 pounds (212.7 kilos) occurred following 11.10 inches (28.2 cm.) of precipitation and a minimum of 75 pounds (34 kilos) after a 2-year drought. Herbage production was also found to increase approximately 46 pounds (21 kilos) an acre (.4 hectare) with each additional inch (2.54 cm.) of precipitation. This close relationship provided a basis for forecasting forage yields and enabled local sheep operators to provide supplemental feed or otherwise make adjustments for indicated shortages of forage before moving their herds to winter range.

In the experimental pastures, the trend of total herbage production during the 12-year study was upward under all three intensities of grazing. The increases were 54, 46 and 34 percent respectively for light, moderate and heavy grazing. Winterfat, the most productive and palatable shrub in the pasture area, showed trend increases of 239, 321 and 33 percent under light, moderate and heavy grazing. Shadscale, more abundant but lower in palatability, increased slightly more under moderate grazing and much more under light grazing than under heavy grazing. Galleta and sand dropseed declined slightly under all intensities of grazing primarily because of infrequent summer rainfall. Indian rice-grass, bud sagebrush (*Artemesia* spinescens) and globe-mallow (*Malva* sp.), which made up small amounts of the plant cover, did not show any consistent response to differential grazing treatments.

Other plant subtypes showed changes in vegetal composition under two intensities of grazing on large range areas inside and outside of the experimental range. In a shadscale-Indian ricegrass subtype, yields of the palatable Indian ricegrass increased 10 percent in 12-years under moderate grazing. Under heavy grazing, production dropped 50 percent. Black sagebrush (*Artemesia* nova) a very valuable plant, increased remarkably in volume under moderate grazing on a depleted subtype which originally produced winterfat, rabbit-brush (*Chrysothamnus* sp.) and only small amounts of grass and black sagebrush. The latter species produced only 7 percent of the herbage at the start of the study but in 13-years made up more than 40 percent of the total, because of increase in vigor and establishment of seedlings. On the adjacent subtype, where heavy grazing was continued, rabbit-brush remained the dominant species.

Low-value annuals and undesirable shrub species were generally supplanted by more palatable species when grazing pressure was reduced or suspended. As an example, an ungrazed enclosure was erected on an area where Russian-thistle (*Salsola* sp.) was producing about 60 percent of the vegetation. Three years later, this species was almost completely supplanted by winterfat and Indian ricegrass within the enclosure. Seven years later, Russian-thistle produced only 2 percent of the herbage in the enclosure. On neighboring heavily-grazed ranges, Russian-thistle production was 402 pounds an acre of 54 percent of total herbage production.

GRAND PRAIRIE STUDY.—In Texas (USA), three different grassland range sites were studied—(1) valley; (2) upland and (3) ridge. The vegetation on each range site was graded into four range-condition classes: excellent, good, fair, and poor. On excellent condition range sites, 75 to 100 percent of the vegetation was composed of original or climax grasses; on good condition sites—50 to 75 percent; on fair condition—25 to 50 percent; and on poor condition—less than 25 percent.

As shown in the following chart, yields roughly doubled when the range was improved from a poor to an excellent condition.

Range Site	Range condition	Average forage yield per acre (.4 ha.)			
		Climax Grasses	Climax Forbs	Invaders	Total vegetation
		Pounds *	Pounds	Pounds	Pounds
Valley Site	Excellent	2,810	406	-0-	3,216
	Good	2,183	351	176	2,710
	Fair	1,720	244	344	2,308
	Poor	1,189	63	606	1,858
Upland Site	Excellent	1,616	371	-0-	1,988
	Good	1,266	274	164	1,704
	Fair	969	171	299	1,439
	Poor	523	83	509	1,114
Ridge Site	Excellent	1,193	200	-0-	1,393
	Good	906	158	138	1,201
	Fair	629	105	309	1,043
	Poor	346	43	339	729

* 2.2 pound = 1 Kilogram.

Improvement in the quality of forage was even more striking. On the upland range site, for example, climax grasses made up 80 percent of the forage. Post of these were the high-producing little bluestem (*Andropogon* scoparius), sideoats grama (*Bouteloua* curtipendula), big bluestem (*Andropogon* farcatus), and Indian grass (*Sorghastrum* nutans). On the range in poor condition, these climax grasses made up only 20 percent of the ground cover yet produced 46 percent of the forage. Principal invaders included buffalograss (*Buchloe* dactyloides) annual broomweed (*Gutierrezia* sp.), and western ragweed (*Ambrosia* sp.). Excellent and good-condition ranges also produced more of the better and more nutritious climax forbs (broad-leaved herbs) than those in fair or poor condition. These plants included catclaw sensitivebriar (*Schrankia* sp.) groundplum milkvetch (*Astragalus* sp.), Indian paintbrush (*Castilleja* sp.), heath aster (*Aster* sp.) and about 20 native legumes. Although their yield was less, their protein content was 20 to 40 percent higher than grass forage. Also, some are srping-growers, some summer, and some fall while others, like the Engelman daisy (*Erigeron* engelmanni) form nutritious rosettes for winter grazing.

The total amount of protein in the edible forage produced by the four condition classes also increased as range condition improved. Although the percentages were about the same—6.0 percent for poor condition and 6.5 percent for excellent—total weights were quite different. For example, the upland range produced 67 pounds of protein per acre in poor condition, 90 pounds in fair, 110 pounds in good, and 129 pounds in excellent condition.

These differences show up in the land, in the plants, and in the livestock as ranges improve. The condition of each range is wholly under the operator's control; his management determines what kind, and how much, forage his land produces. Through conservative management, with full use of forage each year after maturity, individual range areas have been improved from poor to good condition with doubled forage production in less than 25 years.

SUMMARY.—Even though local research is limited or lacking, the results of many studies in other parts of the world have direct application to Middle East areas. In other words, the application of conservation management practices need not and should not await additional research work—as desirable and valuable as further studies may be.

As range managers, then, our job is to bring about conservative range management in every way possible. We should not hesitate to utilize results of research work elsewhere. Moreover, we should endeavor to initiate such work locally while continually stressing the beneficial effects of good range management.

PART V

RANGE IMPROVEMENTS

INTRODUCTION

Too many times, range improvement is considered merely as the structural features which man can build. At other times as certain, artificial or unnatural treatments of range lands, including reseeding or the eradication of undesirable plants. All too frequently, however, little or no reduction in excess livestock use or change in destructive grazing practice is contemplated even though so universally necessary on poor, deteriorated range lands. It is only infrequently, and to quite a limited extent, that reduction in grazing pressure and changes in grazing use will not be required for range improvement. Generally, and especially in the case of reseeding and similar treatments, nature will make more lasting and less costly improvement in ranges if only man would cooperate and observe good, sound range management principles and practices in his use of grazing lands.

There are, of course, the exceptions where structural improvements and mechanical treatments, including reseeding, merit primary attention. As range managers, we must, in such cases, refrain from initiating uneconomic structural or artificial range improvement measures if we are to deserve and maintain the confidence and support of range people, the general public and government. Sound judgment is very necessary.

Some of the really worthwhile range improvements, in addition to proper range management, include those which complement good management. Examples include (a) water developments in areas of unused or little used feed where water is a principal limiting factor or where such development will result in better range use on the surrounding area—good control of livestock is also necessary; (b) fencing to make possible deferred and rotation-grazing, or to eliminate trespass (unpermitted use), or to protect areas needing protection or for similar purposes; (c) range waterspreading where water, particularly flood-flows, which would otherwise be wasted or perhaps cause down-stream damage can be diverted so as to irrigate and thus improve forage producing lands; (d) range pitting and contour furrowing, particularly in arid and semi-arid regions to better conserve and utilize all water that comes in contact with the soil; (c) access roads and trails to make otherwise unused range forage available and usable; (f) reseeding where recovery by natural re-vegetation will not result within reasonable time limits; (b) poisonous and noxious plant control where natural control through better management would be either impossible or too long delayed and (h) rodent and insect control of range destroying species when, economically justified.

Many structural and artificial range improvement projects require a working knowledge of engineering methods and equipment. Whenever possible the range manager, unless unusually qualified in range engineering, should solicit the services of a qualified engineer—at least for the more precise phases of engineering work. We should all have, however, a basic knowledge of at least the more elementary engineering tools as for example: levels (dumpy, abney and carpenters); the magnetic compass for bearings and land-line surveying; chain, tapes and other measuring devices and hand tools of various kinds.

CHAPTER XIX

RANGE ENGINEERING EQUIPMENT

GENERAL.—Range surveys, studies and structural range improvements, in particular, require some knowledge of engineering. For this reason we, as range managers, should understand and be able to use simple engineering equipment. Obviously, the best way to become familiar with equipment is through use. Even so, there is often a value in having access to simple written instructions to which we may refer for aid in using unfamiliar equipment or in the event that we may have forgotten some of the steps in the use of more familiar engineering tools.

This chapter includes some of the reference material that could prove useful. Engineering handbooks as well as instructions provided with most engineering equipment are additional sources of information.

THE DUMPY LEVEL.—The Dumpy is used for differential leveling, profiles, cross-sections and layout-work on water spreading systems, stock ponds, terraced contour-furrows and ditches. It is the instrument most used by engineers and is and should be regarded as a scientific implement. Care must be exercised at all times in the use of the level and in transporting it to and from the field.

To operate the Dumpy level the following steps are necessary: (1) set up the tripod with the legs well apart and placed firmly in the ground; (2) tighten the wing nuts in the triplod legs, and remove the cap from the tripod; (3) carefully remove level from the box (care should be taken in this operation so that the level is not bumped or jarred) and place the level on the tripod head, then screw it firmly into position; (4) remove the dust cap from the telescope of the level and place the sunshade in the telescope; (5) level the instrument by placing the telescope directly over two opposite leveling screws and adjust the screws until the level bubble is centered, then repeat the above operation until the bubble remains centered when the telescope is turned through an arc of 360°; (6) adjust the eye piece until the cross-hairs are plainly visable and the instrument is now ready to be used. . . the focusing screw should, of course, be adjusted each time until the image of the rod is perfectly clear before attempting to read the rod.

LEVELING RODS.—There are two general classes of leveling rods: (1) the self-reading variety that may be read directly by the observer as he looks through the telescope of the level and (2) the so-called "target" rods or those on which a disc or "target" sliding on the rod is set by the rodman as directed by the leveler. Rods are available in a variety of patterns and graduations and are either in single pieces which are joined together or slide past each other and are clamped together. A common length is 12 feet (about 4 meters).

Used in conjunction with leveling instruments, these graduated wooden rods of rectangular cross-section are the means by which differences in elevation are measured. The lower end of most rods is shod with metal to protect them from wear and is usually, though not always, the point of zero measurement from which rod graduations are numbered.

From papers by: Jack A. Griffin Agricultural Engineering Advisor, USOM/Pakistan.

A most important item to remember is that leveling rods must be held in a true vertical position since the reading of the rod as indicated by the horizontal cross-hair of the level is a measure of the vertical distance between the point on which the rod is held and the line of sight. Oftentimes, an attachment called a "rod-level" is used to insure that the leveling rod is correctly held.

HAND LEVELS.—For rough leveling, a simple hand level is often employed. Ordinarily, these instruments consist of a brass tube about 6 inches (15 cm.) long on top of which is mounted a bubble. In the tube beneath the bubble is a prism and openings are left in the tube whereby the image of the bubble is reflected by the prism to the eye-end of the level. Just beneath the bubble vial is a cross-wire which is adjustable by means of a screw protruding through the end of the case enclosing the vial.

The eye piece usually consists of a peep hole mounted in the end of a slide, then on the right half of the inner end of the slide is mounted a semi-circular convex lens which magnifies the image of the bubble and cross-wire as reflected by the prism. The magnifying lens is then focused by moving the eyepiece shade in or out.

In using such levels, the object is viewed directly through the left half of the tube without magnification while with the same eye and at the same time the position of the bubble with respect to the cross-wire is observed, apparently in the right-half of the field of view. The level is held with the bubble vial uppermost and is tipped up or down until the cross-wire bisects the bubble, when the line of sight is horizontal. After practice, better observations are possible if both eyes are kept open.

A very common and useful hand level is the so-called "Abney Level and Clinometer" as this instrument is suitable for both direct leveling and for measuring the angles of slopes. When used as a level the index of the vernier scale is set at zero. When used as a clinometer, the object is sighted and the level tube is moved by means of its control screw until the cross-wire bisects the bubble as viewed through the eye piece—the reading resulting being the percent or degree of slope depending on the system into which the scale is graduated.

Hand levels should, of course, be kept in proper adjustment. The simplest procedure is to hold the hand level alongside an engineer's level which has been leveled and sighted at some well-defined point. The line of sight of the hand level should strike the same point when the bubble is centered. Lacking the opportunity for such a check, the so-called "two-peg" test may be employed.

In the two-peg test; two posts, trees or other convenient objects are selected on nearly level ground. Holding the level (with bubble centered) at a marked point on the first object, sight and establish a mark on the second object. Without making any adjustment of the level take a "back-sight" or sight back from the mark established on the second object to the original mark on the first object. If they coincide, the level is in adjustment. If they do not coincide, mark the back-sight point on the first object and since the distance between the original mark and the back-sight mark on the first object represents double the error, adjust the level to back-sight from the second object to a point midway between the two points established on the first object.

On the Abney Level, adjustment is made by raising or lowering one end of the level tube until the bubble is centered, the index having first been set at zero on the graduated arc. On the "Loche" and similar levels, adjustment is made by means of a screw at one end of the level tube which moves the cross-wire defining the line of sight.

COMPASS.—There are two principal types of compasses in general use: (1) ordinary pocket varieties which are sometimes usable on very rough exploratory surveys and (2) engineering compasses, with which we are most concerned and interested. The essential features of the latter are (a) a compass box with circle graduated from 0° to 90° in either direction from the N (north) and S (south) points and having the E (east) and W(west) points interchanged, (b) a line of sight in the direction of the N-S points of the compass box and (c) a magnetic needle which may be raised from its pivot and clamped in position. Usually such compasses are also provided with a ball and socket joint to facilitate attachment and support on a tripod or, more normally, on a pointed metal-tipped, small, round 4 1/2 to 5 1/2 foot (1 1/2-2 meter) pole or stick—the so-called "Jacob's Staff."

In using the compass, where the line of sight is pointed in a given direction, the compass needdle when brought to rest, gives the magnetic bearing—always read the north end of the needle, the one which is usually marked with an arrow. Obviously, the compass should be leveled (using the level tubes on the instrument) each time a reading is taken.

The magnetic bearing (compass needle position) and the true bearing are different. Accordingly, and in order that true bearings may be read directly, most good compasses are so designed that the compass circle may be rotated with respect to the plate on which it is mounted. This adjustment is termed "setting off the declination." Before using a compass, check to be certain that the proper declination has been set off so true-bearing readings will result.

Other possible sources of error in compass work include: bent needle; bent pivot; plane of sight not verticle or graduated compass circle not horizontal; sluggish needle; reading wrong end of needle; and deviations due to local magnetic attraction (metal pencils, local magnetic deposits, static electricity, etc.).

CHAINS AND TAPES.—In determining distance, the most accurate and most common method is by direct measurement. Generally, direct linear measurements are made with metallic tapes of varying lengths but in engineering these tapes are usually 66 feet or 100 feet long. Pacing may be used in very rough determinations but even so the basis of paced distances are established by the measured length of the pacer's step.

Important things to remember in using chains and tapes is to keep them taut, horizontal, free of twists or "kinks" and, of course, making correct reading and recording of measurements. Correction factors must be applied unless horizontal measurements are made, particularly on very rough land or on very steep slopes.

OTHER ENGINEERING EQUIPMENT.—There may be occasions when we, as range managers, may be confronted with problems requiring engineering tools other than those which are considered in this chapter. In most cases, however, we can secure the assistance of qualified engineers or through study, equip ourselves to use such other equipment as: transits; photogrametric implements including radial line plotters and projectors; plane tables; planimeters and other area-determining devices; etc...

The important thing is that we become familiar with the simpler and most-used engineering tools. Keep in mind that the infrequently used implements can be explored and studied, then used as the need arises.

CHAPTER XX

RANGE WATER DEVELOPMENTS

GENERAL.—Range water developments are important, not only to improve the availability and quality of water for livestock but, also, to aid in obtaining a more even distribution of livestock on range lands as well as to secure utilization of areas which would otherwise not be as completely usable. Many types and kinds of water developments are common throughout the world. The principal ones, however, include: spring and seep improvements; stock ponds or reservoirs; and wells with windmills, pumps, hoists or other lifting devices.

Generally, livestock are limited in the distances to which they will or should travel for water. Cattle, for example, should not have to travel over 3/4 of a kilometer in rough country, 1-1/2 kilometers in rolling areas and 3 to 3 1/2 kilometers on level ground. Sheep watering places, on the other hand, may be up to 4 or 5 kilometers apart in level country. In rough country, sheep should not have to travel over 2 to 2 1/2 kilometers. Cattle also require more frequent waterings—daily preferred—whereas sheep may easily go several days without watering.

In addition to spacing, another very important factor in water developments is the quantity of water. Cattle can take better advantage of limited supplies at springs and seeps since fewer head normally water at one time. This is true, even though cattle will drink a minimum of 6 to 10 gallons daily as against only 1 to 1-1/2 gallons for sheep at each and usually less-frequent watering.

SPRINGS AND SEEPS.—Springs with large flows or those on wet sites should be fenced and the water piped or otherwise conducted to troughs or tanks, preferably metal, cement-masonry, or wood. Fencing is also desirable on most low-flow springs and seeps. In nearly every case, and particularly when supply is limited, the water source should be dug-out and enclosed in a well-built, open-bottom, closed-top box of cement, stone-masonry, brick, or wood construction. Lead-in pipes or conveyors from the water source to troughs or tanks should be large enough to prevent "clogging" or plugging-up. Furthermore, they should be firmly anchored and protected against damage from livestock, usually by being well-covered or buried. Troughs and tanks should also be well protected against damage from livestock, have solid foundations, and include facilities for draining or diverting waterflow whenever livestock use is not desired in the vicinity or, for example, where freezing damage would otherwise result. In addition, overflow water should be properly carried away from the trough or tank location to keep the area dry and in better condition.

An important factor to remember is that flows of less than a gallon per minute are not usually sufficient to justify development for regular use by sheep. Also, that where troughs have insufficient capacity for a full band of sheep they must depend on refilling as the sheep drink. In many such cases, extra troughs or tanks or other storage capacity is necessary.

Trouble is frequently encountered with green-algae growth, often called "moss," developing in tanks or troughs. This trouble can be eliminated by using a dilute solution of one part of blue vitrol

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From papers by: Jack A. Griffin, Agricultural Engineering Advisor, USOM/Pakistan, and Clarke A. Anderson, Leader, 1957 Regional Range Management Course (Iraq).

(crystalline copper sulfate) to a million parts of water. Water diluted to this extent is perfectly safe for livestock.

STOCK PONDS OR RESERVOIRS.—In arid or semi-arid countries where surface springs or seeps and irrigation water is not available, or very temporary in nature, the possibility of developing ponds or reservoirs merits consideration. Obviously, livestock water must be available at all times and in adequate quantity if animals are to live and produce satisfactorily.

There are certain conditions that must be met in selecting a suitable site for a pond. It should be located so that it is easily accessible to livestock and so animals do not have to travel great or excess distances. The site should also be located on a source of water that is free of filth and the ratio of the runoff area should be approximately fifty acres (about 20 hectares) for each acre foot of water storage in the pond.

The soil, which is of primary importance, should be deep and impervious. The best material for construction purposes and waterholding ability should have a ratio about as follows: coarse material or sand and gravel about 50 to 70 percent; intermediate soil particles 20 to 30 percent; and fine or clay materials about 10 to 20 percent. If the coarse materials are greater than in the above ratio, then problems such as seepage through the fill may occur. On the other hand, if the fine materials or clays are in a very high percentage, then there is likelihood of dry-weather cracks forming due to the shrinkage of the clays.

The depth of the water in the pond should be at least six to eight feet in order to take care of surface evaporation. Remember that the depth of the water and not the size of the pond determines the permanency of the water supply.

The area over which the water will discharge in times of heavy rains, should be flat and smooth and have a good cover of grass—this area is called the spillway of the dam. Care should be taken in the building of the dam itself to have a stable fill across the stream. The dam should have a slope of 3 to 1 on the upstream face and 2 to 1 on the downstream face. The top of the dam should be at least six to eight feet (2-2 1/2 meters) in width.

In most cases, as in other water developments also, fencing may be desirable to prevent damage by livestock and to keep the water as clean as possible.

WELLS.—The development of well-water on range lands is most important where livestock water is limited or not available and adequate from other sources. Wells are a most expensive type of water development. On the other hand, even deep-wells are economical and practical when they provide a source of water, especially for both local use and for hauling to livestock at more distant locations.

Several factors should be considered in determining the need for wells including: the results obtained from other wells in the vicinity; the proximity and relative elevation of nearby water locations such as springs, streams and lakes; and the possibility of finding well-water based on geological factors existing at the site.

Common methods of constructing wells include digging, drilling or driving a well-point. Many methods are used in drawing water from wells. Where wind is adequate and dependable, windmills are very useful. Where winds are not dependable, pumps are usually powered by gasoline or diesel motors or sometimes by electricity. Quite often, power-driven equipment can be supplemented by windmills during part of the grazing season. In other places, hand or animal-powered hoists or lifts may be necessary.

As with all range improvements, the development of water and well-water, in particular, must be based on actual need and benefits in relation to the cost of their installation.

CHAPTER XXI

RANGE FENCES

GENERAL.—Fences are often a vital factor in sound range management programs, particularly where grazing animals are not herded or well-controlled. There are many classes of fences as: exterior or boundary to prevent trespass by livestock; pasture and division to improve or facilitate livestock management on a specific range or forage area; and plot or protection to exclude livestock where grazing use would be harmful or for range study or other purposes.

There are also many kinds and types of fences including wire (generally barbed); pole or rail; brush; rock; and electric. Fences also require openings for lawful passage as through gates on road and trail crossings, and so called "cattle guards on road crossings.

As range managers, our principal concern will, normally, be with simple barbed-wire fences and gate openings or in rare cases with "cattle guards." Occasionally, we may use electric fences but, generally, the instructions furnished with electric fencing materials will be adequate to insure proper installation of such fences.

BARBED-WIRE FENCES AND GATES.—There are, of course, many methods of building range barbed-wire fences. Without entering into a treatment of the relative merits of any particular system, some of the characteristics of good barbed-wire fence and gates, using steel posts, are as follows:

1. *The posts* should be properly aligned, faced, spaced, set in the ground, and braced. Insofar as possible, always run the fence in a straight line between necessary corners or angles. Face the post (the side to which the barbed-wires will be attached) toward the direction from which the greatest pressure from livestock will come. except for corner posts, which should be faced away from the inside of the angle formed when the fence changes direction. Space the posts 5 meters apart. Line posts (between corners) should be set in the ground to a depth of 75 centimeters, and firmly tamped with a mixture of stone and clay-bearing soil, or they should be set in concrete. The main justification for setting line posts in concrete is to prevent them from being stolen. Where theft is not an important factor, line posts in a range fence need not be set in concrete. Gate posts and corner posts are best set in concrete, to a depth of at least 85 cm. All corner posts, gate posts, posts to which wire will be stretched (about every tenth line post), and posts in the bottoms of draws or depressions should be properly braced against the direction that tension from the barbed wires will be exerted.

