ARID AND SEMIARID RANGELANDS

Guidelines for Development

Winrock International

Arid and Semiarid Rangelands:
Guidelines for Development

prepared for:

AID/NPS Natural Resources Expanded Information Base Project
Division of International Affairs
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Preface

This set of guidelines is focused on the arid and semiarid lands of developing countries. Although the coverage is worldwide, the emphasis is on Africa. The objective is to bring together the technical understanding of these ecosystems and the experience of past development efforts to assist development planners to design and implement programs/projects in arid and semiarid lands of developing countries that will 1) better meet both short- and long-term human needs from these resources, and 2) minimize the environmental impacts on these systems, ensuring a sustainable production system. Specific information is provided that can ensure that the total ecological and socio-economic environment is considered throughout the process of project planning, implementation, and evaluation.

Both this publication and the companion review publication are part of a project that formally began in 1979, when the National Park Service (NPS) and the United States Agency for International Development (USAID) signed an agreement to begin working together in natural resource management. This agreement resulted from USAID's increasing involvement with natural resources and the realization that personnel within the agency were generally not specialized in environmental protection or natural resource management. **Arid and semiarid rangelands** was one of three biogeographical provinces selected for improvement of USAID's and other development assistance agencies' abilities to conserve natural resources while meeting the short-term and long-term needs of the people. The **humid tropics** and **coastal zones** were the other two biogeographical provinces considered.

The companion publication, Arid and Semiarid Lands — Sustainable Use and Management in Developing Countries, should be studied together with this volume. Key concepts from that publication are referenced throughout this publication.

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Executive Summary

Increasing demands on the land for goods and services are placing greater burdens on traditional management systems in developing countries. Most of the lands in these countries are classified as arid or semiarid. When you consider that every **developed** nation with arid and semiarid rangelands has experienced problems when attempting to cultivate them, it is clear that meeting these increased demands will take careful planning. Arid and semiarid lands have the potential to be more productive, but they are fragile and must be wisely managed.

Development activities on arid and semiarid lands have historically been less successful than had been hoped. One of the reasons for this apparent failure is that past projects often did not consider the total system — including people — in the planning, implementation, or follow-up phases of development.

Another problem is that technologies that work in the developed areas of the world are not necessarily appropriate for developing countries. Most of these countries have tropical climates, particular socioeconomic infrastructures, low levels of total wealth, and limited renewable natural resources. And even though the ecological principles behind the technologies remain constant worldwide, the actual application of these technologies must be adjusted to local conditions.

The sustainable use of arid and semiarid rangelands depends upon the development of projects and programs that take into account the fact that all the components of rangeland systems directly or indirectly affect all the other components. Accordingly, this guidelines book begins with a section describing a basic arid/semiarid ecosystem and discussing the interrelationships of its components: soils, microclimate, decomposers and microconsumers, vegetation, animals, and people.

The three remaining sections are divided into 21 stand-alone modules.

The Natural Resource Base

Most rangeland resources are renewable. Thus the goal of wise development efforts is to manage the natural resources so that their productive capability is protected. Grazing affects all ecosystem components; a change in any aspect of grazing — intensity, frequency, or season of defoliation — also changes the degree to which different forages are chosen by both livestock and wild game. This interrelationship makes it possible to manipulate vegetation, using it as a tool. Vegetation can be manipulated by altering the distribution of water and livestock, using fire or mechanical or chemical means, or controlling seeding and planting. And every decision that is made will affect how devastating the next drought will be.

The 11 modules in this section cover:

- vegetation management through 1) grazing, 2) water and livestock distribution, 3) fire, 4) mechanical and chemical means, and 5) seeding and planting
- livestock management and breeding
- game cropping
- water harvesting
- agroforestry
- mining
- coping with drought

National and Regional Institutions

In interacting with the resource base, range institutions face a wide variety of issues. Rangeland policy, regulations, and institutions form the framework necessary to establish authority and responsibility for formulating and executing programs and projects. In order to improve development efforts and make them more coherent, attention must first be given to creating the essential institutional infrastructure, and to defining the functions of the institutions.

The seven modules in this section comprise:

- government policy and service institution development
- training and education
- research
- extension
- infrastructure development
- marketing rangeland products
- agency personnel selection for development activities

Planning, Assessment, and Monitoring

The planning process consists of 1) setting goals; 2) analyzing situations, problems, and needs; 3) creatively thinking through alternative actions; 4) evaluating possible side effects;

5) selecting the best options; 6) executing the planned sequence of options; 7) monitoring progress and side effects to ensure attainment of project objectives; and 8) following up to ensure host-country assimilation of the new procedures. Also necessary is a documentation center or archive in which to store easily accessible information on natural resources.

The final three modules are:
- program planning
- assessment and monitoring
- documentation centers

A Final Word....

These guidelines were developed to provide a framework for the efficient, intelligent development of lands that are critical to our future. It will not be easy, but increased productivity from arid and semiarid rangelands is possible, and can even be sustained. If informed planners design and implement projects and programs that minimize environmental impacts, natural resources can be conserved for future use at the same time that the short- and long-term human needs are being met.

Introduction

Development activities on arid and semiarid rangelands have had a history of not being as successful as hoped. Many of these activities focused on livestock and failed to meet the expectations of planners during the relatively short funding periods. Some projects even seemed to leave the resource in a more degraded state. This seeming failure has caused many to be skeptical of the possibility of success of future development projects that, in particular, involve livestock. We suggest that one of the reasons for this apparent failure is that past projects often did not consider the total system, including people, in the planning, implementation, or follow-up phases of development.

The key guideline for the development of arid and semiarid rangelands is to remember that all the components of the system are related and that any activity directed at one of the system components will directly or indirectly affect the other components. Anticipation of these interrelationships will assist in minimizing conflicts between demands placed on the resource base. Inherent in the definition of an ecosystem is the fact that the human population is a major component of the system, one that must be involved during all phases of development.

This publication brings together some of what is currently known about the structure and function of arid and semiarid ecosystems and the experience of past development efforts. Its purpose is to assist planners to design and implement programs/projects in arid and semiarid lands of developing countries that will 1) better meet both short- and long-term human needs from these resources, and 2) minimize the environmental impacts on these systems, ensuring a sustainable production system.

The Approach

This guidelines publication has been divided into four parts. A preview of these four parts follows.

The Ecosystem

This first section describes a basic arid/semiarid ecosystem and the importance of understanding the interrelations of the components of the system. The remaining three sections contain specific guidelines, in the form of stand-alone modules, in three of the more common areas of development activity. These common areas are 1) the natural resource base itself, 2) national and regional institutions that interact with the resource base through the human inhabitants of the ecosystem, and 3) the planning-assessment-monitoring process. Emphasis is given to the following six major components of a rangeland ecosystem.

- soils — the supporting component and nutrient warehouse for all living organisms
- microclimate — the environmental controlling factors that regulate the speed and efficiency of ecosystem functions
- decomposers and microconsumers — the component that facilitates the return of dead plant biomass to the soil and the cycling of nutrients within the ecosystem
- vegetation — the primary producers in all ecosystems
- animal populations — the consumers within the system, many of which form the link converting vegetation into products required by people
- people — the eventual target of development activities

Section I. Guidelines for Natural Resource Development

Development activities often have as a primary goal the improvement of the natural resource base from which the indigenous people derive their livelihood. This includes the management of the natural resource base for the production/extraction of goods and services for local consumption or export to other areas. For the most part, rangeland resources can be considered as renewable. The most notable exception is mining, where once the products are extracted the resource will not be replaced naturally in the near future.

Abusive management, or lack of management, of even renewable resources will lower the productive capability and in some cases destroy the resource base to the point where it is no longer productive on a sustainable basis. The following modules have been prepared to provide guidelines when one of the development objectives is manipulation of the resource base for the wise use (conservation) of this resource, along with harvesting and marketing goods and services produced there.

- Module 1. Vegetation Management Through Grazing
- Module 2. Vegetation Management Through Water Development and Livestock Distribution

- Module 3. Vegetation Management Through Fire
- Module 4. Vegetation Manipulation Through Mechanical and Chemical Means
- Module 5. Vegetation Manipulation Through Seeding and Planting
- Module 6. Livestock Management and Breeding
- Module 7. Game Cropping
- Module 8. Water Harvesting
- Module 9. Agroforestry
- Module 10. Mining
- Module 11. Coping with Drought

Section II. Guidelines for Development of National/Regional Services

Most developing countries do not have the pool of trained manpower or resources to adequately accomplish the level and rate of development they desire. An essential component of the development process is preparing the host country to assume its own development activities.

One of the most important keys to successful development is to involve the local people throughout the planning-and-implementation process. The following modules have been prepared to provide guidelines for building the host country's capabilities for planning, development, and conservation of its natural resource base.

- Module 12. Government Policy and Service Institution Development
- Module 13. Training and Education
- Module 14. Research
- Module 15. Extension
- Module 16. Infrastructure Development
- Module 17. Marketing Rangeland Products
- Module 18. Agency and Personnel Selection for Development Activities

Section III. Guidelines for Program Planning and Documentation

Planning for the integrated development of an ecosystem or collection of adjacent systems requires a high level of planning along with continuous monitoring and assessment. The following modules were developed to provide guidance in applying integrated planning concepts to development activities for arid and semiarid lands.

- Module 19. Program Planning
- Module 20. Assessment and Monitoring
- Module 21. Documentation Centers

THE ECOSYSTEM

Ecosystem Structure

A system is a set of interrelated components within a defined boundary. Systems typically interact with other systems across their boundaries. In fact, each of the components of a larger system can be thought of as a system in itself. This definition generally fits rangeland ecosystems — both small land areas like pastures or ranches and large portions of a continent like the Sahel of Africa. Figure 1 shows some of the major components of a rangeland ecosystem as it might be found in the arid and semiarid areas of developing countries. The relationship of the modules developed in this publication to the ecosystem is also shown.

The basic ecosystem diagram in figure 1 shows the level of detail required for planning. It is essentially the same at this level for rangeland ecosystems anywhere in the world. Two types of inputs and outputs are shown:

- Those that occur without human intervention and over which development has little or no control. The sun's energy, general climate, living organisms or gene pool available within the ecosystem, and impacts to and from other natural systems are examples.
- Those that result from human manipulation of the ecosystem (i.e., inputs of fertilizer, capital, management, or other raw materials or activities resulting in either increased production to meet internal needs or outputs of goods and services from the system). Note that existing outputs and linkages to other systems are often modified as a result of human intervention.

The general landscape of arid and semiarid rangelands looks much the same everywhere in the world when viewed from afar. Yet, the differences between individual ecosystems emerge when the components within the system are examined in greater detail.

Some of these differences may be of critical importance to development planners. For example:

- Most developing countries are near the equator and do not have temperate climates as do rangelands found in most developed countries. This may seem like a small difference, but even though the physical appearances may be similar, the effect of temperature-induced plant dormancy, freezing and thawing, etc., can dramatically influence management strategies. Differences in climatic and other factors also markedly influence adaptability of both animals and plants.

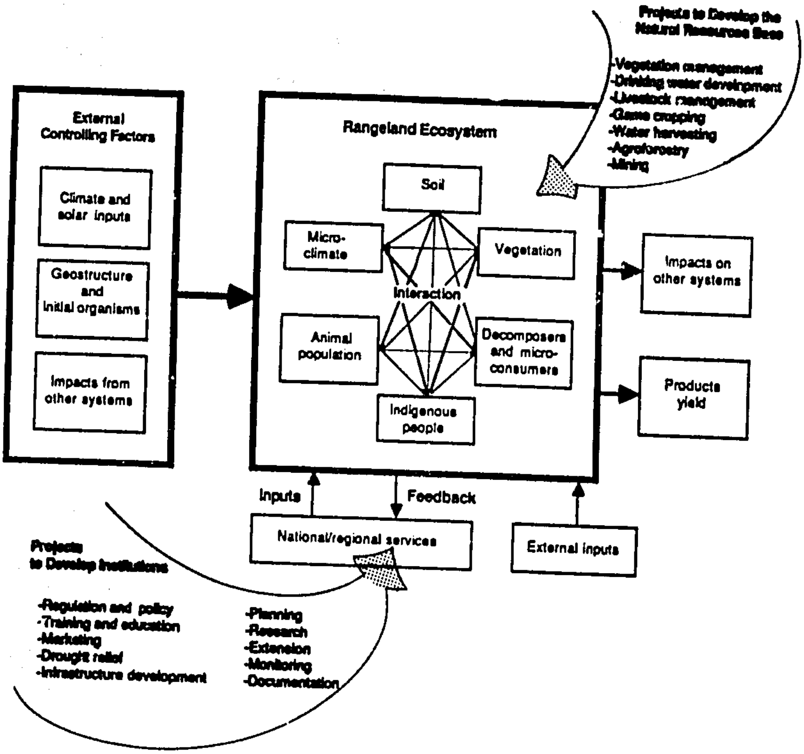


Figure 1. **A basic ecosystem diagram with potential project focuses (shaded areas) overlaid.**

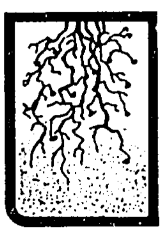
- Social considerations like the customs and goals of the indigenous people may vary greatly among countries, regions, or even neighboring communities.
- Political and economic environments are also extremely variable in both space and time. Political systems in many developing countries either are not particularly stable or are in a state of evolution. In addition, the world economy has dramatic effects on some of the developing countries.

Outputs from one system to other systems can be modified by human intervention in either positive or negative ways. We often think of changes that have resulted in negative outputs such as air pollution, or increased sediment loads or chemical residues in the streams that flow into other systems. Yet effective integrated planning can provide good management, which in turn produces positive changes. Integrated planning also contributes to reducing conflicts in land use and to meeting the needs of growing populations.

Integrated planning implies that the total system (including people) is being considered throughout the development process. By definition, most components of the system are interrelated. Therefore, development activities, even when focused on one component, will often affect other components of the system. For these reasons, development activities should be considered within the context of the entire biological system.

Major Components of a Rangeland Ecosystem

The six major components of the rangeland ecosystem are shown in figure 1: 1) soils, 2) microclimate, 3) decomposers and microconsumers, 4) vegetation, 5) animal populations, and 6) indigenous people. Each of these interrelated components is described in greater detail on the following pages.



Component 1: Soils

Many books have been written on soil, soil conservation, and erosion control. Some expound on taxonomic or historical aspects, often in a mood of handwringing over the destruction. Others are more concerned about placing the blame for certain types of land mismanagement. Still others concentrate on the physical and chemical characteristics of erosion, and numerous writings describe the specifications for repair of the land. This discussion attempts to abstract aspects of soil conservation and erosion control and to emphasize current attitudes toward some control measures.

Rangelands the world over have experienced more extensive damage by wind and water erosion than is normally expected from geological causes. This acceleration of damage is a result of overgrazing, direct harvesting of fuelwoods, excessive use of fire, cultivation, and other activities associated with development. Soil erosion from rangelands during and immediately following droughts may be accelerated because of previous mismanagement.

Erosion is a normal process and few lands are without it. It is therefore important to distinguish when possible between erosion as a normal process and as accelerated destruction. Severe normal erosion probably occurs only following rare events, i.e., floods, severe droughts, climatic changes, and geological changes in the earth's surface. No soil would exist on most terrain if erosion were faster than soil formation. However, persistant abuse can markedly increase soil loss.

Until the last few decades, erosion was accelerated by the lack of knowledge about its causes and cures. A limited population that could move to new land as land was destroyed and land-management traditions based on an incomplete understanding of soil-management principles led to unnoticed erosion throughout the world. The rock terraces in the Middle East illustrate the fact that soil management and erosion have been problems since cultivation and grazing began. These neatly contoured rock walls, many now abandoned, may have been used to keep soil in place that was already there, to hold soil that was hauled from the lowlands by donkey, to catch soil and water from above, or some combination of these reasons. It is not clear whether loss of soil from these terraces caused the downfall of civilizations or came after people were forced to leave because of war, drought, disease, or other reasons. However, it is certain that abandoned man-made structures are reduced by the forces of nature. Natural erosion and the forces of nature must be considered in the evaluation of severity of erosion and the permanence of structures to control it.

The Erosion Process

The amount of erosion that will take place in a given situation is the result of several interacting factors (figure 2). Soil erosion is the movement of soil as a result of the forces of water and wind. These forces first dislodge and then transport the soil particles. Other factors modify the degree to which these forces can act. For example, increasing slope causes increased velocity of runoff water, all other things being equal, and overgrazing reduces vegetation cover and exposes soil particles to easier detachment. Let us look at these processes in more detail.

Water action. The impact of falling raindrops is the most common dislodgment force. Fifty millimeters of rain per hectare deliver enough force to lift 18 cm of soil to a height of 1 m. If the raindrops are large, the force is delivered in blows that dislodge soil particles and splash them in all directions. When the drops are tiny, little dislodgment occurs. On smooth,

Figure 2. Factors influencing soii erosion.

level land with rain falling vertically, splash would be equal in all directions, and there would be little net loss of soil. But the greater the slope, the greater the downhill creep of material. On 10% slopes the downgrade splash is about three times the upgrade movement. A violent storm could splash as much soil material as 250 t/ha. These effects can be easily seen as mud splashed onto objects during a rain.

Splash erosion destroys soil structure, places particles in suspension, and mixes water and soil. This mixing action is called puddling. As muddy water infiltrates the soil, the suspended particles tend to plug the soil pores, sometimes completely preventing water intake. A dry, unstructured soil such as dust traps air. This prevents wetting except on the puddled surface. When the sealed layer dries, it forms a crust. All this tends to waterproof the land and to increase surface runoff.

The overland flow of water transports soil materials and nutrients dislodged by raindrops, and further loosens soil particles by abrasion. The first sheet erosion of soil may not be noticed readily, but it results in concentration of water, loss of fertility, and scouring action that soon is evidenced by rills and grooves in the land. The deeper water-cut channels become gullies, the worst of which often occur toward the bottom of watersheds.

Wind action. Wind erosion is similar to water erosion in causes, results, and cures. It occurs where the soil is exposed to the dislodging force of moving air and varies with soil structure, moisture, and texture; surface roughness; slope; soil cover; air velocity; and duration of air movement. Air moving over a surface is slowest near the surface, and increases in proportion to the logarithm of the height above the surface. At less than 2 mm above a bare and relatively smooth surface, the wind velocity is zero. Above this, the wind movement is parallel to the surface and still higher it becomes turbulent; all this is within approximately 1 cm. Soil particles and debris extending into the turbulent air receive most of the force. Tiny particles may be lifted and carried away. Those of greater size or mass may be bounced along the soil surface to be lodged or deposited in a place with less wind velocity. This bouncing or skipping motion is called saltation. Soil creep is the movement of still larger particles along the soil surface (particles moving particles by nudging each other along).

Winds as slow as 2 km/hour produce turbulent flows, but roughness of the soil surface determines the depth to which turbulent air penetrates through the layer of zero velocity. When vegetation and rocks naturally increase the roughness of the terrain, the turbulent force is spent on the larger soil particles that are less likely to be moved. Rough tillage on cultivated land produces the same results. On rangelands a common practice is to plant tall grasses in narrow strips perpendicular to prevailing winds, as miniature windbreaks. However, the effects of the wind increase as the square of the

The Universal Soil Loss Equation (USLE)

The USLE is the mathematical model most often used to predict soil losses caused by water erosion. It was first proposed by Wischmeier and his associates in 1957 for use on cropland in the central United States and was later extended to rangelands and forests. The formula was developed from measurements on experimental plots. It is a simple equation to express (A = R*K*L*S*C*P) but a complicated one to apply in the field.

A is the computed or predicted soil loss per unit of area.

R is the rainfall factor that is an index of the kinetic energy of the storm for a period of 30 minutes. The raindrop size differs on a regular basis in different climates, and workers have found that the index (published in tables) is not so precise in high-intensity tropical storms as in North America where the index was developed.

K is the soil erodibility factor and it is akin to the splash erosion concept. It was determined as soil loss from plots of fallow soil (not rangeland) with a slope of 9% and a length of 72.6 m.

L and **S** are slope factors; the former is length of slope and the latter is percentage of slope. Responses of erosion to these two factors are well understood, and they are usually combined in the calculations.

C is the cropping factor and describes the total effect of vegetation, residue, soil surface, and management on soil loss.

P is the factor that expresses the effectiveness of erosion-control practices such as contouring and terracing.

The USLE and guidelines for its use were derived from data collected under farming conditions in the central United States. It cannot be expected to be equally valid for rangelands nor for soils in the humid tropics and arid regions. Attempts to use it to measure soil erosion on a practical scale and in the context of research beyond the central United States have been only partially successful. For the interested reader, the following references are suggested: Arnoldus (1977), Branson et al.(1981), Hudson (1977), Wischmeier and Smith (1965). To be most accurate the equation should be applied on a single soil series or range site, not upon a complete range watershed.

velocity. A 40-km/hour wind has four times the power to pick up soil as has a 20-km/hour wind. Dune sand begins to move with wind velocities of 15 km/hour to 25 km/hour. As soil particles are moved by air, their abrasive action dislodges more soil. Control can be attained by decreasing exposure to wind with tillage practices or by planting vegetation that covers the soil and adds organic matter, thereby promoting improved soil structure. More on wind erosion can be found in Food and Agriculture Organization (1960).

Recognition of Erosion

Obvious early signs of erosion are pedestaled plants with roots showing and lines on rocks and woody stems that indicate previously higher soil surfaces. The newly exposed rocks and stem bases differ in color, so it is simple to measure the depth of the soil that has been removed. Often fine debris will have accumulated in small contour ridges or lodged at the uphill side of obstructions to water flow. Rills or small V-shaped grooves and an accumulation of pebbles or gravel on the soil surface are strong evidence that accelerated erosion has occurred. More or less level areas are sites of accumulation when the slopes above begin to erode. More serious and characteristic of later stages of erosion are exposure of subsoil and bedrock, mud flows from slopes and mud bars along drainages, gorged channels, floods with record-breaking peaks, undercut stream banks, lowering of the water table, and large gullies that are deepening. Any of these should be recognized as a warning that erosion is occurring. In most situations, the steeper the land, the more essential it is to recognize early signs of erosion, to determine the causes, and to take corrective action if accelerated erosion is suspected.

Control of Erosion with Plant Cover

Erosion begins at the soil surface; protection of that surface is the most important way to prevent erosion and to heal eroded areas. Soil cover composed of standing vegetation, plant residue, and rocks on the surface breaks the beating action of rain, intercepts some of the rain, keeps the surface soil moist longer than does bare soil, improves soil structure by adding organic matter, and protects the soil from wind. Cover reduces the rate of water flow across the surface by damming it and continually breaking large volumes of flow into smaller volumes. Unattached organic material may float and move with runoff water, but it tends to lodge, making tiny dams and settling basins. The reduced surface flow results in lower flood peaks, more water infiltrating the soil, and more storage of water in soil.

After long experience, most rangeland conservationists have learned to concentrate their efforts on managing vegetation rather than on making structures of concrete and stone. Such structures (sizeable dams and gully plugs, for example) are often bypassed with new gullies unless steps are taken to reduce peak flows. Terraces and contour furrows aim at controlling surface water flow, keeping water where it falls. They fill with silt and overflow, and may be breached by burrowing animals. Splash erosion tends to flatten terraces. Any break in a contour furrow concentrates water flow that may cut a new gully in the downhill rush of water. As a principle, surface water flow should be prevented by soil and vegetation management on each square meter of soil rather than by stopping runoff water and soil somewhere downstream.

Control of Water Erosion with Mechanical Structures

Mechanical structures are necessary to control erosion in certain situations. A series of small dams is often used to raise the water table in meadows or semimarshy areas that have been excessively drained by a central gully. Dams of this type can be constructed of wire and posts and filled with material available at the site. A principle to follow is to place each dam so that the water held nearly reaches to the dam above. Each dam creates a settling basin supporting vegetation.

Gullies may be especially active in different positions along their length. One point of concern is head-cutting. If a gully is more than a few decimeters deep, it usually grows by undercutting the sides and allowing the soil to slump.

Another point of concern is deepening of the gully near where it reaches a main drainage area. Experience with controlling erosion on large areas with extensive gullies has led to recommendations for control of large gullies. The first step is to build dams designed to accomodate an overflow and to be filled with sediment. When a stable gradient is reached between dams, vegetation may be planted or it may come in naturally, causing further deposition of sediment. Large dams are needed for deep-gully control, and vegetation planted in the deposited sediment further increases their stability and effectiveness. Sedimentation builds the V-shaped gullies into U-shaped valleys and eventually into flat valleys as the sides are smoothed by erosion and plants become established. A discussion and suggestions for design of structures may be found in Heede (1977) and in module 8 (Water Harvesting) of this publication.

Small but critical areas sometimes need contour terraces and trenches to hold water until vegetation can be established. Specifications for the terraces include zero grade, spacing and depth sufficient to hold precipitation from the largest expected storm, and check dams at no more than 8-m intervals across but slightly lower than the terrace dike. Mechanical maintenance of the terraces may be needed until the vegetation, usually seeded or planted as part of the operation, substitutes for the terraces in holding soil and water in place.

Control of Moving Sand

Permanent control of moving sand usually is accomplished with plantings of sand-loving plants, such as *Ammophila arenaria* on coastal sand and *Tamarix* spp. near desert oases. If there is enough rainfall, the sand surface may be covered with herbaceous debris that is anchored in the sand, and a crop planted. The most likely crop is a quick-growing cereal grain.

Planting on sands in arid areas may not be as risky as it seems because coarse sands in dunes often remain moist at depths available to roots for considerable lengths of time. This happens for two reasons. The spaces between the sand grains are large, permitting rainfall to penetrate quickly as it falls, so there is little or no runoff from the sand. Second, the water-holding capacity of the sand grains is so low that a small quantity of precipitation can penetrate deep into the sand where little evaporative loss occurs. Plant deep on sand dunes so that woody cuttings and young plants are in contact with the moist sand. Where wind direction changes and moves the sand in different directions, plantings should take the form of strips around hollow squares or rectangles, rather than as plantings that cover the whole area or that are in one-directional, parallel rows.

Other barriers (figure 3) such as slatted wooden fences and rows of piled brush also tend to hold sand in place. These work well if the sand is in narrow strips or if the areas are small. Picket fences at a slight angle to the wind also promote scouring of the dunes. The distance between pickets should be about the same as the width of a picket so that nearly the same proportion of air goes through as over the fence. Placement of the fence determines the pattern of deposition. One on the windward side of a dune crest results in narrow and high

Figure 3. Illustration of physical structures being used to hold dunes in place (adapted from FAO, 1976).

depositions. Fences on the crest result in long accumulations downhill to leeward. Barriers placed on the lee slopes of dunes are likely to be covered.

Large sand deserts like the Great Nafud in Saudi Arabia can hardly be controlled or stabilized to protect a road or a canal. Justification for sand stabilization is difficult where square kilometers of sand are moving toward low-value developments. One approach in such situations is to build structures that tend to channel or intensify the wind into smaller areas, thereby causing the wind velocity to increase, as through a funnel. This type of channeling has been accomplished by sealing about half the sand surface near the development with 2-m-wide strips of asphalt that are parallel to the prevailing wind. The tendency is for the wind to move the sand between the strips at a velocity that carries the sand beyond the road.

The objectives of controlling moving sand are to lower dune crests, to reduce the lee slope of dunes to less than a 3:1 horizontal-vertical ratio, and to spread the sand as evenly as possible. When these objectives are accomplished, vegetational controls will be most effective and replace the mechanical barriers. Animals must always be carefully managed in sand-control programs because sandy sites have a fragile soil structure and are vulnerable to trampling and grazing damage.

Component 2: Microclimate

The microclimate of range ecosystems plays an important role in the interactions between the major components of the system. Changes in this microclimate resulting from various management actions can have a major impact on the ecosystem.

One of the most common ways management dramatically changes the microclimate of a rangeland ecosystem is by removing or thinning a shrub or tree overstory. This usually results in a modification of the temperature in the immediate area near the soil surface, an increased intensity of the sun's energy reaching the herbaceous plants, and changes in the interception and infiltration of rainfall into the ground.

Canopy reduction often results in a change of the herbaceous species. Plants that once thrived under the canopy are often reduced or eliminated. Other components, such as the insect and wildlife populations, may also be altered as the microclimate changes in conjunction with changes in the canopy cover. Many species have a narrowly defined habitat and their population density is dependent upon the stability of that particular habitat. The tsetse fly population, for example, decreases dramatically as the canopy opens. Each of the many varieties of this insect has its own unique habitat requirements and, as the habitat is altered, different varieties often replace those that can no longer survive.

It was stated earlier that man does not affect the overall climate of an area through his management practices. Even though this may be true in most cases, it is theorized that the cumulative effect of changing the microclimate over many smaller areas will eventually change the overall climate. There is some evidence, for example, that the very arid areas of eastern Jordan were once forested with oak and pine trees. Centuries of harvesting and overgrazing have removed this woody vegetation as well as most of the herbaceous vegetation. This degradation has occurred over such a large area that the microclimate appears to have been modified to the point that the resource base will require substantial inputs and time before it can again support a forest ecosystem. On a more global basis, the "greenhouse effect" and "polar warming" are two of the many terms used to express postulated worldwide climatic changes resulting, in part, from the accumulated effects of human manipulation on the microclimate within individual ecosystems. It should be noted that the impact of human-induced changes versus natural climatic fluctuations has yet to be worked out with sufficient clarity to support specific recommendations.

As was mentioned earlier, the microclimate is very closely related to succession. Rehabilitation of degraded lands may require that a progressive restoration of the microclimate occur before some of the desirable plant and animal species can be reestablished.

Component 3: Decomposers and Microconsumers

Decomposers and microconsumers play a vital role in the ecosystem and are integrally involved in energy flow and nutrient cycles. Microconsumers can be important as human food (termites, ants) particularly in "hunger months," and may even be preferred to meat in some areas. Understanding the key concept that nutrients cycle within, while energy flows through, ecosystems is critical to the management of natural resource systems. The capture and conversion of energy by plants was discussed earlier in this section. As plants grow, they form protein and carbohydrate substances using the sun's energy and elements found within the ecosystem. These elements (carbon, nitrogen, phosphorus, potassium, etc.) are bound up in the plant and, in lesser amounts, in animal tissues, even after the organism's death. These nutrients are then released into the soil by the actions of decomposers. Most ecosystems don't have an abundance of these nutrients available for use by plants and rely on using the same ones over and over again. Hence, the term nutrient cycling. The nitrogen and phosphorus cycles are illustrated in figure 4.

Decomposition and mineralization are important factors in the development and maintenance of soil. As plants mature and die, decomposers and microconsumers (for example, termites) break down the plant structures and return the nutrients to the soil and air, thus making them available for new plant growth. In arid and semiarid areas this cycling process may be very slow. The efficiency and rate of nutrient cycling is affected by the health and status of the decomposers and microconsumers within the ecosystem. They can be affected by the stability of

> A **decomposer** is an organism, usually a bacterium or a fungus, that breaks down the bodies of animals and parts of dead plants into simpler compounds.
>
> A **microconsumer** is a small organism that consumes living and dead plant material. Examples of this category include nematodes, protozoa, termites, and grasshoppers.

the top few centimeters of soil and the litter layer on the soil's surface. The rate of decomposition plays an important role in soil fertility, as does the nitrification activity of some leguminous plants. Both make nutrients available for plant uptake and growth.

In arid and semiarid areas, microconsumers consume up to 25% of the standing vegetation annually. In some years this can be much higher. Of course, microconsumer and decomposer organisms also use roots, where large consumers do not have access to this energy and nutrient source. The balance between production by the plants, consumption by consumers, and

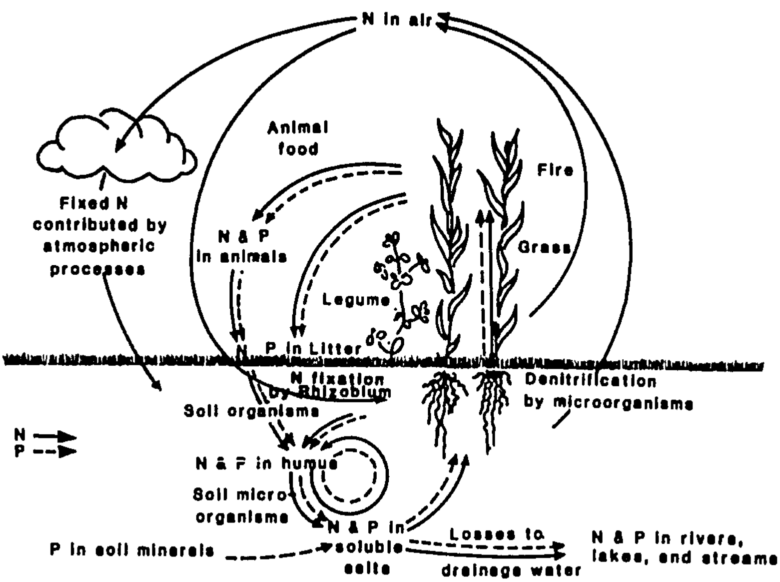


Figure 4. The nitrogen and phosphorus cycles (adapted from Bradshaw and Chadwick, 1980).

decomposition is of prime importance. Management practices often alter this balance without the manager realizing the importance of decomposers or the degree to which they occur. When an area is burned or cropped, some of the nutrients are not returned to the ecosystem's nutrient cycle, which can upset the balance. Adding fertilizer or other additives is a management strategy aimed at bringing the nutrient cycle back into the desired balance.

Component 4: Vegetation

Plants are the primary producers of the ecosystem, converting the energy from the sun into energy usable by man and animals through photosynthesis. The energy flow through an ecosystem is illustrated by Odum's classic drawing in figure 5. Anyone who plans or implements development activities must understand basic ecological concepts that involve vegetation, what constitutes a range or vegetation site, the significance of range condition and trend, and the autoecology of dominant or important species. This section will summarize some of these important concepts as they relate to development planning.

Vegetational Change

Vegetation management focuses on the naturally occurring dynamics and practical manipulation of rangeland vegetation. A key to understanding the selection and application of techniques for vegetational manipulation is knowledge of the characteristics of natural vegetational variation. The individual plants and the communities of vegetation on every piece of rangeland are changing continually and may repeat plant expressions in a decade or less. Most of these changes are beyond the control of managers and graziers; only a few can be directed by the manager.

Within most development projects resource surveys and vegetational assessments are conducted before management techniques are applied. These assessments are measurements and evaluations of conditions during a specified time. The resource at that point is the culmination of past influences of drought and flood, grazing animals, use of the land for raising crops, wood cutting, fire, ravages by insects, and many other processes. The relative importance of each of these factors in shaping the structure and composition of the vegetation and condition of the resources can only be estimated, but is sometimes fairly accurately determined. An understanding of how vegetational composition changes is necessary to improve decision-making in vegetation management.

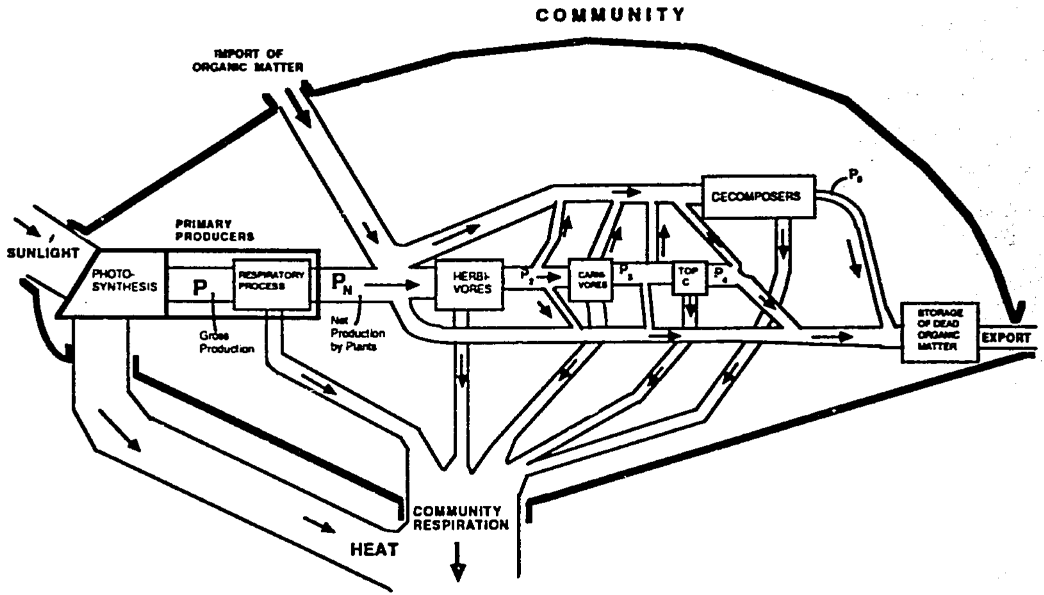


Figure 5. Energy-flow diagram of a community showing large respiratory losses at each transfer (adapted from H. T. Odum, 1956).

P = gross primary production
P_N = net primary production
P_2, P_3, P_4, P_5 = secondary production at the indicated levels

Another aspect of the assessment is that it contains the baseline information for assessing effects of future changes. These changes result from the same influences as in the past (drought, grazing, cropping) plus the additional impacts of applied management techniques. In order for the manager to monitor results of various practices, resource changes of many types must be measured and interpreted.

The skilled manager either encourages or works against the natural changes in ecosystems to further program objectives. Each alteration of grazing, seeding, fire pattern, wild animal population, small organisms, soil minerals, and human presence results in a new set of ecosystem changes. The manager needs to know what is happening, what might happen, what goes on where — in short, the dynamics of the whole ecosystem. Following are brief discussions of ecosystem changes, climax, and stability.

Daily and seasonal changes. Ecosystems experience many physiological, behaviorial, and phenological changes that closely correlate with the dynamics of weather and energy flow. For plants, 24-hour cycles characterize concentrations of water and photosynthates, position of leaves, and flower opening and position. Many species of insects are found on the vegetation at different heights above the ground at various times during the 24-hour day. Numerous animal rhythms are keyed to solar and lunar influences. Other cycles correlate with wet/dry seasons and with warm/cold seasons.

It is important to recognize that daily and seasonal changes in organisms occur no matter what the stage of biological succession. The effects of these repetitive changes need to be isolated from other types of changes through careful timing of field sampling and interpretation of results. For example, individual plant species reach their maximum biomass at different times in the growing season. Annuals often mature rapidly and perennials somewhat later. Early sampling of vegetation may give dominance to annuals and later sampling to perennials. If sampling is done on a fixed sequence for vegetational treatments, misleading results can be obtained. Comparison of sampling results from different phenological times confuses seasonal changes with treatment results or other effects.

Yearly changes. Daily and seasonal changes do not follow the same pattern every year. Fluctuations such as occur during drought periods are especially drastic in rangeland regions classed as arid, semiarid, and subhumid. Some climatic changes are cyclic: From one year to another, individual plants and the herbaceous vegetation as a whole fluctuate in response to variations in weather patterns. Parameters such as life cycle, growth rate, mortality, basal cover, height growth, and many more differ from year to year. Rodents, insects, mammals — in fact most animals — exhibit demographic changes from year to year, some of which are predictable.

Yearly changes continue with little control by the resource manager. Daily and seasonal changes may be confused with the longer term cycles and annual variations if measurements are keyed to calendar dates alone, because vegetational processes do not occur at the same time every year. As with daily and seasonal changes, care in sampling and evaluating the results of intervention are needed to separate the results of management from changes over which the manager has no control. Sampling should be scheduled in concert with the growth cycle of key plants rather than by calendar dates.

Successional changes. Succession refers in part to the replacement of species by other species as subtle micro-environmental changes to soil, vegetation, and animals progress. Consider the sequence of vegetation and animals that occurs on a piece of land made bare (by cultivation, for example) and left to return to its undamaged state (figure 6). Certain species will dominate the first year, likely the annual species that grow rapidly from abundant seed. In the following years they will give way to others, probably many perennials.

Many species are likely to be present in the natural systems at all stages of succession, but only certain ones will be dominant at a given time. Changes in microenvironment accompany the succession of soils, plants, and animals, reflecting the dominant species. Unfortunately, some literature refers only to the succession of organisms, mainly plants, and not to ecosystem processes. However, for successful planning and management, succession should be considered as a progression of organisms, environmental inputs, and processes.

In nature, daily, seasonal, and yearly changes are so thoroughly superimposed upon successional changes that their measurement and separation have not always been attained, perhaps not even realized. Extremes of droughts, winds, and freezes; severe fires; and epidemics of herbivores from insects to elephants may catastrophically reduce the current dominants. Succession is then set back (this is called retrogression), to continue again toward a balance with regional climate and local environment.

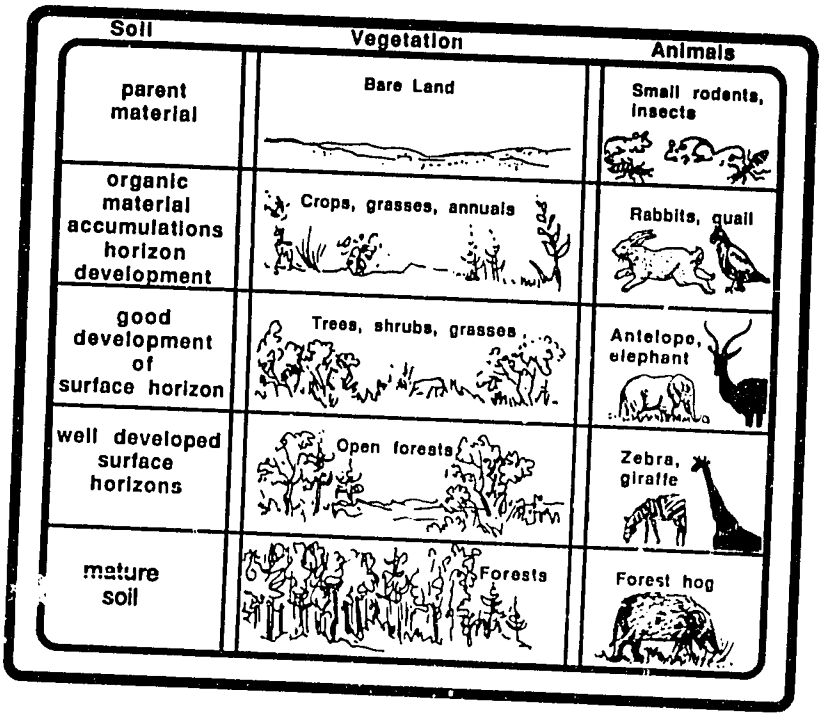


Figure 6. **Representation of soil development and successional changes of vegetation and animals that can occur if disturbed land is left to return to its previous state.**

Pioneer stages occur locally under a dung pat and on soil mounds built by animals, as well as over large areas. Disasters large and small continually present conditions that encourage the presence within higher climax stages of species that are usually found only in lower stages of succession. Regardless of these setbacks and oscillations and whether or not climax is ever attained, natural systems move toward stability or equilibrium with the overall environment. Equilibrium results from interactions within the ecosystem and signifies the ability of natural ecosystems to remain in or return to climax in the face of external disturbance. This orderly progression of organisms and processes to climax is referred to as primary succession. If the manager wants some other vegetation, its establishment and maintenance will require a struggle against natural forces.

Secondary succession refers to those vegetational changes that follow the structural change, often by people, of existing communities. The change may be as sudden as a fire or as slow as slightly-too-heavy grazing. Such change, even short-term cultivation, is usually not a total elimination of species nor a complete structural change. The soil that remains after change may be partially developed and organisms may be freed from severe competition, resulting in rapid succession after the cause of the change is eliminated. Then either the climax returns rapidly or, if the change is permanent, a new climax community may be attained.

Human activities that cause secondary succession differ only in degree from the natural causes. Vegetational changes following catastrophic fire are similar whether the fire was set accidentally by lightning or intentionally for resource management. Other types of influences that cause similar changes include construction of ponds by machines or nature, overgrazing by wild or domestic animals, destruction of vegetation by insects or herbicides, and actions of machinery or burrowing animals (figure 7).

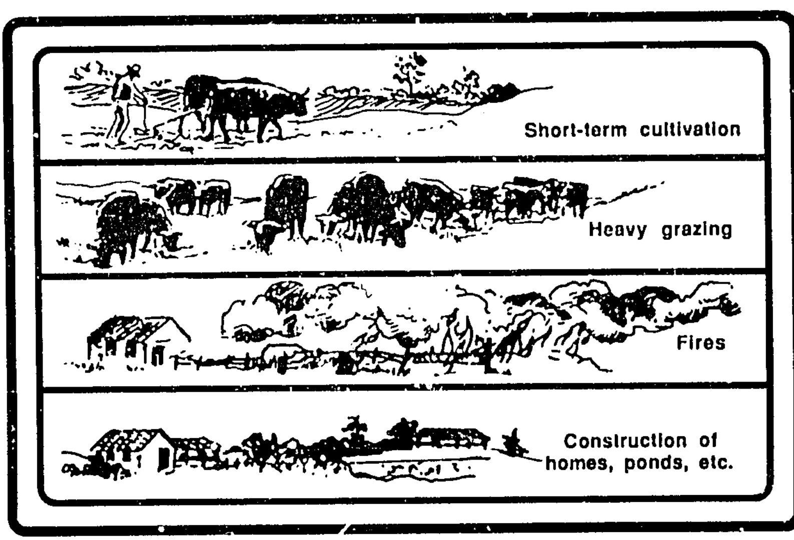


Figure 7. **Human activities that affect the structure and function of range ecosystems.**

Changes due to immigrations. The fifth type of change results from the permanent immigration of organisms and minerals, the latter through erosion and transportation by humans. Many organisms have potential to move because of highly evolved dispersal mechanisms. They ride wind and water currents for great distances. Animals that migrate, especially birds, move seed. A safe assumption is that immigrations have occurred for a long time and that they will continue.

For several centuries increasing travel by people has multiplied the number of plant and animal immigrants. Many newcomers quickly become naturalized and become a part of the local succession and climax; some are difficult to eliminate from their new habitats. Examples include the movement of Mediterranean annual plants to similar climates around the world, the European rabbit in Australia and New Zealand, and the establishment of numerous new populations of plant species in Hawaii.

Early man altered succession and climaxes by burning the vegetation and harvesting plants and animals. These influences intensified as people multiplied and new areas were occupied. Since people are part of the ecosystem such changes should be considered natural phenomena, as should the resulting successional stages and climaxes. In other words, current human impacts differ from the older more in degree than in principle.

Evolutionary changes. Still another type of change results from the evolution of new characteristics and species, which usually replace older ones. Each organism struggles for survival. Those species best adapted to the extremes of their living conditions survive, altering their gene frequencies, their population characteristics, and the system in which they live. As one species evolves, others react; thus the structure and function of the whole assemblage changes through time.

The evolution of communities and ecosystems seems as reasonable in theory as does that of individuals. Genetic gradients are in harmony with gradients observed in geographic and community characteristics such as diversity, physiognomy, succession, and nutrient cycling. Genetic gradients are the cumulative effects of species evolution. Significant adaptations, whether developed through biotechnology, suddenly as a single evolutionary step, or gradually over eons, alter ecosystems, successions, and climaxes.

Changes in plants, animals, and ecosystems resulting from evolution, earth changes, or climatic drift are of more interest in theory than in resource management. Such changes usually do not concern development planners. However, they do occur and activities such as plant breeding and genetic engineering may be considered as accelerated changes.

The Climax

Much theorizing and research have been devoted to the characteristics of stability and climax. Most definitions of climax refer to a self-perpetuating community of organisms in equilibrium with their environment. This definition implies that climax organisms interact with each other and that these relationships result in ecosystem stability, and that non-directional vegetational changes are no longer present. An absolutely stable climax could be reached only if the physical inputs remained constant — but they never do. Although there is a trend toward stability and a dynamic state around which variation fluctuates, an absolutely steady state is never achieved.

Vegetative changes within an ecosystem occur over a continuum of different time scales. Some changes, like plant growth, can be observed on an hourly basis, while some successional changes can only be observed over many years. Daily, seasonal, and yearly changes are rapid and respond little to managerial efforts. Successional changes in deserts take so long that only slight changes can be measured over long periods. Natural resource managers, when evaluating and monitoring ecosystem changes, tend to center measurements and judgments on a time scale similiar to their own life span. So it is understandable that when an ecosystem's life span reaches beyond human comprehension, as it does in many forests and shrublands, intermediate successional stages may be mistaken for the climax.

Stability in Communities of Organisms

Determining ecosystem stability requires interpretation of trends, cycles, variability, probability, qualitative relationships, and above all, repeated measurement. Rangeland monitoring is the means by which this information is acquired and is absolutely necessary to quantify and evaluate plant succession and climax on rangelands. The concepts of range condition and trend are closely related to these ecological concepts.

Most early ecologists believed that less complex ecosystems were more unstable than complex ecosystems. This concept has been questioned in recent years; in fact, some feel that just the opposite is the case. After defining the terms complexity and stability, Pimm (1984) reviewed some recent modeling efforts and compared the results to field studies to examine the relationships between complexity and stability. He concluded that many of the important questions about this relationship had not yet been asked and suggested the following theory.

- The more species present in the community:
  - the less connected it will be, if it is stable
  - the less resilient will be its populations
  - the greater will be the change in composition and in biomass when a species is removed
  - the longer will be the persistance of species composition in the absence of species removal

- The more connected a community:
  - the fewer species it must have if it is to be stable
  - the more likely it is to lose other species if one is removed
  - the more resilient will be its populations
  - the more persistant will be its composition
  - the more resistant will be its biomass if a species is removed

Table 1 shows selected attributes of ecosystems at developmental and climax successional stages, using the classical climax theory. It is intended to be inclusive, but not to show relative values. The characteristics apply differently to diverse areas such as deserts, grasslands, and forests; some may not apply to a specific place.

Application of Vegetation-change Concepts to Resource Management

The preceding summary of climax and succession should be helpful to resource managers in evaluating vegetation condition, trend, and management. Certainly the manipulation of vegetational change and the stability of soil and vegetation are central activities of vegetation management. Understanding the dynamics of rangeland vegetation is fundamental to its management. These tenets of vegetational change are applied at the resource-management level through the use of three concepts: range site, range condition, and range trend.

Table 1. Attributes of ecosystems at developmental and climax stages[a].

Ecosystem attribute	Developmental stages	Climax
Species composition		Stable
Diversity of species of life forms	Low	High (patchiness and mosaics evident)
Dispersal mechanisms	Physical control (predominantly wind with seeds)	Biological control (animal movement and vegetative continuations)
Biomass per unit area	Low	High
Net production	High	Low
Mineral cycles	Open	Closed
Niche specialization	Broad	Narrow
Nutrient exchange between organisms and their environment	Rapid	Slow
Amplitude of abiotic extremes	High	Somewhat lower

[a]Adapted from Odum (1956).

Range site. The first consideration is delineation of range sites (natural resource units). Each site is an area of land that responds homogeneously to climatic variation and has uniform topography, vegetation, and productivity. A range site should respond uniformly to grazing and to any applied management practice. Sites are mapped with the degree of rigor demanded by the intensity of managerial decision-making. For practical purposes the scale or size of a range site needs to be no smaller than a few hectares and no larger than a few square kilometers in area. This is in contrast to research that is often in square meters and country planning where several square kilometers may be minimum size. The ideal size of range sites is one that promotes uniform grazing management and cultural treatment.

Each mapping unit may be a site or a complex of sites forming a management unit. It is defined in terms of vegetation of a particular botanical composition (with a known level of production), one or more soil series (of great similarity), range of precipitation, and physiographic uniformity. The existing and potential productivity of one site will often be different from another. Mapping units are the basic land units on which range condition and range trend are assessed and prescribed management practiced.

Range condition. Range condition is an assessment of the present state of health of the range site in relation to its potential. Descriptions of good range, or the highest potential for that range site, depend upon evaluations of moderately grazed areas, relic areas, exclosures, historical accounts, and vegetational changes following relief from overgrazing. Information from these sources helps especially in the separation of vegetational changes that the manager can control from those beyond manipulation. A model of a rangeland ecosystem illustrating the way grazing relates to condition and trend is shown in figure 8.

Determination of range condition is difficult for many sites. Widespread resource deterioration may have caused the site potential to decrease. Information on vegetational changes and what the climax might be helps in this process because the highest potential for grazing in grasslands is likely to occur during a late successional stage or even climax. The best grazing for domestic cattle is usually perennial grasses of a medium height, less than half a meter. In tall- and high-grass savannas, the short- and medium-height grasses are most desirable and usually constitute an intermediate stage of succession. In deserts, where the forages are annual grasses and shrubs, there may be little relationship between range condition and climax. This is also true in dense woodlands and forested areas. Wherever the site, the manager must be concerned with the increases and decreases of both desirable and undesirable plants. Placing these sites into various condition classes — excellent, good, fair, or poor — is useful for comparing the present vegetation in relation to potential or desirable vegetation.

Range trend. Range trend is the direction of change in condition for the site. It requires determination of the range condition of the same site at two different times. Fewer and fewer desirable forage plants, increasing erosion, more bare soil, and less plant vigor characterize a downward trend. Decreasing vigor of perennial grasses is indicated by shorter leaves and stems, fewer seed heads, sometimes a yellowish color, and dead tillers. With experience these indicators of downward trend can

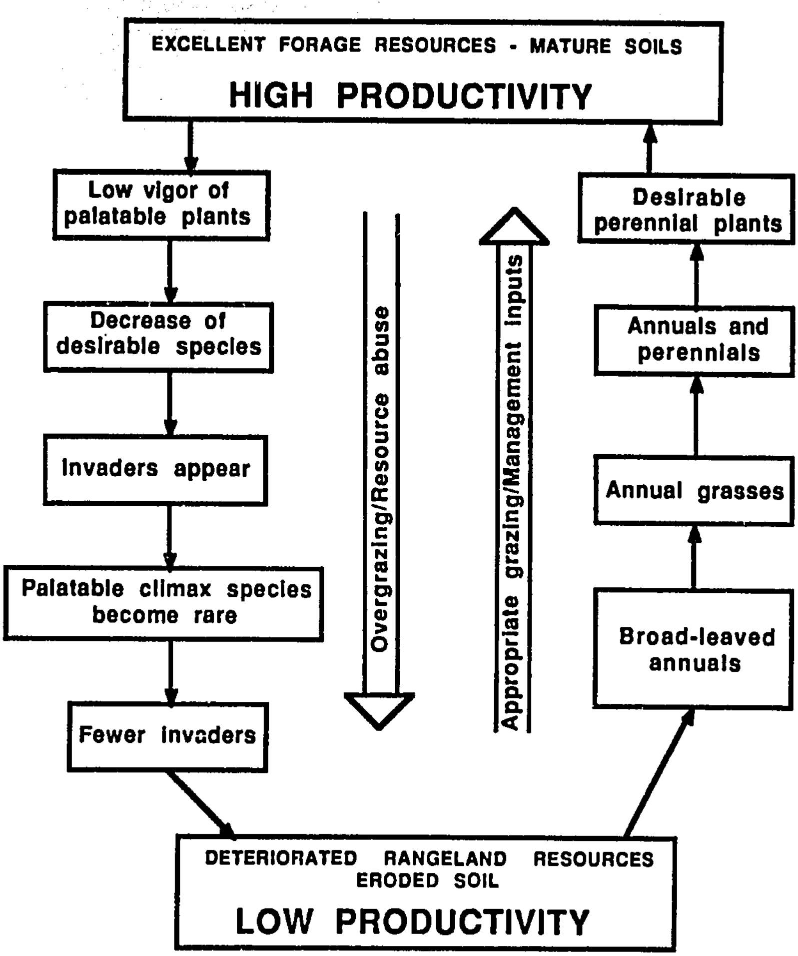


Figure 8. A comparison of the effects of overgrazing a rangeland ecosystem with the effects of appropriate grazing management (adapted from Heady, 1975).

be detected in one examination, but they can be quantified only on the basis of repeated measurements over time. This is currently referred to as monitoring of range condition. Changes in the vegetation that are due to drought or some other uncontrolled cause may also result in a downward trend.

Presence of young, middle-aged, and old plants of a grass species (all-age stands), indicates that regeneration is taking place. If the species are desirable ones, the trend is upward. Factors such as livestock condition and production, degree of forage use, and populations of insects and rodents only indirectly suggest range condition and trend, and can often be misleading. Even low-condition ranges, if properly managed, will sustain some animals at a satisfactory production level. Thus, the evaluation of range trend must account for vegetational changes resulting from all causes. Measurement and evaluation of range trend require an understanding of plant succession and other types of vegetational changes. For example, trend analysis is more difficult for range sites dominated by annuals.

Component 5: Animal Populations

In this section, the term "grazing animals" refers to domestic livestock and wild ungulates. This does not imply that rodents, insects, etc. are not important. Rather, the concentration is on the animals that in general are of direct use to humans, and that may be managed to a considerable degree and on a regular basis. That is, the impact these animals have on the rest of the ecosystem can be significant, but can be controlled.

Domestic livestock and wild ungulates are of particular importance because they produce high-quality energy (and protein) and other animal products that constitute the main outputs from rangeland ecosystems that can be used directly by people. By modifying or controlling relationships among the animals and important components of the rangeland ecosystems, changes in the output can be effected. Furthermore, the types of relationships established will influence the continued functioning of the ecosystem, because the relationships may either improve or impair the overall functioning. In this section, our objective is to describe some of the more important aspects of how grazing animals affect and are affected by the rest of the ecosystem.

Animal/Vegetation Interactions

The most important interaction that involves animals is when vegetation is being grazed/browsed (Child et al., 1984). Two simultaneous actions occur: **removal** of foliage and other plant parts and **consumption** (intake) of that material by the animals. Trampling is a third associated action of considerable relevance.

The primary factor influencing the response of plants to grazing is the degree to which the foliage removal interferes with solar energy interception and capture. (Physical injury also may be important, particularly in palatable browse species.) While such interference obviously depends upon the amount of green foliage left, it may also be strongly influenced by moisture availability, root development, physiological differences among plants, and general growing conditions. Energy interception also depends on stage of growth and frequency of grazing.

Too heavy and too frequent grazing during the growing period reduces subsequent growth of both tops and roots. Rate of growth also is slowed and efficiency of soil moisture use is likely to decrease. Acceptability to animals and relative intensity of foliage removal varies among plants. Preferences for particular plant parts and species vary among animal species, plant associations, and stage of plant growth. Goats and camels, for example, have quite different grazing preferences than do cattle and sheep, and these differences may vary with the seasons. Their grazing capabilities may also be notably different due to size, structure, agility, etc. Among wild foraging animals, one species may prepare the environment for other species. Elephants, for example, may demolish a forest, making way for brush-eaters such as the kudu. In turn, kudus may open the way for grass growth, creating conditions favored by grass-eaters such as the wildebeest. Removal of old herbaceous material through grazing may be vital to the maintenance of vigorous stands of grasses. Trampling of seeds into the ground often helps natural regeneration.

One can therefore postulate that the impact of grazing upon the vegetation will vary with the degree, frequency, and time of grazing; with the mix of plant and animal species present; and with environmental conditions. Response to changes in floristic composition and structure will reflect modifications in competitive relations caused by the complex of factors in which animals often play a primary role. Tolerance to very heavy grazing may be exceptionally high where strong selective grazing pressures have been operative for a long time — as in the Near East and much of Africa. Vegetation changes and the influence of animals are further discussed in the section dealing with vegetation as a component of the ecosystem (in this chapter) and in module 1 (Vegetation Management Through Grazing).

Animal responses (weight change, reproduction rates, etc.) to grazing conditions depend mainly on the quality and quantity of what is eaten, i.e., intake. The main concern on arid and semiarid rangelands has to be with quantity. The fact that dry-matter content on these ranges is relatively high even during the growing season, and quality remains higher than in more humid grasslands means essentially that a satisfactory intake of energy and protein is possible, providing an adequate quantity is available. Not nearly enough is known about how much forage and water should be available to meet animal requirements under the diverse conditions of arid and semiarid rangelands. However, it is known that when the quantity falls below a certain level, weight gains will decline rapidly. If quantity continues to decrease, animals will lose weight until an equilibrium between energy consumed and energy expended is reached, or they die.

Because of different food preferences and capabilities, response to a given type and quantity of vegetation will differ among animal species. For example, sheep and goats can more efficiently select forage that meets their nutrient requirements than can cattle. Camels can range over larger expanses of ground and eat coarser material than can most animals — so they remain in excellent condition while other animals are malnourished. Goats can select more nutritious materials among bushes than can either cattle or sheep.

Animal/Soil/Water Interactions

A principle objective in the management of arid and semiarid rangelands is to use as much of the rainfall as possible for plant growth. This requires that as much of the rainfall enter the soil as possible, i.e., that runoff is kept at a minimum and that evaporation from the soil surface is low. In some cases root development (to reach and use all the moisture in the soil) may be important.

Animals affect moisture relations by grazing and trampling. When they remove plant foliage, transpiring leaf surface and leaf cover are reduced. Additionally, the potential litter production is lowered. The likely results are lower rates of transpiration and therefore slower rates of moisture removal from the soil, more bare soil, more raindrop erosion and sealing of the soil surface, less rainfall entering the soil, more runoff and erosion, and higher soil temperatures and greater evaporation from the soil surface.

The consequences of these interactions will vary according to rainfall intensity, slope, grazing intensity, rate of plant regrowth, plant growth habits, soil texture and structure, organic matter content, and other circumstances. For example, on sandy soils little if any sealing of the soil surface would be expected to occur and most of the rainfall would enter the soil. Evaporation from the surface of sandy soil would not be greatly increased because with its low water-holding capacity little water is to be found in the upper 8 cm to 12 cm from which most of the evaporation would be drawn. Because a given amount of water in a sandy soil will be distributed deeper into the profile, the "green-feed" period might be extended. Over a period of time with heavy grazing, however, root penetration would probably be decreased, leaving unused moisture in the soil. This would in effect leave an open niche in the community that might be filled by unpalatable, deep-rooted shrubs. The consequences could be somewhat different on clay soil, shallow soil, etc. Differences in the original vegetation, e.g., annuals versus perennials and shrubs versus grass, would also influence the outcome.