2. *The wire* should be securely fastened (so that there will be no slipping) to all gate, corner, and line posts. It should be tightly stretched, and properly spaced. On posts with built-in "staples" or wire fasteners, spaced 7 1/2 cm. apart, where five barbed-wires are used, the bottom wire should be 22.5 cm. above the ground line, the second wire at 45.0 cm., the third at 67.5 cm., the fourth at 95.7 cm., and the fifth or top wire at 127.5 cm. This spacing for 5 wires gives maximum protection against sheep and goats, and is sufficiently high to turn cattle and horses. If six barbed wires are used on posts of this sort, the bottom wire should be 15.0 cm. above the ground line, the second at

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From papers by: L.R. Short, Range Specialist, USOM/Iran, and
Clarke A. Anderson, Leader, 1957 Regional Range Management Course (Iraq).

37.5 cm., the third at 60.0 cm., the fourth at 82.5 cm., the fifth at 112.5 cm., and the sixth or top wire at 142.5 cm. above the ground line. In stretching the wire, start with the ground wire, and progress upward with successive wires after the first has been securely fastened to all posts.

3. *Gates* made of wire are the most common type used in conjunction with barbed-wire fences. Normally they consist merely of a short section of fencing with a metal or small wooden post (usually about 1/2 meter shorter than line posts) at each end and with wooden or wire stays in between to prevent the barbed-wire strands from tangling as the gate is opened or closed. The left side of this gate section is normally, and more or less permanently, attached to the fence-line gate post with 2 or 3 heavy or twisted wire loops to make that side of the gate fast to the gate post. The right side of the gate section (the side that is free for opening and closing) is attached more temporarily, usually by inserting the lower portion of the gate end-post into a wire loop at the base of the fence-line gate post and dropping over the top portion of the gate end post another wire loop similarly attached near the top of the fence-line gate post. In other cases, of course, wooden or metal-swinging types or other forms of gates may be used.

Proper and improper fence alignment as well as gate post details are shown in Figure 9.

ELECTRIC FENCES.—Often-times, a need exists for very temporary fences as to protect reseeded areas for one or two seasons or to cross-fence pastures when cross fences are to be frequently moved as aids in securing even and proper range utilization. A most suitable fence in such situations is the so-called "electric fence."

A very simple electric fence consists of a single strand of wire (usually barbed) strung on insulators to temporary posts at a height of about 1 meter above the ground to which is attached a battery (wet or dry) in conjunction with an "electric fence controller." Instructions are usually provided with the controller unit. Special batteries are also available which will energize as much as 16 kilometers of fence. Wire splices should, of course, be very tight.

Electric fences provide a high voltage, low amperage electric impulse which is very effective in "shocking" or keeping livestock away from the fence line. Accordingly, there is no appreciable strain on the wire, so very light construction is practicable.

In dry soils that act as poor "grounds," as much as 600 to 700 volts may be required to keep stock away from the fence or else a second wire must be added about 1/3 meter above the surface-soil line. This second wire should also be fastened to the posts but be "grounded" at both ends of the fence—suggested are regular copper-coated telephone ground rods.

Electric fences should, of course, be well signed so the public will be adequately forewarned. Because of obvious dangers, no "homemade" installations using power plants or other sources of high voltage should be attempted. Needless to say, also, the instructions furnished with the electric fence "controller unit" should be carefully followed. Moreover, regular inspections, at frequent intervals are a necessity if electric fences are to function satisfactorily.

DIAGRAM OF PROPER AND IMPROPER FENCE ALIGNMENT

RIGHT

1. Fence runs in straight line between corners.
2. Corner posts on inside of angles.
3. Wire on face of post toward livestock pressure.

WRONG

1. Fence changes direction at nearly every post.
2. Wire is on face of post away from livestock pressure.

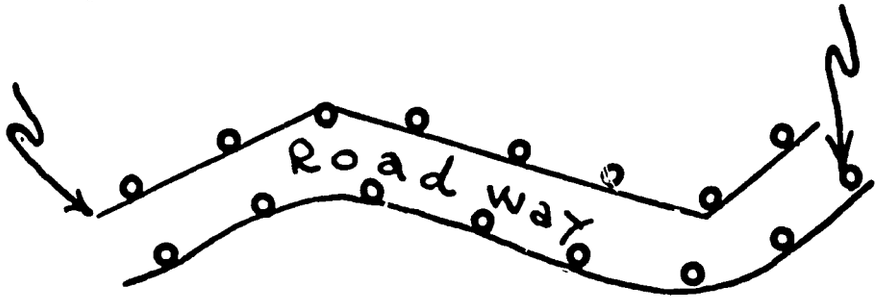


DIAGRAM OF POSTS PROPERLY BRACED

CORNER POSTS

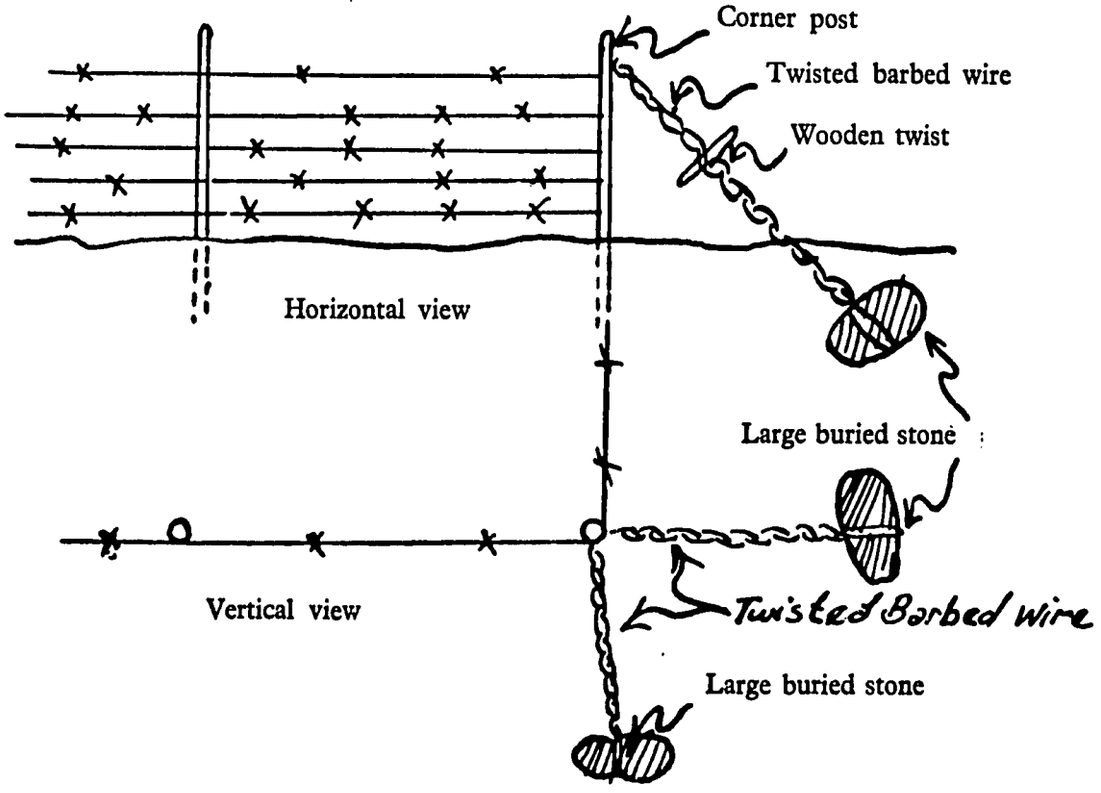
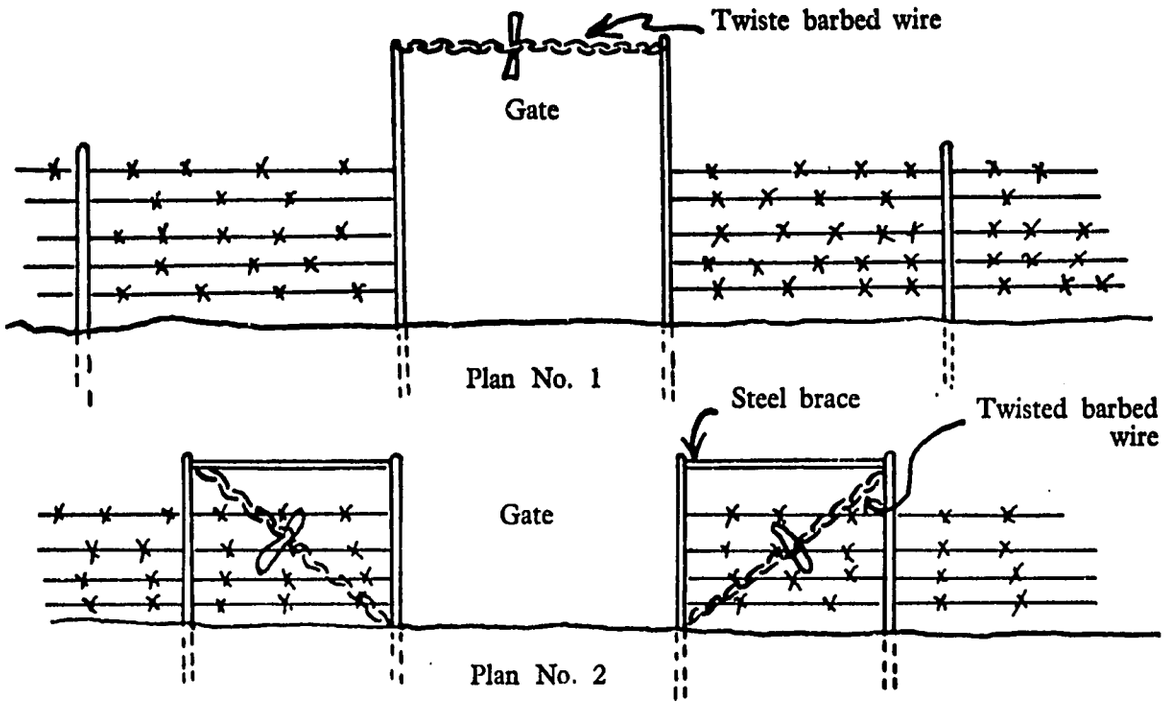


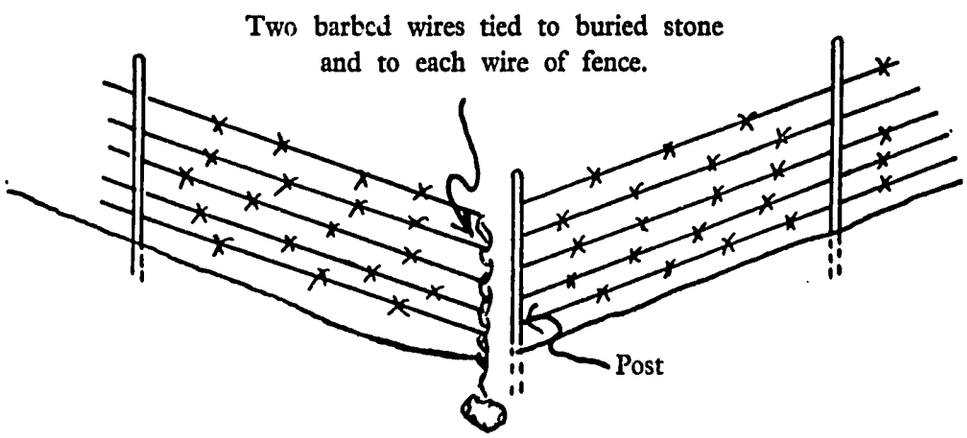
FIGURE 9

(OVER)

GATE POSTS



POST AT BOTTOM OF DRAW



NOTE: The twisted barbed wires shown in the above diagrams are made up of two strands (untwisted) of barbed wire that are firmly tied to the post or stone, then twisted by means of an iron rod or a stick of wood inserted between them, until they are quite tight.

(OVER)

CHAPTER XXII

WATER SPREADING ON RANGE LANDS

GENERAL.—The growing of vegetation in arid climates is a constant challenge to man. Water in the form of rainfall or snow is often a most limiting factor in the growth of range forage. In an attempt to supplement such annual moisture, a crude form of irrigation, or so-called "water-spreading" is sometimes employed.

Water spreading systems may sometimes be multiple-purpose systems so that erosion is controlled while runoff water is conserved through allowing it to be diverted over flat, level lands. If the water can be made to stay on the land for a reasonable length of time then it can penetrate into the soils to depths of three to four feet (about a meter) where it will be available to growing plants.

In order for a system to be successful, certain conditions recognizable to the range, engineer such as the source of water, the area on which water is to be spread and the spreading system itself must be met.

THE WATER SUPPLY.—The water supply is usually from a stream which is normally dry except during rainy periods or when snow melt causes it to flow at certain times of the year. First, then, we must determine if the water supply is dependable; that is, if it will flow at least once or twice each year. There should be enough water to irrigate the area and yet not so much that uncontrollable flows are encountered. The supply of water should not have a large amount of silt as a silt overflow is very detrimental to plant growth.

In addition, the engineer must determine (1) the rate of peak flow per second and (2) the total volume of water that will be available to the area.

1. In determining peak flow the following must be considered: (a) Topography —examine the area and determine the watershed conditions so that an estimate of the amount of water that will run off the watershed is obtained. Usually, steeper slopes will contribute a larger percent of runoff. (b) Rainfall—study all available precipitation records for the area so that the total amounts of rainfall will be known. The rainfall intensity for the area is very valuable if such information is available. Talk to local people as they can give valuable information about rainfall. (c) Soils—examine the soils of the runoff area and the area on which the water is to be spread. Ordinarily, shallow soils are not used to spread water—deep soils are generally selected. If the soils are deep and have a high rate of moisture intake, then by spreading water over the land good results can be obtained. If however, the soils are high in clay then the water must be impounded on the land for best results. (d) Vegetation—the land should have a cover of vegetation—do not attempt to spread water on bare areas. If water spreading is attempted on bare soils, erosion is certain to result.

When the above four steps are completed, then the peak rate of runoff can be computed by using what is commonly called the "slope-area"method as follows: (a) Determine the x-sectional area of the channel by noting the high water mark of the stream and taking an x-section with a level and

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From a paper by: Jack A. Griffin, Agricultural Engineering Advisor, USOM/Pakistan.

tape. This step can best be demonstrated in the field. (b) Determine the slope of the stream by taking a profile up and down the stream channel for a distance of 200 meters. (c) Determine the roughness factor—"n"—of the stream bed.

2. With the above information, the engineer can then determine the peak rates of stream flow by using certain engineering formulas that deal with hydraulics of water, such as $Q = av$ and the Chezy Velocity Formula of $v = c\sqrt{rs}$.

When the peak flow is determined, then the total volume of water must be determined. For average streams, this volume is usually arrived at by taking the peak flow and dividing by two then multiplying this value by the time in hours that the stream will be in average flow. The formula is: *Volume Q (peak flow in CFS) x time in hours x* 0.0827 or the number of acre feet of water available to the area. In other words, the water supply.

THE SPREADING AREA.—Topography of the spreading area should be flat with slopes of 0 to 3 percent. Where the soils are tight and do not permit water intake at a rapid rate, then slopes should be one percent or less. The area should have a flat, uniform grade and be devoid of depressions or gullies.

Soils of the spreading area should be deep and have a good rate of water intake. The water must not contain large amounts of silt for the silting of an area can kill the vegetation and also decrease the moisture intake rate of the soil.

Vegetation on the area should be capable of using additional water and should be sufficiently dense in ground cover so that erosion will not occur. Certain areas may need to be contoured to help in distributing the water evenly over the surface and some may need to be seeded in order to spread the growth of desirable vegetation on the spreading area.

SPREADING SYSTEM.—The kind of system best adapted to an area will be selected on the basis of the water supply and the nature of the spreading area.

If the water supply is large, then the best method is usually a diversion channel that may divert all or only a small percentage of the total stream flow. When small flows are encountered then diversion dykes are best as they are more stable.

When the area is flat, with soils that have a good rate of water intake and if the water is allowed to flow over the area, good results can be obtained. If the area has a soil that is tight then, usually, dykes that impound the water on the area must be employed. In addition, contour furrows, pits, or chiseling may be necessary in order to open the soil and increase the rate of water intake. These are, however, merely temporary expediencies until a vegetative cover can be obtained on the soil which will increase and maintain intake rates.

In some areas, where rock is available, excellent structures can easily be built that will give good spreading results. These may be concrete and rock or loose-type structures that allow water to flow through them as well as to divert stream flow.

There are many combinations of the above methods. Each area will, in itself, determine the best system to be employed.

CHAPTER XXIII

PITTING AND CONTOUR FURROWING

GENERAL.—Moisture deficiency is generally recognized as the chief limiting factor in range-forage production. To some extent, moisture shortages are due to losses of precipitation in run-off (overland flows) during intense storms exceeding the absorption capacity of the range. The answer is, therefore, to find a practical and economical method of preventing water losses through run-off and thereby increase range-forage production. The extensive areas of native range throughout the world suggests the possiblity of significant increases in economic returns with increases in range forage production.

Two important mechanical processes, as reported by Mr. O.K. Barnes of the Soil Conservation Service on studies made near Cheyenne, Wyoming (USA) are the so-called "*Pitting*" and the "*Contour Furrowing*" treatment of range lands. Pits are merely man or machine-made depressions or basins usually 3 to 4 feet (about a meter) long and about 16 inches (40 cm.) apart. Contour furrows are simply small ditches or water channels constructed on a level gradient or contour across a land area—optimum spacing has been determined to be about 5 to 6 feet (1-1/2-2 meters).

Barnes study indicates that closely spaced furrows or basins are most effective in holding water. Also, that the tillage effect of mechanical pitting and furrowing treatments stimulated and renovated range plants with the result that a marked increase in forage followed even though extra water was not held in the furrows or basins. Similarly, almost three times as much mulch (dried vegetation) resulted the first four years as on adjacent untreated ranges.

The area on which experimental work was concentrated is at an elevation of 6000 feet (1818 meters). Land surface is nearly level (1 to 2%) to gently undulating (up to 8%) and major soil type is brown, loose, porous, mellow, non-calcareous, fine sandy-loam having no discernible structural features. Vegetation is dominately short-grass: *Boutelona* gracilis and *Buchloe* dactyloides—with some *Agropyron* smithii, *Stipa* comata, *Poa* secunda and *Koeleria* cristata as well as *Shaeralcea* coccinea, *Plantago* purshii, *Lepidium* apetalum, *Artemisia* frigida and *A.* glauca. Average precipitation is 15 to 16 inches (38 to 40 cm.).

PITTING.—Pitting is usually accomplished with an ordinary one-way "Wheatland" plow—having alternate discs off-center. These eccentric discs should be 2 inches (5 cm.) larger than the regular discs which are usually about 18 inches (45.7 cm.). They should also have the gang-bolt hole 2 inches (5 cm.) off center. To mount such eccentric discs properly on the wheatland plow and starting from the rear of the gang-bolt proceed as follows:

1st disc — 18 in. (45.7 cm.)
2nd disc — 20 in. (50.8 cm.) *Eccentric* with long side up.
3rd disc — 18 in.
4th disc — 20 in. *Eccentric* with long side to the rear.
5th disc — 18 in.

From a paper by: W.M. Nixon, Soil Conservation Advisor, TCM/India.

6th disc — 20 in. *Eccentric* with long side down.
7th disc — 18 in.
8th disc — 20 in. *Eccentric* with long side to the front.
(Continue in this same rotation until all discs are mounted).

The gang-bolt hole in every 20 inch (50.8 cm.) disc is 2 inches (5 cm.) off-center to form the eccentric discs. The same principle can be applied to most disc implements with variations to meet requirements of the equipment. Such a system of mounting the discs not only produces the desired pattern of pits, but also gives an even distribution of the draft (pulling or drawing stress) on the implement.

The eccentric disc-plow is also useful in summer-fallowing. In pitting, however, the implement must be carefully regulated as to depth in order to prevent cutting the sod by the smaller discs. If considerable pitting is to be undertaken it is advisable to remove all smaller discs and in their places put large washers to take up the width on the gang bolt. Also, by removing the smaller discs it is possible to deepen the pits 1 inch (2.54 cm.). The resulting pitting operation leaves the surface resembling a "waffle", with pits about 16 inches (40.6 cm.) apart. The actual volume or holding capacity of an area so pitted amounts to a rain of approximately 0.3 of an inch (0.8 cm.). This result may be obtained with large grooves spaced at 10 feet (about 3 meters) intervals, or small grooves at 2-foot intervals. Since the pits are not connected, it is not necessary to place them on a level contour. Rather, the implement can best be run on a course that appears to be approximately at right angles to the slope.

In general, pitting was found to increase forage production by 25 to 100 percent on mixed shortgrass ranges. However, little effect was evidenced on the production of pure stands of wheatgrass (*Agropyron*), in sage brush-wheatgrass types (*Artemisia-Agropyron*) and on desert shrub vegetation. "Hard-land" ranges that were relatively barren and crusted were especially benefited by pitting operations since the rate at which rainfall entered treated soils was approximately doubled. Cost of pitting ranged from 30 cents to one dollar per acre (.4 hectare). However, if only labor charges and tractor-operation expense were considered the unit cost was somewhat lower.

CONTOUR FURROWING.—Experiments were conducted using three types of furrowing equipment —plows, groovers and killifers. Furrow intervals tested were 5-, 10-, 20-, and 30-feet (1 1/2 to nearly 10 meters). The 5-foot (1-1/2 meter) interval was the only spacing that significantly increased forage production. Both the plow and the groover were equally effective. However, the killifer failed to increase forage production at any furrow interval.

Effect of the closely spaced type of mechanical treatment on the range cover was, apparently, a general stimulation of the vegetation. Thinning the cover appears to make more moisture and plant food available per remaining plant, and such plants exceeded, in most instances, the production of a greater number of plants on untreated range. The tillage and thinning also brought about an increase in western wheatgrass and other desirable species but at the expense of the blue-grama grass. The resulting dominance of these species raised total forage yield, increased the food available in early spring, improved the ability of the range to hold and retain moisture, and bettered the quality of the range feed through a greater volume of a variety of grass species.

Influence on the original composition of the cover seemed to vary with the spacing of the treatment. The wider the interval between the furrows, the less the effect on the cover as a whole. Generally, however, any treatment spaced wider than 4 to 5-feet was not found to have a real influence in overall vegetative composition on short-grass range.

SUMMARY.—Field trials of pitting and contour furrowing on different soils and vegetative types indicate that such treatment can be expected to improve all shortgrass types of range. However, no appreciable increase in production resulted on the other types tested. The increase resulting in different locations may or may not be as great as the increase obtained on the study area since climatic conditions, actual application of treatment, and other factors also greatly influence plant response. However, in no instance is pitting or contour furrowing expected to reduce forage production.

Pitting increased shortgrass range grazing capacity about one-third and resulted in an average of 9 pounds more lamb per acre (.4 hectare) each year over a 10-year test period. Even under heavier stocking rates, pitted pastures had a 70 percent carryover of perennial grass than did similar untreated

pastures. In earlier experiments, pitted and groved (contour-furrowed) pastures, supported 22 percent more grazing and produced 6 and 8 pounds more lamb per acre (.4 hectare) along with 30 to 50 percent more grass remaining at the end of the grazing season.