The pressure exerted by animal hooves is substantial and enough to compact the soil, reduce the rate of infiltration, and increase runoff. Under certain conditions infiltration may be reduced to a fraction of total rainfall. Compaction and damage to the vegetation is only too apparent on animal trekking routes (areas over which animals are frequently moved — as to market), around watering points, and at other places where animals gather. But it can also occur in grazed areas where the effects of erosion and damage to the vegetation are not apparent.

The ease with which compaction may be expected to occur varies directly with the soil's moisture content, its clay content, and noncapillary pore space (large air spaces in the soil through which water passes easily), and inversely with root density and foliar cover. The amount of compaction that occurs in any situation depends on the number of animals present, especially during the time when conditions are favorable for compaction.

Compaction by trampling is most likely to occur during the rainy season, most notably on heavier soils. Noncapillary pore spaces in soils high in clay are essential for good water infiltration. These soils are very vulnerable to compaction and loss in infiltration rate. At the other end of the scale are sandy soils with small pore spaces and with a low water-holding capacity. Trampling these soils will affect compaction and infiltration very little.

The structure of soils compacted by trampling will return to normal over time if trampling is eliminated. How long this takes will depend upon root action, soil freezing, and other factors.

Animals and Soil Fertility

Soil fertility is usually not an important limiting factor on arid and semiarid rangelands. For this reason, recycling of organic matter and minerals through the animals is less important than under more humid conditions. Nevertheless, return of animal wastes to the soil is desirable. Removal of animals and animal products over a long period may cause some depletion of minerals in short supply because they are not returned to the ecosystem for recycling.

When rainfall exceeds about 500 mm, soil fertility is much more often a limiting factor in production because of increased leaching (and perhaps because of other factors). Grazing too heavily can reduce root penetration and thereby increase leaching. Elimination of palatable browse species with deep root systems is particularly undesirable. However, grazing intensity during the dry season or during drought years has less of an effect on root penetration than does grazing during seasons of rapid plant growth.

Animal Responses to Temperature and Humidity

Besides vegetation, animals may be greatly affected by weather — especially temperature and humidity. The degree to which animals are affected by temperature and humidity depends upon how well they are adapted, and to some degree upon their physiological state. Adaptation is of profound importance because it affects productivity directly — especially intake and health. This topic and others discussed above are treated more fully in Child et al. (1984).

Component 6: Indigenous People

The activities of the earliest known human civilizations depended to a large extent upon the rangeland half of the terrestrial world. This relationship was and continues to be two-way in that people receive their livelihood from the system and influence or service the system, usually for their own benefit. The characteristics of rangeland peoples and their practices as they should be considered for rangeland development were reviewed in Child et al. (1984) and are not repeated here. However, many of the guidelines in this publication are intended to serve the indigenous rangeland people, and a few statements are needed to make that service more effective.

After several decades of assistance, rangelands throughout the developing countries remain in poor condition and many are still deteriorating. Projects have failed outright and projects perceived as being successful seldom survive after withdrawal of donor support and guidance. Causes for these failures are many and they may be found within any of the separate components or boxes in figure 1. More likely they are due to the failure to account for the interactions, the lines between the boxes, which are little realized and poorly understood. Among these, and considered most important by many, is the failure to take human and social factors into account in planning development projects. Some important principles and guidelines follow.

Understanding Indigenous People

The tendency has been to aim for technological and physical development before working with people, instead of bringing them forward together. However, understanding the indigenous people should be the initial step in project planning. Such an understanding permits the adviser to demonstrate his/her personal integrity and gain the confidence of the local pastoralists. All too often the traditional systems of livestock production have been less responsible for degradation than attempted changes to these systems have been. Planners and advisers tend to collect inadequate information about social organization of space, property, seasonality of resource use, and other aspects of the survival system. Advisers should spend more time in the bush listening to the indigenous people and using the local language.

Social Reorganization

Subsistence pastoral systems have social and survival characteristics that have evolved over centuries of nomadic and transhumant use and management. Many planners and projects assume that social reorganization is necessary when further analysis would show that little change is needed. When a change is necessary, it must start with the actual situation of the people at the time. Change should build upon existing organizations using development steps that are not too large.

Participation of Beneficiaries

Much has been written about the principle that the beneficiary must be a part of the project from the very beginning. The beneficiaries are the pastoralists, not the traders, processors of products, or government officials. Seldom has a project been successful without the beneficiaries having been included from the beginning. Regardless of the project's logic, scientific soundness, or possibilities for economic enhancement, it will be either implemented or destroyed by the local people, depending on whether or not they see it as beneficial to them.

Inappropriate Technology

Application of the wrong technology is closely related to erroneous preconceptions of advisers. Traditional use is a form of management that has evolved through the sortings of catastrophe. Advisers with a high-technology, basic-research approach tend to start at a level too Westernized for the pastoralist to accept. A simple example is the attempt to increase beef production when the real need is for improved yearlong milk production. Another is the tendency to work with only a part of the system, but one that does not include the basic problems. Cattle breeding may be emphasized when the real problem is feeding or rangeland management. Social and economic changes may be the thrust and the biology forgotten, or the other way around, because of the expertise of the adviser. Projects frequently fail because of unsound conceptualization, resulting in inappropriate and incomplete technology.

Sensitivities About Destocking

Local people feel that sufficient livestock production comes only with large livestock numbers. Milk is needed every day of the year, so livestock must be milked throughout the dry season and through droughts as far as possible. Goats, sheep, camels, and cattle all play a significant role in survival by providing milk during adverse times. However, young animals must mature and be bred before they can produce milk — in other words, time is necessary before the animals become productive. In some situations cows calve (and begin giving milk) only about every 3 years. Since each person needs a certain amount of milk, people believe that several animals must be maintained for each person in the family. Doubts arise when advisers tamper with this belief. This subject must be addressed with care.

Crop- and Livestock-production Systems

Livestock-production systems often are associated with cropping systems on small farms. Some tribes are largely farmers while others mostly raise livestock. Competition for the use of higher potential rangeland is increasing, largely as expansion of sedentary farms restricts rights of passage and reduces available grazing resources. Still another aspect of mixed livestock/crop-production systems is the potential for increased production of forages from the crop fields that might be used by the resident livestock or traded to other owners. Improved integration of cropping and forage production should receive more attention by both research and development activities.

Project Success

Early and local participation by planners and advisers does not guarantee project success, but success can hardly be attained without it. Many problems lie outside the expertise and control of range management professionals and the local people — for that matter, outside the knowledge and influence of any professional. It is critical in project planning and implementation that problems and causes be defined, not merely that the symptoms be identified. The understanding of the role of people as both contributors and harvesters in the rangeland ecosystem is of ultimate importance. It is people in the system who determine the need for and the use of the guidelines presented here.

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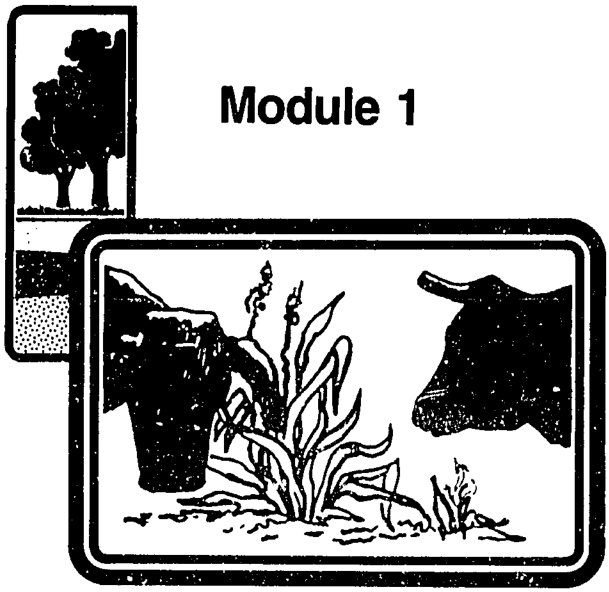
SECTION I

GUIDELINES FOR RESOURCE DEVELOPMENT



Module 1

Vegetation Management Through Grazing

Grazing management implies control over the influence that grazing animals exert on the rangeland systems. In the rangelands review (Child et al., 1984), the complexity and wide variations among rangeland ecosystems were stressed. The impacts of herbivores on these systems are also complex and highly variable. This module examines the grazing factors and comments on how they are taken into account by the manager. Briefly, grazing combines defoliation and physical processes that damage plants and move minerals and seeds about the landscape. Figure 9 diagrammatically summarizes the different interactions between vegetation and animals. The emphasis is on the impact of grazing on other components in the ecosystem, not the responses of animals to the grazing systems. That important aspect of grazing is the subject of modules on livestock management and game cropping.

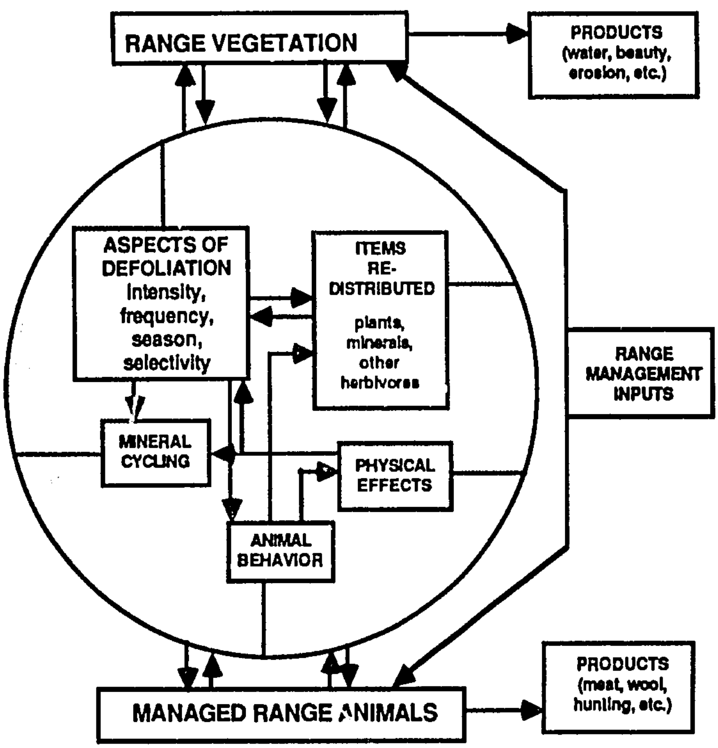


Figure 9. **Interactions between vegetation and animals under grazing conditions (adapted from Heady, 1975).**

Defoliation

Most range plants can be defoliated to some degree without appreciable damage. However, while moderate removal of live herbage may stimulate one species to produce more branches or tillers, it may severely reduce another's size and growth rate. The manager's purpose is to keep grazing at the highest degree of defoliation that still maintains production levels with minimum impact on other ecosystem components. Unfortunately, that degree of defoliation is difficult to determine because it depends largely upon the phenological stage of the plant at the time of defoliation.

An interdependent relationship has evolved in which defoliation is a part of the rangeland systems. Natural selection operates both to provide herbivores with food and to permit plants to meet their needs. The fact that plants palatable to grazing animals dominate the world's grasslands and commonly occur in shrublands and forests suggests that adaptive processes through natural selection operate to foster both the eater and the eaten. This adaptive process has been demonstrated in exclosures throughout the world that have prevented grazing by large herbivores. Many have shown decreased density and production of grasses and changes toward woody plants and large, unpalatable herbaceous plants. Grazing is a natural and normal process in grasslands, but it can and does get out of balance.

Intensity of defoliation refers to the proportion of the current year's growth that has been consumed or destroyed by grazing animals. Intensity may be expressed as the proportion of height or weight of materials that have been removed from the plant. Where animals harvest the forage, direct measurement of the amount removed is impossible; therefore, a better approach is to define intensity of use in terms of the amount of material remaining on the ground. However, in most studies "proper use" is based upon percentage of weight removed from the plant, but can also be expressed as percentage of plant used. For grasses, proper use is commonly expressed as the average stubble height or weight of unused plant material per land unit. The condition of the soil and the state of the decomposers are related to the plant residue rather than to the amount removed. Note that on annual grasslands, the critical factor is the seed source and supply, and not necessarily residue.

Frequency of defoliation includes the number of defoliations and the intervals between them. Clipping experiments have not clearly established many details about the effects of frequent defoliations. The frequency with which plants are defoliated in clipping experiments seldom accurately simulates the schedule of animal movement for schemes that use large numbers of animals in small areas for short periods in grazing situations.

Season (or phenological stage) of defoliation refers to herbage removal at different times, measured along the growth curve of the plant. Some grasses and most forbs are highly susceptible to defoliation and lose vigor when growing points are removed. Others show little effect in terms of vigor, dry weight, and seed produced. Sensitivity of some species to defoliation increases rapidly as the plants approach maturity. Growth patterns are subject to great variation due to weather, as was discussed in the vegetation component in section I. Rotation and other grazing systems are based on manipulation of the effects of seasonal defoliation.

Selectivity and Physical Effects of Grazing Animals

Different animals prefer to eat various plants to different degrees — this is called grazing selectivity. Each herbivorous species and individual — wild or domestic, large or small — selects a daily ration from available plants. All grazing includes elements of choice ranging from obligatory grazing on a single plant species or genus to a display of little or no food preference for any species. Food selectivity results from a highly complex interaction among three sets of variables operating differently over time: the plants being eaten, the animals doing the grazing, and the abiotic environment of both.

Whenever grazing animals move about they affect soil, vegetation, and other animals. Major impacts include pulling plants from the soil, trampling or treading that injures plants, compacting the soil, and covering the vegetation with soil and dung. Trampling and soil compaction have received considerable emphasis and have been shown to be directly related to increasing intensity of rangeland use, especially during the wet season. Trampling during the dry season causes plant residue to be incorporated into the soil, loosens soil crusts, and covers seeds, all of which are beneficial. The periodic resting of areas from grazing probably allows the actions of small animals (like rodents) and growth of underground plant parts to ameliorate any trampling damage.

Another physical effect is the influence on energy flow and nutrient cycling in the rangeland systems. The digestive process in ruminant animals certainly changes the rate of mineral cycling in the system, but the magnitude of these changes is not great. Less than 1% of any element in the rangeland system cycles through the large herbivores. Perhaps a few percentage points of some elements, nitrogen in particular, may be in the plant component of the cycle. Removal of a 450-kg cow from an area only takes away approximately 16 kg of nitrogen, 6 kg of calcium, 3 kg of phosphorus, and less than 1 kg of any other element supplied to plants by the soil. Considering that several hectares of rangeland were needed to raise that cow, few minerals per hectare were removed by her.

Still another effect, which is easily observed, is the movement of minerals and seed about the area. At any location, the supply of nutrients in the ecosystem constantly changes. Increased and improved nutrient availability results from the weathering of rocks, deposition of erosion products, precipitation and fixation from the atmosphere, immigration of organisms, and transportation of minerals by organisms. Mineral concentrations from accumulations of dung and urine change the vegetation, as does the deposition of seeds. Large herbivores often concentrate minerals near watering points and resting areas. Management through grazing systems attempts to minimize these concentrations, just as it tries to reduce trampling effects.

Effects of Grazing as a Whole

Individual plants and the vegetation community respond differently to changes in the grazing factors. These differences can be observed both in below- and above-ground plant parts (figure 10). Unfortunately, intensity, frequency, or season of defoliation cannot be changed without also changing the degree to which different forages are selected. Different animal species graze and behave differently. Knowledge about the interrelationship of grazing animals and the vegetation is useful to the manager, who must make decisions about stocking rates, kinds of animals, seasonal grazing schedules, and other range inputs.

Managing Intensity of Grazing

Control of defoliation through manipulating the numbers of livestock and the length of time they are grazing an area is one

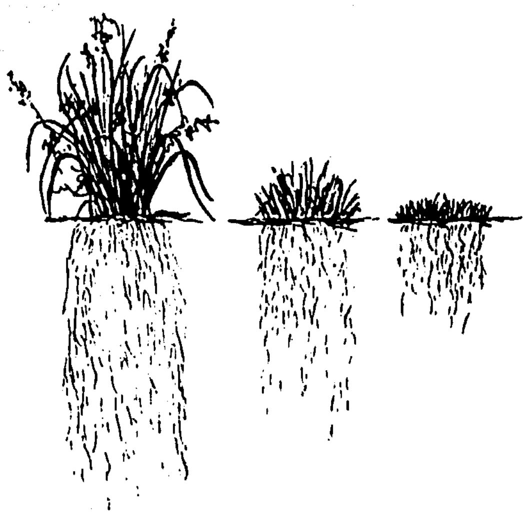


Figure 10. Root deterioration in relationship to defoliation.

of the important tools available to the rangeland manager. To effectively use this tool, several concepts and definitions concerning animal numbers need to be clearly understood (see box).

Determination of Grazing Capacity

The relationships between forage supply and animal production per individual and per land area were given in conceptual form in figure 19 in Child et al. (1984). That figure suggests that the stocking rate is a point where optimum production of both forage and livestock occurs. These points can be measured by weighing animals and determining the available forage. An average of these determinations for a number of growing seasons gives an estimate of grazing capacity.

Planners and managers of land frequently are asked, "What is the livestock carrying capacity of a prescribed range area?" The answer must be in general terms and reflect the current season's forage availability. It has about the same relationship and value to stocking rate and management as average rainfall has to the current year's amount and pattern of forage production.

A commonly accepted definition of **carrying capacity** is "the average maximum number of individual animals that can survive the greatest period of stress on a given land area." The definition has the connotation of "supporting permanently." Carrying capacity is not a single number to be determined and used as a goal in management. Rather it changes as the managerial inputs change; thus, the carrying capacity of rangeland will be increased or decreased depending upon the management as well as the environment. All management opportunities should include flexibility to cope with fluctuating forage production.

Stocking rate is the actual number of animals or animal units on a specific area for a specific period of time, usually for a grazing season. The average of the annual stocking rates for grazing animals for a period of years has been termed the "grazing capacity," which should not be greater than the carrying capacity.

Grazing capacity is closely related to carrying capacity but refers only to the grazing animals. Commonly it is the number of animals that produce the greatest return without damage to the biological resources, and that can be maintained in concert with the other values received from the land. Carrying capacity and grazing capacity are sometimes used interchangeably, which confuses the overall capacity of the land for all products with its capacity for producing only grazing animals. Determination of grazing capacity before the animals have grazed under a management system for at least 1 year is seldom worthwhile because climatic variations must be considered. It may require 5 to 10 years in some areas of Africa where periodic droughts are common.

Stocking density is a relatively new term used to describe both the number of animals in one prescribed area at a specific time and the animal-to-land relationship in rotational grazing schedules.

Grazing pressure is defined as a relationship between the demand for forage at a given moment and a combination of standing crop and its daily growth increment. Expressions of grazing pressure embody the concept of degree of forage use. Heavy pressure occurs when daily consumption exceeds the daily growth increment and the available forage supply is low.

A much more important question to ask is, "What is the impact of the current stocking rate on vegetation, soil, or other users of the resource?" If the answer is that the range condition is deteriorating, or the range trend is downward as described in section I, then the obvious need is to reduce the grazing pressure by every means available. These include but are not limited to reducing animal numbers, distributing the grazing more evenly, using a grazing schedule, and providing more forage. When the manipulations have achieved a good, stable range condition, the grazing capacity will have been reached. But the manager must always keep in mind that the seasonal and annual variability in resources will result in variability in forage use and livestock production.

Mixing Animal Species

The practice of grazing two or more species of domestic animals together on the same range has long been known as common-use grazing. The more developed rangeland regions generally support flocks and herds of single species, but this may be changing because a few experiments have shown that mixed species are more productive than single species. In developing areas, such as most of the arid and semiarid parts of Africa, most if not all the herds are mixtures.

Mixing animal species is a managerial technique for taking advantage of a wide range of forage palatabilities and animal preferences for different plant species. All rangelands have or could have wild grazing animals. In situations where rangeland is used by more than one animal species, all species should be considered when determining carrying capacity. Selecting, maintaining, and manipulating the mix of species using rangeland is both a means to greater production and a tool for molding the vegetation into desired botanical compositions and production.

The mix of animal species selected for any given situation results from the interplay of many factors such as human nutritional needs, traditions, laws, market demands, animal health, handling facilities, and, above all, food and habitat requirements of the different animals. In a general way the proportions of grass, broad-leaved herbaceous plants, and shrubs or browse determine the desirable kinds of animals for a given range.

In developing countries, the domestic species are often herded, which prevents them from expressing a habitat preference. On the other hand, the wild species concentrate in parts of the vegetational mosaic that they prefer. Wildebeests and zebras choose grassland and open woodland; kudus stay in heavy brush and dense woodland. These species change their habitat preferences in response to changing supplies of water and feed. No two species have the same food and habitat requirements.

Assuming water and shelter needs can be met, an animal species finds its best habitat to be the one furnishing to the greatest degree those foods that it needs. Each combination of species needs a certain combination of forages and other range conditions that involves three sets of factors: 1) the manager's choice of animals and operating procedures; 2) the vegetation, soil, and other physical factors that constitute the rangeland habitats; and 3) the influence that the grazing animals exert on their own and others' habitats. A change in the numbers of one animal species influences the numbers of other species by changing vegetational composition. Such a relationship can be used for managerial purposes.

An example from southern Africa will illustrate the possibilities. Annual burning of the rangeland for several decades had resulted in grassland and open savanna. The fires were eliminated for a few years, during which time the brush increased, as did impala and greater kudu, but the grassland antelope species decreased.

An East African example shows the use of animals to change vegetation. Woody plants were reduced by burning and charcoal making. Then many sprouts and seedlings of the woody plants were killed by rotational grazing with goats and wild species of browsers in the area.

Too little information is available on this subject of the relative influence of different species on their habitats, but enough is available to justify using mixed grazing species and to include them in rangeland assessment and planning. Grazing mixed species can also increase productivity from rangelands.

Seasonal Grazing Management and Schedules

Seasonal management implies that, whether a range is being used by livestock or game, a portion of the range will be relatively free of animals for a sufficient time during a particular season so that the vegetation will benefit from not being grazed at a critical time, excessively trampled, or otherwise disturbed. The principal reason for moving animals from one area to another is to permit at least part of the range to rest (give plants the opportunity to renew photosynthetic tissue and reserves) during the time that the vegetation is most subject to damage by defoliation. The goal is good range condition, or at least an upward trend in condition where it is below potential. Other goals are reduction of "sacrifice" sites around water and higher animal production. Management of seasonal grazing is accomplished by developing schedules that indicate when each pasture is to be grazed. Of course this requires delineating boundaries and seeing that adequate water for both people and animals is distributed. Fencing is extensively used in developed regions but continuous herding can accomplish the scheduled changes as well as, or even better than, fences.

A rationale for seasonal grazing is that many grasslands in the world evolved under intermittent grazing pressure from migrating herbivores, for example, the bison in North America, wildebeest in East Africa, and caribou in the Arctic. These animals used a given range during a short period, perhaps overused it, then moved to a new range in a pattern that more or less repeated itself yearly. Migrations became fixed in the behavior of many species and, consequently, exerted seasonal grazing pressures to which the vegetation became adapted through natural selection. Seasonal grazing plans developed as land managers attempted to fit their domestic animal species into naturally evolved plant and animal systems. Seasonal grazing schedules were first suggested for rangelands about 100 years ago.

The review document (Child et al., 1984) associated with this series of guidelines contains short descriptions for five different seasonal grazing schedules: continuous grazing, deferred grazing, deferred-rotation grazing, restricted-growing-season rotation (sometimes called short-duration, high-frequency grazing), and the hema system. Further description of advantages and disadvantages of the various schedules as well as diagrams that show sequences of animal movement from one pasture to another can be found in Heady (1975). Avoid quick-prescription guidelines for grazing systems — only after careful consideration of available resources and requirements should a grazing system be proposed.

Grazing systems require an understanding of the response of plants to defoliation and of animals to the forage supply. They also require flexibility in the movement of animals from one pasture to another that is based on an understanding of the changes that can be expected as other conditions change. Rangelands in the tropics and subtropics are not subject to the rigid controls of fencing. Therefore it is extremely important that herders understand the grazing system and be motivated to put it into effect. The application of range management principles, as with any other agricultural principle, must be accompanied by an effective educational effort. This combination helps ensure that rangelands will be well managed.

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Module 2

Vegetation Management Through Water and Livestock Distribution

Ideally, animal grazing should be managed so that the area of range-forage use is as large as possible. There should be few areas of little-used forage; none should be overused. This ideal requires reducing the number and size of places where animals congregate and the numbers that congregate. Areas where animals must gather and where damage is unavoidable are called "sacrifice" areas.

In developing countries, especially in the arid and semiarid zones, the major tools controlling animal and human distribution are herding and establishing new water points. Water distribution also influences social and communal activities and the spread of disease. Although fencing is usually impractical, boundaries can be described and marked that will help in managing grazing programs and maintaining uniform grazing pressure.

Poor Animal Distribution

Poor livestock distribution causes rangeland deterioration. Animals concentrate near water, shade, and salt, and on relatively level areas where the nearby topography is steep. A permanent water source such as a spring, reservoir, or well serves as a focal point to which grazing animals are brought on a regular basis. They trail to and from water and repeatedly graze along the way. In principle, the degree of impact (such as defoliation and trampling) varies as the square of the distance from points of regular concentration. Areas around water that are completely bare of vegetation are common on rangelands. Due to heavy camel grazing in Saudi Arabia no perennial vegetation occurs within 15 km of some water points; in extreme cases the distance is 50 km. A common situation in rangelands of developing countries is that water points are too few and poorly distributed, and their use is unmanaged.

Permanent water sources such as wells with or without pumping machinery, springs, and large reservoirs encourage larger numbers of livestock on the nearby land than do smaller and temporary water sources. The permanent sources are the only water supplies during the dry seasons and many of them provide water for animals during the wet season as well. However, overgrazing is also evident near most temporary sources of water, at least partly because the vegetation is more susceptible to damage during the wet season than during the dry season. When temporary pools and streams are available, the permanent water sources (such as wells) should be closed to use so that the surrounding ecosystem can rest. Forages furthest away from permanent water should be used first. Roe (1984) has determined that this restricted access results in better range condition than does unrestricted watering. Developing many small-capacity water sources is another way to spread grazing pressure, but controlling when and where the herds graze is essential.

Watering Facilities

Water for livestock and game has been developed with dams, artificial ponds or tanks, wells, opening of springs, pipelines, troughs, metal tanks, sealed runoff aprons, and sand traps (figure 11). The problems associated with water discovery, storage, and delivery to the user have been present for centuries. Only the means of dealing with them have changed — for example, hauling water along desert travel routes by camels has given way to hauling by vehicle.

Each species of animal has its own specific water requirement. Here are some daily requirements expressed in liters per day for mature animals.

Camel*	75	Goat	4
European cow	45	Sheep	4
Eland	35	Grant's gazelle	3
Zebu cow	30	Thomson's gazelle	1
Cape buffalo	30	Oryx	0
Wildebeest	20		

*Camels drink this amount per watering every 4 or 5 days.

These data cannot by themselves be used to determine required supplies of drinking water because of temperature variations and because the feeding habits and ability to use water present in the feed differs among species and by season. The requirements are much lower if the feed is lush with a high moisture content, and higher if the feed is dry and(or) the air temperature high. Animal species vary in ability to use water from the forage and in controlling body losses. For example, the oryx uses about 3 liters per 100 kg of body weight, getting most of it from digesting the forage. Requirements such as those given above, plus estimates of water losses through seepage and evaporation, multiplied by the number of animals and days of expected use, give estimates of capacity needed in water developments. Evaporation from an open water surface can exceed 3 m per year under desert conditions. This suggests that in terms of water conservation, deep storage with little surface is better than wide, shallow reservoirs.

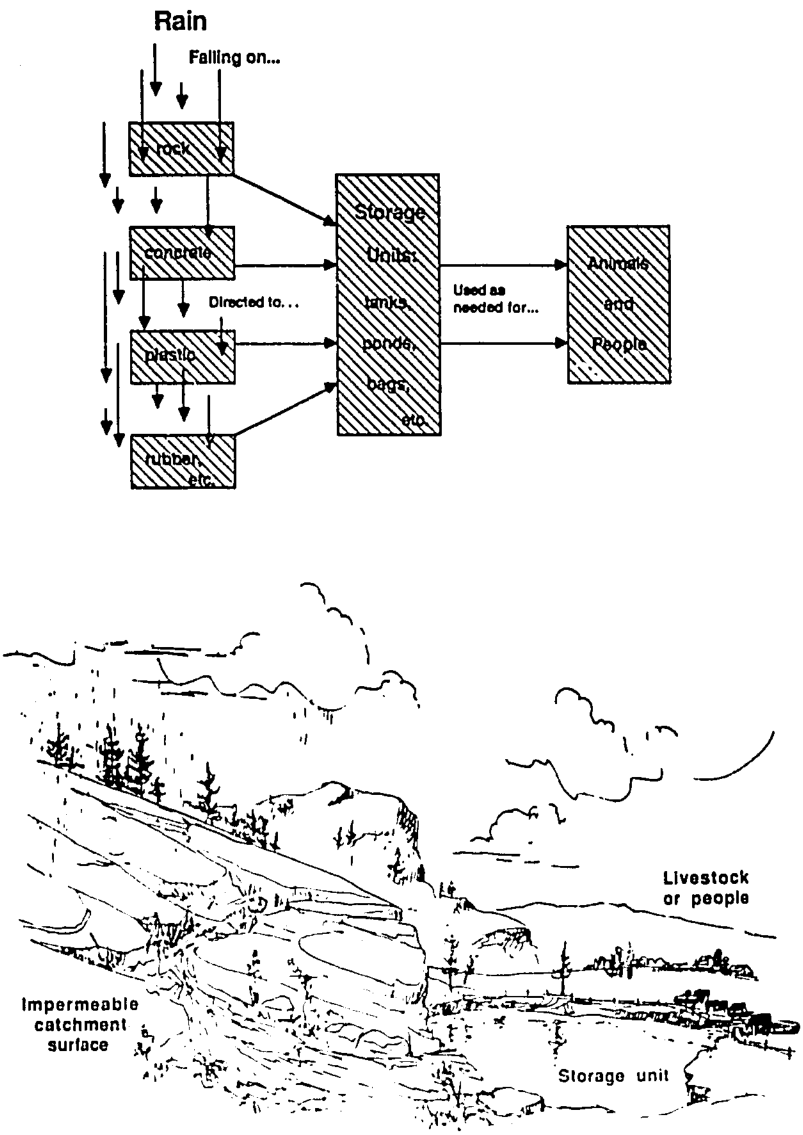

Figure 11. **Rainfall-collection and -storage devices that can provide drinking water for people and animals during dry seasons (adapted from FAO, 1976).**

Sand trapped above a dam holds water in the voids among the sand grains. In coarse sand, water spaces amount to 25% to 30% of the volume. Evaporation from sand reservoirs almost drops to zero after the top 20 cm or 30 cm of sand have become dry. No plants can be allowed to grow on the sand because transpiration uses large amounts of water. Water in the sand reservoirs may be obtained from a well on the upstream side or from a pipe through the bed of the dam. Desert sand reservoirs have been used for a century or more in the southwestern United States, Mexico, and parts of Africa. For centuries Bedouins in Arabia have dug wells by hand, some 10 m to 20 m deep into sand river beds, and concrete cisterns have been made for water in the desert. Also, the African elephant is noted for its ability to dig for water in sandy river beds.