Both treatments also aided in holding run-off during heavy rains. The actual holding capacity of the pits was about 1,000 cubic feet per acre or the equivalent of 3/10's of an inch (0.8 cm.) of rain. Moreover, and on limited tests, pitting was found to increase the infiltration capacity of ranges by over 50 percent. In addition, seeding grass into the pits appears to hold some promise as a reseeding method on sparsely covered sagebrush and desert sites, although when applied to shortgrass range types it failed to establish any appreciable amount of seeded grasses.

Pitting has proved to be the most economical of all the successful treatments tested. Grooving or contour plowing (furrowing) at 2-foot intervals can, however, be expected to accomplish about the same results as pitting, but at higher cost.

CHAPTER XXIV

OTHER STRUCTURAL AND NON-STRUCTURAL RANGE IMPROVEMENTS

GENERAL.—In addition to the more common range improvement structures, particularly fences and water installations, a real need often exists for such developments as: livestock bridges; driveways; access roads or trails; and plant, insect or rodent control measures. Actually, however, the worth and value of these and similar improvements may often be quite intangible. Moreover and even though their economy of installation may be less than with more direct improvements, the latter will ordinarily return a greater income per individual grazing animal.

Again, as with other range improvements, careful studies should be made and all values thoroughly weighed before work is begun. In addition, other agencies or organizations will usually be involved.

BRIDGES.—For many areas, particularly where water crossing facilities are inadequate or lacking, stock-bridges may be necessary to secure proper range use and prevent livestock losses in trailing to and from range areas. Bridges are especially necessary when sheep are involved but seldom, if ever, should bridges be constructed solely for cattle use.

Factors to be considered in choosing locations for a livestock bridge include: selecting minimum spans and utilizing, where possible, narrow necks or points of constriction in stream channels; using firm bases safe from scour for bridge sills or piers and providing good straight bridge approachways whenever possible. Obviously, sufficient clearance and the use of sound abutments, stringers and decking are also very important. The materials used will depend on those available at the site but the most common include timbers, rock masonry or cement.

DRIVEWAYS.—More and more, as traffic increases on roads, a problem develops in the movement of livestock to and from seasonal ranges. In many parts of the world, animals that were once driven long distances are now moved by rail or truck. In other places, such a transition may never occur or, if so, not within the immediate future.

Location of stock driveways involves a number of factors as, for example: keeping the route on top of divides or ridges and through easy topography both to minimize clearings where woody plants or trees are present, and to hold erosion to a minimum; avoiding excessively steep slopes and rocky areas; providing feed and water for use by animals passing along the driveway; etc. Driveways should also be well signed so livestockmen will not trespass on adjacent range areas or lose their way.

ACCESS ROADS AND TRAILS (Driftways).—In most places in the Middle East, woody plants or trees are not a sufficient barrier to require the clearing of access routes. Generally, the timber-forage present is readily available and little need exists for passageways for livestock through wooded canyons to make better use of drainage-ways and adjacent slopes. In some cases, however, driftways might make inaccessible forage and water available and whenever such benefits would result; we, as range managers, should certainly encourage their location and use.

From lectures by: Clarke A. Anderson, Leader 1957 Regional Range Management Course (Iraq).

CONTROL OF POISONOUS AND NOXIOUS PLANTS.—On many areas throughout the world, extensive programs of plant control are quite common. The objective in some cases is merely to reduce plant competition from undesirable species on range reseeding projects; in others, the wholesale eradication of specific plants. Many methods are commonly employed including: plowing; harrowing; burning; cutting, railing, rotobeating or mulch chopping; and spraying with chemicals (herbicides). No single method will work on all plant species or on the same species on different sites. Moreover, proven and practical procedures have not yet been developed in most areas for thinning or eliminating many species of undesirable plants.

The situation regarding desirable and undesirable plants throughout the Middle East, however, is usually much different. Often-times, vegetative cover is so sparse that plants are needed or desired which in other locations would be subject to extensive control efforts. In such instances, possible exceptions might be to control only the most poisonous or especially noxious plants. Very often, the adverse effect of such plants can be greatly minimized by changes in livestock management. Wherever this is not feasible or practical, other control or eradication measures are indicated. With sparse vegetation, grubbing may be satisfactory. In other instances, perhaps plowing and reseeding may be the answer. If chemicals are available they might also be tried. Burning, however, should be approached with greatest caution, if for no other reason than the harmful effects of fire on soil.

CONTROL OF RANGE DESTROYING RODENTS AND INSECTS.—As range managers, we are generally familiar with the work being done by most Middle East governments on locust (grasshopper) control. Usually, this work is assigned to sections or divisions other than those responsible for range and livestock management. Our main concern, then, may be to watch for and report build-ups of infestations, particularly where new stands of grass (reseeded ranges) are involved.

Similarly, gophers, squirrels, and field mice may merit control during periods of high populations, particularly if success is to be attained on range reseeding projects. As with range destroying insects, build-ups in rodent populations should also be watched and reported. If serious damage is resulting then control measures should be undertaken. Usual methods include trapping and poisoning (cyanogas, strychnine, 1080 etc.). Sometimes, exhaust from automobile engines or the use of firearms (shooting) is effective.

CHAPTER XXV

RANGE RESEEDING

GENERAL.—All too often, the benefits of artificial reseeding of rangeland, as a range improvement practice, have been overemphasized in most parts of the world. Many times, a sparse though highly potential cover of native vegetation has been completely destroyed in unsuccessful efforts to reseed unadapted or introduced (exotic) species. Even when native vegetation has not been completely destroyed the result has too often been a great and further delay in range recovery and improvement through succession and revegetation. Actually, artificial reseeding of rangelands should be undertaken only when no source of seed remains to naturally start another generation of desirable native forage plants. An important fact to remember is that excellent and good condition ranges should never be artificially reseeded and that most fair condition and a good many poor condition ranges can best be improved through good grazing management.

When artificial reseeding is determined to be necessary and economical, there are a number of principles which must be observed if the work is to be successful. A most important one is to select a favorable site. Others are to prepare good seedbeds; seed adapted species; plant at proper depths with suitable equipment and at favorable times of the year. Lastly, the stand must be protected until well-established followed by proper grazing use and management.

SITE SELECTION.—In addition to favorable and adequate precipitation, a most important factor in successful range reseeding is to select sites with favorable soils. In most instances, an area that will not produce a reasonably good cereal-grain crop cannot be expected to produce good forage crops. Sites should, therefore, be selected on the basis of maximum returns for the expense and effort of reseeding.

Another important factor is that selected sites should be large enough and so located as to comprise a natural grazing unit, or important part of such a unit, following establishment of the reseeded species. In too many instances, reseeding poorly-selected areas has actually resulted in lowering the grazing capacity on entire range units. True, the capacity of the reseeded site itself may have been greatly increased but in order to prevent its overuse and destruction a reduction in over-all stocking rates for entire range unit has often been necessary.

Sites that can be irrigated once or possibly twice, at least during the first year, are preferable to completely dry sites. A most important factor is to always select the most favorable sites for reseeding. Generally, failures with range reseeding have, thus far, exceeded the successes.

SEEDBED PREPARATION.—To date, poor seedbed preparation has been the cause of range reseeding failures much more often than has adverse weather although the latter is usually blamed. Some years, weather conditions are so favorable in all respects, that merely putting seed on the ground is sufficient to assure success. At other times, only the really well-prepared seed beds will yield results. Generally

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From papers by: W.M. Nixon, Soil Conservation Advisor, TCM/India;
Dr. George Stewart, Acting Chief, Agricultural Division, USOM/Iran; and
Clarke A. Anderson, Leader 1957 Regional Range Management Course (Iraq).

speaking, a reseeding will be only as good as the farming and planting work that went into the reseeding operation.

Most range lands in need of reseeding will have heavily-compacted soils and little or no desirable plant cover. Very often, however,u ndesirable plants may be present to compete with seedlings of better plants for the available, and usually limited, water and nutrients in an area. A first step in successful seedbed preparation is relieving soil compaction and removing plant competition. Many types of plows and discs are used, from the simplest earth-turning instruments through moldboards plows of various types to the very heaviest gang-disc equipment. Use of the best equipment available locally for a suitable plowing job is, of course, very necessary.

Merely plowing the land is, however, only part of the operation in making a seedbed suitable for planting. Either time must be allowed, or cultivation practiced in order to pack the soil sufficiently to permit successful seeding. When no packing is practiced, the soil quickly loses its moisture to the depth of soil disturbance and thus becomes unsuitable for seeding. Seedbeds must be in such condition that seeds may be planted not more than two or three centimeters deep and still be in contact with a firm undersoil. Generally, the undisturbed soil, before, it is plowed, is over-compact. In the preparation of seedbeds a medium compactness is recommended. Such compactness or so called "firm seedbed" may result from plowing well in advance of seeding or through the use of cultipackers, rollers or other compaction implements when soil cannot be allowed to settle naturally or is otherwise too loose.

In the case of range reseeding on abandoned farm lands, satisfactory results will usually result by seeding directly into grain-stubble or through the use of stubble-mulch cover. Such a cover is easily obtained. The year previous to planting range grasses, sow any adapted forage sorghum (*Andropogon* sorghum) in close drills at locally recommended rates in a well-prepared seedbed. Seeding may either be done in early summer with the expectation of taking one or more crops of hay from the field, or in late summer at a time when the sorghum will probably not mature seed before frost. In any event, mature seed should not be allowed to form and shatter or the result will be competition from volunteer plants the next spring. The objective is to leave the field at the end of the growing season in standing sorghum 6 to 8 inches (15 to 20 cm.) high, and with a good ground cover of litter. The following spring, grass is drilled in this undisturbed stubble-mulch cover without precultivation of any sort. Such a seedbed reduces rapid surface evaporation, prevents soil blowing and crusting of the soil surface, guards against sheet erosion and packing during heavy, dashing rains yet, is desirably firm, and remains free of weeds longer in the spring than does bare ground. At least one, and usually more, of these conditions is normal during spring planting seasons. The stubble-mulch seedbed is equally advantageous either for grasses planted in rows to facilitate subsequent cultivation, or when drilled for a solid stand.

ADAPTED SPECIES.—The choosing of species that are suitable and grow well in the areas where they are to be planted is of the utmost importance. Grasses differ more widely in their ability to withstand drought, cold and heat than any other group of plants with which we are ordinarily concerned.

A good rule to follow is that unless previous experimental evidence has more or less established the adaptability of a given species, an effort should be made to use species growing within the area or having adaptation similar to these species. It is known, for example, that several *Agropyrons* (wheatgrasses) are native to the Middle East. Hence it is likely that, other things being equal, the wheatgrasses will succeed better in many dry areas than most other species. Similar observations and selection can and should be made in regard to other species. At the same time, trial should be made or continued with as many other seemingly suitable species as possible. Such experimental work is tedious and not always completely rewarding. For example, in testing as many as 100 species, only 40 or less will generally be found suitable and perhaps only 10 to 15 will produce stands in sufficient quantities to be actually available for large-scale range seeding. Some of the species which should be quite suitable under Middle East conditions would be crested wheatgrass (*Agropyron* cristatum), tall wheatgrass (*Agropyron* elongatum), tall oatgrass (*Arrhenatherum* elatius), orchardgrass (*Dactylis* glomerata), smooth bromegrass (*Bromus* inermis) and several legumes as alfalfa (*Medicago* sativa) and sweet clover (*Melilotus* sp.). A further tabulation of species adapted and recommended for areas in the Western United States, which are similar in many respects to much of the Middle East is given in Figure 10.

Species Adapted and Recommended For Range Reseeding in Utah, Nevada and Southern Idaho (USA) - An Area Similar in Many Ways to much of the Middle East.

Species	Lowland			Mountain lands			
	Below 8 inches (20 cm) Precipitation	8-12 inches (20-30 cm) Precipitation	Above 12 inches (30 cm) Precipitation	Salty Soils	Mountain (2) Brush	Aspen (3)	Subalpine
Sand drop seed	C	C					
Bottlebrush squirreltail	C	C					
Indian ricegrass	C	C	C		C		
Russian Wildrye	C	B	B	B	C		
Crested wheatgrass (Standard)	B	A	A		B		
Crested wheatgrass (Fairway)	B	A	A		A	C	
Bulbous bluegrass		X	X		X		
Bluebunch wheatgrass		B	B		B	C	
Beardless wheatgrass		B	B		B	C	
Pubescent wheatgrass		C4	A		A	B	
Intermediate wheatgrass		C4	A		A	B	
Western wheatgrass		C4	B		C	C	
Beardless wildrye		C4	B	B	C	C	
Big bluegrass		C4	C		C		
Mountain rye			X		X		
Great Basin wildrye			B		B	C	
Tall wheatgrass			B	A	B	C	
Tall fescue				B4		C	
Bulbous barley					B	C	
Blue Wildrye					B	B	
Bearded wheatgrass					B	B	
Smooth brome (southern strain)			C4		A	A	B
Smooth brome (northern »)					C	A	A
Slender wheatgrass					B	B	C
Mountain brome					B	B	C
Meadow brome					B	B	B
Kentucky bluegrass					X	X	X
Tall oatgrass					A	A	A
Orchardgrass					B	A	C
Reed canarygrass					B4	B	B4
Timothy					B4	A	B
Meadow foxtail					B4	A	B
Sheep fescue (Sulcata)						C	C
Red fescue (sod-forming)						C	C
Subalpine brome							B
Winter rye		X	X		X		
Alfalfa		C4	B		B	C	
Sicklepod milkvetch		C4	B		B	C	
Chickpea milkvetch		C4	B		B	B	C
Yellow sweetclover			X4	B4	X	C	
Strawberry clover				X4			
Birdsfoot trefoil					C	C	
Mountain lupine						C	B
Alsike clover						C4	C4

(Figure 10)

(over)

Other Broadleaf Herbs

Species	Lowland			Montain lands			
	Below 8 inches (20 cm) Precipitation	8-12 inches (20-30 cm) Precipitation	Above 12 inches (30 cm) Precipitation	Salty Soils	Mountain (2) Brush	Aspen (3)	Subalpine
Summer cypress				X			
Fivehook bassia				X			
Palmer penstemon		X	X		X		
Wasatch penstemon					X	X	
Showy goldeneye					X	X	X
Common cowparsnip					C	C	C
Sweetanise					C4	C	C
	SHRUBS	SHRUBS					
Winterfat	C	C	C		C		
Fourwing saltbush	C4	C	C		C		
Antelope bitterbrush		C	C		C	C	
Oldman wormwood			X		X	X	
Blueberry elder			X		C	C	

Legend

(1) A — Proved to be productive and widely adapted for seeding throughout the zone or type.
B — Valuable over much of the zone or type, but value or adaptation either more restricted or not as well determined as species designated as A.
C — Value or adaptation more restricted than those species designated B, but useful in some situations.
X — Recommended for special uses or condition, usually as pure-stands.
(2) Applicable also for seeding openings in the ponderosa pine zone.
(3) Applicable also for seeding openings in Douglas-fir & Spruce timber.
(4) Adapted only to better than average sites in the zone or type.

When plantings are made using native grass species, it is extremely important that only seed of adapted origin be planted. Local origin is first choice, whether or not the seed may have been reproduced elsewhere or collected locally. Next choice would be seed from south, southwest, or west of the point where it will be planted. Seed originating to the east or southeast of the point is also satisfactory, providing the rainfall conditions are not materially different. Seed originating more than 150 miles (240 kilometers) northwest, north, or northeast should not be used under any conditions because resulting plants will lack vigor and productiveness. This applies to native grasses, and "origin" is meant to be the original source of the material. Climatic and to some extent, soil conditions where grasses originate, control their adaptation; so lacking knowledge of such soils and climate, it becomes necessary to find suitable counterparts by trial and error. Unfortunately, most of the seed supplies available for regrassing use at the present time, consist of introduced species. Several have found a real place in grassland agriculture, but perhaps none can ever replace the best native species because of their usual lack of resistance to plant disease and extremes of local climates. There are also other generalities to keep in mind in choosing species for planting. For example, short-grasses, such as (*Bouteloua* gracilis) and buffalograss (*Buchloe* dactyloides), should not be planted in high rainfall areas because they do not have the ability to produce a tonnage or forage equal to that of tall-grasses under these conditions.

In range seeding, as with all other crop seedings, good quality seed should be used. Many failures are the result of using seed of poor viability. The amount of seed which should be sown will depend upon the purity, germination and percent of viable or so-called "hard" seed. For example, seed with a purity of 30 percent and a germination of 40 percent has a live pure-seed content of 12 percent. It will, therefore, require 8.3 pounds of this seed to make one pound of clean seed (2.2 pounds = 1 kilo). Seed with a purity of 40 percent and a germination of 60 percent, has a live pure-seed content of 24 percent. Accordingly it will take only 4.1 pounds of this seed to make one pound of clean seed. Whenever possible, purchase grass seed that is labeled giving germination percent, purity percent, and the percent of hard seed. With unlabeled seed, germination tests should be made before use and seed with questionable viability should not be used. Keep in mind that regardless of how much care is taken to see that competing vegetation is destroyed and to see that a suitable seedbed has been prepared or even if the seed is properly planted, grass cannot be produced from seed of low viability. It is, therefore, imperative that good seed be planted. Difficulty will be experienced in establishing specific seeding rates which will apply to all different soils, climates and sites. For most of the wheat-grasses. however, the seeding rate should be between 8 and 16 kilograms of good viable seed per hectare for dry-land seeding with slightly higher rates under irrigated conditions.

Mixtures of two or three adapted species with similar palatabilities and seasons of growth take better advantage of site conditions and will usually withstand extremes of weather, diseases, and pests better than pure-stand plantings. Mixtures also generally result in a better cover and provide a greater variety of forage. However, purestand plantings are very useful to provide supplemental grazing at particular seasons and species that vary considerably in palatability and season of use should not be planted in mixture.

PLANTING METHODS.—Establishing grass on arid and semi-arid range land is difficult and all conditions that will contribute to chances for success should be met. Time, method, and depth of planting are of extreme importance. Planting should be done so that seeds can germinate as soon as favorable conditions occur. In most areas this means immediately prior to, or during the period of good rainfall. The growth requirements of the plant also influence the time-of-seeding period. It has been found best to seed too early rather than too late. Most range grasses should be seeded at a depth of from 1/4 to 1 inch (.6 to 2.5 cm.). Seeds should be covered sufficiently to insure that they are kept moist until the roots can develop, reach and become established in soil with a dependable amount of water. Larger seeds, of course, can be planted somewhat deeper than small ones.

Grain drills can be used for some species but specialized drills are usually better. A number of such specialized grassdrills have been developed for seeding in one-foot width rows. Many are equipped with depth gauge-band attachments which allow for a uniform depth of planting and also cover the seed and firm the soil. Most of these drills will seed all kinds of clean and trashy seed at desired rates and can be equipped with a fertilizer applicator. Generally, however, fertilization is usually neither economical nor practical under average range conditions. Moreover, chemical fertilizer applied

to the ground surface at the time of seeding has usually resulted in a heavy growth of weeds and annual grasses to the detriment of reseeded perennials.

If drills are not available, the following seeding procedure is recommended: (a) distribute seed at a proper rate and uniformly over the area to be seeded, either by hand or preferably by means of a "cyclone" (hand operated, mechanical) seeder; (b) cover seed by means of a "peg-tooth" harrow by tilting the teeth correctly for the particular seed-bed in question—if a tooth harrow is not available, a disc harrow may be used by running the discs straight or turning the discs only slightly to make sure that seeds are not covered more than the desired depth (seed may also be covered by driving a herd of sheep back and forth several times over the planted area or by use of brush or similar drags).

Airplane seeding of range land has not proven practical. However, grasses can be successfully established by spreading grass-hay cut after the seed has matured. The hay should be spread at a rate of from 1,500 to 2,000 pounds per acre. This "seed-hay" method is well adapted for use on badly eroded sites, gullied areas, and for sand dune or "blow-out" stabilization.

PROTECTION AND MANAGEMENT.—Range reseeding should be done only where good range management can be provided. Reseeded ranges must have protection from grazing until the seedlings are well established and moderate grazing practiced seasonally thereafter. Protection from all grazing is usually necessary for several years. In general, the chances for successful reseeding of rangeland by artificial means requires the use of species that are adapted to the local climate and that will continue to produce satisfactorily under reasonable grazing use. In most instances, the good native grasses which have survived, under adverse conditions; have been found to be best for range seeding. Exotic species can, of course, be used when proven to be well adapted but generally there has been too much searching for a "miracle grass" while overlooking the good native species which have stood the test of time.

In a few specially located places, it may be possible to provide one or two irrigations to the young reseeded stand from high waters in the spring of the year or after the regular irrigation season. After that, adapted grass stands should not require additional irrigation and the water may be used on other areas. This practice permits, in a few years, a small amount of water to supply irrigation to newly reseeded stands over a considerable area and great success has been obtained in a number of places following this procedure. Once the root system of the grasses is well developed, they are able to make growth on the natural precipitation and hold the land against competition from other plants. Of course, there are a few species that will be unable to hold their own against this competition, and these should be abandoned as species useful in reseeding.

A most important factor to remember is that when the time has come that grazing can commence, only about 30 or 40 percent of the current growth should be removed during the first years' grazing. It is likely that in subsequent periods, grazing use may be increased up to 50 or 60 percent of growth and under a few, very favorable conditions grazing use may be as high as 70 or 75 percent of current plant growth. The safe figure to adopt, however, under normally favorable conditions will be 50 to 60 percent utilization. After this second year's grazing, the area should be observed very closely to see that the stand is not being damaged or to determine if it can be grazed more heavily. A most current mistake is that of grazing new seedings too severely and greater emphasis needs to be given the fact that it is much better to graze a little too lightly than to over-use the young plants. We should expect the reseeded stands to last fifteen to twenty or more years when properly managed. If this is kept fully in mind, the livestock men who are reseeding such lands will understand that it is very short-sighted to overgraze and kill in two or three years, plants that should last fifteen or more years.

SUMMARY.—Range reseeding should be undertaken only where natural revegetation cannot be brought about by improved management within a reasonable time.

If range reseeding has been determined to be necessary then it should be initiated only after thorough study and in accordance with the most suitable methods and practices for the area. The following four factors are among the most important in a reseeding operations:

(1) Areas to be seeded must be on the best sites, having both the most favorable moisture conditions and the most favorable soil conditions.

(2) Species that are adapted to the conditions that exist in the reseeding area must be chosen and those not suited must be eliminated.

(3) Plowing, discing, or other methods must be used to reduce competition from the stand of native plants remaining on the area. If plowing is the method used, it should be done far enough ahead of planting time to permit the soil to settle to medium compactness.

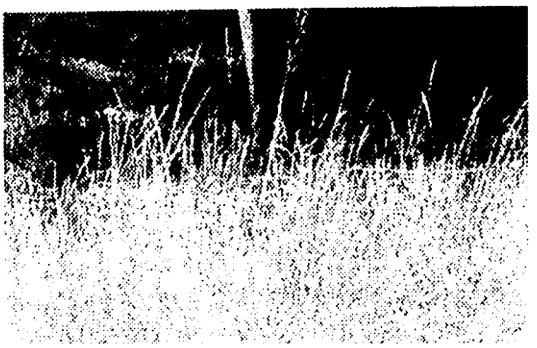
(4) The methods of seeding must be such that the plants will have a firm seed bed not more than two or three centimeters below the surface. Seeding is best done with a drill so regulated as not to cover the seeds more than this depth. If a drill is not available, the seeds may be broadcasted and covered with a harrow, or by other means. The seeding is best done in the late fall or early winter just before a period of cool, moist weather. After the grass stands have begun to grow, they must not be grazed for two or three years, and after that they must be grazed moderately.

In all areas where reseeding is important, there is need to develop local guides and instruction to insure greatest success. An example of such a local guide is the "Conservation Job Sheet" in Figure 11 as developed by the U.S. Soil Conservation Service for seeding native grasses in Nebraska, which follows.

SEEDING NATIVE GRASSES

(15-19" and 20-24" Rainfall Zones)

MAKE EVERY ACRE PAY



FOR THE LAND'S SAKE, PLANT GRASS

SUCCESSFUL SEEDINGS DEPEND ON:

A firm seedbed, proper depth of seeding, packing after seeding, early clipping of weeds, cover to prevent blowing, and previous weed eradication to provide minimum competition for young grass seeding. Always use tillage methods which will leave the maximum residue on the surface to prevent blowing and provide cover. Chemical spraying may be used for broadleaf weed eradication both before and after seeding.

SEEDBED PREPARATION FOR:

1. FIELDS IN CULTIVATION:
   Plant in stubble of small grain, millet, sudan or sorghums whenever possible. In preparing seedbed, carry on tillage so as to leave maximum residue on the surface to prevent blowing. Where annual weeds are prevalent, till seedbed after they have started and just before seeding. Sub-till or disk lightly 2 or 3 inches deep to work up the soil.

2. ON "GO BACK" LAND OR RANGE IN POOR CONDITION:
   Kill existing annual weedy grasses and weeds to reduce competition by sub-tilling during dry period of summer or fall the year before or in the spring before seeding. May require more than one operation. If sub-tillage equipment is not available, one-way in such a manner so as to tear up sod and leave maximum residue on the surface to prevent blowing. If sod needs to be torn apart, use disk. Till only deep enough to get the best weed kill.

SEEDING OPERATIONS:

Plant in a firm seedbed to obtain better germination. May require packing or treading before seeding if soil is loose. Pack or tread soil after seeding to cover seed and obtain a firm seedbed. Leave surface as cloddy as possible.

Use drill equipped with grass seeder attachment which provides more accurate control of seeding depth, requires less seed, and has more positive control of seed distribution.

Grasses that cannot be handled in regular grain drills require drills or grass seeders equipped with agitators. Fertilizer spreaders and gate seeders will broadcast light fluffy grass seed.

Plant grass seeds at these approximate depths: In sands and sandy land, 3/4--1" deep and in medium textured soils, 1/2--3/4" deep.

(Specific recommendations are shown on the back of this sheet)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

NEBRASKA

5, L-13, 717

(FIGURE 11)

(OVER)

NATIVE GRASS SEEDING RECOMMENDATIONS ON DIFFERENT SOIL TEXTURES IN 15-19" AND 20-24" RAINFALL ZONES

SELECT ONE COMBINATION FROM GROUPS A, B, C, AND D FOR MIXTURE :

GRASSES	Seed You Need For ——Ac.	MIXTURE COMBINATIONS			
		Sands and Sandy Land (C, L, & S Textures)		Silty and Clayey Land (M, F, & H Textures)	
		Rainfall 15-19"	Rainfall 20-24"	Rainfall 15-19"	Rainfall 20-24"
A. TALL GRASSES					
Big bluestem		- - -	- - -	1 2 0	3 5 0
Indiangrass		1 0 0	1 0 0	1 0 0	2 0 0
Switchgrass		1 1 2	1 1 2	1 1 2	1 1 2
Sand bluestem		2 3 0	4 6 0	- - -	- - -
B. MID-GRASSES - WARM					
Little bluestem		2 1 0	2 1 0	1 2 3 0	1 2 3 0
Sideoats grama		0 2 0	0 2 0	2 3 0 7	2 3 0 6
Sand lovegrass		1 1 1	1 1 1	- - - -	- - - -
Tall dropseed		- - -	- - -	1 0 0 0	1 0 0 0
C. MID-GRASSES - COOL					
Western wheatgrass (a)		0 0 0 2	0 0 0 2	2 3 3 5	2 2 3
Green needlegrass		3 0 0 0	4 0 0 0	2	1 0 0
Canada wildrye		3 3 4 2	2 3 3 2	1	0 1 0
Slender wheatgrass		0 1 0 0	0 1 0 0	1 1	1 0 0
D. SHORT GRASS					
Blue grama		- - -	- - -	1	- - -
E. LEGUMES (Use of legumes is optional.)					
Alfalfa		0 0	0 0	2 0 0	2 0 0
Sweet clover		0 2	0 2	0 2 0	0 2 0
Vatch (b)		5 0	5 0	0 0 5	0 0 5

(a) Western wheat posibilities on sandy soils limited to "S" texture.
(b) Vetch is a winter annual and probably most adapted to sands and sandy soils.

EROSION CONTROL MEASURES RECOMMENDED : _____

REMARKS : _____

5, L-13,717

(OVER)

PART VI

RANGE STUDIES

CHAPTER XXVI

INTRODUCTION TO RANGE STUDIES

GENERAL.—Range management in the Middle East is at about the same stage of development as it was in Western United States 50-years ago. It is a recognition stage in which interested men begin to realize that the ranges and the forage they produce are a valuable resource and that something must be done to make them produce more and provide a better cover on the soil to prevent soil erosion and loss of productivity.

Research and experience in range management in the United States, Australia, South Africa and other places have established principles of management which can be applied to ranges in other parts of the world. Accordingly, range management programs can be implemented much more easily and quickly today than they could before these principles were developed.

Each country and region, however, often has its own range problems and the solutions to those problems must be such as to fit specific local conditions. Research and study of such problems must, therefore, be done on a local basis and each range management organization should provide for carrying out range studies to fit existing needs. Furthermore, range studies are often useful to serve as demonstrations of certain principles known to range technicians but not accepted by range users and administrators. In other words, range studies have two purposes: (1) to increase the knowledge of the range management technician so he can analyze problems on a sound scientific basis, and (2) to provide material for teaching, guiding and demonstrating to people the principles and facts about range management.

THE NEED FOR INFORMATION.—Range management is a relatively new activity in Middle East countries. In fact, it has not yet been generally approached on a really scientific basis so there are many different concepts and ideas of what certain circumstances mean and what should be done about them. There are, of course, the basic principles of (a) balancing numbers of animals with the available forage supply, (b) using the kind of animals most suited to the forage and the objectives of management, (c) avoiding grazing of valuable forage plants during seasons when grazing is most harmful or damaging and (d) obtaining a uniform distribution of use on forage over the entire range area.

In addition, there are many questions that need answering to fit particular circumstances as for example:

(1) What is the rate of recovery of this range under total protection?
(2) What is the grazing capacity of this range (for sheep, for cattle, for goats)?
(3) What are the valuable forage plants on this range and what are their growth requirements?
(4) How much can the valuable forage plants be grazed to provide maximum forage year after year?
(5) When do the forage plants grow and what is the most critical time to graze them?
(6) Is there any advantage of rotation-deferred grazing over season-long grazing?

From papers by: Clark E. Holscher, Food and Agricultural Organization, Rome, and
Wayne Wenburg, Grassland and Range Improvement Specialist, USOM/Turkey.

(7) What is the present condition of this range and what kind or type of livestock and management should be used?

(8) What areas should be reseeded and what plant species and seeding methods should be utilized?

(9) What effect will different methods of management have on forage yields and animal production?

Answers cannot be obtained to all of these questions quickly or at the same time. Work should proceed with caution, and complicated studies should not be started without a thorough knowledge of problems and basic scientific facts. At first, range studies should be kept simple.

KINDS OF RANGE STUDIES.—There are numerous kinds and types of range studies which, with adaptation, will fit any given situation and provide the basic information necessary in the solution of range management problems. Some of the more important include (1) Range Surveys and Inventories—probably the most basic of all range management studies; (2) Experimental Ranges—the truly demonstrative type of study so useful in convincing people of the value of correcting poor management practices; (3) Livestock Exclosures—the best method of measuring soil and plant response and range potential with the grazing factor; (4) Vegetative and Plant Measurements—list quadrats and line transects; (5) Range Production—forage yields and weights and (6) Reseeding Studies.

RANGE INVENTORY

This type of study is so vital to proper range management that it is treated as a separate chapter. Essentially, range inventory is the determination of the basic resources of a range operation. To be complete, it must also program the sustained optimum use and perpetual maintenance of these basic resources.

EXPERIMENTAL RANGES

At the end of this chapter there is a sketch (Figure 12) of an outstanding experimental range, the Starkey Experimental Range, located in northeastern Oregon (U.S.A.). This experimental range is one of the most recently established in the States and has more than ten years of intensive planning behind it. It is a good example of a valuable type of range study.

The Starkey area is used for summer grazing, June 15 through October 15, and contains three broad vegetation types—grassland, open forest and dense forest. The dense forest is not used by livestock and does not contribute to the forage supply. The total area is approximately 10,000 hectares of which 3,000 hectares are used for experimental pastures and the remainder as open range where practical tests are made of the results obtained from studies on the experimental pastures.

Capacity studies are an important phase of experimental range research. They are intended to determine how many animals of a certain kind or type can be grazed on a given unit of range land. Such studies usually consist of comparisons between experimental pastures grazed by different numbers of animals per unit of range land. Results are normally measured in terms of changes in forage production or plant composition and of differences in animal production.

On the sketch, there are two groups of six experimental pastures. In each group—two pastures marked "L," two marked "M" and two marked "H," meaning light, moderate and heavy grazing use. In the pastures marked "M" the object is to balance the number of animals with the forage supply as closely as possible. The "L" pastures then have about 25 percent less animals per unit of range and the "H" pastures have about 25 percent more. These treatments are repeated in the second group of pastures to give more reliability to the results. Size of the pastures can vary considerably depending upon the complexity of problems and the resources available for doing the research. The smaller the pastures the easier they are to measure and interpret but as size decreases they also become less and less of a practical unit. Small pastures and simple treatment should be undertaken at first—at least until a good appreciation of research procedures and problems is acquired. If possible, the pastures should be planned to suit the habits of the grazing animals, and they should be as nearly alike as possible. Things which are alike can be easily compared, when differential treatments are applied, but things which are different at the start cannot be easily compared. If animal production is to be measured, the animals in the different pastures should also be as nearly identical as possible.

Another important phase of experimental range work is rotation-deferred grazing studies. On the sketch, three pastures of each group are marked "SL" (season-long) and three are marked "RD"

(rotation-deferred). Furthermore, one of the three "SL" pastures is grazed lightly ("L"), one moderately ("M") and one heavily ("H") so that in each group of six pastures there are six different combinations of grazing intensity treatment, both with season-long and with rotation-deferred grazing.

The thinking behind rotation-deferred grazing is that there are certain periods during plant growth when grazing should not be permitted. In countries where summers are dry and most of the growth takes place in early spring, plants are most harmed by grazing just before they mature and turn brown and when the seed is forming. Therefore, the plan for rotation-deferred grazing must be such as to fit the growth requirements of the important forage plants in order to give them every possible advantage to become stronger and more productive. Dates of grazing a given area must, of course, be rotated from one year to another. On the sketch, the rotation-deferred pastures are fenced (dotted line) into two parts. One part is grazed early in the season and the other late in the season. On alternate years, the order of grazing the parts is reversed. It should be noted as well, that the two large units, A and B, are also grazed on a rotation-deferred system.

Livestock Exclosures

The purpose of livestock exclosures (areas totally protected from grazing) is to compare the growth and development of vegetation without effects of grazing animals with that on ranges grazed in the usual manner. Such exclosures reveal the species of plants growing on the range and the rates of recovery of the vegetation from abusive grazing. They tell nothing about grazing capacity except that the range is or is not suffering from abuse.

In establishing livestock exclosures the following principles should be observed: (a) make them large (not less than 4 hectares), (b) locate them so as to be representative of the surrounding range, (c) select an area which is relatively uniform throughout—it is much better to place a separate exclosure in each vegetation type than to include several types in one exclosure—; (4) establish a companion plot of the same size close by the exclosure with which to compare the changes brought about by protection, and (e) make records of the vegetation when the exclosure is established and at regular intervals thereafter.

Supplemental uses can be made of exclosures in addition to those mentioned including: studies of seasonal growth and development of plants; studies of the response of individual species to closely controlled treatment; adaptation of species for reseeding; studies of site factors including soil moisture, soil temperature, etc., or any other studies which require protection to eliminate the grazing factor.

Methods of Measuring Vegetation

In range studies there must be measurements of the vegetation in order to indicate what is happening under the different treatments being applied. Obviously, it is not feasible to measure all of the vegetation on large areas or keep account of each individual plant so measurements must be made through sampling the entire vegetation population within the range unit. Actually, records of what is happening on the samples serve as estimates of what is taking place on the entire range. Such work requires that we, as range technicians, observe certain important rules as: (a) we must know the vegetation, (b) since our measurements are only samples of the whole they must be accurate, (c) observations and measurements must be honest and without bias, and (d) we must diligently train ourselves and our fellow workers and submit to periodic checking.

A relatively simple but somewhat slow process of measuring vegetation is with so-called "list quadrats." The method consists of recording the species of plants present on a given sample, often a meter-square area or quadrat. Sometimes, the sampling area is divided into small parts and separate records made for each part to a better indication of the distribution and abundance of species within the quadrat. The procedure is particularly suited to recording changes in protected plots. An adaptation, the so-called "Species Plot Method of Determining Range Trend" is treated later in a separate chapter.

The line transect method is one whereby records can be made either of the occurrence of a species along a line or of the actual measured distance along the line occupied by a species. The procedure is to stretch a graduated tape between two points, preferably permanently established points. Then beginning at the "O" end of the tape proceed along the tape, recording each plant of each species

which is found directly beneath the tape. This gives a record of the relative abundance of each species of vegetation in the stand in terms of numbers of plants. Sometimes, knowledge of the relative area of ground occupied by the different species is desirable and in such cases the distance along the tape occupied by each plant is also recorded. It may even be helpful to record the location of the plants along the tape so that on permanently located lines their progress and welfare can be traced. For example, the record might show: 0-5 centimeters, *Poa* bulbosa; 7-9 centimeters, *Agropyron* squarrosa; 17-25 centimeters, *Cynodon* dactylon; etc. Simple field sheets may easily be developed for record purposes.

The line transect is, therefore, a relatively simple method of recording vegetation. It is rapid and requires a relatively small amount of training. However, it does require a thorough knowledge of the vegetation and since only a small amount of vegetation can be sampled along such a line, a relatively large number of transects ought to be established in each range area studied. The number of transects established, of course, will depend upon how different the vegetation is from one transect to another. The greater the differences, the greater the number of transects required.

Another study very well adapted to use in Middle East Countries, "The Loop Transect Method of Studying Range Vegetation," is treated in a separate chapter.

Range Production

Weight estimates are a simple means designed to record the production of range plants in terms that can be accurately checked, whenever such checking is desired. The most common weight-method produces records expressed in pounds per acre or kilograms per hectare, the same as if the vegetation were mowed or clipped for hay or similar usage. In application, the technician is intensively trained and learns to judge how much a plot of vegetation, species by species, would weigh if actually put on the scales. In the training, the trainee seeks to establish a unit of vegetation which he finds will consistently weigh a certain amount as: 5, 10, 25 or perhaps 50 grams. He keeps estimating such units and checking them by clipping and weighing until they are firmly fixed in his mind and this he repeats, species by species, until he is able to make quite accurate estimates of weight on plots containing many plants of many species. The important part of the method is adequate training and constantly checking the estimates of weight against the actual weights of foliage clipped from the plants or plots.

Because of the general usefulness of forage production data in the Middle East, a separate chapter is devoted to clipping and weighing determinations.

Reseeding Studies

Studies of range reseeding have two important objectives: (1) to determine which species of grasses, legumes and shrubs is adapted to each major site; and (2) to test procedures most suitable for planting the adapted species, including methods of destroying plant competition.

Initial studies of species adaptation should consist of small plot plantings so that those not suited to the environment can be quickly eliminated. Species which seem adapted can then be additionally tested on larger plots and under a variety of conditions and this will further eliminate the more questionable species. Even then, pilot (limited-scale) plantings may be desirable on certain sites before larger-scale field plantings are actually made. In testing species for adaptation it is important that all plots be as much alike as possible and that more than one planting of each species be made.

Tests of various methods of planting should be carried out with equipment readily available within the area or country. They should also be made with adapted species but more than one species should generally be included since methods may need to be varied somewhat according to the species being planted. Tests should be carried out on several important sites to be sure the methods chosen are universally useful. Correct methods of planting are extremely important in the success of reseeding on range lands and this phase of range studies should not be neglected.

Points on the Design of Range Studies. The following points are very important in all range studies:

(1) In any comparison, seek uniformity between units to be compared.

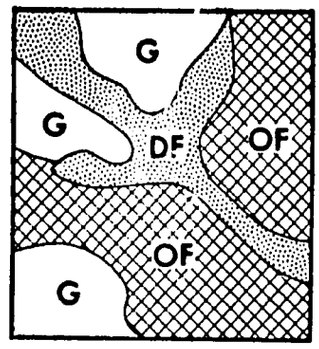
(2) Seek uniformity within units as well, but if variation cannot be eliminated, it is better to have it within units than between units.

(3) Include as few variables as possible in the study.

(4) If livestock are used, they should be uniform and of similar habits and breeding.

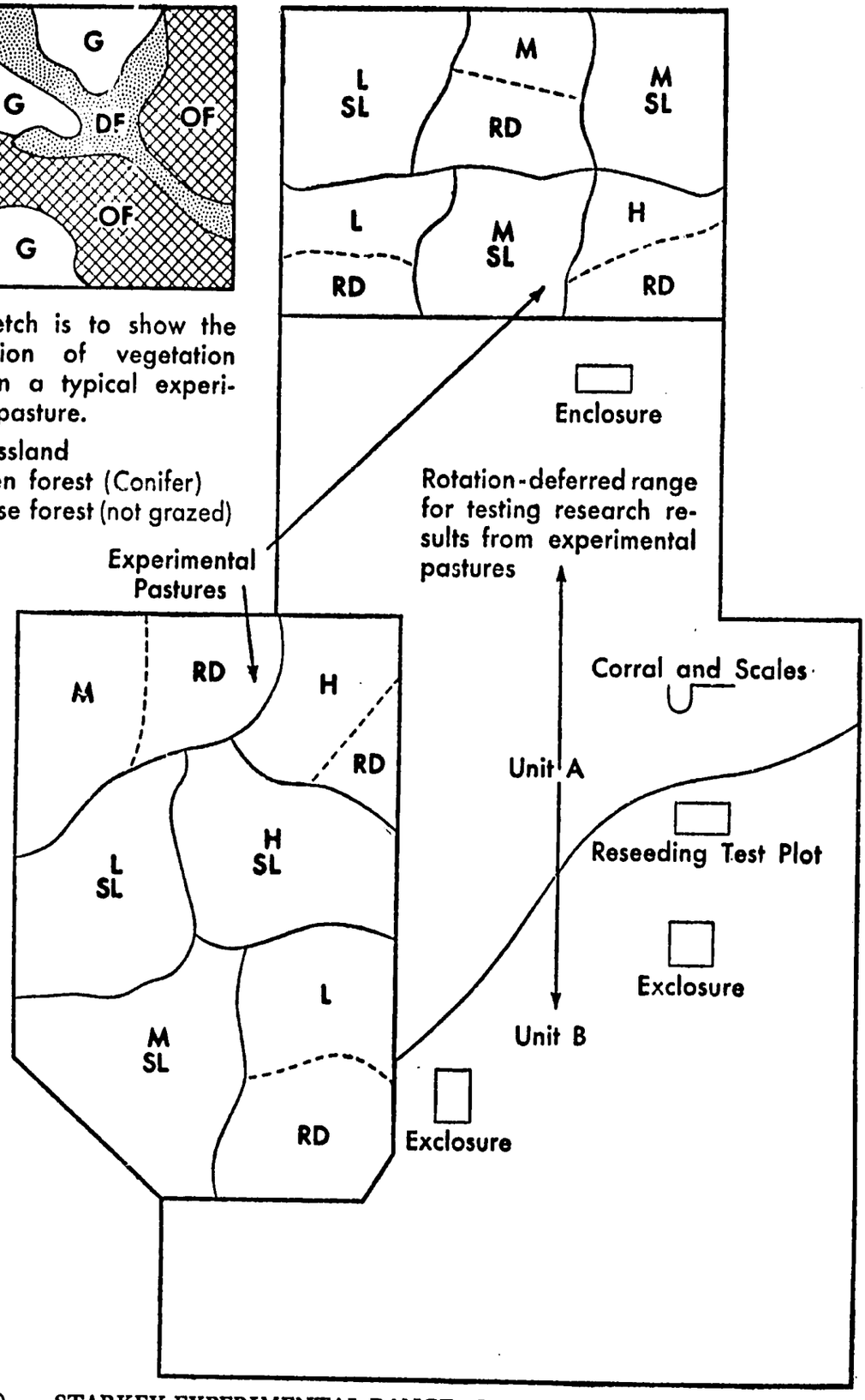
(5) Records should be taken at the same time each year and by the same methods. Use of the same personnel is desirable, wherever possible.

(6) For proper interpretation of results a clear understanding of plant ecology is essential.



This sketch is to show the distribution of vegetation types on a typical experimental pasture.

G - Grassland
OF - Open forest (Conifer)
DF - Dense forest (not grazed)



(FIGURE 12) STARKEY EXPERIMENTAL RANGE - LAGRANDE, OREGON, U.S.A.

CHAPTER XXVII

RANGE INVENTORIES

GENERAL.—Inventory is usually defined as the listing or "taking stock" of goods or assets. A Range Inventory, then, is "taking stock of the range and the range job." Anything we do toward making progress in worthwhile endeavors requires an evaluation of the elements of that undertaking; a determination of the resources available with which to work; and the development and publication of plans leading toward final and lasting accomplishment. Without useful and workable plans, well thought out in advance, progress or accomplishment is delayed or even impossible. This reasoning is applicable in all situations, large or samll, whether involving, for example, a business trip, building a house, or managing a range.

An adequate inventory of any range usually requires the collection of at least five kinds of basic information—(1) knowledge of the principal kinds and communities of range vegetation, their characteristics, and response to grazing; (2) delineation of the different kinds of rangelands, called range sites as, for example, "run-off," "normal," or "run-in" sites; (3) determination of range condition and trend in condition on each kind of rangeland; (4) determination of the recommended stocking rate to reach the correct degree of grazing; and (5) adjustment of the correct season of grazing to the growth requirements of the best kinds of vegetation.

Such basic information may be recorded in a number of ways. Perhaps the simplest and most usable are graphic records, including aerial photographs or maps either developed from such phtographs or by other accurate means; map overlays; charts; tables; graphs; etc. In most cases, some written records will also be desirable either to supplement the graphic information or to present details not adequately shown by the graphic records.

METHODS AND PROCEDURE—Over the years, few simple but many complicated range survey systems have been developed and continued in use throughout the world. Included are such processes as (a) the use of highly involved mathematical factors in attempting the determination of grazing capacities as, for example, the so-called "forage-acre factor" method (b) overly detailed vegetative typing procedures often with 20 or more so-called "vegetative types" (many of which are actually condition classes within a much smaller number of true or natural vegetation groupings) and (c) very theoretical processes of computing stocking adjustments due to soil limitations, topographic barriers, climatic fluctuations, etc. Unfortunately, the data resulting—both graphic and written—is often too complicated to be valuable to the average range-livestock operator or even usable by the average range technician.