Paved or otherwise sealed areas that lead to covered storage cisterns can accumulate considerable water from small drainage areas. Precipitation of 100 mm on a 1,000-m^2 area provides 10,000 liters of water, enough for over 200 cow-days. A common formula is to make the collection surface of such a size that one-half the average rainfall fills the storage capacity. Water for game, livestock, and household use can be provided in this way, but the installations are expensive and constantly need sanitation care. Efficient use of water requires covered storage and watering of animals by hand. These types of developments are more for private and small special requirements than for large numbers of livestock on an uncontrolled basis.

The distance between watering points is always a question in rangeland management. Some say that water points should be as close as a kilometer to each other. Perhaps so, where the grazing capacity is high. There, each point should water 50 animals on a yearlong basis. Others say that an easy day's travel is a sufficient guide. That would increase the distance between points to about 5 km for sheep and cattle, but for camels, which can go 2 weeks without watering, the distance is more like 100 km. While these guidelines are highly generalized, they indicate several principles in the development of rangeland watering points.

- Much planning is needed before construction of watering points begins to ensure the natural resources are used efficiently. Water should not be developed until animal management is assured.
- Watering points should be small enough that hordes of animals do not overgraze and trample the nearby vegetation. The grazing capacity of the land determines the well capacity.

- Watering points should be spaced in order to encourage uniform use of the forage.
- Use of watering points must be carefully controlled; otherwise the ecosystems may be destroyed.

Herding To Gain Even Distribution of Grazing

Controlling grazing distribution with fencing and the spread of salt licks is too expensive for developing countries. In these countries herding is a way of life. Whether nomadic or village based, someone is with the animals during the day and the herds are placed in corrals at night. This protects against theft and predators. Mature animals in the herd respond to the voice of the herder, which provides a level of control. These practices are the beginning for management of both water and range vegetation.

Herding is as important as water in determining the distribution of grazing pressure upon the resources. The herders should be trained to determine whether the range is used evenly, too heavily, or too lightly. Animals should be allowed to graze in open formation with only their direction determined. This means quiet handling so that the herd will spread over the area to be grazed. This type of management increases production per animal over that of the generally practiced "close herding."

In all countries the major constraint to improved vegetation management is education of the manager and herder. Women and children as well as men must learn new techniques and be convinced of their value if the traditional ways of managing livestock water and forage are to change. Some of the management tools are improved distribution and use of water, and more even use of the rangeland forages. The educational and sociological aspects of the techniques are the subjects of other modules.

A cautionary note: First determine whether traditional ways should be changed. Unfortunately, often an alternative is offered that is not as effective as the well-adapted traditional method.

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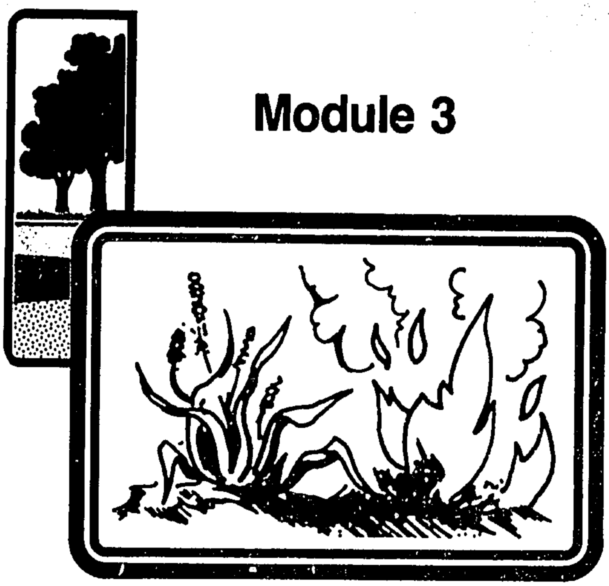
Module 3



Vegetation Management Through Fire

Fire is a part of nearly all rangeland ecosystems; it is an environmental factor, just as are moisture and energy. Many people believe that fire causes grasslands to develop. Grasslands do burn frequently, but the presence of fire does not prove that grasslands need or are caused by fire. Other vegetational types, such as forests, burn occasionally and do not become grasslands (Mooney and Conrad, 1977). Alpine and circumpolar ecosystems burn — some are grasslands but others are forests (Wein and MacLean, 1983).

Where climate and vegetation favor fire, species have evolved differing mechanisms for resisting and avoiding damage from burning. Some species even require periodic fire for regeneration. In addition to being an environmental factor, fire is also a useful tool in natural resource management (Gill et al., 1981).

Fire as an Environmental Factor

Both plants and animals have proceeded through their evolutionary changes in response to competition for a limited environment. Reciprocal relationships developed between grazed plants and grazing animals: structural features of grasses that reduce damage by defoliation, and the ruminant type of digestion.

Fire is not as selective as grazing, and it does not often occur during periods of plant growth. However, it is a defoliating agent, and plants have had to adapt to it in order to survive.

Adaptations of Plant Species to Burning

Adaptations of grasses, forbs, and even shrubs that permit them to resist, evade, or endure burning are similar to characteristics that provide tolerance to grazing. These include short basal internodes, vegetative growth by rhizomes and stolons, and basal meristems in linear leaves. Others are an annual life cycle, an abundant seed crop, provisions for rapid distribution of seed and its burial, and a short period of vigorous growth followed by rapid maturation of above-ground herbaceous materials. Dry-season removal of accumulated dry herbage by fire (or grazing) has relatively less effect on the grasses than does removal of green growth. However, dry-season burning can alter plant species composition in natural ecosystems by killing plants (when the heat in the crown of the plant is great).

Responses of Soil to Fire

A fire in grassland, chaparral, or forest reduces the litter and mulch, consumes most of the dead material, and can kill both above- and below-ground organisms, including plants. Bare soil experiences greater temperature variations than does soil covered with a blanket of plant material. Also, the black surface after a fire readily absorbs heat, and so surface temperatures may be higher than in unburned areas. This short period of higher temperatures promotes rapid growth.

With the exception of very hot fires, infrequent burning has little permanent effect on soil organic matter. It alters the amounts of plant material available for decomposition by reducing the above-ground portion and often increases the soil organic matter by killing some plants, which allows their roots to decompose quickly. Ashes left after a fire in vegetation are composed mainly of potassium, calcium, magnesium, and phosphorus. The first three are basic (as opposed to acidic) in reaction, so a slight but temporary change in soil pH may occur. These elements are only lost through wind and water erosion. Nitrogen and sulfur are volatilized and lost, especially where the fire is hot enough to leave white ash. The ashes are too scant after grassland fires to significantly change the mineral composition of the soil, even though the burning of large amounts of woody materials has a brief fertilizing effect.

Burning grasslands may either reduce or increase soil moisture. Soil moisture may be reduced when higher temperatures increase evaporation and transpiration through more plant growth. Soil moisture may be increased by less interception of rainfall by plants and litter and by less transpiration if the first vegetation is composed of low-growing and shallow-rooted species. The moisture content is altered only in the top few centimeters of soil. On steep slopes, extensive runoff and erosion may occur during the short period between the fire and reestablished cover. Accelerated erosion after a fire on relatively level land is of little consequence.

Responses of Animals and Plants to Burning

Insect populations are never directly eliminated by burning. Many individuals are killed but enough escape to replenish populations. Certain species flourish on specific food plants that become abundant as the vegetation changes through the successional stages after the fire. Rodents generally escape, but some may be adversely affected by the lack of cover. Ground-nesting birds are vulnerable to loss of nests, cover, and food. Rangeland fires seldom affect the larger mammals because of their mobility — they respond more to the changed habitat than to the fire.

Fire damage to individual plants depends upon the temperatures reached in live tissue, the length of time critical temperatures are maintained, and the physiological state of the plant at the time of burning. Growth stage, growth form, and size of plant influence the susceptibility of live tissue to heat damage. A grassland fire occurring when some species are green and others are dry may damage the green species more than the dry ones. However, some green growth in the plant crowns near the soil surface may keep the temperatures from reaching critical levels.

New growth on burned areas may be higher in crude protein and ash immediately after the fire. Generally, the moisture content of new herbage is higher in burned than in unburned areas. Certainly the new growth is more readily available to large herbivores than where old and mature herbage remains unburned. Two points are clear: 1) Grazing animals prefer the new growth on burned areas; 2) the effects of burning on herbage quality are short term, seldom lasting into the second growing season after the fire. Excessive concentrations of grazing animals after fires may, in fact, be a greater source of damage than was the fire.

Vegetational Changes Due to Burning

Changes in the botanical composition of an area are related to the degree to which the vegetation is affected by burning. One ecosystem may be taken back to bare soil or to the very beginning of succession, another may be converted to a shrub stage with a scattering of the climax dominants still alive. Fires in savanna vegetation maintain the openness by reducing shrubs and small trees but not materially changing the taller trees, grasses, and forbs. Fire in extensive grassland has little effect on the botanical composition beyond temporary changes the first year or two. For many organisms a fire is a catastrophe because conditions favoring their development are destroyed. They must retreat to unburned areas and await the return of a suitable habitat. The waiting time may be short in a grassland or centuries long if mature climax forest is required. For other organisms, burning brings favorable conditions. Fire management takes advantage of these differences (Booysen and Tainton, 1984).

Vegetational change caused by either wildfire or prescribed burning is a subject of wide concern. Each type of vegetation, perhaps the vegetation on each range site, responds in a different way. If more were known about the site, better planning could be done. However, some generalities can be made. Rhizomatous (having a subterranean stem) grasses and sprouting shrubs mostly survive a fire and soon regrow to dominate the vegetation. Annual plants and some herbaceous species respond to fire by reproducing more quickly, which results in numerous individuals and dense stands after severe burning of forest and full-canopy woodlands. The dominance of animal species may also shift as the vegetation changes toward the climax. For example, at first grazing animals dominated the African grasslands, but lack of fire and an increase in woody plants resulted in fewer of them and more browsers.

A cursory search of the vast literature on fire leaves no doubt that a change in burning pattern results in a change in vegetation throughout the many different types of rangeland vegetation. Depending on the study or opinion cited, fire is destructive, fire is a rejuvenative force required for the continued well-being of the landscape, or fire is a useful management tool. Whether prescribed fire is used as a management tool depends upon the chances of accomplishing specific objectives. The use of prescribed fire is increasing as more information is accumulated on how to control fire to obtain predictable results. Following are some objectives and guidelines in the use of fire on rangelands.

Fire as a Tool in Rangeland Management

Primitive man used fire as a tool with which to manipulate vegetation and animals for his benefit. Fire is still used as a tool for resource management but some countries now have fire-fighting organizations aimed at eliminating or controlling fire in forests and on rangelands (none has achieved full control). Increasingly, land managers are taking advantage of these organizations and their own resources in the use of prescribed fire. The objectives of using fire are numerous and vary widely, but the main one is brush control.

Objectives in the Use of Fire

Prescribed fire is commonly used to reduce the amount of undesirable plants — usually woody plants where grasses and forbs are desirable. Land clearing nearly always requires fire, whether for the purpose of a shift in cultivation, developing forests of desirable trees, or modern types of agriculture. Although undesirable plants are rarely eliminated by fire, their reduction is effective and worthwhile.

Burning favors certain species. Frequent fires in the tall and high grasslands in the tropics tend to permit the shorter and more palatable grasses, legumes, and forbs to become part of the forage supply. Stands of the cord grasses and other coarse species in coastal marshes are thinned by frequent fire. Burning in the Mediterranean chaparral types often results in a temporary stand of grasses or forbs with palatable and nutritious sprouts from the shrubs.

Burning to produce ash for fertilization is common in woodlands and forested regions of the tropics. Occasionally woody materials are cut, carried to small fields, and burned for the ash.

Fires to produce more forage may or may not be effective. Results depend upon changes in botanical composition, such as grasslands replacing woody vegetation. Shrubs that are preferred by both domestic animals and game often grow beyond their reach. Burning can be used to kill the taller growth, maintain the shrubs at a suitable height, and stimulate sprouting. The seeds of some species germinate only after a fire has broken their dormancy.

Burning of grasslands appears to increase nutritive quality in most situations, which usually increases animal production. Where grasses are tall and coarse, it may be necessary to burn them to reduce accumulations of poor-quality and undecomposed old growth. Where the mature forage is palatable and of reasonable quality, burning does more harm by reducing quantity than good by increasing quality.

Fires influence animal distribution. Domestic and game species prefer and are attracted to freshly burned areas, probably for the higher quality feed. If these areas are small and the animals numerous, overgrazing occurs. Size of prescribed fire, then, is a consideration. Perhaps 100 ha should be the smallest, but that will vary with the situation.

The numbers of some undesirable animals may be reduced but they will not be eliminated with prescribed fire. Control of tsetse flies and other insects, ticks, and reptiles has been attempted with varying success in Africa. In tsetse-fly-reduction schemes, the real purpose is to change the habitat from woody vegetation to grassland in which the fly cannot live. These schemes failed because the vegetation was not completely converted to grassland and(or) because management was not adequate to stop woody vegetation from invading.

Burning encourages certain animals, just as it encourges certain plants. Different species of animals become abundant depending on the stage of plant succession. Prescribed fire is a useful tool in developing and maintaining wildlife habitats that favor preferred animal species (including food and cover) and ideal conditions for animal harvesting.

Prescribed burning reduces the hazards from wildfires by removing undecomposed organic materials. The more litter (fuel) available, the hotter will be the fire, so the danger of a damaging conflagration increases as these materials accumulate. This is one reason why preventing fires can result in much hotter and more damaging fires at a later date. Temperature and developed regions appear to be more susceptible to damage by large wildfires than do those in the arid and semiarid tropics.

Prescribed burning often facilitates management and encourages human occupancy. Fewer woody plants and reduced height of vegetation results in easier movement of animals and herders, better visibility for the traveler, and more protection from dangerous animals.

Fire Behavior

Fire must be confined to predetermined areas if it is to be useful in range management. This means that the intensity of the fire's heat and its rate of spread must be skillfully controlled. Weather, topography, and fuel influence combustion by providing different combinations of heat, oxygen, and fuel. Prescribed burning should not be attempted without a thorough knowledge of fire behavior.

Precipitation, air temperature, relative humidity, and wind velocity are the major weather variables that affect prescribed burning. Light fuels quickly become less combustible if dampened, but they dry rapidly. Thus a grass cover may be unburnable in the early morning and extremely combustible a few hours later. Conversely, heavy fuels (e.g., woody vegetation) soak through and dry slowly. Less heat is required to raise fuel temperatures to the ignition point when air temperatures are high. High temperatures also decrease fuel moisture through high evaporation.

Relative humudity is the measure of air dryness. The drier the air, the drier the fuel. Experience in temperate regions suggests that prescribed fires may burn out of control when the humidity is less than 25%, but not at all above 70%.

Wind brings oxygen to the flames and removes carbon dioxide, increasing the combustion rate. It also moves hot air masses ahead of the flame, drying and preheating new fuels. Seldom should fire be set if the wind velocity is or will be greater than 10 km or 12 km per hour.

Topography or roughness of the land surface influences fire behavior. Fires burn faster uphill than down, other factors being equal, because the fuels on the upslope side of the flames receive more heat than do fuels on the downslope side. Narrow and steep-sided canyons tend to act as chimneys, so fires burn rapidly with the help of the upward air movement. Slope may be used to advantage in prescribed burning. Fires set at the bottom may burn to the ridgetop and go out when fuel moisture and humidity are high enough to prevent downhill burning. At other times, fires set on ridges can be backed down the slopes without heat damage to the tree canopy or the soil.

The third major element that controls fire behavior is fuel. Water, as moisture in fuel, acts in three ways. It has a cooling effect, because heat is used to convert water to steam, thus reducing intensity of burning. For this reason, water used to stop a fire should be directed toward the fuel in front of a fire rather than onto the flame. Second, moisture in the air (humidity) reduces radiation. Third, the cooling reduces the release of volatile oils from woody plants, thus retarding combustion. The fuels themselves have varying characteristics (such as size, continuity, and compactness) that influence burning. Although a grass fire may not release a great amount of heat because of the small quantity of fuel, it burns quickly and spreads rapidly. Brush fields and woodlands burn at an intermediate rate; forest stands with little or no finely ground fuels burn least rapidly.

Prescribed Burning

Prescribed burning consists of four main types of activities. The first is planning, the second concentrates on preparation for the fire, the third concerns the fire itself, and the fourth is postburn management. In practice the second, third, and fourth steps include continual updating of plans. Diagrams, criteria, and guidelines for conducting a prescribed fire are given in Cheney (1978).

Planning for a prescribed fire begins when the manager realizes that a certain area of land might be improved for his purpose if it were burned. Evaluation of alternative land treatments should indicate that fire would do a better job at less cost than other methods. Costs include labor, rental of equipment, supplies, food purchase and preparation, liability insurance (if available), and the value of the forage (for grazing animals) that must be left to carry a fire. Often areas must be protected from grazing for 1 year to accumulate enough fuel to carry a fire. Soil and vegetation must be such that they will produce a profitable return, or the area must be capable of being improved.

The area selected must allow for reasonable expectations of successful burning to reach the objectives, and complete fire control within the burn boundaries. A common adage about prescribed burning is that preparation gives a successful burn, planning promotes adequate preparation, and cooperation among interested parties permits adequate planning.

Preparation of the site centers on the construction of fire lines that completely enclose the proposed burn. Fire lines are strips of land devoid of flammable materials. They may be roads scraped clean with a bulldozer or other machinery, or prepared by hand. Two fire lines 15 m to 25 m apart, with the area between them burned when danger of the fire escaping is extremely low, make a highly effective firebreak in grasslands. Many fire lines are placed on ridges and otherwise take advantage of topography and special fuel conditions. Internal lines permit burning in blocks, so that large areas are not aflame at one time. Trees that might ignite and spread sparks some distance, as well as brush piles near the fire line, should be removed before the principal fire is set.

On the day before the prescribed burn, check on preparations and notify cooperators. Although the day of the burn may have been selected a year in advance, the final decision to set the fire is made at the last minute. Predictions of wind direction and velocity, temperatures, and relative humidity must be within prescribed criteria. The cool of the morning, when the humidity is higher, is the time to set as much of the perimeter of the burn area on fire as possible. As the fuel is consumed inward, slowly at first, from the prepared fire line, the line is widened and the fire is not so likely to escape later in the day when winds and temperatures are higher. Many designs for igniting rangeland fires have been used. One is to set single or multiple headfires with the wind or a backfire against the wind (figure 12). Another is to ignite the entire perimeter of the

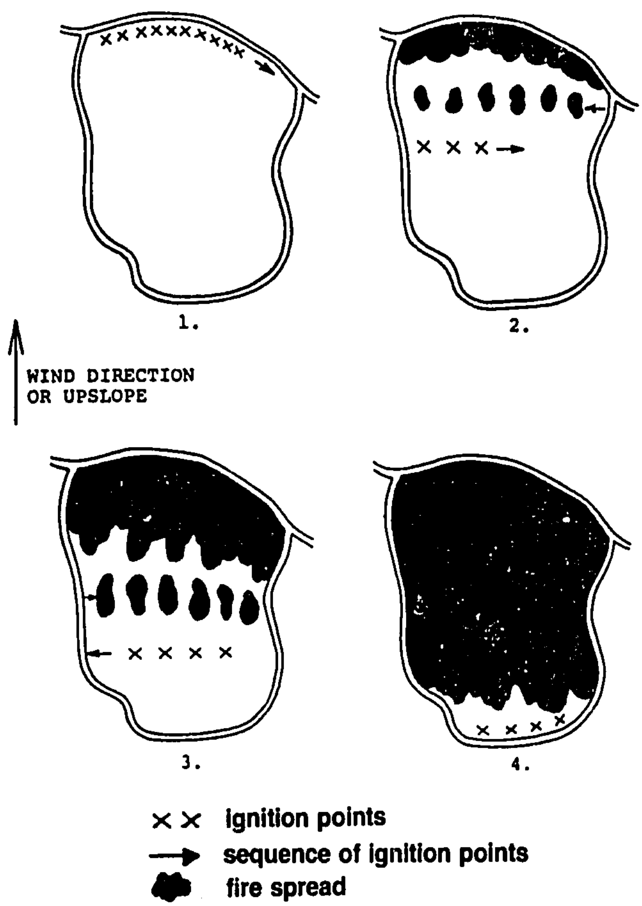


Figure 12. Sequence of ignition points and fire spread used in controlled burns involving multiple headfires (adapted from Cheney, 1978).

prescribed area (figure 13). Before that is finished, fires are set in the center. As the fires burn toward each other, heat accumulates and the fuels in the center burn rapidly. Whatever design is used, the original fires should be set 15 m to 30 m inside the perimeter fire line. This tends to pull sparks and burning embers to the center of the prescribed area. The principle is that one fire tends to draw another toward it (in this situation, across the already-burned strip).

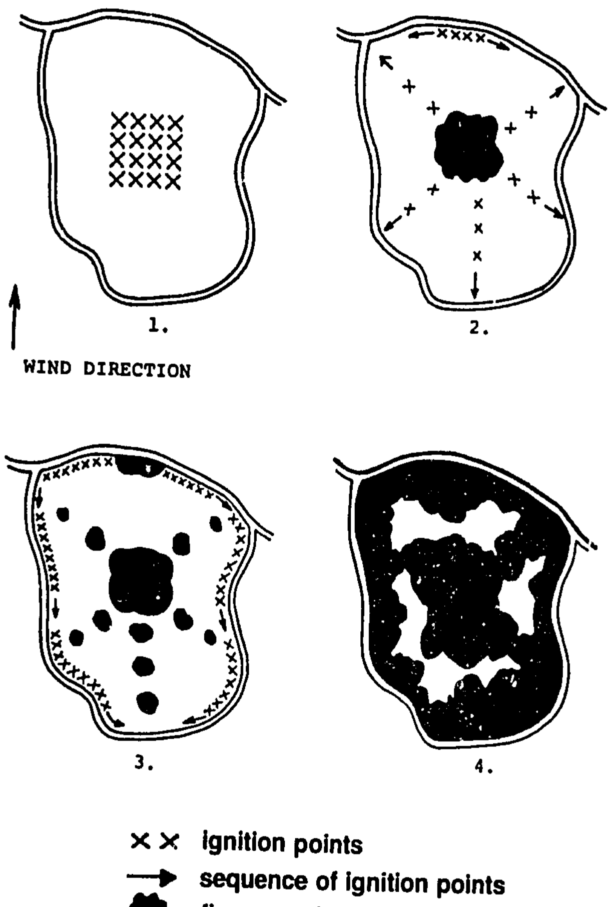


Figure 13. Sequence of ignition points and direction of fire spread used in controlled burns that involve igniting the center and then the entire perimeter (adapted from Cheney, 1978).

Burning is only a part of a managerial program. It presents the manager with an area where many other techniques may be applied. Any seeding must be planned ahead of time in order to have materials on hand because in most instances seeding and planting should be done soon after the fire. Immediate and heavy grazing reduce establishment of desirable native and introduced plants. Sprouts of woody plants may need special attention, such as rotational grazing with goats or spraying with herbicides. Other modules deal with the management of areas burned with prescribed fire.

Fear of Prescribed Fire

A cautious attitude toward using prescribed burning as a management tool is justified. The fear of prescribed fire escaping stems from an inability to predict fire behavior; catastrophic fires destroy property, resources, and lives. The use of fire has increased in recent years, as has the research and experience basic to understanding how to use it. This recent interest is largely due to concern over herbicides in the environment. Because of this, fire will increasingly be a tool of the natural resource manager.

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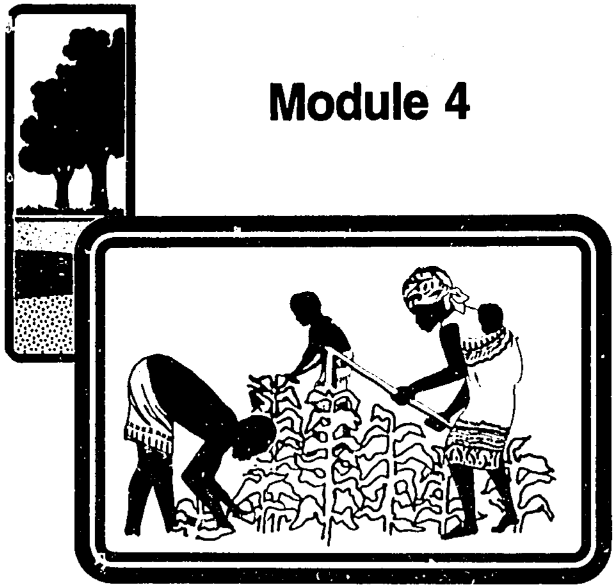
Module 4



Vegetation Manipulation Through Mechanical and Chemical Means

In addition to burning for controlling undesirable plants, mechanical, chemical, and biological procedures are available. This module is limited to the mechanical and chemical techniques.

Opinions vary on the substitution of these sometimes heavy-handed control techniques for natural controls. A common statement about brush control suggests that objectives and procedures be altered to take advantage of the natural systems, rather than that the systems be altered to meet the objectives. Certainly woody plants have many values for such things as browse, fruits, charcoal, fuelwood, posts, shade for animals, gum arabic, oils, and wood stock for furniture. The public's distrust of chemical brush control on rangelands and other types of tinkering with these ecosystems has promoted caution in the use of most management techniques. However, every vegetative change stimulates the natural ecosystems to action. Weeding a garden brings a new crop of weeds. Brush soon returns after a fire. A management error seldom is absolute and repairs usually come rapidly. In this context mechanical and chemical controls of plants can be considered as severe but temporary treatments. Also, these treatments are only two of the options available to the manager. Others are described in the various modules.

Mechanical Control

Man has modified range vegetation by removing certain plant species or individuals ever since he has had domestic livestock. Salt and arsenic have been used for centuries and fire even longer. Hand-pulling followed by the use of hand tools preceded animal power and machines. All of these methods are in use today. Hand tools for chopping and grubbing are mainly used in developing countries. There, machines for brush control are limited to the large projects — for example, the establishment of a large forest plantation or large-scale bush control for limiting tsetse-fly invasions.

Sometimes the word "eradication" is used to describe this activity. However, eradication is seldom if ever attained on rangelands — the usual result is a reduction of undesirable species. "Control" is the word to use, except where a complete removal is the objective and is actually possible.

The practical problems of brush control are how to alter the species composition and the height, succulence, and density of plants. These problems require decisions on objectives, sites of the work, methods of control, time of control, and follow-up management. Answers to these questions during early planning will determine whether or not the control is biologically and economically justified.

Objectives

Altering the plant cover on a rangeland has many purposes. Increased herbaceous forage and better quality browse for domestic and wild animals are the principal objectives. Other reasons for brush control include increasing the flow of water from springs, making areas more accessible for hunting and viewing of wild animals, erosion control, preparing sites for seeding and planting, and decreasing the risk of damage by fires. To be cost effective, mechanical techniques are usually limited to woody plants on selected sites.

Site Selection

Normally sites with the best soil and water regimes are treated first. These sites are relatively level and have a fertile and deep soil, as indicated by tall, lush, growing native vegetation. They normally present the least risk of erosion during the conversion process. The site has a major influence on the type and intensity of management. Steep slopes, rock outcrops, and irregular drainage patterns increase the costs of control and decrease the likelihood of success. Mechanical controls are used on steep slopes to control or modify fuel for wildfire, and to improve wildlife habitats more often than to increase forage for domestic animals.

Methods of Mechanical Brush Control

Several points must be considered in choosing a technique for brush control, whether mechanical or chemical. Among them are effectiveness on the target species and other less desirable plants, potential damage to desirable species, effects on regeneration by seed and by sprouts, matching of equipment and procedures to the size of the problem, erosion hazards, environmental considerations, and costs/benefits of expected results.

Methods and equipment commonly used have developed more from accumulated experience than from research, resulting in much local variation. Choice of procedures always starts with consideration of local experience, including timing and intensity of control. Some well-established principles or guidelines are as follows:

- Plants should be mechanically removed before the seed crop matures.
- Breaking and crushing of woody material works best when materials are dry and brittle.
- Machines that remove woody plants from the soil operate most efficiently and with least cost when the soil is moist.
- Timing of control is important — for example, sprouting of some species may be as high as 100% for plants cut in the wet season but only 25% in the dry season.
- For sprouting species to be killed, root crowns and other organs with stem buds must be removed from the soil.
- Brush removal nearly always increases forage for livestock but woody plants return to reduce the forages within a few years.
- A second pass with most machinery increases effectiveness.
- Disturbing and compacting the soil are to be avoided as much as possible.

Hand-clearing is the only acceptable means of brush control where machinery is inefficient or damages other resources. The common hand tools are the axe, grubbing hoe, brush hook, chain saw, and backpack power saw. Hand-clearing is labor intensive and of limited value where labor is expensive. However, it is the common method in developing areas where funds are scarce and the areas to be cleared are small. A major advantage of hand-clearing is that the target species can be selected without error. Hand-clearing is effective because it can have a high degree of success and a little area each year soon adds up.

Machines used to control brush operate differently on various kinds of terrain, soils, and types and age classes of woody plants. Nonsprouting species do not require cutting below ground level, and light brush is easier to remove than heavy brush, but some species bend before the blade with little damage. Rocky soils reduce equipment maneuverability. Each of the following machines is effective in different situations, such as dry sandy soils or wet clay soils.

The tractor with dozer blade effectively crushes brush, removes whole plants from the soil, and piles woody materials for burning. The usual blade may be modified to make it more efficient for different situations. One type is a short blade about a meter in length and often V-shaped with the point forward. The tractor is also equipped with a push bar, which is used for pushing or lifting individual plants from the ground. A second common alteration of the blade is to add teeth to the bottom. It then has a raking action in the soil that combs plants and roots, leaving the soil behind.

Chaining or cabling is a favorite technique for knocking down heavy brush and some trees. It is most effective on non-sprouting species. The operation involves dragging an anchor chain or several strands of heavy wire rope (cable) between two tractors. Preferred chains weigh approximately 100 kg/m and are roughly 100 m long. The tractors maintain a swath width somewhat less than half the length of the chain. The links may have 75-cm-long bars welded to them for increased effectiveness. This equipment is widely used because of its low cost per hectare, effectiveness on some species, and adaptability to difficult terrain.

Cutting equipment also comes in several forms. Heavy models of the disk harrow and the wheatland plow do well on small brush. The rolling disks cut off many stems and lift some plants from the soil. They leave the soil in place but loosen it and increase rainfall infiltration. However, disking damages remnant perennial grasses. The rolling cutter is a large weighted drum about 3 m long that has blades parallel to the axle of the drum. As the drum rolls over the vegetation, it chops the plants and leaves a small depression in the soil, which helps to reduce runoff. These machines only remove the tops of sprouting species.