While many of the really detailed systems are quite workable in some areas and under given conditions, a simpler procedure is usually adequate in most situations. Fortunately, a great deal of recent effort has been directed to less complicated methods of so-called "range surveys, range inventories and range analysis." The newer systems, which seem most usable, ordinarily provide for *first*

From papers by: Leslie R. Albee, Leader 1956 Regional Range Management Course (Iran), and Clarke A. Anderson, Leader 1957 Regional Range Management Course (Iraq).

mapping and determining the area of two broad land-use breakdowns within the area being studied (1) *range* and (2) *non-range*. *Next* the range land is separated and mapped simply as (a) *primary or normal use* range—ranges which can be grazed and maintained without special management practices, and (b) *secondary range*—areas which should not be grazed or be grazed only with the application of special management practices. The non-range land in such classifications generally includes arable lands, timber lands, lands covered by permanent water or occupied by cities and other structures and lands which are not or should not be used as range lands.

Once the area and location of such range sites are known, the remaining and final step is to establish their range values and secure the types of management necessary for their improvement, if not in satisfactory condition or their maintenance, if in satisfactory condition. For these processes, study is largely limited to strictly range areas except as non-range areas may be included from the standpoint of supplementary feeds or feeding operation. In other words, valuable time is not used in detailed mapping or study of waste-range areas (dense timber, unstable slopes, etc.) and more time is thereby available to devote to analysis and planning on the truly range portion of the area being studied.

In establishing range values a basic consideration is, of course, grazing capacity. If the range manager knows (a) range vegetation, (b) understands the potential of local range sites, and (c) recognizes range condition and trend in condition then (d) correct determinations of range capacity and proper use and management will result. As an example, if satisfactory range conditions (soils, plants, water) on a grazing unit cannot be maintained when the better or "key" grazing plants are utilized in excess of 50 percent by weight on the average, then the animal months of grazing each year to obtain that degree of utilization (50%) represents the grazing capacity of that particular grazing unit. Such studies continued over a period of years, will provide accurate, longer-term grazing capacity data. Numerous other equally simple procedures can, of course, be used to similar advantage.

Range Vegetation

An experienced range manager or successful livestockman can tell how good a range is by checking the kind and amount of vegetation present. Moreover, he can tell whether there are enough climax plants left to revegetate the range when managed correctly or whether these plants will have to be reintroduced artificially. Condition of both soil and plants provides the soundest basis for determining what future programs will be necessary to improve grazing lands. Also important is a knowledge of such plant characteristics as: adaptation to the site; response to grazing; season of growth and reproduction methods—whether by seeds or rhizomes; and palatability (animal preference).

A simple form developed in Iran for recording vegetation on a site is shown in Figure 13. Many variations of such forms are possible.

Range Sites

Different kinds of range-land, producing significantly different kinds or amounts of climax vegetation, are called range sites. They are, essentially, complexes of the soil and climatic conditions of an area on which determinations of range condition and trend in condition are traced. The patterns of range deterioration as well as of range improvement, through secondary plant succession and as a result of range management, are directly related to the range site. Each range site has its own production potential.

Considering the natural features on which range sites are based, there are perhaps 15 to 25 different major kinds of rangelands, or range sites, in each Middle East country. When mapping is undertaken, each range site should be delineated on the map to separate it from other sites, if it produces a significantly different kind or amout of climax vegetation. Such climax plants can be determined from a careful study of well-managed ranges or from observations on relict areas. A relict area is any piece of range land which has withstood important changes in vegetative cover.

Terminology of range sites is usually based upon soil and topographic conditions of the area as, for example: *rolling sandhills*, or *loamy upland plains*. Other variations may include names that place hazards or limitations on range use, such as *saline lowlands*. Still other classifications include such simple groupings as *run-off*, *normal*, and *run-in* sites.

RANGE SURVEY FORM

Location _____ Range Site _____ Total Plant Density _____

Examiner's Name _____ Date _____

Name of Perennials	Per cent Density	Name of Annuals	Per cent Density
Grasses and Grass-like Plants		*Grassss and Grass-like Plants*	
Forbs		*Forbs*	
Trees and Shrubs			

(FIGURE 13)

The general deterioration which has occurred throughout the Middle East in range sites, complicates proper classification. Accordingly, and as time permits, technical determinations should be made on the extent of site deterioarion and its influence on climax vegetation.

Range Condition

Range condition is often defined as range health and trend as the direction in which that health is moving. One range may be healthy or in excellent condition. Another may be unhealthy or in poor condition. In between there may be other ranges in only fair or good condition. The unhealthy range may be improving, in which case trend is up. If a healthy range is deteriorating, trend is down. Where trend direction cannot definitely be determined, the range health is normally termed static or stationary.

A very common method of determining range trend is on the basis of departure from the climax. Therefore, before we can determine range condition we must know the range site and the vegetation the site is potentially capable of producing under the best possible range management. This again, points out the need for study of the relicts of climax vegetation. From such studies, reconstruction of the climax can most easily be accomplished.

Though not maintainable under practical grazing management, or even under the cutting of forage for hay, a 100 percent level of range health—absolutely climax vegetation—must still be regarded as the "measuring stick" against which to judge range condition. For this reason, the *excellent* condition class, which has 100 percent climax vegetation, as its top limit and measuring stick, is generally considered to have a practical latitude down to 75 percent of the present vegetation being climax for the site. *Good* condition range is usually considered as having 50-to 75-percent of the climax vegetation remaining, *Fair* condition 25-to 50-percent, and *Poor* condition less than 25-percent. Ranges in good, fair and poor condition can, by management, be improved through one, two, or three classes to excellent condition. Forage production per unit of area increase in direct proportion to range condition class from poor to fair to good to excellent.

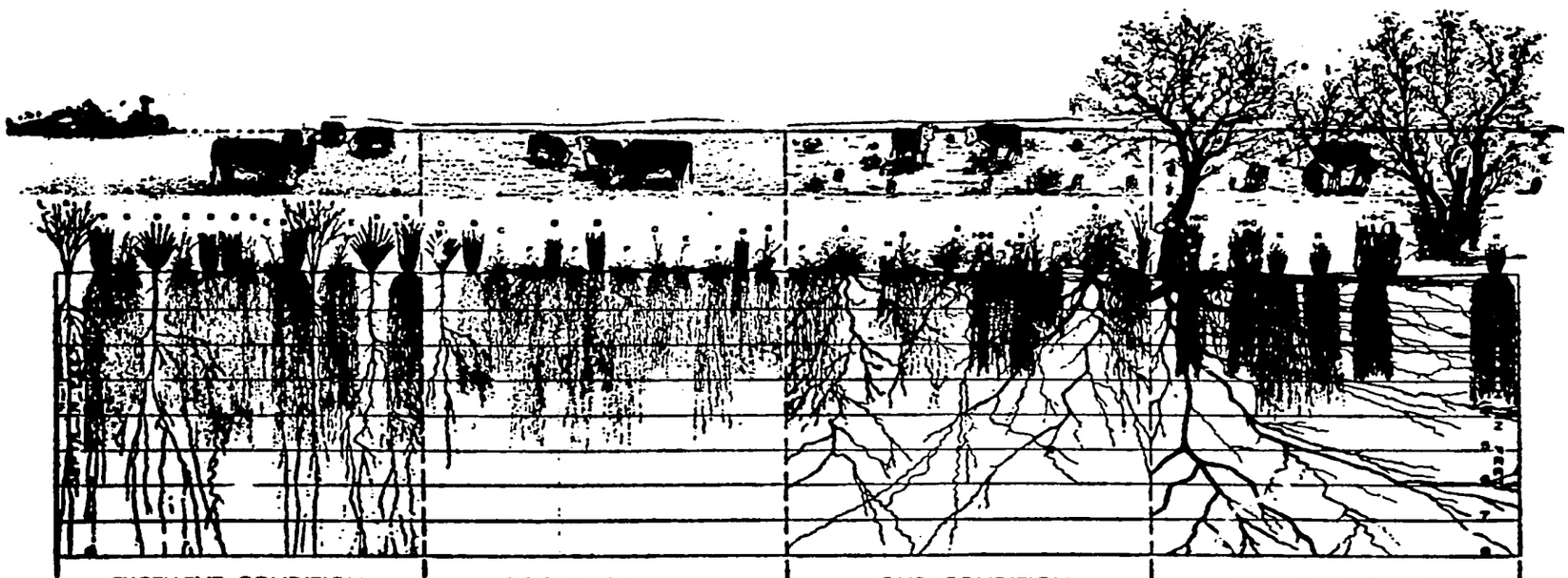
An illustration of how this system helps in classifying basic forage crops is shown in Figure 14: "Four Range Condition Classes in Central Texas and Southern Oklahoma (U.S.A.)." In this illustration the site is productive upland in a bluestem grass area.

In the classification illustrated in Figure 13, only one main factor was used in determining range conditions—that of plant composition. This factor is very practical because it can be quickly evaluated after a range manager has had but little training. However, other factors to consider include: plant density and vigor; soil-tilth; erosion; and livestock gains. Other illustrations include a Range Condition Guide developed in Iran (Figure 15) and one developed for the Northern Mixed Prairie area in the United States (Figure 16).

Grazing capacity is usually defined as the number of livestock that a range is capable of supporting for a certain grazing period year after year without real damage to either soil or vegetation. Stocking rate, on the other hand, normally refers to the number of livestock and season of use that will permit improvement of vegetation and soil. The greater the difference between current and potential condition and forage production on a site, the greater the difference between grazing capacity and recommended stocking rates. Thus, a very shallow site in excellent condition might be stocked heavier than a lowland range site in fair condition even though the lowland site produced the highest yield of forage per unit area and would easily carry the most livestock. Obviously, nothing would be gained by stocking the very shallow site below grazing capacity because the vegetation is already in top condition. On the other hand, stocking the lowland site at capacity would mean that it would continue indefinitely to produce only about one-third of what it could produce if so managed as to improve from a fair to an excellent condition.

The stocking rate is a very important part of every range inventory and a summarization of the recommended animal unit months use by range sites and range condition for the entire grazing unit is a major step leading to intelligent grazing management. Although not always practicable, stocking rates should be adjusted from year to year according to major fluctuations in forage production brought about by extremes in weather, or other causes, as fire, flood or range destroying insects. The stockman raises a crop of grass to harvest by grazing livestock and the stocking rate he uses from year to year may be the greatest factor in the success or failure of his operation over a long period. In other words,

FOUR RANGE CONDITION CLASSES IN CENTRAL TEXAS AND SOUTHERN OKLAHOMA (USA)



EXCELLENT CONDITION
Little bluestem, sideoats grama and forbs are most prominent plants. Roots penetrate deeply.

GOOD CONDITION
Buffalograss has invaded and is about as prominent as little bluestem and sideoats grama. Forbs are scarce, root systems are shorter.

FAIR CONDITION
Short grasses dominate; mesquite and other woody vegetation have invaded Forbs have been killed and grass roots have shortened.

POOR CONDITION
Woody vegetation, threeawn and inferior weedy vegetation have replaced the better forage plants.

LEGEND

A WILD-ALFALFA
B LITTLE BLUESTEM
C SIDEOATS GRAMA
D DOTTED GAYFEATHER
E HAIRY GRAMA
F BUFFALOGRASS
G MESQUITE
H SILVER BLUESTEM
I CACTUS
J TEXAS WINTERGRASS
K THREEAWN

U.S.D.A.-SOIL CONSERVATION SERVICE

(FIGURE 14)

what the stockman sees and how he reacts in using the range is what fattens livestock. If his eyes see the history of the range and if he pays particular attention to the kind and amount of erosion and the decrease or increase in natural mulch influencing condition and trend of the range production, then he can properly stock his range and obtain maximum livestock production per unit of pasture area without real damage to either soil or vegetation.

Determining proper numbers of livestock and proper seasons of grazing use may be accomplished in many different ways. Some of the more common are to (a) stock in accordance with grazing use on similar areas where utilization has been determined to be satisfactory; (b) remove livestock when 60 percent or less utilization has occurred on principal forage plants—the number of livestock and their period on the range to obtain such degree of utilization would normally represent proper stocking, particularly if soil conditions also remained satisfactory; (c) compute total forage production by clipping or similar studies—research has proven that half of the total forage production (air dry weight) can be safely utilized in most situations so approximately proper stocking rates can be computed through the use of established animal feeding requirements of about 600 pounds (272 kilos) of air dry forage per 900-1000 pounds (454 kilos) cow per month or 120 pounds (55 kilos) of air dry forage per sheep per month; and (d) use as a basis the results of studies on similar range areas even though at some distance from the range on which stocking information is desired.

An example of a recently developed and useful tabulation, correlating precipitation, range condition and grazing capacity follows:

Average Annual Rainfall (Inches)*	Percent of Composition of Range Plants in the Different Range Conditions (Animal Unit Months** per acre***)			
	Excellent (75-100)	Good (50-75)	Fair (25-50)	Poor (0-25)
5-9	.2	.15	.1	.05
10-14	.4	.3	.2	.1
15-19	.6	.45	.3	.15
20-24	.8	.6	.4	.2
25-29	1.0	.75	.5	.25

* An inch = 2.54 cm.
** A mature cow or 5 sheep for 30 days grazing
*** An acre = 0.4 hectare

The foregroing tabulation was prepared by Dr. E. T. Dysterhius, Soil Conservation Service (USA), from research data resulting from many grazing capacity studies. Its use is presumed to perpetuate ranges in excellent condition and to improve deterioarated ranges from poor to fair to good to an excellent classification. Similar tables could and probably should be developed in all Middle East countries. A good source of basic information might be secured from government farms and livestock institutions. Whenever possible, however, such basic records should be the result of ten or more years of experiemental work.

Season and Degree of Grazing Use

Each primary range plant has its optimum season of growth. Cool-season plants grow early in the spring and perhaps again in the fall or winter, if moisture is available, and temperatures permit. Warm-season plants grow in the hot weather when moisture is available. Range plants are most palatable and nutritious when grazed during the periods of their most rapid growth. They must also be rested during their growth period if the range is to improve. Accordingly, the inventory must take note of the growth period of principal range plants.

Range condition can be maintained or improved only when the degree of use allows the better plants to maintain healthy root systems. Grazing top growth too closely and too frequently stops root growth and, if this condition persists, the plant dies. The degree of grazing use observed during the range inventory is a good clue to present range management. Taking about half and leaving about half of the annual forage growth will yield maximum sustained forage production and yet maintain or improve range conditions.

Conclusion—*In summary*, the range inventory, properly conducted, is absolutely necessary to plan for proper management of grazing. The management of time and intensity of grazing to restore and maintain excellent range condition, offers greater opportunities for increased and stable *net* income from range lands than any other range improvement practice or measure.

The inventory, to be most valuable to the proper management of grazing, must include a study of range vegetation, range sites, range condition and trend in condition, stocking rates, and season and intensity of grazing use.

RANGE CONDITION GUIDE
FARHARABAD

Site Name (Uplands Plains, etc.) _____

Description of Soils (Silty, gravelly-sand, etc) _____

Examiner's Name _____ Date _____

Name of Plant	*Range Condition Class*			
	Excellent	*Good*	*Fair*	*Poor*
Stipa Spp.	many	some	few	very few
Oryzopsis holciformis	many	some	few	very few
Poa bulbosa	few	few	many	many
Annuals	very few	few	some	many
Artemesia scoparia	few	some	many	some
Convolvulus cantabrica	many	some	few	very few
Ephedra distachya	some	some	few	very few
Hedysarum spp.	some	some	few	very few
Astragalus spp.	few	few	some	many
Lactuca	few	few	some	many
Oxyria digyna (unpalatable)	few	some	some	very few
Other Shrubs	few	some	some	very few
Peganum harmala	some	more	few	many
Abjective ratings : Many—Some—Few—Very Few	Initial Stocking Rate : Cow Months per hectare _____			

(FIGURE 15)

FOUR RANGE CONDITION CLASSES ON THE SAME KIND OF LAND IN NORTHERN MIXED PRAIRIE

The pictures on the other side of this sheet were all taken on the same range site (Ordinary Upland in the 10 to 14 inch rainfall belt) on the same ranch. The rainfall on each was the same.

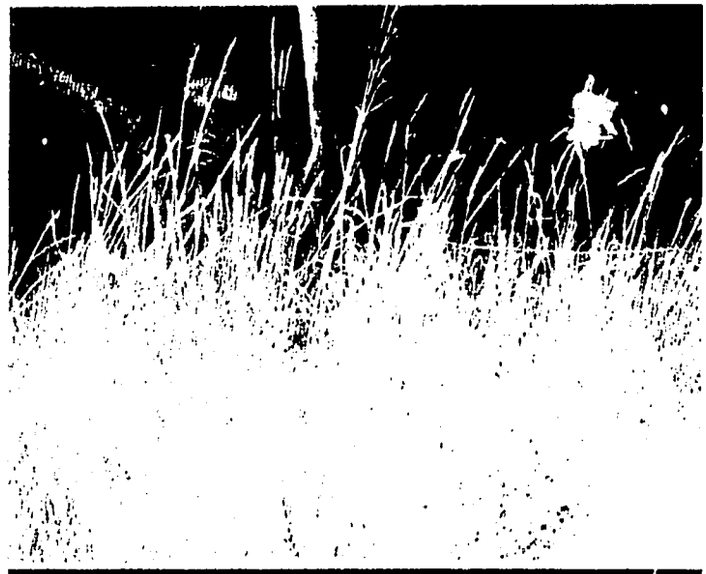
The differences in the grassland shown in the pictures are the result solely of differences in grazing use. All should look like the top picture. With proper management, they can be brought to that Excellent condition.

These pictures and text are presented to show how to recognize range conditions on this kind of land.

U.S.D.A.-SOIL CONSERVATION SERVICE

(FIGURE 16)

(OVER)



FOUR RANGE CONDITION CLASSES OF SAME KIND OF LAND IN NORTHERN MIXED PRAIRIE

Differences in use alone caused the differences in these native pastures. Soil and climate are same. Proper use can make all look like top picture.

EXCELLENT RANGE CONDITION

Taller grasses, such as GREEN NEEDLEGRASS, NEEDLEANDTHREAD, WESTERN WHEATGRASS, are abundant. These grasses, with an understory of BLUE GRAMA and JUNEGRASS, make up most of the ground cover. Seed is produced in favorable years. Good natural mulch accumulated on the surface lets water soak into ground faster. Forage production is at its highest and erosion is controlled.

GOOD RANGE CONDITION

BLUE GRAMA, a warm-season, short-growing grass, has partly replaced the taller, cool-season grasses. It now makes up a larger percentage of the cover than for Excellent Condition. When BLUE GRAMA replaces cool-season grasses the season of green grazing is shorter.

FAIR RANGE CONDITION

Very few of the original taller-growing grasses remain. There is much bare ground, soil crusting and runoff. Rainfall is lost instead of stored for grass growth. Use of range conservation measures will restore POOR or FAIR condition ranges to EXCELLENT condition.

POOR RANGE CONDITION

Nature tries to keep the ground covered with something. When use is so heavy that taller growing grasses cannot survive, she substitutes cactus, annual weeds, or very short kinds of plants that can escape grazing.

(OVER)

CHAPTER XXVIII

DETERMINING RANGE FORAGE PRODUCTION

GENERAL.—Forage is usually defined as the gross plant growth on a given area of land. Essentially, it is the food consumed by domestic animals for the benefit of people. These benefits, among others, include: meat, milk, butter, leather and wool. The amount of benefit depends upon the quantity of forage available for consumption by domestic livestock. This forage may be in the form of either native vegetation or crops grown on cultivated lands.

THE CLIPPING METHOD.—In determining the production of range forage under different conditions and sites a most practical and extremely simple method is to clip and weigh vegetation from representative small plots and thereby estimate and demonstrate the amount of production from entire range areas. Using the clipping method the actual production of one range site as compared with another can easily be obtained and demonstrated even though the potential production may be a great deal more or less. It is also possible to compare the amount of forage on a range site that is well managed with one that is unmanaged, as well as to compare yields under different types of management. Moreover, the method may be used to compare the production of different mixtures of irrigated pasture under various systems of irrigation, or between different amounts and kinds of fertilizer, both on artificial and on native vegetation. In addition, the amount of hay production can be measured for any area by weighing and clipping on plots of known size.

Throughout the world, many rather extensive records have been compiled on the production of most agricultural crops. Usually, rangeland forage is an exception although the compilation of data on grasslands is very important. With most agricultural crops, whether for livestock or other uses, the average production under nearly any soil or climatic condition can be predicted with reasonable accuracy. However, very few records actually indicate the average range carrying capacity or range forage production that can be expected from various types of soil under given climatic conditions. As range managers then, one of our major jobs should be to accumulate reliable and usable rangeland production records. Such records, to be of real value, must be carefully maintained and the data must be accumulated over many years so that other technicians can use the information to greatest advantage.

EQUIPMENT NEEDED.—The tools or equipment needed in determining forage production from rangeland on the basis of clipped plots are merely a spring scale graduated in grams and a pair of grass-clippers, sheep-shears, or scissors. Such cutters are best for clipping grass as they facilitate uniform clipping heights whereas knives are not generally satisfactory because uniform heights are not as easily obtained. Some kind of container is also necessary to collect the vegetation for weighing —paper sacks, small cloth bags, or small boxes are suggested. In addition, measuring devices are needed to lay out plots of desired and known size.

SELECTION, LOCATION AND SIZE OF PLOTS.—In the selection of plots, there is nearly always a tendency to pick the better spots. To prevent such personal bias, random plots must be selected.

From a paper by: Wayne Wenburg Grasslands and Range Improvement Specialist, USOM/Turkey.

Randomization can easily be accomplished by throwing a stone in any direction and taking the point it strikes as the center of circular plots or a given corner of square plots. If more than one plot is to be clipped, then a prior determination should be made that a point at exactly ten steps, two steps, or any fixed number of steps from the first plot, will mark the location of the next plot with succeeding plots to be located in like manner. Prior to locating the first plot, the direction in which all plots are to be laid-out should also be determined.

The size of plots selected for clipping will depend largely on the amount of ground cover, time available, and the data to be obtained. When the metric system is used, plot size will, normally, be a square meter. Such plots may be a meter on each side or circular with a radius of approximately 56.5 centimeters. If the square plot is used, round stakes are usually driven into the ground at the four measured corners after which a heavy string is drawn around the stakes. Then, all vegetation is clipped inside the marked square. If the circular plot is used, a small round stake is driven into the center of the plot as a pivot to which is attached a heavy string, light rope, or wire 56.5 centimeters long. The plot is then marked by scratching the outside boundary with another stake at the end of the string or by using the points of a pair of clippers or shears. It is suggested that a small band of vegetation be cut on the outside of the scratched line and removed or thrown to one side so the plot will be more clearly delimited. The next step, of course, is to clip and weigh the vegetation within the plot.

WEIGHTS AND COMPUTATIONS.—After a plot has been clipped, the clipped vegetation is placed in a paper sack or other container. The container weight must be known, as when the clipped vegetation is weighed on a spring balance or scale the weight of the container must be subtracted to obtain the true-weight of the green forage. Air dry weight is obtained by weighing the clipped material each succeeding day until the same daily or approximate air-dry weight is obtained. The weight lost in this process is moisture and the difference between the original weight and the final weighing is the amount of moisture in the green material.

Computing yield per hectare is quite simple as the weight in grams from a square meter is equivalent to kilograms per decar. Kilograms per hectare is, therefore, computed by multiplying the weight in grams from a square meter plot by ten (10). If ten square meters are clipped, the total weight in grams from the 10 plots is equivalent to kilograms per hectare. To obtain pounds per acre, merely multiply kilograms per hectare by 0.891, or for simplicity, use 0.9 as the factor.

SUMMARY.—All range managers are encouraged to use clipping and weighing procedures to obtain and show others the differences in production yields as well as to secure local data as a basis for more definite recommendations on stocking rates and various other phases of range management.

An example of the manner in which clipping and weighing procedures can be used is the following table comparing forage yields on various range sites by range condition classes at Grand Prairie, Texas (U.S.A.) in midsummer for the period 1946 to 1949 inclusive:

			Average Forage Yield Per Acre**	
Site	Range Condition	Climax Plants Pounds*	Invaders Pounds	Total Vegetation Pounds
Valley Site (Run-in)	Excellent	3216	—	3216
	Good	2534	176	2710
	Fair	1964	344	2308
	Poor	1252	606	1858
Upland Site (Normal)	Excellent	1987	—	1987
	Good	1540	164	1704
	Fair	1140	299	1439
	Poor	606	509	1115
Ridge Site (Run-off)	Excellent	1393	—	1393
	Good	1064	138	1202
	Fair	734	309	1043
	Poor	389	339	728

* 2.2 pounds = 1 kilogram ** 2-1/2 acres = 1 hectare

RANGE FORAGE USE CHECK SHEET
(For Training Purposes)

OWNER _____ RANGE OR PASTURE NAME _____ DATE _____

SITE _____ CONDITION _____

EXAMINER'S NAME _____

Key Plants	CHECKS MADE						Total	Average Percent Use
	1	2	3	4	5	6		
							TOTAL.	
							AVERAGE	

Legend

U — Under use, less than 40%
P — Proper use, 40 to 60%
O — Over use, 60% and over

Degree of Forage Use _____

Estimated dry weight of all vegetation including litter _____

(FIGURE 17)

(OVER)

Another example is a recent clipping study reported from Iran on a range site with an average rainfall of about 375 mm. Part of the site was in fairly good condition and part was in poor condition. The better condition portion yielded 200 kilograms per decar of good grass-forage whereas the poor part yielded less than 50 kilograms. An important factor in this study is that the weight of all vegetation was approximately the same but 150 kilograms per decar was unsuitable as forage from the poor condition portion of the range.

Another manner in which clipping and weighing proceedures can be used is in determining forage utilization. The simplest procedure is through clipping to stimulate grazing and weighing to determine percent of use or percent of left ungrazed of all or of individual forage plants on a range area. Sometimes, small protected plots are used for comparison and obviously, many other adaptations and variations are possible to fit specific needs. A simple record form which can easily be modified for wider application or use is shown in Figure 17.

CHAPTER XXIX

THE LOOP TRANSECT METHOD OF STUDYING RANGE VEGETATION

GENERAL.—The loop-transect method of estimating range vegetation, which is suggested for use in Middle East countries, follows closely the procedure outlined by Kenneth W. Parker (1) under "Step One" of the so-called "Three Step Method." Those interested in greater detail are referred to Parker's paper. A most urgent need throughout the area is to enable range tcehnicians to evaluate accurately the changes which take place in the vegetation on depleted native range lands in response to grazing treatment. The method proposed is particularly valuable where extremely heavy grazing use has long prevailed and where there is no sound information available as to the rate of improvement which would take place if grazing management were practiced. Used in conjunction with livestock exclosures on the more important sites, loop transect data will provide some extremely valuable leads as to degree and rate of improvement to be expected from controlled grazing use. It is also a valuable means of determining upward or downward trend in range condition where controlled grazing use plans are in effect. A primary objective in developing the method was to obtain data by simple, practical, accurate, and technically sound methods which would yield concrete measurements as well as sound observational evidence of trend or change in range condition.

Factors involved in the application of the loop transect method include (a) selection of the site to be sampled, (b) determination of the number and location of the transects, (c) establishment of the transects on the ground, (d) recording data from the transects, and (e) analysis and interpretation of data. Each of these steps is described in sufficient detail tc give range technicians a working knowledge of the method with a minimum of field instruction.

SELECTION OF THE SITE.—The site on which permanent transects are to be located should ordinarily be an important range type, representing an extensive range area which produces or is capable of producing the major part of the forage in the area. Areas should be avoided where grazing animals concentrate unduly, such as along trails or driveways, near villages, or adjacent to watering places. If comparisons are to be made between grazed and ungrazed range by establishing transects inside and outside of livestock exclosures, two separate areas must be chosen, each at least 50 meters by 50 meters in size, separated from one another by a strip at least 20 meters in width (to avoid the effect of animals being attracted by the fence), and uniform in such characteristics as soil, slope, exposure, drainage, vegetal cover, and other important site characteristics.

NUMBER AND LOCATION OF TRANSECTS.—A group or "cluster" of three transects is recommended for sampling any one site or condition on the arid or semi-arid rangelands of the Middle East. This

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From papers by: L.R. Short, Range Specialist, USOM/Iran, and
Clarke A. Anderson, Leader 1957 Regional Range Management Course (Iraq).

(1) Parker, Kenneth W., "A Method for Meaduring Trend in Range Condition on National Forest Ranges," Forest Service, U.S. Department of Agriculture, October 17, 1951.

means that where transects are used in conjunction with livestock exclosures, three transects are needed both inside and outside of the fenced area. Transects inside of a livestock exclosure should not be closer than five meters from the fence, nor less than two meters from each other. It is suggested that a randomized block design be used in determining the location of the transects. Assuming a 50-meter by 50-meter fenced area, there would be 20 blocks each two meters wide and 40 meters in length that are not closer than five meters to the fence. Three of these 20 blocks should be selected at random (by chance), and the transects located down the center line of each. But since the blocks, in this example, would be 40 meters in length, and the transects only 20 meters long, randomization of the transects along the center line of each block is suggested. Starting from one end of a block and using one meter intervals, a transect might begin anywhere from zero to 20 meters from the end of the block, the exact point to be determined by chance for each of the three transects. The group of three transects outside of the fenced area would be located in a similar manner. For example, if the fenced area was 50 by 50 meters in size, the area on which the transects were located would be 40 by 40 meters, and a like-sized area at least 20 meters away from the fence would be used on which to locate (on three of the 20 two-meter by 40-meter blocks) the transects outside of the fenced area.

Establishment of the Transects.—When the location of the transects has been determined as described above, a 20-meter section of a tape (preferably 22 or more meters in length) should be stretched as tightly as possible between the ends of the transects in such a manner that the 1.20-meter point falls at the starting point of the transect, and the 21.00-meter point falls on the opposite end of the transect. The tape is best held at each end by a tapeholder of the sort described by Short (2) set in the ground in line with the transect but at a point 40 centimeters or so beyond the limits of each end of the transect. The tape should be suspended about 15 centimeters above the soil surface at each end. Slight notches in the tape (on the right-hand side when viewed from above and facing away from the zero end) at 20 centimeters intervals, starting at the 1.00-meter point and ending at the 21.20-meter point, makes location of the observation points along the tape easier when observations are being recorded. Following this procedure, there will be 102 notches in the tape, the first and last of which serve as guide notches for relocating the tape along the transect line at some later time. With the tape thus suspended, and using the specially centered 3/4-inch loop (also described by Short) to locate a point directly below the guide notices (1.00 and 21.00 meters), set a 60-d or 80-d spike (nail) in the ground at these points, so that the head is barely above the soil surface, and record the location of these spikes (which are 20 centimeters beyond each end of the transect) with reference to some readily located object, such as a stone or fence post. Relocation of the spikes marking the location of the transects at some future time is in this way insured.

Recording Data From the Transects.—When the tape is in place between reference points which mark the location of the transect, a record is made of the observations at each of the 100 points along the 20-meter transect, and between the spikes which mark the location of the transect. The record should show the name and location of the transects, whether or not they are inside or outside of a fenced area, the number of the transect (always follow the same order of numbering that is assigned at the time the transects are established), the date measurements were taken, and the name of the observer. The record should also show the various species that fall within the 3/4-inch loop at the ground level at each of the 100 points, as well as such other information as bare soil, rock, erosion pavement, mulch, etc.

In taking the reading at the ground level, only herbaceous species, or the woody bases of shrubs, that fall within the loop at that point are recorded. Occasionally, two or more species may occur in the same loop. If this happens, an entry in the "species" column is made (on a separate line), showing a "hit" for the two or more species present. This is done, even though individually the species may occur elsewhere, in order to maintain the correct ratio between vegetated and unvegetated loops. Usually, tiny annual plants are grouped, either as annual grasses or as annual forbs, the record for different species encountered being kept separate only for the more important annuals, as well as for all perennials. In the case of woody perennials, such as shrubs, which have a sizeable "crown,"

(2) Short, L.R., "New Equipment for the 3-Step Method," Research Note No. 111, Northern Rocky Mountain Forest and Range Experiment Station, Forest Service, Missoula, Montana, August 1952.

loops that fall within the crown area, but miss the perennial base of the shrub at the ground level are recorded the same as if the shrub were not there, except that a separate line is used, and the name of the shrubs is circled, after which follows the name of the appropriate loop entry at the ground level.

Records should be made at the time of the year when the bulk of the plant species are most easily identified. Records of the same group of transects that are repeated in subsequent years should be made at about the same stage of plant development.

Since improvement may be made in height or vigor as well as by lateral spread of plants, it is desirable to determine average heights of one to three of the "key" species present. This is done by tossing an ordinary lead pencil ten times for each species to be measured in the immediate vicinity of each transect, and recording maximum (straightened) height of that species that is nearest the pencil point. In the case of bunchgrasses, such as *Stipa*, the maximum height of the tallest basal leaf, rather than of culms is taken. These height measurements may be entered on the back of the "Permanent Loop Transect (short form)" or front of the "Record of Permanent Line Transect (long form)," examples of which are included at the close of this chapter (Figures 18 and 19).

SUPPLEMENTARY OBSERVATION AND RECORDINGS.—There is almost no limit to the amount of supplementary information which may be secured through adaptation of the loop transect or similar methods. Examples include (a) more specific data on plant vigor, (b) more representative information on vegetative composition where plant density is sparse; (c) age and form classes of shrubs (woody vegetation) and (d) approximate stocking by domestic livestock and wild herbivorous animals when actual stocking information is unknown or lacking—this on the basis of the so-called "pellet-group (feces) count" method.

(a) Additional Plant Vigor Data.

With extreme differences in vigor of individual plants on a range site, a minimum of ten measurements each on key plants may not be sufficient. In such instances, more detailed measurements are suggested. Additional measurements may also be desirable whenever questions arise over the difficulty of describing or measuring vigor, whenever current weather tends to obscure such determinations or when lack of competition may give scattering plants a more robust form on poor than on better range sites.

One system that is particularly valuable—especially where areas lightly grazed for 10 or more years or those with a long history of moderate use or plots protected from grazing are available—is to establish so-called "vigor guides." In this process, a minimum of fifty plants of each key species are selected at random and measured. Measurements are recorded to the nearest half-inch (1.27 cm.) with the data arranged from the longest to the shortest leaf-length. These data are then divided into five equal subgroups so that each such sub-group makes up a proportionate part of the total record. The longest leaf-length group thereby represents excellent vigor and with similar measurements on the same plant species in any area being studied in the same general locality, vigor would be considered excellent. The same reasoning would apply with the other four leaf-length sub-groups as: good, fair, poor and very poor.

An alternate method is to measure average maximum leaf or flowering stem length of the 50 or more randomly selected plants which are considered to be in optimum vigor. Then, with this as a base the following scale is used to compare measurements and so classify vigor of the same species randomly measured on the study area:

Excellent	—	95% or more	of	average	maximum	length
Good	—	95 to 85%	"	"	"	"
Fair	—	84 to 75%	"	"	"	"
Poor	—	74 to 65%	"	"	"	"
Very poor	—	64 or less	"	"	"	"

As an example, if a *Festuca* used in setting up the guide had an optimum leaf length of 6.0 inches (15.2 cm.) and the average maximum leaf length on the study area is 5.2 inches (13.2 cm.), vigor on the study area would be classified as good, or 86% of the base.

(b) More Representative Plant Composition.

In sparse or in tall, lush but low-ground density vegetation (plant density of 20 or less) the loop method may not give a really representative idea of plant composition. Again, additional detailed measurements are indicated. More transects or more readings per transect will usually suffice but may be tedious or prohibitive in time consumed. Where time is limited, alternate methods are suggested.

One very simple method is to record the transect as usual but maintain an extra, preferable dot, tabulation (under the subheads—desirable, least desirable and intermediate plants) in which to record vegetation nearest each loop measurement in which no plant occurs. The extra tally added to the usual tally then represents a full 100 plants and results in direct percentages for the purpose of the overall plant composition occurring on the study area.

(c) Age and Form Classes of Shrubs.

The absence of one or more age-classes of various plant species on range lands is usually indicative of a need for changed management. This is especially the case when younger-age classes are scarce or absent even when older classes are dying out. Exceptions might include competition from optimum stands for the site or stands where fire is prerequisite to successful reseeding of given species. Certainly, on over-grazed ranges the younger-age groups of preferred forage species are particularly susceptible to losses resulting from over-cropping. On the other hand, younger-age classes of desirable forage species will be present and younger-age classes of undesirable species will be sparse or lacking on understocked or properly stocked ranges.

With shrub species (woody vegetation) the form-class is a particularly valuable index to both the degree of hedging (past grazing use) and present availability (height, location or density) of shrub forage. Data on form-classes of various browse species can also be used to determine browsing pressure in the immediate past and present relief if any, as well as relative importance of different browses and amount of forage currently available. In addition, when form-classes are correlated with age-classes an understanding can be obtained of indicated trends in carrying capacity as influenced by both availability and productive vigor of browse plants.

Age-classes are usually shown as:

S (seedlings)—established and very young plants.

Y (young plants)—larger than seedlings.

M (mature plants)—older plants but with crowns made up of more than 75% living wood.

D (decadent plants)—old plants dying from age or other factors and with crowns showing over 75% dead wood.

Form classes are usually shown as:

Form Class 1 —	All available to grazing animals,	little or no hedging
2 —	" " " " "	moderately hedged
3 —	" " " " "	tightly hedged
4 —	Largely " " " "	little or no hedging
5 —	" " " " "	moderately hedged
6 —	" " " " "	tightly hedged
7 —	Mostly unavailable to grazing animals	
8 —	Unavailable	

Examples of these shrub age and form classifications and the symbols suggested for recording grazing use on transect record forms are shown at Figures 19 and 20.

(d) Pellet Group (Animal Feces) Counts.

In Western United States, pellet (feces) counts have been found to be a very useful method in separating current game (wild-animal) use from domestic livestock use and in arriving at an estimate of actual use vs. proper grazing use. The method involves a simple count of pellet groups or droppings within a plot of 1/100 acre in size or multiple thereof, circumscribing permanent loop transect lines. By the use of metric conversions data can easily be related to decars or similiar land units.

Plot layouts and converting factors in most common use are as follows:

Plot size	Alternate Dimensions Using Loop Transect Line as Pellet Count Plot Center-line	
	Width	Length
1/100 acre	6.6 feet or 79.2 inches	66.0 feet
1/100 acre	6.0 feet or 72.0 inches	72.6 feet
1.5/100 acre	6.6 feet or 79.2 inches	99.0 feet
1.5/100 acre	6.0 feet or 72.0 inches	108.9 feet

Converting factors: 12 droppings per cow day,
13 pellet groups per sheep day.

For example, on a cattle range where cattle have been removed for the season and actual stocking is not known but the average number of cattle droppings during the current season is determined to be 6 per 1/100 acre sample the per acre equivalent is 600. Accepting a cattle average of 12 droppings per day, the use indicated is 50 cow days per acre ($600 \div 12 = 50$). In this example, therefore, the range has been stocked for the current season to date on the basis of 1-2/3 acres ($50 \div 30$) per cow month.

The vast application of this kind of information (when actual stocking records are not available) is readily apparent. In the example, for instance, if proper utilization of say 50 percent of key forage plants was obtained the range should be stocked on the basis of 1-2/3 acres per cow month. If, however, use of key plants was determined to be 75 rather than 50 percent, then the range has already been overstocked 50% and the proper stocking rate would be in the neighborhood of 2-1/2 acres per cow month, not 1-2/3 acres. Similarly, if current utilization of key plants was under 50 percent, the stocking rate would be indicated to be less than 1-2/3 acres per cow month. A caution, however, is to test the method widely and develop converting factors suitable to the area being sampled—we must remember that the method is new and only approximate, even though very useful. Records are necessary and, as an example, recording space has been provided in the long form Record of Permanent Line Transect (Figure 19).

Analysis and Interpretation of Data on Line Transect Studies.—The number of "hits" for all plant species is totaled (see the form in Figure 19) to obtain the plant density index. The total for all entries should be 100 for each transect. The ground cover index is the total of all entries except "bare soil." "Overstory" is the total of all circled entries. "Understory" is the total number of "hits" of forage species that occur under the crowns of shrubs. The data for each transect are tabulated in this way, and totals for the three transects can then be grouped and averaged on a separate summary sheet, on which subtotals for all "hits" of vegetation are shown as "desirable," "intermediate," or "undesirable" species. (These three groups are sometimes referred to as "decreasers," "increasers," and "invaders.") The percentage that each of these three groups of plants make of the total for all plant "hits" serves as a basis for classifying the range as to condition class. Such a classification can be worked out when more is known as to the composition of native ranges as they approach "top" or excellent condition.

Supplemental information should, of course, be included to the extent desired. Forms most suitable for any given situation may vary quite widely. The "long form" and "short form" records which follow (Figures 18 and 19) are merely samples of the type of forms which may prove useful.

RECORD OF PERMANENT LOOP TRANSECT
(SHORT FORM)

Name and Location of Transects _____

Date Measured _____ Observer _____

Species	Transect No. _____ Hits	Total	Transect No. _____ Hits	Total	Transect No. _____ Hits	Total
Plant Density Index						
Bare Soil						
Erosion Pavement						
Rock						
Mulch	Total	100.0	Total	100.0	Total	100.0

Forage Density Index . . . . . _____ _____ _____

Annuals . . . . . _____ _____ _____

Ground Cover Index . . . . . _____ _____ _____

Overstory . . . . . _____ _____ _____

Understory . . . . . _____ _____ _____

_____ . . . . . .

(FIGURE 18)

(OVER)

Vigor Measurements :

Other Measurements :

Comment :

RECORD OF PERMANENT LINE TRANSECT

(LONG FORM)

Cluster Name and Transect No. _____

Forest _____ Ranger District _____ Allotment _____ Date _____ By _____

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

KEY INDICATOR SPECIES NOT RECORDED
(Include undesirable invaders and annuals)

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

VIGOR MEASUREMENTS

Species _____
1 _____
2 _____
3 _____
4 _____
5 _____
6 _____
7 _____
8 _____
9 _____
10 _____
Total _____
Av. Max. _____

Tape Height at Stakes :
_____
_____
_____

	SYMBOL	
Bare Soil	-	_____
Erosion Pavement	P	_____
Rock	R	_____
Litter	L	_____
Moss	M	_____
Plant Density Index		_____
Total		100
Forage Density Index		_____
Desirable Plant Index		_____
Ground Cover Index		_____
Overstory		_____
Understory		_____

SPECIES
(List by symbol, name and number of hits)

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

PELLET GROUP COUNT

Plot Size _____
Deer _____
Elk _____
Other _____

ANNUAL (List by Species)

INDICATORS	OTHERS
_____	_____
_____	_____
_____	_____
_____	_____

(FIGURE 19)

(OVER)

GENERAL INSTRUCTIONS

List overstory species at the top of each block and circle symbol when it is a dead portion of a living shrub.

AGE CLASSES OF BROWSE PLANTS (*)	Class	FORM CLASSES OF BROWSE PLANTS (*)
	1	All available, little or no hedging
S — seedling	2	» » moderately hedged
Y — young plant	3	» » closely hedged
M — mature	4	Largely available, little or no hedging
D — decadent	5	» » moderately hedged
	6	» » closely hedged
	7	Mostly unavailable
	8	Unavailable

On game ranges classify all browse hits up to 5 feet as M3, D6, S1, Y2, etc. Tally in block directly behind browse species as "ArtrM2", etc.

PELLET GROUP COUNTS

Plot size should be 1/100 acre, or a multiple of same, using the tape as the plot center line. Alternative dimensions that may be used are:

Width:	6.6 feet or 79.2 inches (3.3 ft. each side of tape)	OR	6 feet or 72 inches (3 ft. each side of tape)
	and		and
Length:	0 to 66 ft. give 1/100 acre 0 to 99 ft. gives 1.5/100 acre		0 to 72.6 ft. gives 1/100 acre 0 to 108.9 ft. gives 1.5/100 acre

Example: A cluster with two transects and plots 6.6 feet wide and 0-99 feet in length samples 3/100 acre.

CONVERTING FACTORS:

13 pellet groups per day for deer
13 » » » » » elk (tentative estimate)
12 droppings per day for cattle

NOTES

(*) Dasmann, Wm. P. Some deer range survey methods. Calif. Fish and Game, Vol. 37, No. 1, Jan. 1951.

CHAPTER XXX

SPECIES PLOT METHOD OF DETERMINING RANGE TREND

GENERAL.—Various methods of determining trend in range condition are in common use throughout the world today. In addition, there are many adaptations and modifications in procedure designed to better fit individual needs and local conditions.

Generally, the most accurate methods are those relating to the various kinds of transects including, in particular, measured-line, point-intersect, area-intersect, belt or strip, paced and photographic-plot. However, good results can often be obtained by using more simple methods most of which require less time for establishment and recording. Many also have an added advantage in that they can be readily seen or interpreted by anyone. Such a system is the so-called "Species-Plot" method.

DESCRIPTION OF METHOD.—The "Species-Plot" method is based on the counting and recording or charting of the perennial plants occurring on permanently marked plots. Only those plants on which trend determination are desired should normally be listed. Periodically, and usually at 3 to 5-year intervals, on identical or nearly identical dates each year, the same plots are recharted and the differences found in vegetation from one year to another indicate the changes that are taking place and also whether the range is improving or deteriorating. Photographs of plots taken from identical points at the time of each recharting are always a valuable supplement.

SELECTION AND LOCATION OF PLOTS.—Species plots should be located at random on important range sites. Their general location should be on areas representative of a large proportion of the major range site being sampled. Areas should not be selected where the plant species to be studied are either particularly abundant or particularly sparse. The number of plots necessary will, of course, vary with the size and complexity of the range site being studied. As a general rule, however, a minimum of 3 to 5 plots is suggested on very uniform sites with several times this many on more complex sites.

SHAPE AND SIZE OF PLOTS.—The plot area does not have to be of any particular size or shape. Preferable is an area containing a few to several square meters on which the plants to be studied are present. The area may be square, rectangular, circular or most any other shape. A very workable plot in arid areas is one containing 25 square meters in either a square or rectangular shape.