Chemical Control

The number of chemicals available for use as herbicides is large and growing. Papers that give the results of experience as well as research with chemical control of rangeland plants number into the thousands. Thus, recipes for chemical controls of specific plant species that take local conditions into account are probably available and should be used.

The requirements of an ideal herbicide are that it has selective action (affecting only plants that are to be removed), is easy to handle and apply, is nontoxic to people and animals, is non-cumulative and nondamaging in food chains, and is economical to use. No herbicide is ideal in all respects.

Of major consideration is the risk to all life on the rangelands. Danger from most herbicides is generally less than from the commonly used insecticides, with at least one major exception. Research has shown that the commonly used phenoxy herbicides like 2,4-D, 2,4,5-T, and Picloram (4-amino-3,5,6-trichloropicolinic acid) are moderately to mildly toxic to humans, about the same as common table salt.

The major exception concerns the occurrence of dioxin, a highly toxic poison to humans, in 2,4,5-T because of faulty manufacturing controls. This raises the question of "How safe is safe?" in the use of herbicides. The question cannot be answered for two reasons. One is that procedures for measurement and evaluation continually improve. This permits the determination of chemical contents in food chains with increasing accuracy. The other is the fact that the effects are being determined for increasing numbers of organisms over an increasing amount of time. Keep in mind that safety involves stability; movement; accumulation in humans; hazards of handling and residues; effects on nontarget organisms; and known and unknown environmental impacts.

Application of Herbicides

To be effective, foliar sprays of herbicides such as 2,4-D must be applied at a certain time or growth stage. The susceptible stage varies among species but for many it is after leaves and shoots have developed and before the leaf cuticle has thickened. During this short period carbohydrates are rapidly manufactured and reserves are replenished.

The equipment for spraying foliage may be hand-operated sprayers or booms with several nozzles, and may be fixed to tractors or to airplanes. The basal stems and stumps of trees may be wetted with the herbicide using a sprayer or the herbicide may be poured into or brushed on the stumps and cut surfaces. There is even an axe-like device to inject the herbicide under the bark. Soil around bushes and trees is treated with pellets or powder sprinkled near the plant.

One of the common hazards with spray applications is drift of materials onto sensitive nontarget plants. Mist blowers are particularly prone to drift problems. Aerial application should be in winds less than 8 km per hour and in air temperatures less than 32° C; otherwise evaporation and drift will be too great. However, air temperatures above 20° C are necessary for some herbicides to be effective. Nozzle design should be such that large droplets are sprayed.

Herbicides may enter water in lakes and streams through drift of materials and through direct application where water surfaces are within the treated area. Herbicides may enter lakes and streams by overland flow and by leaching. However, the short half-life of most herbicides and their resistance to leaching reduce their potential for water pollution. When the widely used and approved herbicides are applied according to recommended procedures, there is little hazard to man, animals, or the food chain.

Prior to using any chemical in developing countries, local policies and regulations should be checked and complied with. In addition to these standards, the World Bank, USAID, and other international development organizations have published guidelines for the selection and use of pesticides in projects they finance. The term pesticides, as used in these guidelines, is a term that describes the many types of chemical control materials (including insecticides, acaricides, fungicides, nematicides, herbicides, etc.) The World Bank guidelines are divided into four categories and are briefly summarized as follows:

1. Pest- and pesticide-management practices. An integrated pest-management concept should be used that considers that pesticides are a short-term response to the build-up of a particular pest and that whenever possible, a narrow-spectrum pesticide be used to minimize the effect on nontarget species.

2. Handling, storage, and application safety. People handling concentrated materials should have protective clothing and proper equipment, and be adequately instructed and supervised. The instructions on the pesticide label must be read and followed. Where pesticides are being supplied to farmers it is essential that materials be selected that can be safely applied without close supervision and that the farmers are adequately supported by trained extension services.

3. Selection of pesticide materials and pesticide formulation. The selection of a pesticide must consider the safety and effectiveness of the product in the local circumstances. The World Health Organization periodically revises and reissues its Classification of Pesticides by Hazard. This list can serve as a guide to the relative hazards associated with the

products available for a specific application. Preferences should be given to products that are registered in the country of the proposed project.

4. Procurement of pesticides. If possible, competitive bidding should be used. Since variations in formulation and carriers cause different responses in each locale, trials of products claiming to meet specifications should be made. Where available, containers that cannot be reused should be specified.

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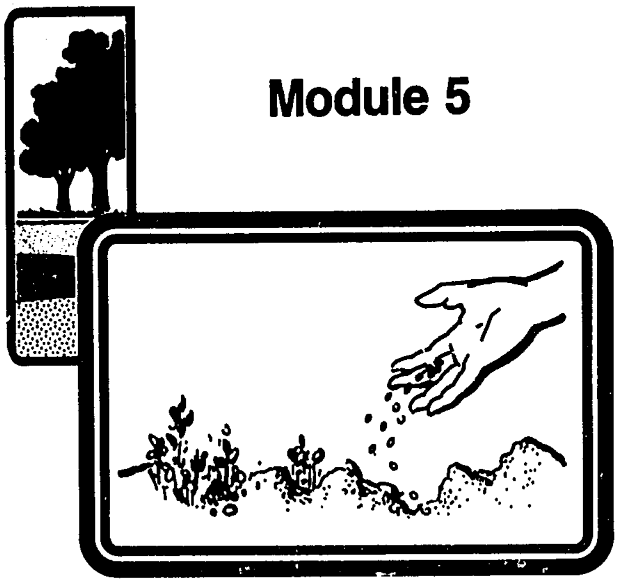

Module 5

Vegetation Manipulation Through Seeding and Planting

The human population in many developing countries is accelerating at a rapid pace. Consequently, there is pressure on pastoralists to increase their herds to meet the needs of an ever-expanding population. For example, Niger livestock numbers were greatly depleted during the 1969-1973 drought. By 1983, the national herds had recovered to pre-drought levels. However, the number of livestock for each family member was only 70% of that for the pre-drought period because of the increase in the human population.

Many rangelands throughout the world have been depleted by excessive livestock grazing, cultivation, drought, activities of wild animals, and other causes. In many cases grazing has been indicted as a major factor in range deterioration and the desertification process.

Although many plants have evolved mechanisms to resist or avoid heavy defoliation through grazing, not all plants are successful. Defoliation beyond a fairly conservative level reduces the ability of grazed plants to compete with ungrazed or lightly grazed plants by reducing photosynthetic tissue and root growth. Heavily grazed plants do not have the ability to grow at a maximum rate or to reproduce at a rate necessary to ensure their presence in the community. Eventually these palatable plants may be replaced by more vigorous, less palatable species. Such patterns are all too common on rangelands around the world.

Desertification is becoming a worldwide concern. Degradation of fragile arid areas by excessive numbers of livestock and related factors is a common situation in many countries. In many cases, simply a lessening of the destructive factor may not result in a restoration of the formerly productive condition. Direct seeding or revegetation may be necessary.

In many areas of the world, seeding has improved conditions for livestock grazing and for other purposes. However, seeding is a difficult, expensive task fraught with many uncertainties. It should never be used as a substitute for proper range management. Poor management can ruin the best seeding operation and limit economic returns. On the other hand, seeding offers a direct method for increasing primary productivity or quality of forage for selected animals within the herd.

Many principles and general guidelines have been developed for seeding rangelands. However, these guidelines need to be modified before they can be applied in a specific situation. In each case, the problem to be solved by seeding should be clearly defined.

Issues

Rangeland seeding is done for a variety of reasons. They include, but are not limited to, the following (Heady and Heady, 1982):

1. to improve the nitrogen status of soil and plants by the use of legumes
2. to improve the forage available for herbivores and the nutritive quality of forage, especially for late or early dry-season grazing
3. to establish herbaceous cover following brush control
4. to establish vegetational cover on abandoned farmland
5. to stabilize areas susceptible to erosion
6. to increase flexibility in livestock management

On rangelands reasons 2, 5, and 6 are probably the most common.

Analysis of the need for and feasibility of range seeding may be illustrated by a series of questions (Heady, 1975):

Is seeding necessary? Seeding is often an expensive and complex operation for extensive range areas. Natural improvement may be possible through grazing management, depending upon degree of degradation, seed reserves available, etc. On the other hand, where degradation is advanced, site condition may preclude successful seeding without excessive renovation.

Is the climate suitable? Heady (1975) warned against seeding in areas that receive less than 20 cm annual precipitation. However, where precipitation is concentrated during a short growing season, seeding may be successful at lower annual totals than under conditions of the same total precipitation spread over a longer time. Erratic and variable precipitation makes seeding success unpredictable.

Is the habitat favorable? Soil properties and topographic features are critical in determining sites suitable for seeding. Generally it is best to start with the most productive sites first. However, in some cases the revegetation of harsher sites is the critical component of the development plan. In these cases small demonstration or research plots may be necessary to develop procedures and techniques suitable for the specific situation prior to large-scale revegetation.

What species should be seeded? Each species should be adapted to the habitat where it is to be seeded. Using native species generally ensures adaptability, but species vary in their ease of establishment. Also, the availability of seeds is often a problem. If suitable techniques have not been worked out, it may be necessary to initiate small-scale research plots to determine specific conditions required for the species to be used. Generally, indigenous species should be used in seedings. An introduced species may be considered if adequate testing and evaluation have indicated that it will not become a problem and that is clearly better than available indigenous species.

Legumes are usually included in pasture seedings. Under range conditions legumes are difficult to establish and to maintain when grazed. Opinion is divided as to whether legumes should be used in range-seeding projects. There is also a question of seeding mixtures (more than one species or even different plant forms) versus single species. The advantages of seeding mixtures are as follows (Heady, 1975):

- Mixtures often produce better animal performance than do single species.
- Mixtures often extend the green-feed period because they contain different species with different growth periods.
- Mixtures may allow more efficient use of soil water because the component species have different rooting patterns.
- Mixtures represent the optimum chance for different microsites to receive seed adapted for growth there.
- Symbiotic relationships are formed among the species in a mixture.
- The species contained in a mixture will not all be eliminated by a disease or parasite, whereas a single species may.

However, single species also have certain advantages over mixtures.

- Less time and money are necessary to obtain the seed and get it ready for planting.
- Drill-seeding is easier.
- Seed harvesting is easier.
- A single species may be better adapted than mixtures to a harsh site.

- Single species are easier to manage under grazing because in mixtures less palatable species tend to increase at the expense of more palatable species.

In range seedings, the emphasis is generally on grass or legumes. However, do not overlook shrubs and small trees. They often provide a valuable source of protein and minerals in the dry season when grasses are decidedly deficient in these nutrients. Shrubs can be used in small plantings for special purposes at specific sites. Shrubs and trees may be directly seeded or transplanted. Techniques have been developed for successfully planting many species of trees and shrubs (see module on agroforestry). Several sources present lists of species that might be used in seedings for various areas (Heady and Heady, 1982; Pratt and Gwynne, 1977).

Is proper management possible? Improperly managed range seedings will fail, resulting in wasted time and money. This can be a real problem in developing countries where land control is minimal. Economic returns will be reduced if the animals that can best benefit are not allowed to graze the seeding. Grazing a seeding at an inappropriate time can destroy it. In addition, careful management after the seeding is opened for grazing is vital for long-term success. A minimum of 1 to 2 years of rest following seeding is usually essential to ensure that seedings are established.

Are the necessary equipment and seed available? Before an extensive seeding operation is planned, make certain that all equipment, fuel, and seed are available. For large seedings, tractors, drills, fuel, and personnel with experience are necessary. Some seedings can be done by hand-broadcasting with little or no heavy equipment.

Guidelines for Program/Project Development

The decision to include some artificial seedings in a range-development project depends upon several factors. The first concerns project objectives. How well does seeding fit into the overall framework of the project? Seeding may be considered when the existing vegetation has been depleted to the point where natural revegetation occurs extremely slowly. However, in development projects seeding is more likely to be used first for demonstration purposes. Once it has been shown that seeding is a feasible technology, it can be expanded into larger areas as management and funding permit.

The second question to be considered is whether or not a seeding component in the project is feasible. Is it possible to conduct the seeding with follow-up management and evaluation? Revegetation should probably not be undertaken in the following places (Child et al., 1984).

- in areas where grazing animals cannot be controlled for the first year or two
- in areas where the soil is shallow or relatively infertile, and where precipitation patterns are quite variable
- in tropics with granitic (derived from granite) soils where the humus has been destroyed or leached
- in regions where the seeded area cannot be effectively used or where erosion control is not a primary objective

Seeding or revegetation work is done for different reasons. In some cases, seeding might be undertaken to increase herbage production and stabilize formerly productive areas. Such projects would likely be performed by some governmental branch or outside organization that would provide needed equipment or seed. On a smaller scale would be seeding for forage reserves for late dry-season grazing or browsing, or small plantings around villages reserved for use by sheep cooperatives. In these cases the project should provide for some demonstration work to show that the approach is feasible, and some training for herders or others who will provide assistance for those interested in the idea. Shrubs and trees should not be overlooked in these efforts since they serve as ideal sources of protein, minerals, and vitamin A for late dry-season browsing. Shrubs might be transplanted in degradable containers, directly sprigged, or directly seeded.

Guidelines for Technology Selection

Techniques for successful seeding have been worked out through field trials and research on rangelands throughout the world. However, certain techniques may need to be tested and adapted to local conditions to ensure maximum emergence and survival. The following factors should be evaluated before any seeding project is planned:

- land use and management objectives
- present vegetation
- soil conditions and characteristics
- climate — including amount and distribution of precipitation and temperature
- topography
- biotic factors — including small mammals, insects, etc.
- size and shape of treatment areas
- availability of seed and equipment

Several general principles for successful seeding have been developed.

- Remove or reduce competing plants. These are often shrubs or annual forbs. Mechanical or herbicidal treatments can often be used; where labor is cheap, manual methods may be the most cost effective.
- Use either native species or introduced species that have been tested for the area. These might be grasses, shrubs, or forbs, including legumes. Make sure that seed of the desirable species is available.
- Seed at the proper time. The emerging seedlings need water and favorable temperatures. Fall seedings are favored in areas with a Mediterranean climate and where the maximum precipitation comes in the fall and winter. Summer seeding is suitable in areas with summer rainfall, such as the Sahel region of Africa.
- Prepare an adequate seedbed. Generally, a firm seedbed is desirable for adequate support and water-holding capacity.
- Use the proper amount of seed. Seeding rates have generally been worked out for many species. Seeding rate usually depends on seed purity, germination, and size. If the seeding rate is too low, the stand will be sparse. If the seeding rate is too high, some seed will be wasted.
- Use an appropriate seeding method. Drilling is usually the preferred method for seeding, but it may not be appropriate for developing countries. Broadcast seeding can be successful when the ground surface is suitable for germinating particular plant seeds. For example, airplane seeding has been very successful for seeding into ashes following a fire. Generally broadcast seeding requires more seed than does drilling.
- Plant seed at the appropriate depth. Nearly all range grasses are seeded at depths less than 2.5 cm; for small seeds the depth is less.
- Restrict grazing for one or two seasons to allow plants to become established. Proper grazing after establishment will

maintain the seeding. Plants will not become established if grazing animals pull them from the soil during moist periods.

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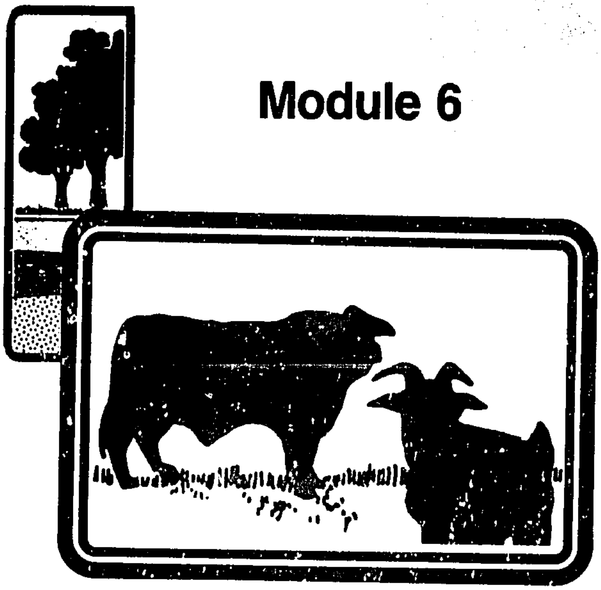

Module 6

Livestock Management and Breeding

The objectives of livestock production differ according to degree of commercialization, alternative feeds available, land tenure, custom, and other factors. Of these probably the degree of commercialization is the most important to livestock producers. The degree to which they directly use milk or meat from their herds, or use the herds as a form of insurance or savings, often determines the degree of commercialization. The nomadic pastoralist depends on his animals to furnish food for his family and has different management objectives than the rancher who depends on cash from sales for his livelihood.

Management choices are increased by the availability of alternative feeds such as concentrates, cultivated pastures, hay, etc. But livestock production in developing countries is characterized by an almost total dependence on forage, including browse, for animal feeding. Most of that forage must come from rangelands, although use of crop residues and supplementary pastures and even conserved forage will no doubt increase. This dependence on rangelands and the complexities associated with these lands strongly influence existing management objectives and limit the available alternatives.

A management practice becomes a custom or tradition due to the role it plays in reducing risks associated with meeting basic needs. Therefore, a change is not acceptable if it is perceived to increase risks — which are always great on arid and semiarid rangelands. Perceived risk accounts for certain practices such as stocking more heavily than desirable from the standpoint of range conservation, even when that practice reduces productivity. It also accounts for the ready acceptance of the nonrisk practices such as vaccination of stock against known disease.

The above list of factors that influence management objectives and practices is far from complete. It does, however, indicate the need to assess existing production systems and the production objectives and practices that guide these systems before embarking on a program for improvement through management and breeding.

Issues

In developed countries animal breeding has been primarily aimed at improved productivity, e.g., more rapid growth and higher rates of reproduction. During the last several decades hybrid vigor (through crossbreeding) has been used extensively with great success. Animal breeding has included importation of exotic breeds as a further means for increasing hybrid vigor. Wide use of proven sires and artificial insemination, especially in dairy herds, has led to a steady and notable increase in production per cow.

Increased production has been achieved through some increases in the efficiency of feed conversion, but mostly it has been a matter of increased energy intake and reduced energy losses. Advances in performance have been accompanied by continuously improved management, especially of nutrition. In some countries, especially the United States, this has included the feeding of enormous amounts of concentrates to augment energy intake. However, this increases the production of fat in proportion to lean meat, which may not be the objective and is becoming less favored by consumers.

On rangelands in developing countries the constraints on feed, water, and management severely limit the improvement of productivity through breeding. These constraints usually reduce animal responses well below the potential represented by available genetic material. Furthermore, periodic severe stress resulting from feed scarcity may make longevity the primary characteristic influencing productivity.

Limitations on feed intake as well as genetic makeup result in low milk production. The widespread use of milk for subsistence may make the duration of lactation more important than daily yield. Similarly, a certain consistency of production (and reproduction) may be more important than quantity, especially in the fluctuating environments of arid and semiarid regions.

Management practices in developed countries are predominantly concerned with improving productivity. Productivity improvements are mostly achieved for range livestock through nutritional management by increasing primary production, using that production effectively over the year, and taking into account differences in animal requirements and potential economic benefits. Generally one-third or more of the feed such as hay and concentrates comes from sources other than range. Breeding is strictly controlled so that the birth of young is limited to the period of the year most favorable for meeting the high nutritional requirements of nursing animals. Practically no milk for human consumption is produced on the range and beef herds are sharply reduced in size annually (usually in the fall) by sales of calves, young stock, and culls. Young stock from the range are sent to improved pastures or feedlots. As a result, beef animals are usually ready for slaughter before they are 2 years old.

In developing countries with well-developed market economies, the emphasis is also on maximizing productivity from the rangelands. However, management to relate animal requirements to forage supply is more lax, and supplementary feeding for the season when range forage is scarce is limited. Fattening is not practiced in most countries (but this may change with more stratification of livestock production and integration with crop production). Therefore, animals may not be marketed until they are more than twice the age at which they are sold in developed countries. Annual offtake is severely reduced. For example, cattle offtake in the United States is around 40%, whereas it is generally less than 15% in developing countries where rangeland is the main source of feed. This means, among other things, that the reduction in the feed consumed by the herd during the most difficult period is much less than in developed countries.

Where subsistence production is practiced, as in much of Africa, the need to maintain a milk supply over the whole year for family use places certain imperatives on management that are vastly different from those of a market-oriented beef-production system. Most critical is the need to maintain adequate forage in spite of highly fluctuating rainfall. This necessitates an inordinate amount of movement to secure adequate forage, a mix of species, and a herd structure in which adult females dominate (a high proportion of adult females ensures that the herd can be rapidly rebuilt after sustaining losses due to drought). Furthermore, breeding must be timed so that milking animals are available over as much of the year as possible. Intervals between breeding must be extended to lengthen the period of milk production, and to allow the milking animals to recover.

Some range-development activities will continue to improve upon the enduring subsistence systems. In most cases, however, the task will probably be to assist in bringing about an orderly transition toward a more market-oriented economy.

In summary, breeding and management practices must fit the environment, be a function of the objectives of the producer, and take into account trends and national needs. For this reason it is essential to understand the nature of the existing ecosystems, the degree of dependence on these ecosystems by the human and animal components, and the related production objectives. An understanding of these relationships will facilitate the transition from one set of relationships (level) to another.

Guidelines for Program/Project Development

The feasibility and nature of a program in management and breeding depends upon the difference between current and potential production. Possible modifications, such as a change from subsistence production to commercialization, are usually gradual but need to be anticipated in development plans. In some cases these modifications need to be actively encouraged.

Benefits from breeding and management depend upon an improved productivity of the entire ecosystem. For this reason programs for animal breeding and management should be considered as components of ecosystem management and should be an integral part of overall rangeland development. Therefore, program/project planning teams making the assessment must have diverse skills and enough experience to make judgments with relatively limited data.

It is of course axiomatic that breeding and management programs must fit the existing production system(s) and take into account the environment, including relevant characteristics of the human society.

General Considerations

Production systems have evolved as ways of meeting human needs within existing cultural, abiotic, and biotic environments. These systems tend to be rather stable and resistant to change — especially in the more traditional setting. Nevertheless, virtually all systems could profit from improvement.

Management objectives in different production systems may vary greatly. For example, subsistence systems in which milk for direct consumption is the main product aim at having milk available during the whole year, with some possible substitution of blood or meat, thus providing regular food to family members. At the other end of the scale, consider a commercial beef farm — its objective is to produce as much meat as possible at a maximum profit. In either case close consideration must be given to establishing the best possible relationship between animal requirements and forage supply, consistent with the basic objectives. This is accomplished through controlling animal numbers, manipulating herd structure, regulating breeding, conserving forage, etc.

Since animal management takes into account animal requirements and production objectives and how these can best be integrated with the feeds available, information about the following is required.

- seasonal distribution of range forage and its approximate composition — grass, shrubs, and herbs
- variation of the frequency and severity of drought
- response of different animal species to those variations, including weight changes, carcass weights, age of maturity, mortality, etc.
- alternative sources of feeds, supplementary pastures, crop residues, etc.
- marketing or other activities that help or hinder adjustment of animal requirements to the feed supply
- ability of animals to tolerate heat stress and local diseases

This information can be used to identify management deficiencies and can suggest corrective action, which involves manipulation of herd requirements or the feed supply or both. Such actions may include reducing animal numbers, changing species or their proportions, changing the breeding schedule, etc. (see Child et al., 1984, for a more detailed discussion).

Most of the preceding comments are relevant to projects as well as programs. The main difference is that projects generally deal with a specific area or problem, and require more detailed information.

Allow ample time during the preparatory phase of a project to obtain sufficient information. This is also the time to work out the administrative components, often the most troublesome element.

During the preparatory phase the staff of the national government, or designated organization, and staff of the donor agency should work together closely. It is essential that there is agreement on what the problems are and what the project will accomplish.

The pastoralists who will participate in the livestock management and breeding projects should also be involved from the preparatory stage on. They know what their current practices and problems are, and whether or not certain changes actually could be made. But perhaps most important, this type of project implies behavioral changes on the part of the pastoralists. They will not make such changes unless they understand the relevant personal benefits and possibly not unless they feel a rapport with and confidence in project staff (which cannot be achieved immediately). Major changes should not be proposed until the locally relevant technical and economic aspects are understood.

Once the problems have been diagnosed and an appropriate solution suggested, the strategy of the project can be determined. The strategy will show the elements that could be modified in order to bring about a solution. For example, if inadequate animal nutrition is the major problem, it might be due to low rainfall, overgrazing, incorrect stock combinations, no integration with croplands, mineral deficiencies, poor marketing practices, no place to move animals, etc. Several factors may be interacting, making the problems worse. The various avenues of possible relief should be identified.

When a clear strategy has been developed, identify the work necessary to achieve the objectives. The plan must be developed within the limitations of money, staff, and administrative support. There is no prescription for this except evaluating the specific situation with the help of the right mix of local and outside experts.

If adequate baseline data (against which changes will be monitored) were not gathered during the preparatory phase, conduct the necessary studies as early in the project as possible. Design these studies so that measures can be made in the future to determine how well the strategy of the project has worked. Monitoring ought to be continued until concrete conclusions can be drawn about the effects of the various activities.

Guidelines for Technology Selection

Decisions on what technology to apply should be based upon the objectives of the production system, all the main components of the relevant ecosystem(s) (abiotic, biotic, and human), and factors that may be outside the ecosystem (demand for a product, social organization, and communication infrastructure). Too often a technology's feasibility is judged in terms of what that technology **could** do if it **could be applied.** Unfortunately, many applications have failed because not enough attention was given to understanding the interests and motivation of the people involved and the capacity of their government to provide the necessary continuing support.

Although specific guidelines must be derived from the study of the local situations, some observations that are generally applicable to most situations are made here.

One of the most important considerations in selecting technology to apply to rangeland breeding and management programs is simply that it can be widely applied. This is because the possible increases in productivity or other improvement per unit of area on arid and semiarid rangelands are almost always small or very costly. However, what can be applied over the entire area, or over a substantial part, can have a significant effect due to the enormous size of the rangelands. Further, the cost per unit area must be small and the application relatively simple. For example, an improved system of culling could affect every household, whereas a crossbreeding program would be difficult, if not impossible, to implement in the majority of households of many countries.

A second major consideration in the selection of a technology is whether it has been both proven and widely demonstrated in the field and to the pastoralists. Otherwise the essential participation and acceptance of the people for whom the practice is intended is not likely. Carrying out the necessary research and demonstration activities to obtain the acceptance and adaption of breeding and management programs will require training and practice involving the pastoralists.

Base programs aimed at correcting deficiencies in current practices on the use of local resources. For example, genetic improvement should be built on better selection of what is locally available, and management improvements should not depend on expensive imported materials.

In general, avoid technologies that involve a permanent and sophisticated support system. A good example of such a troublesome technology is artificial insemination, which requires specially trained staff, transport, refrigeration, semen, etc. Breeding programs must be appropriate to the level of management and feeding. Improved genetic material is of value only as the feed supply and management permit expression of the added potential. Even such a simple technology as a system for dipping animals sometimes strains the support system.

One practice that should be widely used is systematically culling or castrating undesirable animals. This selection process can be adapted to any environment and any production system. Selection of improved, adapted sires is another way to improve a herd. It requires a level of organization and recordkeeping not feasible in some countries. However, importation of nonadapted but highly productive sires and crossbreeding require highly sophisticated management and support organizations to be effective, as well as much better feeding than is available on most arid and semiarid rangelands in developing countries.

Management should be particularly directed toward reduced feed shortages, optimum range use, and grazing schedules that favor animals within the herd that have higher physiological requirements (such as milking animals) or economic value. This implies control of grazing intensity to avoid heavy grazing, while providing the best grazing for young animals being fed to market size, breeding animals during the breeding season, and milking animals. The management plan must also consider ways of ameliorating the effects of drought and differences between animal species. In summary, the basic aim in management must be to find the best possible relationship between the animals and the forage supply in order to meet production goals.

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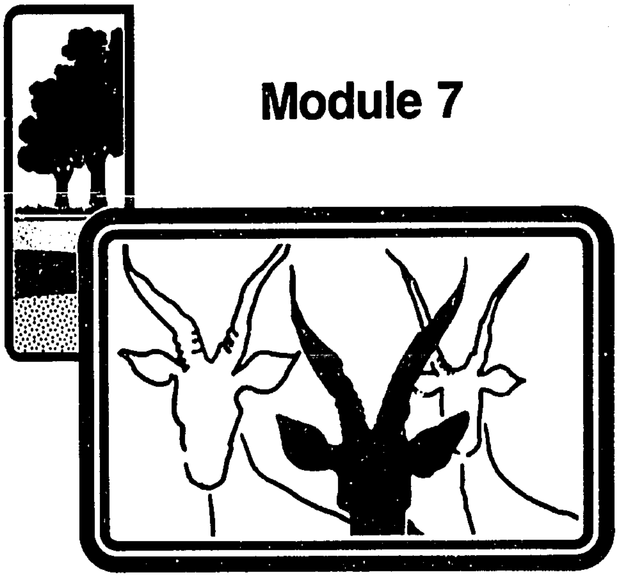
Module 7



Game Cropping

In developing countries managed game-cropping systems are often neglected in favor of more conventional resources and industries that satisfy immediate needs. Consequently, government agencies that are responsible for management of wildlife are often poorly staffed and funded, and sometimes lack scientific leadership. Moreover, except for those countries where tourism in game parks and surrounding areas provides an important source of foreign exchange, governments pay little attention to wildlife.

In some regions, past decimation of wildlife has left the countries bereft of industries and production systems in which wildlife habitats can compete with other forms of land use, when a cost/benefit analysis is applied. Besides, the desperate need for development of the land, and natural and human resources for producing food, education, health services, transportation, communications, energy, and other essentials of life are understandably a priority with governments.

Wildlife is sometimes considered detrimental to development. Various species of large mammals and birds compete with domestic livestock for food from crops, stored grain, and fodder. Many of the larger carnivores are serious predators of domestic animals, and some animals carry or harbor diseases that affect both man and his animals. Some wildlife directly threaten man.

In spite of this, wildlife should be managed for the benefit of the people and protected for its own sake. It can instill a sense of patriotism and pride in the people. It can provide recreational outlets for the citizens of the country as well as for tourists. Where wildlife has not been decimated, it can provide food and a source of income for the local populace as well as benefit regional and national economies. Income can be derived from sport hunting, tourism, and the sale of meat and other products from animals harvested in cropping and culling programs.

Where Has Game Cropping Been Practiced?

Cropping of free-ranging wild ungulates has been a successful industry in several regions of the world since the early 1950s. Some 650,000 saiga antelope *(Saiga tatarica)* were harvested by the Russians between 1951 and 1960 (Bannikov et al., 1961).