Plot size should be such that no more than one-half hour will be required to chart or count the individual plant specimens included in the study. Normal counting or charting time should be about 15 minutes. Plot corners should be plainly and permanently marked. Steel stakes may be used although stones firmly set in the soil may be preferable as they do not ordinarily excite the curiosity of people as readily as other types of markers. The important factor to keep in mind is to so establish corner and other markers that plots can readily be found at recharting time, maybe many years later.

From papers by: James O. Stewart, Range Management Advisor, USOM/Iran, and
Wayne Wenberg, Grasslands and Range Improvement Specialist, USOM/Turkey.

RECORDING.—Two suggested forms are shown in Figures 21 and 22. Regardless of the form developed for recording information, the location of the plot should be well described so so one other than the original examiner can find the plot in future years simply by following the location description on the form. Sufficient copies of the form should also be made so that records can be maintained in all interested offices.

Exact dimensions of each plot can be determined by using a tape or other measuring device. Generally, however, sufficient accuracy will result using paced distances.

On charting forms (Figure 21) the vegetation (generally key species only) is sketched in by eye as nearly to scale as possible with species named or indicated by symbol. When symbols are used they and the plants to which they refer must be included under the "chart legend." Quite often, individual plants will also be counted (if single stem species) or measured (if bunch or sod-forming species) and such counts and measurements also recorded on the form. Charting forms should be developed to fit specific needs but must generally include all the information called for in Figure 21.

On listing and measuring forms (Figure 22) the same information is usually recorded omitting only the charting of location and extent of vegetation on the plot. The purpose for which plots are established and the need to which the information obtained will be put will, of course, dictate the type of records which will be required and the kind of record form needed.

ILLUSTRATIONS OF SHRUB AGE AND FORM CLASSES

FIGURE 1. Bitterbrush *(Purshia tridentata)*. Age Class: Mature. Form Class 3: all available, tightly hedged; Designation: "Putr M3".

FIGURE 2. Bitterbrush. Age Class: Mature. Form Class 6: largely available, closely hedged; Designation: "Putr M6".

(FIGURE 20) (OVER)

FIGURE 3. Juniper. Age Class: Mature. Form Class 8: Unavailable. Designation: "JUN. M8".

SPECIES PLOT FORM

_____
(Name of Plot)

_____ _____
(Established by) (Recharted by) (Date established) (Date recharted)

Location of Plot_____

_____

Description of Site _____

Key Species _____ Other Species _____

_____ _____
(Normal months of grazing use) Dimensions of Plot

CHART (location and extent) OF VEGETATION ON PLOT

Show North direction with an arrow

Principal purpose of plot: _____ Chart Legend (Symbols)_____

_____

_____

COMMENTS:_____

_____

_____

(FIGURE 21) (OVER)

MAP (Show exact location of plot — courses, distances, features, roads, trails, streams, etc.)

PHOTOGRAPHS

ADDITIONAL COMMENTS

RECORDING FORM FOR LISTING AND MEASURING AMOUNTS OF PLANTS IN STUDY PLOTS

Location _____ Examiner _____

_____

Plot No. and Name _____ Date _____

PLANT NAMES	Number or Amount	PLANT NAMES	Number or Amount	PLANT NAMES	Number or Amount

Description of Site _____

_____

Key Species _____

_____

Principal Purpose of Study _____

_____

_____

Comments _____

_____

(FIGURRE 22) (OVER)

MAP (Show location of plot — courses, distances, important reference features, roads, trails, streams, etc.)

PHOTOGRAPHS

ADDITIONAL COMMENTS

PART VI

APPENDIX

SECTION I

ADDITIONAL IMPORTANT FACTS FOR LIVESTOCK OPERATORS

GENERAL.—There are many good publications containing much information useful to livestock operators and range managers in their day-to-day work activities. Covered are such items as: animal gestation periods, puberty and heat periods and mating tables; livestock feeding guides; water and salt requirements; age determination from teeth; symptoms of animal diseases; symptoms of animal poisoning (poisonous plants); animal parasites—treatment and control; various weights and measures; and similar data.

Much of this information has been presented but a complete treatment would require additional volumes of written material largely duplicating that already published in current reference books. We should all, therefore, make frequent use of such reference publications, particularly since the information which follows represents only a few of the most used and more important "Facts for Livestock Operators."

GESTATION PERIOD OF FARM ANIMALS

Cattle	— 283 days	Horses	— 340 days	Sheep	— 148 days
Donkeys	— 365 days	Goats	— 150 days	Pigs	— 114 days

PUBERTY AND HEAT PERIODS OF FARM ANIMALS

Class of Animal	Age of Puberty	Duration of Heat		Interval of Heat	
		Range	Average	Range	Average
Cattle	12 months	6-30 hrs.	12-18 hrs.	19-23 days	21 days
Sheep	4-7months	3-70 hrs.	28 hrs.	14-19 days	16 1/2 days
Horses	15-24 months	120-192 hrs.	156 hrs.	18-27 days	21 days
Swine	4-6 months	48-72 hrs.	60 hrs.	18-24 days	21 days

HANDY MATING TABLE

Class of Animal	Age	Matings per Year		Comment
		Hand Mating	Pasture Mating	
Bull	Yearling	10-12	8-10	Use 1 bull to 25 cows; farm bulls reliable to 10 years of age; range bulls 6-7 years.
	2 year old	25-30	20-25	
	3 year old or over	40-50	25-40	
Ram	Yearling or older	50-75	35-60	Use 1 ram to 25 or 35 ewes; rams reliable up to 6 or 8 years of age.
Stallion	2 years old	10-15	Not recommended	Limit 2 years old to 2-3 services per week; 3 years old 1 per day; 4 years old 2 per day. Reliable to 20-25 years of age.
	3 years old	30-40		
	4 years old	40-60		
	Mature	80-100		
	Over 8 years old	20-40		

From papers and lectures by: B.W. Allred, Leader 1955 Regional Range Management Course (Iran); Leslie R. Albee, Leader 1956 Regional Range Management Course (Iran), and Clarke A. Anderson, '55-'57 Regional Range Mg. Course (Iran and Iraq).

LIVESTOCK FEEDING GUIDE

Feeds	Maintenance Ration (Pounds* per day) Mature Range Cow (1100 lbs.)	Ewe (first 100 days of gestation) 100-150 lbs. animal **
Legumes hay or good grass-legume hay	18-28	3-4
Grass hay or other non-legume dry roughage	18-28	3-4
Protein supplement	1/2-1	1/4-1/2
Silage	55-60	8-10
Protein supplement	1/2-3/4	1/4-1/2
Silage	40-45	4-6
Legumes or good grass-legume hay	5-6	2-2 1/2
Silage	40-45	3-4
Grass hay or other non-legume dry roughage	5-6	2-2 1/2
Protein supplement	1/2-3/4	1/4-1/2

* 2.2 pounds = 1 kilogram

** For last 6 weeks of gestation add 3/4-1 pound of grain to daily ration. For ewes in lactation add 3/4-1 pound grain plus 1/4 pound protein supplement to each ration having less than 2 pounds of legumes.

WATER REQUIREMENTS		AND	SALT NEEDS
Cattle	10-15 gallons per day		1-3 pounds per month
Sheep	1-2 " " "		1/2-1 " " "

TELLING AGE OF CATTLE AND SHEEP BY THEIR LOWER FRONT TEETH.—At birth, a calf has one-pair of incisor teeth. After the first month they have their eight incisors, all on the lower jaw. At two years of age, one-pair of large incisors; at three years, two-pairs; four years, three-pairs and five years, four-pairs.

The age of sheep can be told fairly accurately until after they are four years old. At one year of age, a sheep has one-pair of large incisors; at two years, two-pairs; at three years, three-pair and at 4 years, four-pair.

SYMPTOMS AND TREATMENT OF SOME COMMON ANIMAL DISEASES

Disease	Livestock affected	Cause	Symptoms	Treatment
Anthrax (splendic fever, charbon) an acute infectious disease	All	*Baccilus* anthracis a large, rod-shaped organism	Rapid respiration; lagging; body (especially neck) swellings; fever; excitement depression; often sudden death.	Isolation and in early stages anti-anthrax serum or pencillin; later stages-no treatment.
Blackleg—a very infectious highly fatal disease	Cattle mainly (also sheep)	*Clostridium* feseri an anaerobic bacterium	Lameness and body swellings which crackle under pressure; high fever; loss of appetite and severe depression-death usually within 3 days	Preventative vaccination; veterinary treatment sometime effective; burn or bury carcasses.
Bloat	Cattle Sheep	Unknown—most common on lush, legume pastures	Greatly distended paunch	Keep animal afoot and moving; drench with 1/2-1 pint mineral oil; puncture paunches as a last resort.

Diserse	Livestock Affected	Cause	Symptoms	Treatment
Brucellosis	Cattle Goats Man	*Brucella* shortus *B* suis *B* melitensis	Abortion; swellng joints; lamenesis	No successful treatment; isolate infected animals.
Distemper (strangles) a widespread contagious disease	Horses Mules	*Streptococus* equi, a bacterium	Depression; loss of appetite	Good nursing—food, water, shelter; isolation.
Foot and Mouth Disease—a highly contagious disease	Mainly cattle and sheep; also man	Small filtrable viruses of at least 3 types (A, O and C)	Water blisters in mouth and on skin around hoofs; fever common	No satisfactory treatment known; slaughter and bury infected animals.
Footrot—an infectious disease	Cattle Sheep Goats	Perhaps several soil organisms as: *Spherophorus* necrophorus in cattle and *Actinomyces* necrophorus in sheep	Lameness; reddening and swelling of skin around hoof—sometimes pus; characteristic foul odor	Remove to clean dry place; trim hoofs, stand animals in solution of 5-20% bluestone for 1-5 minutes every 2-4 days; isolation.
1. Lumphy jaw and 2. Wooden tongue—infectious and chronic diseases	Cattle Sheep Horses Swine Man	1. *Actinomyces* bovis causes lumpy jaw. 2. *Actinobaccillus* lignier-esei causes wooden tongue. Both are fungus organisms	1. Lower jaw bones enlarge, become spongy and pus filled, foul odor. 2. Swollen throat tissues; enlarged and hard; tongue-pus discharge	Stop feeding grains; segregate infected animal; administer water treatment of iodine salt; sometimes surgery on abscesses.
Pneumonia,an inflammation of the lungs	All	Micro-organisms, viruses, etc.	Chilling followed by high temperature; quick shallow respiration; coughing; discharges from nostrils and perhaps eyes; loss of appetite and constipation; difficult breathing	Remove to quiet clean quarters; good food and perhaps antibiotics or a sulfa.
Rickets—a nutritional deficiency disease	All and Man	Lack of either calcium, phospherous or vitamin D	Enlargement of knees and hock joints; painful walking; beaded ribs	Provide sufficient calcium, phosphorus and vitamin D
Hemorrhagic septicemia (shipping fever) one or a group of infectious diseases	Cattle Sheep Horse Swine	Uncertain—probably bacterial or virus infection	High temperature; discharges from eyes and nose; hacking cough; difficulty in breathing (although animals may die without symptoms)	Isolation; good feeding and perhaps sulfa or antibiotics
Soremouth (contagious ecthyma) a contagious virus disease	Sheep Goats Man	A specific virus	Depression; loss of appetite; vesicles on lips, gums and tongue with redness and swelling; bleeding and scabing	Isolation; treat sores with tincture of iodine or potassium permanganate (2%) or sulfa ointment; improved sanitation.
Tuberculosis — a chronic infectious disease	All and Man	*Mycobacterium* tuberculosis	Many times no out ward symptoms—sometimes loss in weight; swelling of joints; chronic cough; labored breathing	No treatment for animals—dispose of reactors; improve sanitation; rotate feed lots and pastures.

SYMPTOMS OF SOME COMMON PLANT POISONING AND TREATMENT

Plant	Poisoning Affects	Symptoms	Prevention	Treatment
Cherries, wild (*Prunus*)	Mainly cattle	Staggering; rolling eyes; tongue extends; bloating and death	Do not allow access to branches or wilted leaves	Injections of thiosulfate along with sodium nitrate; also, corn syrup or molasses via stomach tube.
Cockelebur (*Cenchrus*)	Swine (also cattle and sheep)	Prostration; rapid and weak pulse; low temperature and vomiting	Keep animals away from cocklebur areas when seeds are sprouting; cut or mow plants before seeding	Administer fatty substances as: linseed oil; mineral oil; whole milk etc. through stomach tube
Death Camas (*Zigadenus*)	Mainly sheep (also cattle and horses)	Vomiting; frothing at mouth; weakness and staggering; prostration; difficult breathing and coma	Do not graze areas where plant exists	None—quiet and good nursing help
Henbane (*Hyoscyamus*)	Cattle Sheep Horses	Thirst; convulsions; vomiting; loss of voluntary motion; difficult breathing; irregular pulse; stupor and death	Avoid areas where plant is present in quantity	None known
Larkspur (*Delphinium*)	Mainly cattle	Weakness; trembling; constipation; loss of appetite; staggering and falling; sometimes bloat	1. Avoid areas where plant is present. 2. Eradicate the plant	Keep animal quiet; give epsom salts by mouth; if badly bloated, puncture paunch
Oak (*Quercus*)	Cattle Sheep Goats	Emaciation; scabby nose; constipation followed by diarrhea and weakness	1. Avoid oak areas until grass and other herbage is more abundant. 2. Provide hay or other feed	None—move animals to better pastures or put on hay and similar feed

SOME COMMON ANIMAL PARASITES AND THEIR TREATMENT OR CONTROL

Parasite	Affects	Symptoms	Treatment	Prevention and Control
Blowfly—any of many flies which breed in necrotic animal flesh	All	Infected wounds and soiled hair; maggots over body; animals become weak, fevered and unthrifty	Paint affected area twice weekly with smear (MS62) or EQ335 (screw worm remedy)	Eliminate fly by burning or burying dead animals; with traps or poison or use repellents as pine tar oil.
Coccidiosis — a parasitic disease caused by protozoan organisms known as *Coccidia*	Cattle Sheep Goats Poultry	Diarrhea and bloody faces; pronounced unthriftiness and weakness	Good nursing	Segregate infected animals; better sanitation around contaminated feed and water.
Grubs—maggot stage of heel flys, gad flys etc.	Mainly cattle	Carcass damage; injury to hides; shock; decreased production	Dip or spray with Rotenone or similar chemicals	Entire area and vicinity must be treated if control is to be effective.
Intestinal worms	Cattle Sheep	Usually loss of weight; anemia and/or diarrhea	30-60 grams of phenothiazine per animal	Rotate pastures; better sanitation; segregate infected animals.

Parasite	Affects	Symptoms	Treatment	Provention and Control
Lice—small flattened wingless insect parasites; mites; etc.		Retarded growth; lowered production; unthriftiness	Spray or dip using Lindane, Mehoxychlor, Totenone, etc.	Treat all animals in an area simultaneously
Live flukes—a flattened leaflike brown worm usually an inch long	Cattle Sheep Goats etc.	Anemia (pale mucous membranes); digestive disturbances; loss of weight and general weakness	Drench with hexachlorethane in a bentonite suspension each spring and fall	Drain or avoid wet pastures and destroy snails (carriers of flukes) with copper sulfate
Ringworm—a contagious disease of the outer layer of skin, caused by microscopic molds or fungi	All and Man	Round, scaly areas almost devoid of hair around eyes, ears, neck and tail	Clip hair from infected area, remove scabs, sandpaper and wash with soap, paint with iodine or salicylic acid and alcohol	Isolation — disinfection and better sanitation

Measurements

Estimating Contents of Haystacks.—To calculate the contents of a hay stack, measure in feet and tenths the length and width at the ground and the average distance over the stack from the ground on one side to the ground on the other and substitute in the formula:

$$\frac{\text{Over top distance}}{3} \times \text{basal width} \times \text{basal length} \div 450$$

The result is approximately the tons of wild hay or alfalfa stacked 90 days or over.

Estimating Steer Weights from Hearth Girth Measurements

Hearth Girth (inches)	Calculated live weight (pounds)
63	715
64	744
65	773
66	801
67	830
68	859
69	877
70	916
71	945
72	973
73	1002
74	1031

Linear Measurement (Metric Equivalents)

1 inch = 2.54 centimeters
1 foot = 0.305 meter
1 yard = 0.914 meter
1 mile = 1.609 kilometers
3.281 feet or
1.094 yards = meter
1 rod = 0.5029 dekameters

1 centimeter = 0.3937 inch
1 decimeter = 3.937 inches or 0.328 feet
1 kilometer = 0.621 miles

1 meter = 39.37 inches
1 dekameter = 1.9884 rods

Other Metric Equivalents (Approximate)

1 decimeter = 4 inches
1 meter = 1.1 yards
1 kilometer = 5/8 mile
1 hectare = 2 1/2 acres

1 liter = 1.06 quarts liquid, 0.9 quarts dry.
1 hektoliter = 2 5/8 bushels
1 kilogram = 2 1/5 pounds
1 metric ton = 2200 pounds

Weights (Metric Equivalents)

1 gram = 0.03527 ounce
1 kilogram = 2.2046 pounds
1 metric ton = 1.1023 (long) ton

1 ounce = 28.35 grams
1 pound = 0.4536 kilogram
1 (short) ton = 0.9072 metric ton

Avoirdupois weight

27 11/32 grains	= 1 dram	2000 pounds	= 1 short ton
16 drams	= 1 ounce	2240 pounds	= 1 long ton
16 ounce	= 1 pound		

Square Measure (metric equivalents)

1 sq. centimeter	= 0.1550 sq. inches	1 sq. inch	= 6.452 sq. cm.
1 sq. decimeter	= 0.1076 sq. feet	1 sq. foot	= 9.2903 sq. decimeters
1 sq. meter	= 1.196 sq. yards	1 sq. yard	= 0.8361 sq. meter
1 acre	= 3.954 sq. rods	1 sq. rod	= 0.2529 deka
1 hectare	= 2.47 acres	1 acre	= 0.4047 hectare
1 sq. kilometer	= 0.386 sq. miles	1 sq. mile	= 2.59 sq. kilometers

Measure of Volume (Metric Equivalents)

1 cu. centimeter	= 0.061 cu. inch	1 cu. inch	= 16.39 cu. centimeters
1 cu. decimeter	= 0.0353 cu. feet	1 cu. foot	= 28.317 cu. decimeters
1 cu. meter	= 1.308 cu. yard	1 cu. yard	= 0.7646 cu. meters
1 liter	= 0.908 quart (dry), 1.0567 quart (liquid)	1 quart (dry)	= 1.101 liters
		1 quart (liquid)	= 0.9463 liter
1 dekaliter	= 2.6417 gallons	1 gallon	= 0.3785 dekaliter
1 hectaliter	= 2.8375 bushel	1 bushel	= 0.3524 hectoliter

Square Measure

144 sq. inches	= 1 sq. foot	40 sq. rods	= 1 rood
9 sq. feet	= 1 sq. yard	4 roods	= 1 acre
30 1/4 sq. yards	= 1 sq. rod	640 acres	= 1 sq. mile

Cubic Measure

1,728 cu. inches	= 1 cubic foot	27 cu. feet	= 1 cu. yard
40 cu. feet	= 1 ton (shipping)	2,150.42 cu. inches	= 1 standard bushel
1 cu. foot	= about 4/5 bushel		

Dry Measure

2 pints	= 1 quart
8 quarts	= 1 peck
4 pecks	= 1 bushel
36 bushels	= 1 chaldron

Liquid Measure

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 barrel
31 1/2 gallons	= 1 hogshead
2 barrels	= 1 hogshead

Circular Measure

60 seconds	= 1 minute	30 degrees	= 1 sign
60 minutes	= 1 degree	90 degrees	= 1 quadrant
4 quadrants	= 12 signs or	360 degrees	= 1 circle

Surveyors or Chain Measure

7.92 inches	= 1 link	10 sq. chains	= 1 acre
25 links	= 1 rod	1 acre	= 43,560 sq. feet
100 links	= 66 feet	1 acre	= 160 sq. rods
66 feet	= 1 chain	460 acres	= 1 sq. mile (or section)
4 rods	= 1 chain	36 sq. miles or (sections)	= 1 township
80 chains	= 1 mile		

Other Miscellaneous Information

Livestock Shelters

Ranchmen and research workers are generally agreed that it does not pay to build expensive livestock shelters for winter in the country south of the snow line. Animals do not do as well if they are sheltered as when they rough it outdoors because they come with "built-in fur coats" that protect them in all but long, cold, rainy spells. A cheaply constructed shed will keep rain off livestock and during windy or dry-cold weather they will pick a country with brush or breaks in preference to sheds. A man with very open ranges may need only simple windbreaks for winter protection of his livestock. He can grow a live shelter with trees and shrubs around his corrals and yards that will take the "edge" off the wind and let his herds winter comfortably. As an animal digests its food, enough heat is developed to warm its body in winter and its warm fur coat generally does the rest. Normally, 50 degrees is the ideal temperature for animal thrift because it is too cold for insects that customarily bother livestock.

Use of Salt

Use of stock salt has long been a good, cheap way to draw animals into parts of ranges that are passed up because they are too far from water or too steep and rough. By this device, pressure on parts of a range normally excessively grazed is lightened and animals do better.

Recently, meal mixed with salt has been self-fed on the range to supplement protein deficiencies of the forage. The mixture has been fed at water holes because of the fear that animals would die of salt-poisoning unless they could drink as soon as they ate the meal-salt mixture. As livestock have bunched up around water holes to eat the meal-salt ration, a lot of grass has been destroyed through trampling.

Other studies have shown that steers and heifers will make satisfactory growth when self-fed their meal-salt rations at stations one-half to 1-1/2 miles from water. No sign of salt-poisoning was evident and the ranges were grazed far more uniformly where meal-salt stations were a considerable distance from water than when they were placed at waterings. When animals were through feeding at the meal-salt station, they grazed a while before going to water.

Self-feeders for meal-salt should, therefore, be placed at least one-fourth of a mile from water. If drinking water is close to meal-salt, it may also become polluted with the moisture dropped from the animals' muzzles. Animals will then drink less water and the result may be scouring with loss of weight.

Drought

When the rains do come, we need to make effective plans to cut down the effects of the next drought. The last one should have taught us that strong grass is the best protection against prolonged dry spells. A good cover of grass will insulate the ground against pelting rain and burning sun. Our goal should be to keep at least 2,000 pounds of grass and litter on the ground at all times. Soil Conservation Service experiments (USA) show that 2,000 pounds of rotting leaves and grass stems will do an average job of keeping the rain-drops from beating the soil into crust. When the surface is protected, rain water soaks in deeply below the zone of evaporation, which is 10 inches deep, and remains stored there for plant use. Little water runs off under such conditions. Litter also protects the soil from the sun. Hence, delicate seedling grasses can grow as the soil stays wet longer after a rain.

In many places, nearly 60 per cent of the rainfall will soak into the soil. However, most of this rain is confined to the upper 10 inches of the packed, unprotected soil and evaporates before plants can make full use of it.

Soil Productivity

About 90 to 95 percent of grass and farm crop growth comes from air and water. Grass and crop yield depends on the plant food in the soil. The more plant food grass gets from the soil the more it will be able to take from the air. What's in the soil is our problem—the air and water will take care of the rest.