Various species of introduced deer have been cropped for many years in New Zealand for sale of the meat, especially in the low countries of Europe. Capybara *(Hydrochoerus hydrochaeris)* (Ojasti and Padilla, 1972) and its smaller relative, the paca *(Cuniculus paca)*, have been and are being cropped from wild stock in Venezuela. By and large, these cropping schemes have been successful at least on an experimental basis. Efforts are also being made to produce them in "capture" herds.

Cropping of large herbivores in organized schemes was first done experimentally in Africa in 1959 and 1960 by Dr. Raymond Dasmann on the Henderson Ranch in what was then southern Rhodesia (Dasmann and Mossman, 1961; Dasmann, 1964). The experiences and reports of Dasmann and his colleagues precipitated widespread interest in cropping of plains game. Subsequently, cropping of wildlife for meat and for revenue, as well as to reduce populations of large mammals that were destroying crops and forage, spread to many countries in southern and eastern Africa.

Cropping of elephants and various other species in the Luangwa Valley in Zambia (Steel, 1968) followed shortly. Elephants and hippos *(Hippopotamus amphibius)* were cropped to reduce their numbers in Queen Elizabeth and Murchison Falls National Parks in Uganda by I. S. C. Parker and his associates in the 1960s. Other experimental cropping programs were conducted by L. Blankenship et al. (in press) on the Akara and Kekopey Ranches in the Rift Valley of Kenya in the early 1970s.

For several reasons cropping in East Africa failed in many areas where it was attempted. Most of the reasons were economic but some were political and a few were biological. Among the more important reasons were poor transportation and refrigeration facilities for the meat, distant and undependable markets accessible only over very bad roads, and unacceptable competition with the livestock industry. In southern Africa, on the other hand, cropping of animals from free-ranging herds of plains game, but also of bush-dwelling species, has been successful. A great many ranches in Zimbabwe, South Africa, and southwest Africa crop game for sale in markets at home and abroad. Joubert et al. (1983) report on an effective and profitable cropping scheme on private ranches in southwest Africa. In this scheme much of the meat is being sold abroad, but some is being processed — refrigerated or dried — and sold in the local markets. This seems to be the pattern of marketing in most recent schemes.

Parker in Blankenship et al. (in press) reports a profit of KSh65,292 (about US$8,161 at 1971 exchange rates) for 2,358 impala and Thomson's gazelles on the Kekopey Ranch in the Rift Valley and the Suguroi Ranch on the Lakipia Plateau in Kenya. However, Parker qualified his conclusions by calculating that income could have been greater had the two ranches used their own labor and sold only the skins. The expense of sanitation and marketing of the meat was a major item, and demand for fresh game was low. The cropping program was a technical success that had not been achieved elsewhere until this effort in organized cropping efforts for plains game in East Africa.

Some argue that the most efficient and cost-effective method for providing meat from wildlife is to permit local people to practice subsistence hunting, a long-standing tradition in many regions of the world. Distribution, marketing, and goals of cropping may be met in this manner, but uncontrolled harvesting (poaching in the strict sense) can result in impoverished populations of target species. Ultimately the potential for sustained yields of meat and the industry surrounding cropped wildlife may be lost.

Parker (Blankenship et al., in press) believed the objectives of the Galana Ranch cropping program failed to consider that the Watta tribe was traditionally dependent upon elephants, and didn't need another organized cropping program. The Watta had developed an effective if not affluent way of life through subsistence hunting of elephants. They had learned to live with and had protected their resource. It was not until recent times, when money became important in the tribe's life, that excessive killing and poaching for ivory became a part of their existence.

Game Cropping Versus Game Ranching/Farming

It is important to differentiate between game cropping, game ranching, and game farming. Game cropping or culling is using wildlife from free-ranging, unhusbanded populations of wildlife, usually on public land. Game ranching, on the other hand, implies production, husbandry, and harvest of animals from a semiconfined herd or herds of wild animals or from areas where conventional ranching of domestic animals is practiced. Game ranching usually is practiced on privately owned land. Game farming, in the sense of the industry now being practiced with cervids (members of the deer family) in New Zealand and certain countries in the Orient, involves the care and husbandry of confined animals for production of meat and other products. Animals are fenced or penned and carefully nourished and kept. Selective breeding is used to improve the quality of the products being marketed.

This module describes the potential and processes for building an industry from free-ranging wild populations of large mammals. More specifically, it describes the use of wildlife for meat and for income in countries where food is scarce and where large herbivores are relatively abundant.

Biological Guidelines

Concentrate game-cropping schemes on species that are herd animals, have relatively high reproductive rates, weigh at least 10 kg to 15 kg, and are sufficiently abundant to support a reasonable annual offtake. Members of the order Artiodactyla (even-toed, hoofed mammals) are the primary targets of cropping schemes. This order includes antelopes, sheep, goats, deer, and pigs. Many of the antelope in the savannas and tropical woodlands of Africa meet the criteria: They have reasonable reproductive and recruitment rates, occur in fair to large numbers, have some form of herd structure, and are sufficiently large to produce good quantities of meat per carcass.

Large regions in many countries are marginal for production of livestock simply because the environment is not suitable. The kinds of vegetation needed for forage may not be present, markets may be so distant that livestock production is not economical, or various kinds of diseases and parasites such as the tsetse fly may prevent conventional animal agriculture.

Many of the bushlands of Central and South America and Africa, and deserts and semiarid lands throughout the world, may be best suited to goats over any other domesticated species. However, wildlife may be relatively plentiful in such areas. Where the tsetse fly prevents development and even human habitation in large areas throughout Africa, large wild herbivores that are immune to trypanosomiasis may potentially produce meat more efficiently and economically than can even resistant or tolerant domestic livestock.

Notable among the antelopes of East Africa that are abundant and have been cropped are the blue wildebeest *(Connochaetes* *taurinus)*, impala *(Aepyceros melampus)*, Thomson's gazelle *(Gazella thomsoni)*, kongoni or Coke's hartebeest *(Alcelaphus buselaphus)*, and buffalo *(Syncerus caffer)*.

Species of importance in southern Africa include the springbok *(Antidorcas marsupialis)*, eland *(Taurotragus oryx)*, greater kudu *(Tragelaphus strepsiceros)*, and gemsbok *(Oryx gazella)*. The blue wildebeest of the Serengeti-Mara ecosystem of Tanzania and Kenya now numbers over a million and a half animals (Sinclair and Norton-Griffiths, 1979), and represents real potential for producing much-needed protein in the region.

The zebra *(Equus burchelli)* is another species of plains game that has figured in cropping programs. It occurs in great numbers in the tropical savannas of East Africa and has been cropped there for its meat and hides. However, it is not preferred, primarily because of the tastes or customs of the people.

Although many species of the deer family are not herd animals, they occur in sufficient numbers and are large enough to produce sizeable yields of meat. The white-tailed deer *(Odocoileus virginianus)* of the United States is a case in point. An extremely widespread and abundant species, it provides great quantities of protein each year through sport hunting. Over 325,000 white-tailed deer are harvested each year in Texas, which represents more than 11,818,000 kg of field-dressed carcasses. This is more meat than is produced from the livestock industry in some Third World countries. The caribou *(Rangifer caribou)*, another member of the deer family, is a herd animal. Although it has not been the object of an organized cropping scheme in recent times, it is taken in large numbers through subsistence hunting by native North Americans in Alaska and Canada.

Several of the large rodents of South America have been cropped for their meat, and here and there in the world various rabbits, hares, and seals are used extensively in subsistence economies of native peoples. The cane rat *(Thyronomys swinderianus)*, which usually weighs from 4 kg to 7 kg and may reach 9 kg, is an important source of meat in many areas of West Africa, although it is not the subject of organized cropping. Rather, it is taken by native peoples with ordinary hunting methods. In total yields, the take of such species is likely larger than the take of bovids and cervids in organized cropping schemes, and represents an important source of protein for native people. Kangaroos *(Macropus spp.)* and water buffalo *(Bubalus bubalis)* (an exotic) in Australia, and various species of marine mammals in the polar regions of the world are also taken in cropping schemes for their meat and hides.

Reductions in populations of large mammals that are destroying their ranges through overuse of their food supply and are depredating crops need not meet the criteria as stated above. Their reproductive rates are low and thus sustained yields may be too small for profit. Elephants and hippopotamuses can overpopulate their ranges and are sometimes pushed into conflicts with agricultural interests. Control (removal) of those particular animals that are involved in depredation is often the best solution. But where populations of such species have reached high levels, reduction in the herd before they harm their range and become nuisance or problem animals is the best long-term solution. Some of the great parks in southern Africa routinely crop species that have become too numerous for their habitat to support them. They are used for their meat and by-products.

Guidelines for Marketing the Produce from Cropping Schemes

The first requisite in the development of a scheme to use products from free-ranging wild populations of animals is a marketing plan for the products. Where are the products to be sold or where will they be used? Usually cropping is justified on the basis of using the meat for indigenous peoples whose diets are deficient in protein. There are many subsistence cultures in the world whose people are malnourished and whose diets are largely carbohydrates. Improvement in the diets of such peoples is greatly needed.

Second, products from cropping schemes can be sold abroad where tradition and cultural mores have shaped acceptance of game meat and animal by-products. Sale of produce from cropping schemes can generate foreign exchange, which can then be used to improve the lot of subsistence peoples. However, this is still a goal — the record of success is as yet unimpressive. Funds generated from sales have rarely reached those in greatest need.

The Netherlands, Belgium, Luxemburg, Germany, and France are the traditional markets for game meat produced in Europe, Africa, Australia, and New Zealand. Game meat is often used on traditional holidays and festive occasions by these Europeans. Venison is a highly desired food, and most of the meat is identified generically as such, despite it being from different wild members of the cervidae or bovidae families (figure 14). It is usually sold in the same markets as beef, mutton, poultry, and other more conventional meats.

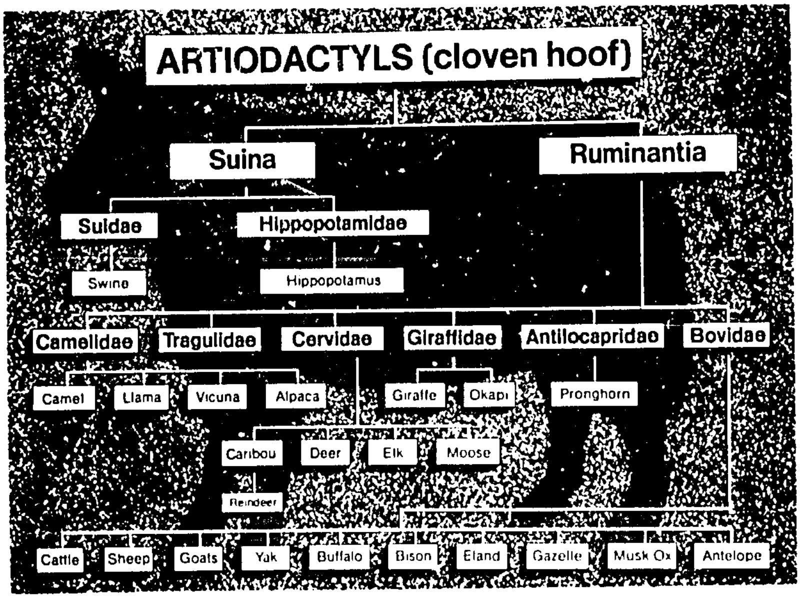


Figure 14. The relationship between larger domesticated and wild herbivores found on rangelands (Winrock International, 1978).

Some products of cropping are sold in Asia. The velvet antlers of cervids now being farmed in New Zealand (Yerex, 1979) are a highly prized and valuable commodity in Oriental markets. Musk used in the manufacture of perfumes is obtained from the small musk deer (*Moschus moschiferus*) and is another product that has stimulated game farming in India, China, and some Southeast Asian countries. Skins and horns of many species are used in the manufacture of curios that have great value in the tourist trade. However, animal products such as skins, ivory, and horns of certain species are no longer legal items of trade. Many of the animals are endangered and most nations in the world have signed the Convention on International Trade in Endangered Species. The tremendous loss of black rhinos and African elephants in East Africa in the 1970s was due to the great value of their horns and ivory in the Orient and certain Middle Eastern countries.

To develop markets for meat and other products, the conventional markets for domestic livestock meat should be explored. The governments of many countries are themselves the distributors of animal products and regulators of domestic livestock markets. In Kenya, for example, the Kenya Meat Commission is the principal regulating body for the livestock industry in the country. It issues quotas to producers for marketing their animals; processes the animals in its abattoirs; and regulates the sale, distribution, and export of livestock products.

If the livestock industry does not permit competition with its products, at least at local or regional levels, markets must be sought abroad. Government agencies sometimes view a source of cheap meat as unfair competition for the livestock industry, as often does the private sector. Contact the export companies and the government ministries involved in animal agriculture and wildlife conservation and management to obtain information on potential world export markets. Without the endorsement and support of regulating agencies, cropping of wildlife cannot succeed.

The government ministries and departments charged with conservation and use of natural resources issue permits and quotas for wildlife cropping. Through surveys and studies these agencies decide if cropping or reduction of animal numbers is desirable. They may carry out the cropping program themselves, but in most cases contracts are made with the private sector. The kinds and numbers of animals to be taken are carefully regulated and the cropping exercises are usually monitored by a representative.

There are several arrangements that can be made between government and contractor, but usually the contract calls for a percentage of the net profit for the operator. Under this system, the operator must make the operation profitable if he is to be rewarded for his work.

Special considerations are required for some markets. Where meat is to be sold in Moslem markets, the animals must be slaughtered in special ways. A Moslem adherant usually is a part of the cropping party. He sees that the animals are slaughtered according to Moslem religious requirements, which usually means positioning the animal toward the east and cutting the throat for bleeding.

Another example is the exacting requirements of some Europeans for wild game meat. Deer produced in semicaptivity on deer farms in New Zealand are not readily accepted because they are considered tame or domesticated animals. Taste is not the issue; rather, it is the source that is at question.

Guidelines for Selecting Cropping Methods and Procedures

Harvesting wildlife from free-ranging herds of large mammals is most efficiently accomplished by shooting or driving the animals into some kind of pen for later slaughter. Many systems that are modifications of the two techniques have been tried. Various kinds of land vehicles, portable abattoirs, meat-handling and refrigeration equipment, and aircraft have been used. Each situation is different and special attention must be given to the terrain, habits of the species to be cropped, and disposition of the meat and other products.

Of the two basic techniques, shooting has come to be used almost universally for cropping large mammals, and for certain large birds such as the ostrich *(Struthio camelus)*. Age and sex classes may be selected for shooting when the animals are taken singly with the gun from free-ranging herds. With careful planning, the animals may be taken without undue stress (stress causes the meat to have an undesirable flavor). Some species are taken at night with the aid of powerful lights. Several species of antelope, including the impala and certain gazelles, can be approached very closely with a light and shot at close range. Being herd animals, several can be taken before the herd disperses. Head and neck shots are made whenever possible.

In choosing which animals are to be taken, consider the social structure and biological composition of the herds for humane reasons as well as to promote sustained yields of the species. Harvest sex and age classes of animals in the same proportion as they occur in the population. The goal is to harvest the animals without disrupting their social structures.

Reduction of elephant numbers in areas of East Africa where they have exceeded their range's ability to support them is done with careful attention to the animal's social, population, and behavioral characteristics. Elephants are herd animals; families are usually led by an old female. Several generations of females, their offspring, and young bulls comprise a herd. Because elephants are so highly social, people who have been licensed to reduce elephant numbers, in East Africa at least, have attempted to take all members of each herd. Old bulls are not members of the herds and thus are spared for the most part. In the actual shooting, the matriarch is taken first and the members rally to her where they, young and old alike, are easily taken. The herd, rather than individuals, is cropped.

Elephants, buffalo, and some species of antelope are routinely cropped in some of the African parks to hold their numbers in check. The cropping system in Kruger National Park in the Transvaal of South Africa is a model of modern technology and efficiency. Elephants are taken with overdoses of drugs by using a capture gun from helicopters. They are then winched onto lowboys for transfer to the permanent abattoir. There they are processed into various products including bonemeal. Nothing is lost. Reduction of buffalo and impala numbers is accomplished in much the same fashion, but with shooting as the method of harvest. Elephant and hippopotamus populations in Queen Elizabeth and Murchison Falls National Parks in Uganda were reduced by a commercial cropping company in the 1960s.

Herding animals into corrals with vehicles and aircraft has been used for plains game, but the system is costly and often damages the animals meant for slaughter. When some species are forced into small confinements, they often kill themselves against the fences and bruise their flesh so as to make the meat unacceptable in the market. The blue wildebeest and zebra were herded into confinements, but at costs and with losses that made the system unacceptable. On the other hand, the blesbok *(Damaliscus albifrons)*, a favorite game-ranch species in South Africa, is often herded into a confinement and held for some time before slaughter. It is semidomesticated and is more docile than other species.

The usual system for harvesting large mammals with the gun involves teams of hunters in vehicles ranging in the animals' habitats where cropping is to take place. The habitat, locations of concentration, and behavioral patterns of the animals have usually been determined. Each team usually consists of a shooter and two or more helpers. The animals are shot and eviscerated in the field. Within 2 or 3 hours the carcasses are collected and brought to a central station where they are skinned and the meat is prepared for refrigeration or drying. In some cases, the animals are loaded onto the vehicle as they are shot, and the party returns to the abattoir to process the kill when the vehicle has been filled. A load usually consists of about five animals. In no case does the team stay out longer than 2 hours with whole carcasses.

On ranches in the Karoo of South Africa, shooters are stationed at vantage points and herds of surplus springbok are driven past them by men on foot and in vehicles. The carcasses are collected and carried to the ranches' slaughterhouses for processing. They are eviscerated, skinned, and cooled for several hours before being carried to local markets for sale. Livers, hearts, and other edible inner parts are saved and marketed. The carcasses of springboks (which are about the size of ordinary sheep), are sold as halves. Many ranchers and markets dry the meat and sell it as biltong, a highly desired product in southern Africa.

Allow for the fact that wildlife cropping in remote areas where water and other amenities are not available is expensive. The central station consists of portable equipment and must be trucked to a river or some other water source. Portable generators are often used to power refrigeration units, lighting, and other electrical systems. Gasoline and potable water must be brought in jerry cans and barrels. Refrigeration trucks are often essential where distances to markets are great, and a number of four-wheel-drive vehicles and lorries are usually needed to transfer the camp and the meat products. Equipment for cropping wildlife in remote areas is expensive, and the need for maintenance is constant.

Remember that all cropping schemes are different. Every cropping scheme differs in geography, kinds and abundances of species, techniques for harvesting wildlife, and potential markets. Thus planning is the essential ingredient for success. Planning requires innovation and inventive minds to meet obstacles that are sure to develop. The very nature of cropping demands it. It is not a common business with conventional established procedures to draw on.

Guidelines for Sanitation and Health

Take precautions — wild animals are subject to diseases and parasites that can be transmitted to man and domestic animals. Carcasses must be inspected to ensure safety for the user and to prevent infection of livestock. Governments often require a veterinarian or meat inspector to oversee the cropping operation and to inspect every carcass. The cropping operation usually must pay for the service. Some species of game have parasite loads that render them unsalable because they affect man and his livestock or simply because they are unsightly, even though harmless, to the user. As high as 5% to 15% of carcasses of such species may be condemned by the inspector. Some nations forbid fresh game meat from being taken from areas where hoof-and-mouth and other highly contagious and epizootic diseases are found. Meat has sometimes been canned to prevent transfer of disease organisms, and hides and horns are salted and otherwise treated before they are sent to markets.

Cleanliness in the cropping operation is difficult but must be rigorously maintained. The animals are shot on the open range, often eviscerated there, hauled by open vehicles to the central station, and butchered on hoists set out in the open. In every phase, the carcasses are subject to damage by egg-laying flies and other insects, and contamination by dust and grime. In southern Africa, cropping is sometimes limited to the cold, dry seasons when blow flies are not encountered. People who skin and butcher are required to dress in clean clothing, including caps, to ensure cleanliness. Water and disinfectants are always at hand to cleanse the people and their utensils. Under the best conditions some animals will not meet the inspector's requirements. Every animal carcass condemned for whatever reason affects the profitability, and thus the success, of the operation.

The Future of Game Cropping

Wildlife can be expected to provide meat for some time in the future in areas where domestic livestock cannot be raised profitably or efficiently. Some regions of the world can support wildlife more efficiently than domestic animals because wild species have evolved and are adapted to the extreme environmental conditions found there. The deserts and cold regions of the world are likely to remain wild environments; livestock will be used there only when every other favorable rangeland has been filled.

However, in areas where conditions (such as the presence of parasites) currently prevent conventional animal agriculture, cropping of wildlife for meat in wildlands can be expected to give way to development of a domestic livestock industry. Technology will eventually solve the management problems, and domestic animals of one kind or another will be used in extensive production systems. They are more manageable and have sufficiently different dietary requirements to use practically all classes of forage.

Producing livestock and wildlife on common-use rangelands may offer the highest potential for profit. The technology for integrating systems of management is not well developed yet, but with continuing world food and population pressures, management systems will be developed. The greatest value of wildlife will probably be as objects of tourism and sport hunting.

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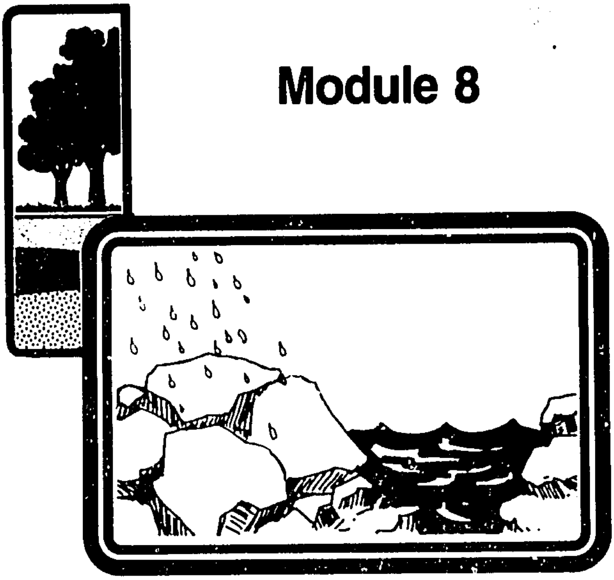

Module 8

Water Harvesting

Water harvesting refers to a collection of practices that are used to reduce the amount of rainfall lost through runoff. These methods are generally small scale and provide water on a seasonal basis for increased forage production, limited livestock watering, and human needs. Historical evidence shows, for example, that a rough soil surface retards runoff, promotes infiltration, and slows evaporation. Water-harvesting methods that are discussed in this module are water spreaders, pitting, and microcatchments. See module 2 for a discussion of water harvesting from a vegetation-management standpoint.

Water Spreaders

A water spreader is a system for spreading flood waters to irrigate land, to reduce and store sediment, or to obtain deep storage of ground water (figure 15). They commonly take the form of a series of dikes across a flat valley (wadi), preferably one with less than 1% slope. Opportunities for successful water spreading are limited.

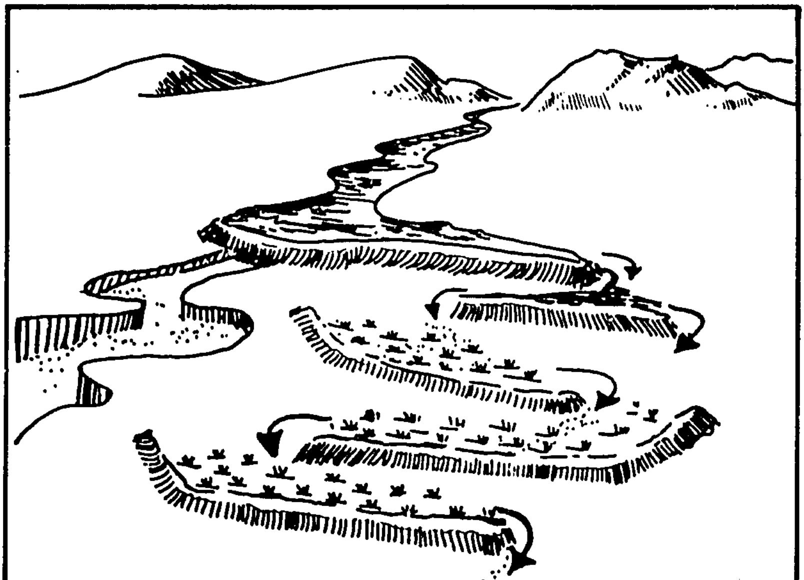

Figure 15. Sketch of a water-spreading system of dikes with crops and(or) forage plants planted in the wet areas behind the dikes (adapted from FAO, 1976).

The goal is to take flood waters from the main channel to one side of the valley, around the end of a dike, then to the other side of the valley where it flows around the next dike. Another design is to join both ends of the dikes to the valley sides and have broad central spillways in the center of each to allow excess water to pass to the next dike and settling basin. The latter design has fewer weak points and is less likely to fail. Basins above each terrace eventually will fill with silt, resulting in a new slope gradient for the whole valley. A break in the dikes then may cause a deep gully where none existed because they were designed to handle the customary flood, but were inadequate for the unusual storm. Successful water spreaders are designed to take all the flow up to a certain amount, and to let larger flows bypass the system without damage.

Dividing large watersheds and flows into smaller ones can minimize damage during unusual storms. Ancient water-spreading systems accomplished this with separate terraces and diversions that could be opened or closed as needed. These terraces kept the volume of flow to small quantities near the source. Other diversions subdivided or concentrated the flows at the entrances to fields.

Reasons for failure of water-spreading systems appear to be inadequate design to handle large flows from the unusual storms, sedimentation that plugs the system causing overflow, and not managing water during each flow.

Rangeland Pitting

Pitting the soil on land with slopes less than 15% is accomplished with a disk that cuts a pit as much as 15 cm deep and 1 m long, then lifts from the soil for 1 m before it cuts another pit. Pitting is used to trap water where it falls, to increase water percolation into the soil, and to roughen the surface for reduction of wind erosion. Sometimes the return is increased forage production. Pits fill with sand and silt in a few years, but their effect may last longer because of the increased water-holding capacity of the soil that has accumulated in the pit.

Another use of pitting and contouring is rehabilitation of bare and badly eroded flat land. Pits and contours break soil crusting and, if combined with deep ripping of impervious soil, promote deep penetration of water. Seeding of desirable forages should always accompany rehabilitation operations; otherwise, the returns will probably not repay the costs.

Microcatchments for Water Harvesting

Harvesting surface runoff necessitates a catchment area and a water-storage facility. The efficiency of water harvesting from a catchment area is usually increased in one of four ways (Medina, 1976): by taking advantage of naturally impervious surfaces of rock or bare clay, by altering the land surface by smoothing or compacting, by chemically treating the soil to prevent infiltration, or by using physical barriers as ground covers. Chemicals include water-repellent silicone, paraffin, and salt. Salt causes dispersion of soil particles, resulting in sealing of the pore space at the surface of the soil. A wide variety of impermeable materials has been used to seal catchments, including concrete, sheet metal, fiberglass, plastics, and tar as an emulsion on paper; some of the most effective have been artificial rubber membranes. The importance of properly installing and maintaining all these types of catchment surfaces cannot be overemphasized.

The water-storage facilities for microcatchments fall into three basic systems:excavated basins, bags made of rubber or plastic, and tanks of metal or concrete (see figure 11 in module 2). Excavated basins are usually the easiest to construct but they should always be sealed, commonly with clay or the same materials that were used on the catchment surface. Evaporation can be controlled by covering the water surface with polystyrene rafts. Bags of butyl-coated nylon are completely enclosed, offering clean storage and no loss through evaporation and seepage. All of these catchment facilities are subject to vandalism, damage by small animals, sedimentation, invasion by weeds, and earth movement due to changes in temperature and moisture content; thus they must be rigorously maintained.

Water harvesting may also be used to increase the water available for individual shrubs or patches of grass. A small catchment, 10 m^2 to 100 m^2, bounded by dikes with finely scratched drainage lines oriented toward a corner collecting basin, has furnished enough water for establishment and production of singly planted fruit trees, saltbushes, and grasses. Grazing should be eliminated during establishment of vegetation. Many techniques are available for the establishment and management of these planted catchments, but soil compaction of the runoff apron and weed control are essential. This type of water harvesting is labor intensive, costly, and justified only for special purposes.

A number of rangeland-improvement techniques are also forms of water harvesting. Livestock-watering points are described in module 3 because of their importance as a technique to improve distribution of grazing, but they are also examples of water harvesting. Rangeland seeding can enhance the efficiency of water harvesting by increasing the proportion of rainfall that infiltrates the soil. Prescribed fire can decrease the efficiency of harvesting rainfall and increase runoff and streamflow because of the decrease in vegetational cover. While the goal of some rangeland practices may not be, in a strict sense, to harvest water, all aim to make better use of water.

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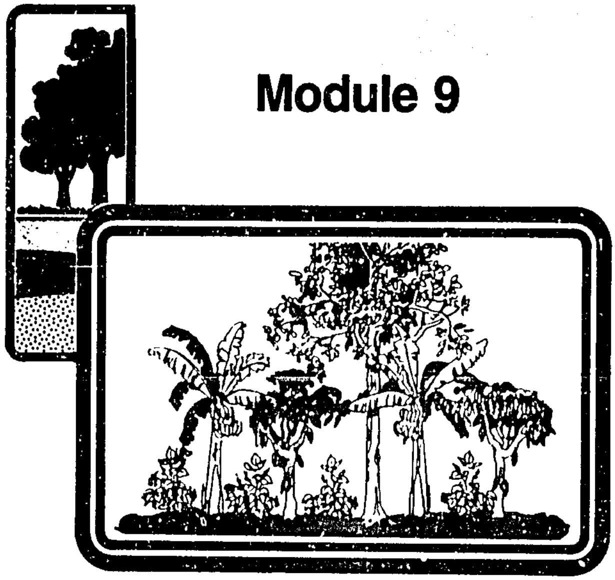
Module 9



Agroforestry

The generic term "agroforestry" refers to sustainable management systems that combine food crops, animals, and woody plants on the same units of land, simultaneously or sequentially, and that apply management practices that are compatible with the social and cultural patterns of the local population. Agroforestry aims to increase overall production for the economic benefit of farmers and pastoralists, while avoiding the adverse effects of emphasizing a single product. An additional goal is to manage the trees, crops, and forages in such a way that ecosystem degradation is prevented.

In the humid tropics the major emphasis is on cultivated crops with trees, but in arid and semiarid regions the emphasis is on pastoralism with trees and other woody plants (figure 16). However, the use of woody plants is sometimes limited to highly selected sites. Most animal feeds are raised on farms in humid regions, but on rangelands in dry regions. This module is for the drier areas. The "Guidelines for agroforestry and mixed farming systems" in Lugo et al. (in press) on the humid tropics discusses the systems approach and gives principles that are applicable to the dry rangelands also.