GUIDE TO RANGE USE DETERMINATIONS BASED ON KEY (BETTER) PLANTS

Degree of Use	Percentage (by weight) of The Current Year's Growth Removed By The Close of The Grazing Season.
Under	40 or less
Proper	40-60
Over	60 or more

DRESSING PERCENTAGE OF LIVESTOCK

Kind of Livestock	Average Live Weight (Pounds)	minus	Average Dressing Percent	=	Average Pounds of Carcass Meat
Cattle	896		51.96		466
Calves	182		62.10		113
Lambs	84		46.96		39
Hogs	215		73.77		159

SECTION II

GLOSSARY OF RANGE MANAGEMENT TERMS USED IN REGIONAL RANGE MANAGEMENT COURSES (1955-1957)

Acre-foot	Quantity of water that would cover 1 acre to a depth of 1 foot. An acre-foot contains 43,560 cubic feet.
Aftermath	Regrowth of range forage or other crops following grazing or harvesting.
Band	Any number of sheep or goats handled as a single unit under range conditions; usually considered as synonymous with herd as it relates to such livestock.
Barren	A range area lacking or practically without vegetation.
Browse	When used as a noun—twigs or shoots (with or without attached leaves of shrubs, trees or woody vines) available and used for forage by grazing animals. When used as a verb—the grazing of such plant materials.
Brush	Shrub vegetation and stands of tree species, such as bur oak, that do not produce merchantable timber. Brush is normally a temporary type of vegetative cover.
Capacity, grazing	In range management, the ability of a range unit, exclusive of severe drought years, to adequately support a constant number of grazing animals for a stated period each year, without deteriorating with respect to grazing value or other proper land uses. Normally expressed in number of livestock per acre of a given kind or kinds of vegetative cover or in the number of acres of such land per specified animal. Preferred to the term "Carrying Capacity" which usually implies fullest grazing use and eventual deterioration.
Clearing	The act of felling woody vegetation.
Climate	The sum total of all atmospheric or meteorological influences which combine to characterize a region and give it individuality by influencing the nature of its soils, vegetation, and land use. Weather is the condition of the atmosphere at a given time; climate is the summation of weather conditions.
Colony, plant	An initial community resulting from two or more species entering a bare area simultaneously.
Community, plant	Any group of plants growing together.
Competition, plant	The struggle for existence in the plant world which results when plants meet each other on more or less equal terms in making demands for limited light, nutrients, or water.
Composition, plant	The relative proportions of plant species in the total vegetative on a given area.
Condition, range	The state of health or productivity of both soil and forage of a given range, in terms of what it could or should be under normal climate and best practicable management. Also, the percentage of present vegetation that is climax vegetation for the site.
Contour	An imaginary line on the surface of the earth connecting points of the same elevation. A line drawn on a map to show the location of points of the same elevation (a series of such contours serves to delineate the topography of the land).
Cover, plant	All plants found on a given range, irrespective of whether they are within reach of livestock, palatable, non-palatable or poisonous.
Crop, forage	In range management, the amount of edible vegetation for livestock on a range area regardless of whether or not such vegetation constitutes forage.
Crop, percent calf (or lamb)	Ratio of number of calves (or lambs), usually at weaning time, to the number of cows (or ewes) bred.

Dam, diversion	A barrier built for the purpose of diverting part or all of the water from a stream into a different course.
Decreaser	A very palatable climax plant that goes out rather quickly under heavy grazing.
Distribution, livestock	Apportionment of livestock over a range area.
Ditch, diversion	An excavated passageway to divert water from its natural course.
Dominant, plants	Species which are the controlling and most widespread within certain prescribed boundaries. They are usually the most abundant, or may be the largest and longest lived. Dominants of climax communities are called climax dominants.
Ecology	The study that treats of the relations of plants and animals to their environment.
Enclosure	An area within which animals may be confined.
Erosion, accelerated	Rapid soil loss due to disturbance; always faster than normal erosion.
Erosion, gully	Accelerated erosion by water that produces channels larger than rills.
Erosion, normal	Erosion characteristic of the land surface in its natural environment; sometimes referred to as geological erosion.
Erosion, sheet	Loss of a fairly uniform layer of material from the land surface; often imperceptible, especially with wind erosion, or evidenced by numerous very small rills where water is the erosive factor.
Erosion, rill	Erosion by water that produces very small and numerous channels.
Evaporation	The process of vaporization at a temperature at or below the boiling point.
Exclosure	An area from which animals are excluded.
Exposure	The direction of a slope with respect to the cardinal points of the compass.
Family, plant	Isolated groups of organisms belonging to a single species; often descendents of a single plant.
Fee	A charge made for livestock grazing on the basis of a certain rate per head for a certain period of time.
Feed	Harvested forage such as hay or other fodder and grain or other processed food for livestock. When grazed and not harvested it is called forage.
Feed, complementary	Feed and forage resources which meet the needs of livestock for the period when they are not on the range.
Feed, concentrated	In range management, cereal grains or their products and other processed food material for animals in which highly nutrient values have been retained with a minimum amount of crude fiber or water.
Feed, reserve	A supply of roughage and concentrates in excess of normal requirements for emergencies, such as droughts or abnormally severe winters.
Feed, supplementary	Additions to the usual animal ration to obtain a properly balanced diet, as concentrates or hay fed to livestock on the range when forage is insufficient, or inferior in quality, or unavailable.
Forage	In range management, unharvested plant material of any kind available for animal consumption. It may either be used for grazing or be cut for feeding. When cut it becomes feed.
Furrow, contour	A furrow plowed along a contour. Also refers to level furrows made in pastures for the purpose of preventing runoff and soil loss and may also be applied to level furrows used in preparation of land for planting trees.
Grass, bunch	A grass that has a characteristic habit of forming tufts in contrast to the thisomatous or sod-forming grasses.
Grass, sod	A grass that reproduces by stolons or rhizomes or otherwise forms a more or less continuous sod or turf.
Grass, stem	Any of the grasses that normally grow as more or less isolated and single stems in contrast with bunch and sod-grasses.
Graze	The eating of any kind of growing vegetation by domestic livestock or wild animals. See browse.
Grazing, conservative	A basis of stocking that results in approximately proper utilization of the range in all but the most severe drought years. A degree of grazing that causes little or no soil disturbance.
Grazing, deferred	The system of management whereby the forage on a part or all of a range area is not grazed until it has attained a certain stage of growth. The growth stage is properly determined by the kind of plants that govern use of the range. Deferment should result in a substantial and vigorous growth on plants that reproduce vegetatively. It should be at the time of seed dissemination, for those plants reproducing from seed.

Grazing, deferred and rotation	The system of range management whereby grazing is deferred on various parts of a range during succeeding years. The practice allows each part periodic rests during the growing season to permit seed reproduction or better vegetative spread.
Grazing, premature	Grazing before important forage plants have reached sufficient seasonal development and, on spring ranges, before soil has become firm enough to prevent cumulative injury to the range under the prevailing degree of stocking.
Grazing, seasonal	The grazing of range only during a certain period or periods of the year, roughly corresponding to one or more of the four seasons—Spring, Summer, Fall, Winter.
Grazing, selective	The tendency for livestock and other grazing animals to prefer certain plants and even to over-utilize them while other important species may be lightly grazed.
Grazing, timely	The practice of running sufficient livestock on a range or pasture at one time to graze-off unwanted plants during the period when they are green and most susceptible to grazing, followed by rest to favor desirable plants which grow later in the year. The practice also includes delayed grazing of areas with poisonous or mechanically injurious plants until danger from them is passed.
Grubbing	The act of removing roots, whether woody or herbaceous.
Gully	A furrow, channel, or miniature valley cut by running water but through which water commonly runs only during and immediately after rains, or during periods of snow-melt.
Habit	The general form of arrangement of stems, roots and branches, or of the entire plant, possessed in common by a species in a given habitat.
Habitat	The kind of place in which the plant or animal lives, such as forest habitat, grassland habitat, and marsh habitat. Often used as synonymous with site.
Halophyte	A plant that grows on saline soil.
Hardpan	An indurated (hardened) or cemented soil horizon. The soil may have any texture and is compacted or cemented by iron oxide, organic material, silica, calcium carbonate, or other substances.
Hedged	The condition of browse plants which have been cropped back so closely as to appear artificially clipped.
Herb	A non-woody flowering plant.
Herb, broadleafed	See Forb.
Herd, breeding	The livestock retained to provide for the perpetuation of the herd or band, not including animals being prepared for market.
Herd, buck	A group of rams managed as a unit in grazing practice.
Herding, close	Handling a band of sheep or goats compactly, and restricting the spread of the animals when grazing.
Herding, open	Handling a band of sheep or goats whereby the animals are allowed to spread rather freely in grazing, but ordinarily quietly and without trailing.
Humus	The plant and animal residues of the soil (litter excluded) which are undergoing decomposition.
Hydrophyte	A plant which grows under wet or moist conditions or which requires a large amount of moisture.
Improvement, range	Any means employed to increase the utility and ease of management of the range, such as development of water supply, fencing and other facilities, revegetation, and noxious plant control.
Improvement, pasture	Any practice of grazing, clipping, fertilization, liming, seeding, contour furrowing, or other methods of management designed to improve the vegetation for grazing purposes.
Increaser	A climax plant that increases for a while under heavy grazing but finally goes out under continual heavy use.
Indicator, plant	Any tree or plant which by its presence, increase, or decrease denotes some particular change in site, soil, or use-condition.
Infiltration (hydrology)	The absorption of liquid water by a zone of aeration.
Invasion, plant	The movement of one or more individuals of one or more plant species from one area into another and their establishment in the new area.
Land, grazing	Land regularly used for grazing except cropland and pasture used in connection with a system of farm-crop rotation. The term should not be confined to land suitable only for grazing.
Litter	Accumulation of leaves, stems, fruits, branches and other plant parts on the surface of the land covered by range, pasture, or forest vegetation. (See mulch).

Livestock — Domestic animals produced or kept primarily for farm, ranch, or market purposes, including beef and dairy cattle, hogs, sheep, goats, and horses. Subdivided by class (i.e., use, purpose or age), as breeding cows, steers, ewes, or drys; by *kind* (species or genus), as cattle, horses, mules, sheep, goats, or swine; by *type* (production purpose or characteristic qualities), as wool or mutton types of sheep.

Management, livestock — Application of business methods and technical principles to livestock production.

Management, range — The scientific management of rangeland for the continuous production of forage and livestock, as consistent with use of the land for other purposes. Specifically, the management of natural vegetation.

Meadow — An area that receives more moisture than adjacent areas. Two classes of meadows are recognized: wet meadows and dry meadows. Wet meadows are characterized by sedges and remain wet or moist throughout the summer. Dry meadows are dominated by grasses and occur as moist meadow-line areas or intermittent meadows, both of which become moderately dry by mid-summer.

Mesophyte — A plant that grows under medium or average moisture conditions; neither an aquatic nor a desert species. The vast majority of plants growing in the United States are mesophytes.

Month, animal unit — In range management, the forage or feed requirement to maintain an animal unit for 30 days. (See month, cow).

Month, cow — The feed or forage necessary to maintain a mature cow for 30 days. In ordinary usage, unweaned calves are often included with cows in estimating cow months. Commonly used as a synonym for animal-unit month where cattle chiefly are concerned.

Month, sheep — The amount of forage or feed necessary to support and maintain a mature sheep, or a ewe and its suckling lamb, for 30 days. Commonly figured as one-fifth of a cow month.

Mulch — Vegetable matter either thrown or strewn on cultivated land to serve as protection from heat, to conserve moisture, and to reduce damage from "heaving". (See litter).

Nonpalatable — Applied to plant species that are not grazed when the range is properly utilized.

Optimum — The combination of conditions that produces the best average result when there is a choice of combinations.

Over-grazing — Grazing so heavy as to impair future forage production and cause range deterioration through consequental damage to plants or soil or to both.

Over-stocking — The placing of more animals on a range area than the range will support or maintain through the grazing period without over-utilization.

Palatability — The relative relish with which forage plants are consumed by domestic livestock or other animals. This may vary with consumption of the plant cover or the season of grazing.

Pasture — In range management, an enclosed tract of grazing land.

A. *Natural or native pastures* are uncultivated lands occupied wholly or mainly by native, or naturally distributed introduced plants, useful for grazing. They include the following main types:

(1) *Brush*—those covered largely with brush and shrubs, where a considerable portion of feed obtained by the livestock comes from browsing woody plants.

(2) *Cutover or stump*—those from which the trees have been removed but on which there are stumps and new growth.

(3) *Range*—a very extensive natural pasture.

(4) *Woodland*—wooded areas with grass and other grazing growing in spaces and among trees.

B. *Tame pastures* are lands once cultivated that have been seeded with and are now occupied largely by domesticated pasture plants and used chiefly or entirely for grazing livestock. They include the following main types:

(1) "*Annual pastures*" is the term usually applied to pastures that are seeded each year to take the place wholly or in part of permanent pasture. Such pastures may include a series of crops like winter rye, sudan-grass, soybeans and rape, which combined, will furnish pasturage nearly all of the year.

(2) *Perennial pastures*—grazing land occupied by perennial pasture plants or by self-seeding annuals, usually both, which remains unplowed for long periods normally 5 or more years.

(3) *Rotation pastures*—a field used for grazing which is seeded to perennials and (or) self-seeding annuals, but which forms a unit in the crop-rotation plan and is plowed within a 5-year or shorter interval.

(4) *Supplemental or temporary pastures*—fields used for grazing when the permanent or rotation pastures are unproductive and do not supply enough feed for the livestock kept on the farm. Supplemental pastures may be provided by the aftermath of meadows, small-grazing stubble, seedling small grains, annuals like sudangrass, lespedeza, and crimson clover, or biennials like sweet-clover.

Period, grazing — The time livestock are grazed or permitted to graze on a range. Sometimes called grazing season.

Permeability — The property of material which permits appreciable movement of water through it when saturated.

Photosynthesis — The manufacture of some simple carbohydrate (probably sugar) from carbon dioxide and water by chloroplasts in the presence of light.

Plant, annual — A plant which completes its life cycle within a year or less.

Plant, biennial — A plant which completes its life cycle in two years.

Plant, exotic — A plant which is not native to the country in which encountered.

Plant, grasslike — A plant which resembles a true grass superficially but which belongs to the sedge (Cyperaceae) or rush (Juncaceae) families.

Plant, perennial — A plant which completes its life cycle in three or more years.

Plant, succession — The process of vegetational development whereby the same area becomes occupied by different plant communities in succession.

Plot, check — The untreated, control, or standard-treatment plot in an experiment.

Plot, sample — An area laid out for the purpose of measurement or experimentation; may be permanent or temporary.

Precipitation — Deposits of atmospheric moisture in liquid and solid form, including rain, snow, hail, dew and hoarfrost.

Range, waste — Any portion of a range area (not including barren areas) unusable by livestock.

Ration, blanced — Range forage and other feeds which contain the dietary essentials for growth, maintenance, and reproduction of livestock.

Readiness, range — That stage of growth of the important palatable plants on the range along with the condition of soil which permits grazing without undue compacting of the soil or endangering the ability of the plants to maintain themselves.

Readiness, vegetation — That stage of plant growth when the vegetation may be grazed without endangering its ability to maintain itself.

Relict — A community of plants (or even an individual plant) that has survived some important change.

Reproduction, artificial — Renewal of vegetative cover by direct seeding or planting.

Reproduction, natural — Renewal of vegetation by self-sown seeds, sprouts, rhizomes, etc.

Reseeding, range — Sowing of seed on range lands to restore or increase forage production.

Reserve, forage — A supply of native or natural growth on range or pasture land reserved for such emergencies as drought or fire. Obtained by permitting unmolested growth or very light use.

Resources, conservation of natural — The protection, improvement and use of natural resources according to principles which will assure their highest economical and social service.

Resource, natural — Those potentially useful materials, forces, capacities, and conditions provided by nature.

Resources, related — Those resources which bear relationship to one another because of common site and dependency, such as range, game, recreational, watershed, and timber.

Revegetation — The reestablishment or improvement of vegetation. It may take place naturally through reproductive processes of the existing flora or be induced by man through seeding or transplanting.

Rhizome — A rootstock. In its simplest form, merely a creeping, usually thickened, stem or branch growing partly or entirely beneath the surface of the ground.

Rootzone — That part of the soil invaded by plant roots.

Rootstock — A root-like stem or branch under or sometimes on top of the ground; a rhizome.

Runoff — The total stream discharge, including both surface and subsurface flow, usually expressed in acre feet. Also the rate at which water is discharged from a drainage area, usually expressed in cubic feet per second per square mile of drainage area.

Runoff, subsurface — Runoff through subsurface streams.

Sample, random	A sample chosen in such a way that each item or individual in the population has an equal and independent chance of being included.
Sample, representative	A sample which represents all the essential variation existing in the population.
Sample, stratified	A randomized sample composed of two or more sets of random samples, each drawn from a single homogeneous unit of a heterogenous population.
Savannah	An area of grassland containing scattered trees.
Scrub	Stunted trees or brush often in dense stand. Also, an animal of inferior breeding or condition.
Segregation	In Range Management—the separation, usually by fences, of different kinds, classes, types, or breeds of livestock. In genetics—the separation of the genes inherited from the two parents in the formation of FI gamets.
Sere	In plant ecology—the series of plant communities that follows one another on any given area of the earth's surface. Two types are recognized: naturally bare areas and others disturbed by man or animals.
Shrub	A woody, perennial, differing from a perennial herb by its persistent and woody stems, and from a tree by its low stature and habit of branching from the base. There is no hard and fast line between herbs and shrubs or between shrubs and trees; all possible intergradations occur.
Site	An area, considered as to its ecological factors with reference to capacity to produce forests or other vegetation; the combination of biotic, climatic, and soil conditions of an area.
Site, range	A combination of soil and climatic conditions of a range area that produces a significantly different kind or amount of climax vegetation from other range sites.
Slope, percent	The slope of land in percent is determined by measurement, and computed in the following manner; slope percent = vertical distance in feet and horizontal distance in feet × 100.
Soil	A soil giving an acid reaction (precisely, below PH 7.0; practically, below 6.6 3/4) throughout most or all of the portion occupied by roots.
Soil, alkaline	Any soil that is alkaline in reaction (precisely, above PH 7.0; practically, above 7.3).
Soil, calcareous	Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly to the naked eye when treated with hydrochloric acids.
Soil, immature	A young and imperfectly developed soil.
Soil, impervious	A soil very resistant to penetration by water and usually to air and to plant roots. In field practice, the term is applied to strata or horizons that are very slowly penetrated by water and that retard or restrict root penetration. "Relatively impervious" or "slowly pervious" are better expressions.
Soil, mature	A noncoherent mixture of sand and clay containing also calcium carbonate and organic matter.
Soil, mineral	Generally, any soil composed chiefly of mineral matter.
Soil, neutral	A soil that is not significantly acid or alkaline (strictly, one having a PH of 7.0; practically, having a PH between 6.6 and 7.3).
Soil, normal	A soil having a profile in equilibrium with the two principal forces of the environment-native vegetation and climate usually developed on gently undulating upland, with good drainage, from any parent material, not of extreme texture or chemical composition, that has been in place long enough for biological influences to exert their full effect.
Soil, organic	Generally, any soil the solid part of which is predominantly organic matter.
Stocking	In range management, the relative intensity of animal population; ordinarily expressed by the number of acres of range allowed for each animal for a specific period, or occasionally, in such relative terms as lightly, conservatively, heavily.
Stocking, proper	Stocking of a range area on the basis of its true grazing capacity; that is, the number of animals that will graze the range to approximately proper utilization during the grazing period of the slightly below average year and thus assure maintenance of forage production and improvement of deteriorated range.
Stolon	A trailing or reclining branch, above ground, that strikes root where it touches the soil, and there sends up new shoots which later become seperate plants.
Stool	In range management, several stems arising from the same root, as in certain grasses.
Stubble	The basal portion of plants remaining after the top portion has been harvested. Also, that portion of plants, principally grasses, remaining after current grazing is completed.
Succession	The progressive development of the vegetation towards its highest ecological expression, the climax. The replacement of one plant community by another.
Succession, primary	Plant succession on newly formed soils or upon surfaces exposed for the first time and which have never borne vegetation.

Succession,	Plant communities that come in after the destruction of part or all of the original vegetation.
Technician, range	A person who assists livestock men and landowners in making the best use of theis ranges by collecting and compiling all information pertaining to proper range management, analyzing it, and collaborating with the operator in the formulation of range-use plans which are technically and economically sound.
Topography	The configuration of land surface, including its relief, the position of its streams, lakes, roads and cities. A map showing the topography of the given areas; lay of the land.
Trailing	The driving of livestock from place to place. Also, the voluntary wandering of livestock about a range, usually in search of forage, water or salt.
Trampling	Treading under foot; the damage to plants or soil brought about by congested movements of livestock, including mechanical injury to tree reproduction and ground cover in woods. Also, the compacting of soil in earthen dams and reservoirs by livestock to make them impervious to water.
Transpiration	The process by which water-vapor leaves a living plant and enters the atmosphere.
Tree	A woody plant having one well-defined stem and a more or less definitely formed crown, usually with a height of at least 8 feet.
Use, actual	The total number of livestock thát have actually grazed on a range and the length of time that they have used it, usually expressed in animal-unit months, cow months, or sheep months.
Use, common	Grazing use of a given range by more than one kind of livestock within the same grazing year.
Use, community	Grazing use of an area restricted to the livestock belonging to a specified local group of owners.
Use, consumptive	The quantity of water used by either cropped or natural vegetation in transpiration and in building of plant tissue, together with water evaporation from soil, snow, or from intercepted precipitation.
Use, dual	The use of a given range by more than one kind of livestock at the same time.
Use, proper	Grazing of a range area to the best advantage, considering all factors, such as numbers of livestock, desirable season of grazing and distribution properly correlated with other uses of the land and with related ranch production.
Value, forage	The relative importance for grazing purposes of a range plant or plants as a whole on a range.
Value, nutritive	A term usually prefixed by "high" or "low" to indicated relative capacity of a given forage in furnishing nutrition for livestock.
Volume, forage	The relative importance for grazing purposes of a range plant or plants as a whole on a range.
Water, available	In range management, water that is accessible to livestochk on the range. Also, the amount of moisture in the soil in excess of the wilting percent.
Water, hygroscopic	Suspended water adherring to the surface of solid particles which molecular attraction of solid for liquid can hold against root absorbtion and evaporation. It does not move as a liquid but may in the form of vapor.
Water, permanent	A watering place which supplies water at all times throughout the year.
Water, temporary	A watering place that does not furnish year-round water.
Watershed	A dividing ridge between two drainage areas; a divide. Also, the region or area drained by a river or lake—a drainage area.
Water, spreading	In Range Management—the diversion of run-off from gullies or other water courses and its distribution on adjacent gently sloping grazing lands needing additional water. The volume of water flowing down the channels is reduced and the moisture absorbed by the spreading area increases the growth of vegetation.
Weed	To the farmer a weed is a plant out of place, espaecilly an aggressive and pestiferous, often coarse, usually herbaceous, introduced plant species such as crabgrass, dandelion, mustard, plantain, and wild carrot, which takes possession of cultivated and fallow fields and pastures.
Xerophyte	A plant that grows in dry situations.

SECTION III

LISTING OF PARTICIPANTS AND INSTRUCTORS
(Regional Range Management Courses of 1955-56-57)

1955 *COURSE IN IRAN*—Leader: B. W. Allred, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

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Iraq	—	Aziz Mahdi Bassam Sa'adun Yousuf Serkahia Husian Ahmad Tikriti
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