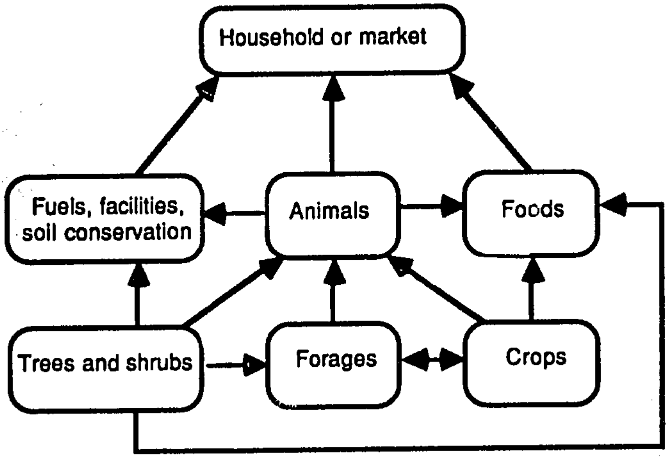


Figure 16. The relationship of trees and shrubs, forages, and crops with people in arid and semiarid regions.

Grazing Systems

A description of the grazing systems of the arid and semiarid regions will help in understanding the application of agroforestry principles. In intensive systems, animals are restricted to areas immediately adjacent to the home or village. The herd size is usually small, often only one or two animals that are maintained in a stall and fed on a cut-and-carry basis. Uneaten materials are tossed into the pen and become mixed with the manure. The compost eventually goes to the farm as organic fertilizer. In another type of intensive grazing, mixed herds and flocks are taken to rangelands, roadsides, and forests in the morning and returned to the farm or corral at night. Herding is commonly done by children and young people directed by older members of the household. Herds must not be allowed to damage food crops and tree plantings.

In seminomadic or transhumant grazing there is a home base from which animals are herded on lengthy migrations, and to which they return. Transhumance is the most widely used of the extensive systems, especially in the arid and semiarid areas of the world. The migrations are well organized, with established routes and dates of movement.

Nomadism differs from transhumance in that the pastoral nomads have no permanent home where they are tied to cultivation and water. Legal land rights seldom exist; if rights do govern movements, they are based on water. Some characteristics of nomadism include human food habits based on animal products and exchange of animals with transhumant and sedentary cultivators for grains, fruits, clothing, etc.

Nomadism and transhumance affect the land differently. Nomads, for example, have little or no incentive to plant trees or shrubs or any other type of fodder plant. Perhaps they use no more fuel per person, but since their habitat produces less wood than others, their impact on fuelwood supplies is great. On the other hand, destruction of the vegetation from overgrazing and erosion is likely to be greater near the centers of sedentary populations than under nomadic grazing. These grazing patterns present different problems to land development through agroforestry; incorporation of agroforestry into grazing patterns in the driest regions is the most difficult.

Values from Woody Plants

Until recently the attention of rangeland managers and researchers was largely directed toward herbaceous plants. Although the value of browse or fodder from woody plants is recognized, browse is still not adequately measured in range assessments. Comprehensive discussions of the importance of browse trees and shrubs are found in the proceedings of a conference held in Addis Ababa (Le Houerou. 1980). The National Academy of Sciences (1979) described nearly 200 little-exploited legumes, most of them trees and shrubs, of interest in agroforestry. A comprehensive discussion of tropical legumes, including leguminous forage and browse, is found in the FAO publication Tropical Forage Legumes (Skerman, 1977). Other lists and descriptions are available for India (ICAR, 1981), Pakistan (Kahn, 1965), and the West African Sahel (Advisory Committee on the Sahel, 1983). Nutritive values of woody plants are given by Torres (1983) and Gohl (1981).

Values of fodder trees and shrubs go far beyond feed for animals. Plantings may be in fencerows to mark boundaries, as barriers to unwanted brush, and for shade at the homestead. Many human foods come from trees and shrubs, including fruit, and leaves for greens. Acacias and other legumes fix nitrogen in their roots and enrich the soil for other species. Fuelwood and wood for construction are important products. Plantings are made in gullies and on sand to control erosion. The only fodder available during droughts may be leaves, fruits, and bark from trees. Yet the accumulation of knowledge about the culture and management of trees and shrubs in arid and semiarid areas is still in its infancy.

Examples of Woody Fodder Plants

These examples were selected from among several hundred that could be recommended for agroforestry use. Some 500 species of *Acacia* are indigenous between 30° N and 30° S. *Acacia albida* is a tree up to 20 m tall that grows along streams in savannas and grasslands of Africa and eastward to India. Its leaves begin to grow with the onset of the dry season and are shed at the beginning of the wet period. The pods are large and a mature tree may yield as much as 100 kg of pods each year. *Acacia senegal*, a bush or small tree less than 5 m tall, produces gum arabic. It is also a fodder tree, and both leaves and pods are palatable and nutritious.

Herbaceous plants are vascular plants that do not develop woody tissue.

Woody plants are vascular plants such as shrubs, woody vines, or trees that contain woody tissue (i.e., persistant ligneous material).

Browse commonly means forage from woody plants including sprouts, young twigs, leaves, flowers, fruits, and even bark. The terms fodder trees and fodder shrubs are synonyms for browse.

Fodder is the dried, cured plants (including leaves, stems, and grain heads) of tall, coarse-grained crops such as maize, sorghum, wheat, and soybeans.

Forage is an all-encompassing term for plant parts, both woody and herbaceous, that are eaten by animals. Forage can be grazed or harvested for later feeding.

Atriplex spp. are often planted and grown as fodder shrubs in near-desert conditions (150 mm to 250 mm rainfall per year). Several species are highly palatable and must be carefully managed so that livestock do not overgraze and kill the young plants.

Leucaena leucocephala is a versatile tropical legume used for human food, forage, wood pulp, fuelwood, and soil improvement. Under some conditions it suppresses *Imperata cylindrica*, an unpalatable and aggressive perennial grass. It mixes with most tropical seeded grasses and should be heavily grazed after it is established. However, more than 30% of *Leucaena* in the diet of livestock causes digestive problems because of the mimosine content.

Prosopis spp. are valuable for grazing, fuelwood, pods, and soil improvement from northern Africa to southern Asia. *Prosopis spicigera* is a prized drought- and frost-resistant shrub or small tree in arid regions from Iran and India.

Taking into account 1) experiences with subtropical grasses and herbaceous legumes that are not adapted to 500 mm of annual rainfall and 2) the above examples of the value of trees to dry areas, it seems logical to encourage the development of desert trees and shrubs, if only on a small scale. However, the culture of these woody plants is little understood, and seeds or young plants are difficult to obtain. Also, woody vegetation can lower water table elevations considerably in arid environments, reducing the amount of water available for wells and other water sources.

Planting Trees

Selecting woody species for successful silvopastoral programs is only one of many considerations. The soil must be a suitable depth, moisture, texture, and structure. A choice between seeding or using nursery plants must be made. Compatibility with grazing and crops is important and is likely to affect the density of planting. Almost all the literature on tree-understory relations shows that, as shade from the trees increases, forage and browse understory decreases. FAO (1981) has an excellent publication on tree-planting practices in African savannas.

Controlling Undesirable Plants

Control of weeds and undesirable woody plants usually starts with some sort of land clearing. This may range from 1 m^2 cleared with a hoe for the planting of one tree to large, extensive clearings.

Fire is a valuable tool when clearing woodland for the first time, but care must be taken to avoid damage to valuable woody plants. Sometimes it is possible with a little hand-clearing to remove fuel materials from the immediate vicinity of planted trees so that a light fire can safely reduce debris. Light fires when the soil is moist have the least effect on seeds, established grasses, and trees. Grazing may take the place of fire if the planted trees are unpalatable, as are teak, the palms, and most conifers. Trampling damage to trees will be light provided overgrazing of the more palatable species is avoided. If the plantation trees or shrubs are palatable and browsed, such as *Atriplex* spp. and *Acacia albida*, they will need a growth period without fire or grazing to allow plant establishment. Even after they are established grazing must be carefully managed.

Chemical control of woody plants was common for three decades following World War II, but recent reactions to adding herbicides and pesticides to the environment have reduced their use. In addition, chemicals are too costly for the small-scale farmer. The preferred methods of plant control in the arid and semiarid tropics are mechanical — fire and the grazing of animals such as goats and certain game species that browse on the woody species. Browsing by goats increases the effectiveness of fire because they trim the canopy of individual bushes so that grass grows within and under the shrub canopy. This places a source of fuel, and therefore heat, near the woody stems.

Fertilizing

There is little doubt that fertilizing increases growth rate and production. However, it is doubtful that purchased fertilizers will return their cost. Certainly the expense is too much for the village farmer. Other means exist to increase nitrogen in the soil, such as using manures and planting legumes. The combination of a legume and *Rhizobium* bacteria on the roots allows the fixation of nitrogen from the atmosphere — part is used by that plant and part becomes available to associated plants. For example, millet and other food crops are grown under the canopy of *Acacia albida* in the Sahel region because of the fertilizing effects of the nitrogen from the tree. Unfortunately, a number of herbaceous forage legumes that improve the soil do not do well where the annual rainfall is less than about 500 mm.

Nitrogen fixation is the conversion of elemental nitrogen (N_2) to forms that plants can easily use for their biological processes, such as growth and reproduction (see nitrogen cycle in figure 4).

Problems

Agroforestry is regarded favorably in the developing world in spite of the fact that large-scale forest plantations have seldom provided much benefit to villagers. In fact, a strong trend to plant trees at the village and small-farm levels has recently developed (FAO, 1982). The demonstrated successes of multiple cropping and the economic benefits, though small in scale, ensure continuing interest and support for development projects that include agroforestry. However, it is dangerous to assume that agroforestry is free of problems. Here are four types of problems that cause failure.

Sociological Problems

Social acceptance of new farming and grazing practices is foremost — people hesitate to change their ways. Some land traditions do not permit land ownership or private investment in land. When possessory rights prevail (whoever occupies the land owns it), there is little assurance that the person who planted a perennial tree or pasture crop will be in possession of the land when it is time to harvest the crop. Some cultures have tree rights, which allow individuals to own trees; to be the sole harvesters of leaves, fruits, bark, and twigs; to even cut the tree down. This tradition of tree tenure causes difficulties in establishing large plantations but can be helpful in establishing and protecting a few trees on a small farm.

Another problem concerns ownership and labor. Most forestry practices in developing countries are labor intensive. Often local labor is difficult to find because there is no motivation to do extra work. Another labor problem occurs when the designation of someone as crew foreman or labor supervisor — thus a person with power — conflicts with long-established village governance. Two sets of leaders are not tolerated for long. This situation may be avoided by selecting a community leader for such a position; however, this doesn't fit into established customs either, and still may cause a problem.

Development activities have often been less successful than anticipated because there was no understanding or consideration of the role of women in the societies in which the activities were being implemented. Activities during the last decade, such as the international conferences on women, have pointed to the vital role women play in agriculture in developing countries. The role of women both in ownership and as a labor source must be evaluated more carefully.

There are many other sociological problems. Since wood products from a small farm may not bring full price, too much wealth moves from the place of production into population centers and the hands of dealers. In addition, water rights, erosion, use of fire, ineffective marketing, poor transportation, and religious customs all affect successful development in agroforestry.

Silvicultural Problems

Uncertainties relating to the development and care of forests (silviculture) constitute another group of problems. While nonfodder trees such as teak, coconut, rubber, oil palms, and radiata pine have been grown in tropical plantations for decades, only a few have been spaced far enough apart to leave room for food crops and forages. Encouragement of agroforestry requires information that does not exist on species combinations, tree spacing, land preparation, and tree thinning and pruning. This lack is on humid areas where forests have been grown and harvested for a long time. Most of the screening of species for forests in humid areas has been for wood, pulp, and single products (for example, rubber), not for agroforestry purposes. Very little silvicultural work has been done with fodder trees and shrubs that might be used on small farms and special sites in the arid and semiarid zones.

Food and Fiber Crop Problems

A third family of problems involves food and fiber plants that will grow with trees. Two characteristics of crops on small farms that are obvious but often not considered by planners: 1) If rows exist, they are crooked, and 2) with few exceptions (rice is one) several crops are growing together.

The improvement of multiple cropping on arid and semiarid rangelands in the tropics has been overlooked to a large degree. Species and varieties of food and fiber crops in the developing countries of the tropics and subtropics are exceedingly numerous, but few have been improved through research.

Animal Forage Problems

Culture of forages is the least well known and the most controversial of the triumvirate — food crops, forage, and trees. Domestic animals commonly feed on *Cynodon*, other weedy grasses, and perhaps the legume *Medicago* in many tropical palm orchards, but the grasses are extremely difficult to eliminate. Sometimes fodder trees have been planted and protected in the Sahel until they were beyond the reach of animals. In temperate regions, grazing in conifer forests is decades old but one still hears the argument that animals destroy trees, which they do. Unfortunately, seldom does anyone point out that the benefits of **proper** grazing far outweigh the few trees lost. Yet, the grazing of forages in pine plantations in New Zealand, Australia, the United States, and other countries has shown that trees and forages profitably complement each other.

Tropical and subtropical pasture legumes have received effective research attention in Australia, where numerous species have been tested with grasses. None of the legumes and few of the cultivated grasses show sufficient tolerance of shade for planting under a tree canopy. This problem needs research. Where cultivated crops are in rotation with pastures and trees, the forage species must be easily eliminated so that they do not compete with the crops. Most grasses that are now used or that come in naturally are not easily eliminated. This is another research problem — and there are many more.

Principles Learned from Experience

Experience with grazing in an agroforestry context has provided some widely applicable principles. Among them are:

- Proper grazing can reduce weed and grass competition with young trees.
- The timing of heavy and light grazing largely determines the degree of damage to trees.
- Domestic animals generally avoid grazing conifers and some other tree species, especially if they learn that they don't like these species by eating the older foliage.
- Grazing reduces grasses and weeds, thereby reducing the fire hazard to planted trees.
- Agroforestry practices can best be applied in areas with rainfall above 400 mm and where some crop agriculture is being conducted or the stockmen are somewhat settled.

The growing body of experience justifies emphasis on agroforestry with a grazing component for projects in developing countries. The subject is complex, requiring attention to natural systems with many types of crops rather than to the culture of single crops with little attention to reactions in other parts of the system.

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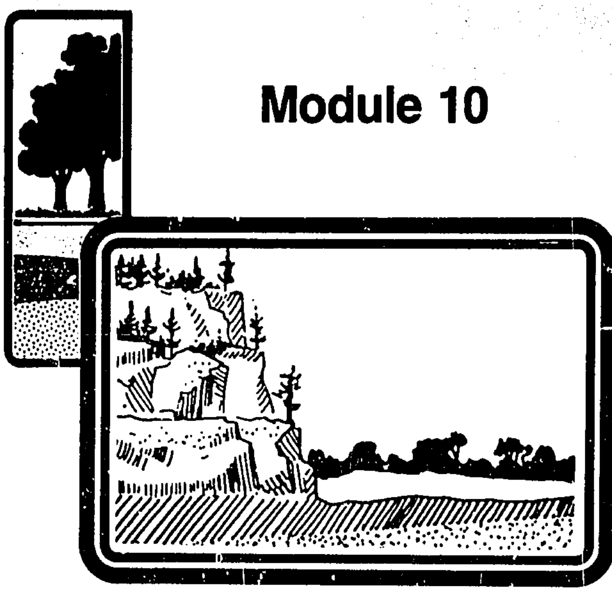
Module 10



Mining

Mining represents an entirely different natural resource, a nonrenewable resource. Mining development is truly exploitive — whatever is removed is not replaced.

The major concerns in development and management of mining operations are the timing and manner of exploitation, what the country does with resulting products and cash flow, how waste products are managed, and how skillfully society and the mining industry deal with environmental impacts and side effects.

This module is not concerned with any of the technical aspects of mining. Those considerations are specific to each kind of mineral exploitation, and are for the geologists and mining engineers. Rather, the concern is with maximizing the complementarity of mining with other rangeland uses and minimizing the adverse effects of mining on rangeland areas.

Mineable products range from petroleum to hard and precious minerals, coal, building materials, and gemstones. However, groundwater resources and nonreplenishable (fossil) water should also be included in this list. The users and managers of rangeland resources, as well as agriculturalists, foresters, and industrialists, are intimately involved with these mineable water resources.

Many of the activities of range managers, agriculturalists, and foresters affect watershed qualities and thus the quality and amount of groundwater recharge (surface water that replenishes the groundwater store). All resource users at one time or another drill wells to tap and use groundwater. The care with which this is done affects the permanency and often the quality of the groundwater resource. For example, drilling and pumping wells near the oceans may allow saline water to intrude and contaminate the groundwater, or industrial activity on the surface may pollute the groundwater. Surface activities often use or transport free-flowing water and prevent recharge. In other cases, fossil groundwater may be exploited for agricultural development with long-term detrimental impacts as the water reserve is depleted.

Saline or highly mineralized water may be pumped to the surface and used for irrigation or industrial purposes that, in the long run, have adverse impacts. In other instances, soil drainage that is essential in many arid-region irrigated projects is concentrating salts and sometimes toxic minerals with extreme and worrisome consequences to bird and fish life — and potentially to humans.

In recent years "reverse mining" has been used to deal with petroleum and some minerals and toxic wastes. Reverse mining is simply pumping these wastes back into the ground for storage. Abandoned mine tunnels or wells have been used for such storage. Another option is to dig a large pit down to an impermeable layer and to fill it with these wastes. This returns those useless fractions of previously mined resources that hold substantial risk for human, animal, or plant life.

Impacts from conventional and reverse mining are not limited to the earth's crust and soil, ground-, and surface water. Extractive and refining industries and many manufacturing industries are producing by-products that have serious consequences when released into the air, onto the ground, or into surface streams. Many of these consequences of mining, industrialization, and agricultural production were not and perhaps could not have been anticipated.

There is still time for the developing world to avoid many of the mistakes that have been made by most developed countries. Fortunately the industrial nations are developing techniques for detection and avoidance of environmental impacts, and safe waste disposal.

Issues for the Developing Nation

Mineral resources represent a great potential to create cash flow and foreign exchange for any developing nation fortunate enough to have a reserve. These resources can be exploited and the returns used for immediate needs or they can be budgeted against other important human and resource-development needs for which the country otherwise has inadequate resources. This tactic can create some long-lasting benefits from an otherwise expendable resource. However, potential returns from mineral exploitations are overcommitted for short-term wants and developing nations can create serious financial problems for themselves, as some developing nations have learned in the handling of their petroleum resources.

Environmental legislation and directives in the developing nations should be carefully thought out, independent of the patterns that have developed from emergency conditions in the industrialized world. Instead of blindly following these patterns, they should apply what these industrial nations have learned toward developing a strategy for dealing with the problem before it becomes apparent.

Guidelines for Planning Mining Programs or Projects

Guideline

The advance analysis of side effects and potential environmental impacts is essential in planning for the development of both renewable and nonrenewable resources. The theme should be prevention of adverse environmental impacts by advance planning. Developing countries have the potential for the same problems that have plagued the industrial world. Therefore, it is critical that development projects be structured to take this potential into account. The time to anticipate adverse side effects and to make provisions to either prevent or minimize them is when the project is being planned. Monitoring especially should be designed to detect these kinds of problems.

These preventive and mitigative measures should either be amortized against the profits from development, whether in renewable or nonrenewable resource areas, or they should be shared by the population as a whole depending on the breadth of benefit from the project and the relative costs of prevention in relation to potential revenues.

There are cases where an otherwise viable development or exploitation program cannot stand the whole cost of impact prevention and mitigation — even though this would probably be cheaper than the option of disregard and eventual clean-up. Either the country and the people need the development and should share in the cost, or they don't need it.

Guideline

The environmental legislation and directives under which mineral wealth is exploited should be very carefully thought out so that they are neither unnecessarily restrictive nor inadequate.

Rational, unemotional analysis is necessary to wisely protect environmental values while developing natural resources. The main reason that the industrial world has been caught up in extreme environmentalism is that it did not anticipate the problems that have now become very serious. For various reasons — carelessness, unconcern, and ignorance — these countries did not initiate prevention tactics until they became ensnarled in extremely serious and expensive clean-up programs. The developing world can benefit from this lesson.

When drafting environmental legislation and regulations, remember that the concept "to restore to the original" is not usually biologically and economically feasible. The goal should be to restore a protective cover and the highest level of production that the new growing conditions of the new ecological site are capable of sustaining. In East Germany, for example, some highly productive irrigated pastures and high levels of dairy production are on restored strip-mined spoil areas that were formerly forested. It was recognized that restoration of the forest was not feasible.

Guideline

In planning for specific mineral- or water-exploitation projects, many of the requirements for impact assessment can be met by adding a capable resource ecologist or range-rehabilitation expert to the planning team.

The decisions about protective measures and exploitation technologies that are less damaging to the environment are specific to resource type, location, and surrounding ecological conditions. Therefore, the most rational way to handle these matters is to plan right from the outset, and to have the proper capabilities represented on the planning team. This makes much greater economic sense than later investing huge sums in environmental analysis and impact statements as a separate function.

Guideline

Normally the three most serious environmental problems associated with mining are 1) mine spoil deposits and their reclamation, 2) prevention of seepage of leachates into streams and groundwater from spoil dumps and processing plants, and 3) reclamation of disturbed areas. It is possible to plan in advance for the solution of all these problems.

The details of what to do are site and project specific but the following are generally successful actions.

Select proper sites for spoil dumps. These should be diked, and either the soil should be sealed before use or the dump should be located on clays that allow very little leaching. This may mean transport of spoils but such costs, if anticipated, can be minimized and should be less than those required for a subsequent cleanup.

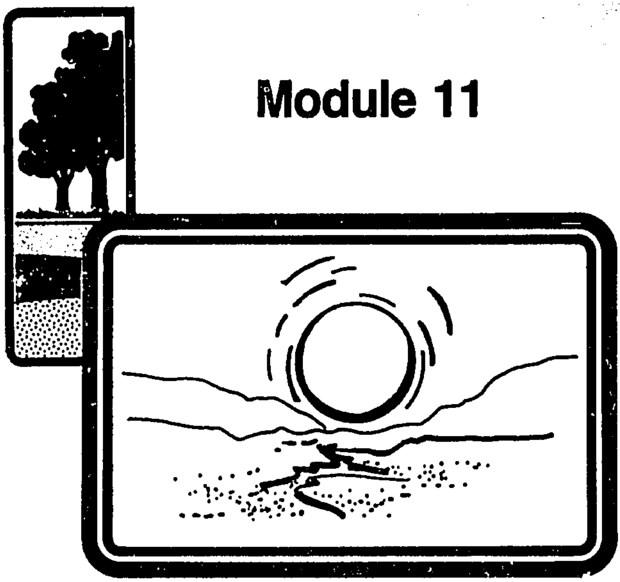
Mine spoils are sometimes reprocessed as extraction technology advances or as prices of specific minerals change. Some of the costs of site preparation should be recoverable in this event. In any case, site preparation should be looked upon as a cost of operation.

The reclamation of a spoil area requires first the recognition that it is now a new environment, which cannot be returned to its original condition. The goal is to find a way to realize a benefit from reclaiming these areas, as compared to leaving them in a raw state. The technology available to achieve these goals includes 1) screening and selecting plant species to use in stabilization (choices may be few but may include grasses, forbs, shrubs, and trees) and 2) using mechanical treatments such as terracing and adding fertilizers or soil amendments to improve the soil as a medium for plant growth.

In open-pit mining, one of the most important steps is removing and storing the overlying soil (overburden) so that it can be returned after mining, thus allowing plants to grow back. Special soil treatments and amendments may be required for successful establishment of a plant cover.

In some cases open-pit mining will produce deep rock faces and surfaces that simply are not practical to revegetate. Then it is best to be content with the natural successional process, which will eventually restore some kind of plant cover to part of the area. If the moisture, temperature, and growing-season duration are adequate, natural ecological restoration may eventually be total, with few adverse environmental impacts when viewed in light of the value of mineral wealth extracted.

Selecting and implementing these measures is a planning job in itself, but must be done at the time the exploitation plan is developed. If both plans are developed together, it may be possible to opt for extraction technologies that minimize the rehabilitation problem. If the planning is done separately, a prior mining-technology decision may lock rehabilitation into a very expensive alternative.



Module 11

Coping with Drought

Drought is a constant threat in arid and semiarid rangelands. Losses from rangelands are high and in some years calamitous. During severe droughts more than one-fourth of the livestock may die; overall production is reduced still more. Immense hardship, suffering, and death among the human population is common where drought results in famine, as has recently been the case in many parts of Africa. Besides other damage, droughts seriously interfere with development programs, normally because development programs don't take into account the fact that drought is a recurring phenomenon. It is therefore surprising that drought has not figured more in the planning of rangeland development.

Numerous definitions of drought were given by a working group of the World Meteorological Organization (1975), but none was considered universally acceptable. One of the definitions of a severe drought vividly described it as a period of months or years during which little rain falls, "the country gets burnt up, grass and water disappear, crops become worthless, and sheep and cattle die." Other definitions have been expressed in complicated mathematical formulas. Central to virtually all definitions is the notion of a substantial reduction in the amount of rainfall and its distribution throughout the growing season (rainfall effectivity). Effectivity of biological systems is a function of solar radiation, temperature, humidity, and wind. Due to the influence of solar radiation and temperature, effectivity of rainfall in the tropics is much lower than in temperate climates. It is also sharply reduced when individual rains are very low — in which case most of the water is normally lost to evaporation.

From the standpoint of agriculturists and the pastoralists, drought is abnormal dryness that causes a pronounced decrease in crop and forage yield relative to what is expected in the average year. The decrease in forage yield, for example, would be enough to increase animal mortality, reduce or stop animal growth or cause weight losses, and lower the rate of conception. These types of interactions between drought and agricultural production led Sandford (1978) to define drought as "a rainfall-induced shortage of some economic goods (e.g., livestock feed) brought about by inadequate or badly timed rainfall." Clearly what is implied by Sandford and others is that drought must be judged in the terms of its effects or consequences (impact) as much as by its causes. This means that as ways are found to ameliorate the effects of drought, drought per se will be less severe.

Rangelands vary markedly in drought susceptibility. Differences may be influenced by vegetation, topography, soils, and geology, as well as by grazing practices. Furthermore, impact of rainfall deficiencies will vary among animal species and management practices. These are therefore important considerations in defining and coping with drought.

Issues

The central issue to be considered in relation to drought is how to plan for reducing the risks, or minimizing the damage. Because droughts may affect the whole society, this is an issue that must concern governments, pastoralists, and the general public.

In approaching the problem, it is necessary to consider the basic factors influencing drought. These include rainfall characteristics, soils, vegetation, and animals and human elements that influence the impact that rainfall may have on the pastoral systems.

Rainfall Characteristics Influencing Drought

The severity of drought is a function of amount of rainfall actually infiltrating the soil. Total rainfall in most cases is a good index for infiltration although far from accurate, as explained later. Very light rain may evaporate without affecting plant growth. More seriously, high-intensity showers, quite common in arid and semiarid rangelands, often result mainly in runoff. Geographical distribution of rainfall is also critical. When rainfall is strongly influenced by convection (vertical air movement) due to surface heating (as in arid and semiarid regions), it tends even in normal years to be irregular and spotty. During severe droughts rainfall is deficient over relatively large areas and is less affected by local features. During less severe droughts, however, rainfall may vary considerably within the area affected by drought. The persistence of the drought-producing features ("meteorological abnormalities") determine the duration of drought, which may be several years.

It is, as Sandford (1978) points out, most important to know the frequency and severity with which drought is likely to occur. This amounts to an estimate of the likelihood of a drought of a certain magnitude occurring during any particular year. The main value of such a calculation would be to give an indication of the kinds of preparations that could logically be made to reduce the impact of drought, and to some degree justify the standby costs that would be required. Data for this comparison are often not available.

Soils and Drought

Soils vary greatly in the rate at which they will absorb rainfall. For example, heavy clay soils will absorb water at much slower rates than will sandy soils. Water-holding capacity, however, is higher in the clay soils, but a smaller percentage of the water is available to plants. Clay soil surfaces are easily sealed by raindrop erosion, and compaction by animals can further reduce infiltration rates. This is not the case in sandy soils.

Depth of soil also strongly influences how much water will be absorbed. Slope of the soil surface is of particular importance because it influences both runoff and erosion.

Vegetation and Animal Responses to Drought

The composition and structure of the vegetation may influence the degree of drought damage to the vegetation and the associated animals. For example, mixed types of shrubs and grasses are likely to withstand dry conditions better than more uniform grassland types. This is because the root penetration among the grasses and shrubs varies, and so there is less competition for the same moisture, and many shrubs stay green during the dry season. Partial shading by the shrubs may also improve the microclimate for the shorter grass and forb species.

Further, in a mixture of vegetation species, the less palatable species can serve as a buffer against starvation — the animals will graze the most palatable species first, saving the other species for later in the drought. If this is combined with an appropriate stocking rate, it is possible to achieve uniform production of animal products even with wide fluctuations in rainfall. For example, in Australia a range with a combination of bluebush *(Kochia)* and an annual *(Stipa)* has given uniform wool production even though the average rainfall is but 200 mm per year. When it rains, the *Stipa* grows and the sheep live on it. When it doesn't rain, the sheep live on the bluebush. But this is possible because the stocking rate is controlled at about 15 ewes and their lambs per square mile. With heavier stocking, the bluebush would not persist.

As drought intensifies, the food requirements of individual animals and their ability to meet those requirements become increasingly critical. Their requirements may be influenced by size, physiological state, activity, and other factors; ability to meet these may depend on how often the animals need water, their ability to travel, their range of acceptable diet (especially their ability to eat coarse material of low nutritional value), their ability to select what little quality feed might be available, as well as a tolerance of the environmental stresses associated with drought, such as high temperatures. Some animal species survive drought much better than others; among the best survivors are camels and goats, along with various wild ungulates. For further details on these relationships and the related management issues that are basic to coping with drought, see Child et al. (1984).

The impact of drought is greatly influenced by human activities. Indigenous people have over the centuries developed practices that have furthered their survival. Keeping a predominance of female animals for milking and quick rebuilding of the herd following drought are common practices. Having as many animals as the family can care for has also been considered important to assure that at least a nucleus would survive a drought. The practice of keeping a variety of species with different capacities for drought survival is also a form of insurance against total loss. Lending animals to other herders improves the likelihood that all the animals will not be equally stressed by drought. And of course, mobility continues to be one of the most important means for reducing the impact of drought.

Planning a Strategy To Cope with Drought

Recent increases in human and animal populations threaten what balance may have prevailed under less intensive conditions, increasing the environmental stress associated with drought. At the same time, the infrastructure, marketing, supplementary feeds, and other features necessary for management are generally not adequate. Serious problems can arise from this combination of factors. For example, people in more remote areas are often dependent on some form of drought relief (food, supplies, etc.) until their crops can produce again. But when the rains finally come there is increased runoff and flooding because large areas of bare ground have been left by the drought. This flooding damages or interferes with the transportation systems providing the people with emergency supplies.

The best strategy for coping with severe drought is learning how to cope with less severe, more regional droughts, which are less spectacular but more frequent. Because the small droughts are more numerous, their economic consequences are as important, possibly more so, than those of the extreme droughts. Further, something can be done to reduce the impact of smaller droughts, whereas the severe droughts demand relief actions more than anything else.

A strategy for coping with drought should include taking advantage of good years to meet the problems of poor years. The particular aspects that relate to rainfall-deficient years should therefore fit into and be an integral part of the overall range-development plan. However, during severe droughts that may extend beyond the rangelands, mobilization at top levels for coordination of international assistance would be essential.

Climate and Drought

Within each climatic region, an estimate should be made of the probability with which droughts of various intensities might be expected to occur and what the associated consequences would be within the various ecological regions of the country. Identification of zones of distinct rainfall patterns and their different susceptibilities to drought is essential. Through this information the more critical zones will be known and complementary relationships can be identified. Some of the approaches that would have relevance are described in the World Meteorological Organization (WMO) technical note (1975), and in the Proceedings of the Symposium on Drought in Botswana (1978). The agroclimatological studies carried out by FAO and WMO in the Near East, West Africa, and East Africa are also helpful.

Predicting Drought

Although much effort has gone into studies to try to learn how to predict droughts, no satisfactory method has been found. Atmospheric circulation patterns associated with drought are understood, but they cannot as yet be anticipated. Some progress, however, has been made in making forecasts up to 30 days, and these have some limited utility.

Early Warning

The advent of drought requires immediate action to reduce the demand for animal feed (by moving or reducing animal numbers) and to find other sources of feed. An early response permits a more gradual transition and reduces the level of the crisis compared to that which occurs when action is delayed until the full force of the drought is felt.

The possibility of early warning rests on the fact that rainfall and forage growth follow somewhat regular patterns. Any marked departure during the early part of the pattern makes it more likely that the pattern as a whole will be affected. For example, suppose that in a given area rainfall normally occurs during May, June, and July with average amounts of 150 mm, 200 mm, and 90 mm, respectively. If in a particular year rainfall in June amounts to only 50 mm, the likelihood of achieving the 440-mm norm is significantly reduced. If by the middle of June only 50 mm more fall, the likelihood of a significant shortfall is further increased. When combined with observations on the available forage, the validity of this approach is further increased. If the deficiency in rainfall was widespread, a substantial seasonal shortage could be anticipated.

If the data required for the early warning were used only to anticipate drought, gathering it might be too expensive relative to the benefits. However, knowing the state of range production is essential for management during all years, good or bad. In fact, the best possibilities of improving the range and optimizing production may occur only during the more favorable years. Therefore the good years should also be anticipated as early as possible in order to take maximum advantage of them.

An early-warning system requires an adequate network for data gathering and sufficient long-term observations so that esti mates of variability can be obtained. The network may pose problems of cost where there is a high rainfall variability because the greater the variability the more observation points are necessary. Nevertheless, such a system provides a rational approach to both grazing management and coping with drought. For further discussion of information gathering and use, refer to the papers by Lee (1978) and Wily (1978).

Remote-sensing data from satellites can show rainfall distribution and vegetative cover. If correlated properly with ground data, this method could vastly increase the area sampled and would be much cheaper than full ground sampling. Indeed, this is a case where the most advanced technology is the one that can do the job properly.

Irrespective of methodology, appropriate action, based on results from an early-warning system, must be taken promptly. One of the first steps would be to inform pastoralists, governments, and others concerned. As drought intensifies, both the movements of animals and feed, and the need for marketing and slaughter increase. As conditions worsen, further nutritional surveillance of the affected human population would be desirable in order to use the food available in the most effective manner, e.g., to help the most vulnerable part of the population (Kreysler, 1978).

The importance of contingency planning for severe droughts is a clear but often unfulfilled need (Wily, 1978). Wily reviews in some detail the efforts that have been made in Botswana to develop an appropriate organization to cope with the drought problem.

Balancing Animal Requirements and Forage Supplies

Finding a balance between forage and animals that will achieve production goals and be economically feasible is a complex endeavor, complicated by enormous spatial, seasonal, and annual variations in forage production.

Variations in resource availability from one place to another may be the easiest to cope with. A good assessment of the basic resources will show the important variations in cover, composition, susceptibility to drought, water distribution, etc., throughout the year. Having information on the cover will make it possible to classify and group similar ecological types and to estimate forage productivity from year to year. Additionally, this information is needed for determining and managing the most suitable combination of animal species (Child et al., 1984). Very few critical studies of diverse animal species have been done to develop criteria for deciding on the best combination. Nor is the importance of diversity of plant species in the diet fully understood or appreciated.

The key to dealing with seasonal variation in forage availability is to have enough feed to get through the dry season. Among pastoralists, the most common solution is migration or transhumance to find fresh grazing. Where moving the animals is not possible, controlling grazing during the rainy season to carry forage into the dry season is recommended. This practice also helps to prevent overgrazing during the growing season.

Browse species are grazed mostly during the dry season. A good seasonal balance can be achieved if these species are properly managed. Browse is also extremely useful during droughts, as are other species that are not acceptable to the animals except when they are under stress.

Migratory and transhumant movement may have prevented excessive stress on the animals because there were smaller numbers of animals and more range area. It has become more important, even in subsistence systems, to reduce animal requirements before the dry season. Where rangelands are used year-round, animal requirements are commonly reduced by allowing lactating females to go dry (e.g., weaning), rationing feed according to critical needs, and culling and selling surplus animals. A principle often applied by commercial ranchers is to structure the herd so as to permit a sharp reduction in feed demand even during the growing season, and to keep animals that can endure for a considerable period on rations at or below maintenance requirements. This is essentially what cow-calf operations do in the western United States (but they can do it only because there is a market for weaned calves).

Many times the stocking rate is simply too high — excessive weight losses occur during the dry season and poor reproduction is the rule during normal years. Under these conditions even droughts that would otherwise be considered mild may have disastrous results. Remember, coping with drought mainly involves developing a system of management that includes drought as a variable.

Planning to achieve a balance between livestock requirements cannot be done without adequate information, such as:

1. A good description of climate and weather variations. To the extent possible, data and maps should be related to the ecologic assessment in point 2.
2. Distribution of the principle types of vegetation with a good description of their composition — especially as to edible shrubs and grasses; information on soils relative to rainfall-infiltration characteristics and fertility would also be valuable. This would help in determining the drought susceptibility of areas, their suitability for various species, and possibilities for intensive improvements (such as seeding of

browse or improved grass species for haymaking, etc.). In some places, areas for making hay of native species might be found.

3. Distribution and numbers of animal species — domestic and wild — related to the vegetation type as much as possible. This is essential to estimate how appropriate the composition of animal species is to the environment (particularly in regard to nutrition).
4. A description of seasonal forage use — specifically an inventory of the amount and kind of forage available at the end of the growing season. Monitoring of forage use should be an ongoing process and be combined with the monitoring recommended for early warning of drought. In each case, the monitoring units should report information based on the principal vegetation types.
5. An assessment of the production systems to identify those characteristics that respond in a positive or negative way relative to drought. This should include types of production, selling practices, movement of herds, etc. This kind of information is crucial because it identifies where adjustments should be made.
6. Identification of the most feasible ways of reducing the amount of forage required to support the herd before the dry season and as soon as drought appears probable. Only if regular and appropriate reductions are made in relation to the dry season can there be real prospects of getting action to meet drought threats. Sales, culling, weaning, and cessation of milking are some of the alternatives.
7. Identification of ways and means to increase feed supply during dry seasons and during drought. A broad, diversified approach is needed here. No single solution is going to meet the needs. Some of the possibilities that should be considered are creating grazing reserves; planting shrubs, or other plants suitable during the dry period; establishing small irrigation schemes, water-spreading areas, etc., within the range area specifically to provide reserves as in the form of hay; and integrating livestock with crop farming to encourage the sale of young stock to farmers for growing to market size.
8. Assessment of the adequacy of the marketing system and the infrastructure to facilitate the action required. Adequacy of slaughterhouses and storage is particularly important where large numbers of animals are coming to market in a short time.
9. Identification of the practices of pastoralists that help to reduce drought risks for the community as a whole and where practical, incorporation of them into the plan.

10. Assessment of the existing government policies and institutions from the standpoint of their capacity to effectively carry out a range program that can cope with the normal dry season and drought of various intensities.
11. Determination of what additional policy, structure, coordination, etc., are needed to reduce losses of animals and people and to use international or other aid most effectively during severe droughts. Existing policies that lead toward the attainment of long-term goals should not be abandoned in the urgency of a severe drought. This is perhaps more of a political than a technical task, but it should not be overlooked.
12. Caution when deliberately expanding livestock numbers and cultivation in years of abundant rainfall — natural increases will likely occur anyway.

Drought is part of the environment. Its effects on the range resources cannot be realistically separated from other considerations that involve management of those rangelands. Nor can range management or range development have much significance unless coping with drought is an integral component. Planning to lessen drought effects must be done within the context of overall range development. Any other approach will assure the perpetuation of the catastrophes witnessed during recent years.

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SECTION II

GUIDELINES FOR NATIONAL/REGIONAL SERVICES DEVELOPMENT

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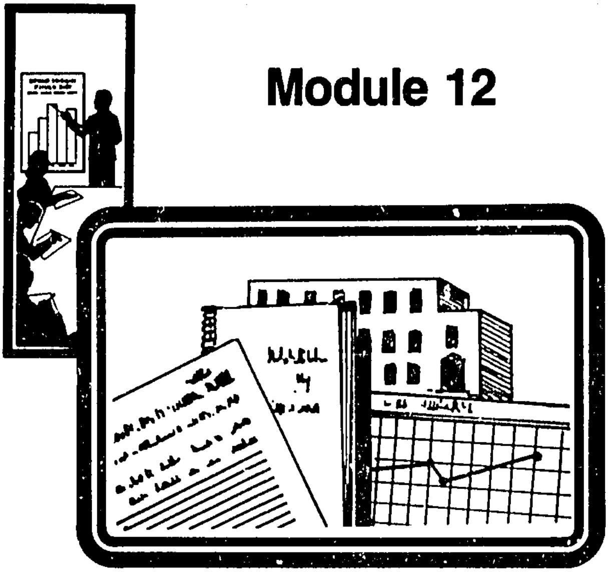

Module 12

Government Policy and Service Institution Development

In developing countries there are few institutional organizations responsible for meeting the needs of rangeland development and management. This is in large part due to the complexity of rangelands, lack of appreciation of their importance, and lack of staff trained in range management. As a result, there are still gross inadequacies in the institutional framework in most countries — programs have been developed in a piecemeal manner, often focusing on individual parts rather than the whole rangeland system. In order to improve programs and make them more coherent, much more attention must be given to creating the essential institutional framework.

On the positive side, the problems and needs of rangelands and their peoples, along with national needs, are now understood much better. Furthermore, an increasing number of trained staff are becoming available.

The first step is to formulate an appropriate government policy. This may at first be primarily a statement of objectives and guiding principles in relation to rangelands. Most especially there is the simple need to recognize the importance of rangelands and express the intention to develop programs. With the accumulation of experience, the policy issue may become progressively more specific. At whatever stage, policy needs to be formulated with great care.

Policy cannot be implemented without the authority and definition of responsibility provided by legal regulations. On the face of it, setting up such regulations might seem relatively simple. However, complications arise because of the way and the order in which agrarian institutions have developed. Overlapping responsibilities and divided authority are common. Effective range organization may require modifying existing regulations as well as creating new ones. Also, responsibilities shared among institutions will need to be carefully defined.

Issues

Rangeland policy, regulations, and institutions set program direction and establish authority and responsibility for formulating and executing programs and projects. Together these elements constitute the framework for rangeland conservation and development.

Too often the institutional framework does not provide authority and scope appropriate to the problems to be coped with. An example of the interrelationships that must be addressed: A policy of grazing control is useless unless it can be enforced; it cannot be enforced unless the pastoralists support and participate in the enforcement; that is not likely to happen unless they know very well the advantages of such control; and this would depend on a technical staff to do research, training, and demonstration. Such interconnections are so common that it is probably fair to say that few institutions have to deal with as wide a range of issues as do range institutions. Further, these issues depend strongly on the active cooperation of the people, so that few of them can be resolved neatly in a laboratory or through edict. Some of those issues are described in this section.

In developing countries, the population is growing at a high rate — particularly in Africa south of the Sahara, where it exceeds 3%. Growth in urban communities is even more extreme — 5% and more in many places. Rapid changes must be made in production if it is to support this exponential population growth.

On rangelands the need to get more from the land causes an increase in the number of animals and a shift toward crop cultivation. On these lands heavy stocking leads to a reduction in forage and browse plants, and in time produces a less desirable cover. The effective use of rainfall is also impaired and sensitivity to drought is increased. Crop cultivation on the better range areas puts further pressure on the remaining range. Where the land being cultivated is too marginal for continuous cropping, the effect is even more negative.

In view of the inherent limitations of rangelands and the existing stresses, the key question becomes: How can they contribute more — or in a more effective manner? Clearly, this may involve substantial changes in the existing production systems, much more integration and stratification of production, better marketing, research information, etc. Because there is no time to lose, strong range policies and effective institutions are needed.

Another issue that needs institutional support and systematic attention is research. Research would allow planners to know with some precision what is happening to rangelands now. Despite clear evidence that range productivity has sharply decreased and composition of the cover changed through overgrazing in many parts of the world, questions remain about what happens in other places. For example, serious doubts have been raised about whether or not significant reductions in range productivity and conditions have occurred in some parts of Africa after years of heavy grazing. As long as the question is unresolved, control of grazing will be difficult to justify, and policy dealing with control will waver.

Similarly, it is frequently said that subsistence production is as efficient as and can support as many or more people as can modern production systems. If this is true, why is it? Is it due to the greater use of milk, the combination of animal species, or what? This is a complex and critically important problem that may strongly influence development directions and therefore needs serious study in the near future.

The feeling that pastoralists are excellent stockmen, while no doubt largely true, may have inhibited critical studies to find out how well their systems actually work in the current situation and how they could be improved. Clearly, many issues can only be resolved by an adequate research organization, oriented to the solution of critical problems that have strong policy implications.

Products available from rangelands have generally been thought of as solely domestic livestock products. The importance of other "products" such as water, wildlife, recreation, and forestry have often been ignored. Also the concept of range as a system and the advantages of multiple use have been largely ignored. This has been reflected in institutional structures — which have given undue weight to such ancillary activities as animal health, water development, marketing, etc. This orientation has delayed development of a more appropriate organization. Moving toward a more system-oriented organization may require policy changes and reorientation of existing institutions.

All semiarid and arid regions are plagued by periodic droughts. Not infrequently they occur several years in a row. In addition to causing livestock losses and human deaths, droughts increase poverty, force migrations, create refugees, and generally disorganize the life of families and communities. By causing a temporary reduction of stock on range areas, drought may provide some opportunity for range recovery, but at a frightful cost. Drought cannot be foreseen or avoided. Its impact, however, can be reduced substantially if appropriate measures (as outlined in module 11) are taken.

Pastoral people in many developing countries have within the last few decades been subjected to a lot of changes over which they have had little or no control. Among those changes:

reduction in the range area available to them, increasing size of the human and animal population, water developments, reduced primary productivity, fixed prices, and occasional technical assistance. They cannot cope well with these types of change, either individually or through their traditional organizations. Governments would like pastoralists to contribute more to the common welfare, and want to bring them into active participation in the socioeconomic aspect of national life. At the same time, there has been a reluctance to involve pastoralists much in decisions that affect them.

It is apparent that clear policy decisions must be made and institutions built so that pastoralists can be prepared to deal better with their own problems through training, participation in planning, etc., and to make modifications in their production for the common good.

Program and Project Development Planning

The issues identified in the previous section relate to the functions of range institutions, as well as to the responsibilities they must assume. The functions are briefly set out below.

Represent the needs of rangelands and the people dependent on them. This function is important to the general public as well as to the government as a whole. Too often rangelands and their people are ignored even though they are important to the country.

Define a national strategy for rangeland development. The value of individual projects is severely limited unless they fit into an overall strategy. This is not to minimize the importance of individual projects — especially as means for developing methods that work. But a strategy should fit the individual efforts into a larger picture, and help to establish priorities. This is especially true of range development because of the huge areas involved and the complex interrelationships.

Provide for the participation of pastoral people in the planning and implementation of pastoral development at all levels. Even if governments had the resources, they could not do what needs to be done without participation by the pastoral people involved. This participation should include training pastoralists and designing range programs that blend in with traditional land-management practices.

Provide the continuity essential in range development, through long-term programs and projects and monitoring, to identify changes needed. Lack of continuity is no doubt one of the main reasons for poor results from range projects.

Establish the standards and coordination needed for an effective national range management program. Isolated and disconnected efforts are costly and not very effective. This applies especially to resource assessment, education and training, research and extension, and the formulation and execution of all projects.

Identify management units for development activities. This must take into account such diverse considerations as natural affinities among the peoples involved, migratory routes, land area, ecology, water, infrastructure, and socioeconomic factors.

To carry out the above functions a clear designation of responsibility for rangeland management is needed. Such responsibility cannot be diffused over several agencies. Cooperative arrangements may be acceptable and necessary, but one agency should clearly have major responsibility and authority. This is consistent with the view that rangelands must be conceived of as total ecosystems with diverse interacting components, which need to be managed as a whole. Most of these components are within particular ecosystems (such as vegetation, livestock, etc.) while others (such as marketing) may be partly or entirely external.

By ensuring that an institution assumes the responsibilities outlined above, it should be possible to put an end to divisions of authority and piecemeal approaches. Such activities as water development, animal health, animal breeding, infrastructure development, and marketing all relate closely to management of the rangelands and the welfare of its users and as such should be closely integrated with institutions responsible for range management.

In order to outline in some detail the kinds of activities that will need to be undertaken by the range institutions and to assign priorities, certain types of information must be compiled. The methods are briefly discussed here.

Describe and assess the general features and importance of the range area. Include size, diversity, environmental conditions, types of vegetation, animal and human populations, and trends. The contribution to the national economy and to aesthetic values should also be assessed to the extent possible, as should the economic structure (monetary and nonmonetary) and marketing-system demands.

In Somalia, rangeland constitutes nearly two-thirds of the land area, with rainfall varying significantly from north to south. Nomads comprise 60% of the population and own about 90% of the livestock. Sale of their livestock is by far the major source of export earnings. These figures, cited by way of example, clearly justify the effort the Somali government has made in developing appropriate range policies and institutions.

Describe and assess the common pastoral production systems. Is the land owned or controlled by the state, by the pastoralists, or by some combination? Who owns and controls the livestock? What are the types of production practiced — nomadic, semi-nomadic, transhumant, settled, subsistence, commercial, mixed, etc.? How are these distributed geographically? The answers to these questions will, to a large extent, determine orientation and broad priorities. The answers might also influence whether the institutions created are centralized or decentralized. For example, nomadic pastoralists are more difficult to reach than sedentary or transhumant pastoralists. A more decentralized type of institution concentrating on regions might therefore be better suited for nomads than for other types of pastoralists.

Assess production potential. Indexes of production such as birth rate, weaning rate, rate of growth, offtake, age at maturity or at time of sale, and carcass weights are not always available, but the collection of data along these lines relating to game animals should be considered. These types of data are valuable because they indicate the margin for improvement.

Assess the condition of the rangeland. A prime objective in range management is to maintain or improve the condition of the range resources. An understanding of the condition of specific areas is essential in the development of management plans that meet long-term needs.

Identify the main technical linkages of the range institution. Many interdependencies and complementary relationships exist among specialized institutions. In the case of range institutions, some of the closely related activities for which other institutions might be responsible are forage crops, animal feeding, crop production (important for residues and by-products), and rural settlements. These relationships should, as much as possible, be identified early on to facilitate collaboration.

Assess and evaluate principle economic factors influencing demand (e.g., internal and export requirements, degree of commercialization, monetary influences, subsidies, price controls).

Rangeland Institutions

Since the function of an institution is to carry out a program, the program should be designed before the institution is created. In other words, successful institution-building requires knowledge of what needs to be done and what has priority. Priority is determined by the importance of an activity and its feasibility at that time. Feasibility may be influenced by availability of staff, the order in which things best follow each other, etc. For example, an extensive assessment of range condition would likely be necessary before concentrated research is done. Monitoring a result from a finished project may deserve higher priority than starting a new project if both things cannot be done.

Central to program development is a problem analysis to bring into focus the problems of range production and conservation characteristic of the country. This analysis should include considerations of climate, vegetation, people, practices, and their important variations — a sort of status report. It should also include economic aspects such as measures of productivity, export earnings, and employment. Social aspects may be significant in problem assessment — especially social organization, income distribution, health and other services, and family organization.

Descriptions of production practices are especially important because this is the area in which a range program can make its major impact. These descriptions should include, besides a description of the production system, such details as grazing practices, animal management, water distribution, etc. What are the effects of the practices on the resource and on productivity? Are they sustainable? How are other range activities carried out (e.g., forestry, game production, and recreation)?

Another common problem is the lack of critical information. Identifying information gaps may be most important in planning the first phases of range programs. Gaps are commonly found in statistical data, inventory data, and production indexes.

The problem analysis for institution building must also include an analysis of existing government services. Aspects that should be covered in this analysis include a description of all agencies that have responsibilities in the rangeland area, their organization and overlap, efficiency in using resources, and major deficiencies from the standpoint of rangeland development.

Closely linked to the above is an assessment of local experts in range-related areas in government, universities, other institutions, and private endeavors. While the inventory of human resources is intended to identify people who might contribute to a new range program, it will also uncover areas where expertise and training are lacking. This is an important problem, and work on it should begin rather quickly. Even though institution-building should proceed from conceptions of problems to programs to be executed, this does not mean that no action can be taken until all the desired information is analyzed. Some immediate needs can be ascertained, especially in the problem analysis. For example, often the number of people with range management training is obviously insufficient. In other cases, it may be evident that knowledge of the resources is inadequate.

Once a rangeland-development program has been formulated, it is possible to decide the scope to be covered by the institution, its primary functions, and indeed its major areas of work. The outline given here contains some of the institutional responsibilities and functions that might be defined.

1. Scope
   a. Area
   b. Components to be managed (grazing land, forest, wildlife, etc.)
   c. Interrelationships with other land users

2. Primary functions and lines of work
   a. Planning range strategy and development at national and regional levels
   b. Establishing policy and regulations
   c. Formulating programs
   d. Providing a voice for pastoralists
   e. Formulating requests and coordinating foreign technical assistance
   f. Coordinating with other agencies
   g. Formulating, coordinating, and executing projects
   h. Providing information and education for the public and pastoralists

i. Developing technical expertise through on-the-job training
j. Carrying out resource assessment
k. Monitoring effects of activities and other influences, such as weather
l. Researching key problems
m. Training — formal and informal
n. Organizing pastoralists
o. Promoting controlled grazing
p. Setting up demonstration centers
q. Developing drought defense
r. Communicating with pastoralists by radio, or other means, to improve management, health, etc.

In order to better visualize the best way for the institutional framework to develop, some priority should be assigned to the above. After priorities have been assigned, the type of organization needed should be defined.

A word about priorities in institution-building. Most institutions start out small and relatively weak. One of the worst mistakes is to spread the limited resources too thin. Effort should be directed where it will count in terms of concrete accomplishments. An important priority is the effective use of technical assistance from donor agencies. Another is building up technical competence (including competence in planning) and establishing effective two-way communication with pastoralists.

Module 13

Training and Education

The term "range management" is new to many peoples of the world and is difficult to translate into some languages. Not surprisingly then, there is neither provision for range management in the curricula of universities in most developing countries, nor any place to train instructors in range management for the local universities. Often people with backgrounds in veterinary medicine or agronomy occupy decision-making positions and fail to recognize the role that range management plays in livestock production.

Since range technicians are scarce in developing countries, training has often included range management projects. Such training is necessary for the benefits of the project to continue after the project ends. A cadre of trained personnel must be in place when the project terminates if long-range goals are to be met. In many cases, selection of participants for the training phase needs to begin before actual project implementation so that the trainees have time after they are trained to work on the project with their counterparts. This will enable them to perform their duties when the project ends.

The record of establishing range management schools and departments in universities in developing countries is spotty. In some cases the programs were established with the assistance of range educators from the United States. Potential instructors were educated in the United States with the understanding that they would return to teach in the fledgling range management program at their university. The university would, in turn, train technicians for a variety of positions in their country. Eventually, it was hoped, some of these universities might develop graduate programs to train and educate instructors to teach at the universities. Thus, the need for training in the United States would be greatly reduced. However, many of these goals have not been realized. In some cases economic incentives are not sufficient to attract and keep qualified personnel in the universities. They have been attracted to other positions and often to other countries. For example, there are many well-trained range graduates in Nigeria with M.S. and Ph.D. degrees from U.S. universities. Yet it is difficult to attract these to teach range management at the Livestock Training School in Kaduna (a branch of Ahmadu Bello University at Zaria).

Issues

Education and training are the key ingredients for the continuation of project objectives beyond the life of the project.

In some developing countries training is needed at all levels (doctoral, masters, bachelors, and associate) to accomplish range management goals. Shortcourse training is also needed for administrators of range science programs who are not trained range managers or scientists. For example, surveys indicate that by 1988 there will be a need for 188 certificate-holders, 53 with diplomas, 80 with B.S. degrees, and 12 with M.S. degrees in the Ministry of Agriculture in Kenya. For the Ministry of Agriculture, other ministries, and commercial concerns, the total requirements would be for 279 persons. This represents an increase of 159 over those in these positions in 1977.

In other countries demand for range-trained personnel is not so great because no range management agency exists in the government. Even so, range training is still useful for other government positions that are responsible for arid and semiarid rangelands.

Initial attempts to improve range management practices in developing countries have repeatedly met with difficulties. This was due in large part to the shortage of qualified range management personnel and the problems that available specialists have had in involving pastoralists in decision-making processes.

Range-development projects should not be attempted without substantial host-country participation. Outside advisers are not likely to understand the inner workings of another society to the extent that it is understood by local technicians. The objective is to provide these technicians with the best training possible, allowing them to make technical adjustments to fit cultural needs. This will help developing countries to become self-sufficient in their range-improvement efforts.

Students coming to the United States often receive some orientation to enable them to adjust to the U.S. education system and to understand some of the social customs, etc. Often it is advisable for students to take a somewhat reduced load during the first quarter or semester to allow them to become comfortable with the U.S. university system. Many U.S. range schools have a rather large contingent of international students. It is easier for other international students to become adjusted in these situations than in those where there are few other international students.

There is, however, no orientation for students returning to their home countries after university training in the United States. In some cases this transition may create a greater stress on the students than that imposed when they came to the United States. Some students attempt to remain in the United States or postpone their return home. Perhaps the projects could provide some orientation and incentives for the students to return home and to the project.

On-the-job training whereby the foreign "expert" works with his counterpart in the field may be useful in many cases. It provides for close contact and personal supervision and is probably best suited for people with specific tasks like laboratory or field technicians. On-the-job training is not suited for the development of a broad background in range management. However, it can be used as an adjunct for other types of training: On-the-job training can be successful and highly productive if it is carefully planned and carried out.

Guidelines for Broad Program-development Planning

The level of training for a specific project may range from courses lasting less than a year to multiyear, advanced graduate degrees. Training programs may be in-country or out-of-country. The advantages of in-country training are 1) more relevant examples are close by and 2) the training is more cost effective. It is usually less expensive to bring in experts from other countries than to transport many trainees to another country. However, the foreign expert will not be as familiar with the country and will likely require local guidance for field trips, etc. But until local experts assume full training responsibilities this may be the best method.

Another difficulty with in-country training is the lack of training sites and facilities. Suitable production-system-demonstration sites or research stations and well-managed ranches are seldom available within a few days' travel time. There are few continuing programs in range management in developing countries. Instructors will probably need to be brought in for shortcourses or training programs. The problem here is that potential teachers often have insufficient language skills, and the use of interpreters lessens the effectiveness of the presentation.

There are few shortcourses in the United States tailored specifically for international students and trainees in range management. USAID sponsors several courses each summer related to a number of natural resource and agricultural areas.

The only one specifically dealing with range management is conducted jointly between New Mexico State University (6 weeks) and the University of Arizona (3 weeks). These courses are offered in English and some carry university credit. Most of the participants are already in the United States on study programs. However, these courses are also offered to trainees coming directly from their home country. In most instances these courses are designed to give a general background and are not designed for a specific topic.

Guidelines for Program/Project Development and Design

Identify qualified, available personnel in the country. The key word here is available. A few countries may have trained personnel, but they may be locked into some other project or ministry.

Select trainees carefully. It is important that the trainees have the necessary background and interest in the type of work projected. Range work is often in remote areas where modern facilities are limited. Often training in the United States or another developed country may be highly desirable, but the routine work on the job is less attractive. There are many examples where trainees, after receiving expensive training, did not prove effective on the project because of lack of interest, motivation, etc. Often a degree from a U.S. university is used to gain political advantage for the recipient, but not to benefit the project.

Select a level of training appropriate to the project. Some projects may need intensive training in specific skills, while others may require a broad, general background. There is little need for degree training for someone working in certain types of extension programs.

University Training

Most university programs are offered at U.S. universities. However, there are now a few universities in other countries that offer a B.S. degree. Examples of these:

- University of Nairobi, Nairobi, Kenya

- Hassan II Institute of Agronomy and Veterinary Medicine, Rabat, Morocco
- University of Ceara, Fortelaza, Brazil
- University of Queensland, Brisbane, Australia
- University of Adelaide, Adelaide, Australia
- University of Chihuahua, Chihuahua, Mexico
- Monterrey Technological Institute, Monterrey, Mexico
- Antonio Norro University, Saltillo, Mexico

In the United States, range management curricula are in English. The following list (current as of July 19, 1984) gives the mailing addresses of universities in the United States that have range programs and are active in the Range Science Education Council. However, only a few offer an accredited degree in range science.

Arizona

Division of Agriculture
Arizona State University
Tempe, AZ 85287

School of Forestry
Northern Arizona University
Flagstaff, AZ 86001

School of Renewable Natural Resources
University of Arizona
Tucson, AZ 85721

California

Department of Animal Science
California State Polytechnic College
San Luis Obispo, CA 93401

Department of Plant Sciences
California State University
Chico, CA 95926

College of Natural Resources
Humboldt State University
Arcata, CA 95521

College of Forestry and Resource Management
University of California
Berkeley, CA 94720

Department of Agronomy and Range Science
University of California
Davis, CA 95616

Colorado

Department of Range Science
Colorado State University
Fort Collins, CO 80521

Florida

School of Forest Resources and Conservation
305 Rolfs Hall
University of Florida
Gainesville, FL 32611

Idaho

Department of Biology
Idaho State University
Pocatello, ID 83209

College of Forestry
Wildlife and Range Resources
University of Idaho
Moscow, ID 83843

Iowa

Department of Forestry
Iowa State University
Ames, IA 50010

Kansas

Division of Natural Resources
and Mathematics
Fort Hays Kansas State College
Hays, KS 67601

Department of Agronomy
Kansas State University
Manhattan, KS 66502

Missouri

Department of Agriculture and
Natural Resources
Box 21
Lincoln University
Jefferson, MO 65101

Montana

Department of Animal and
Range Science
Montana State University

School of Forestry
University of Montana
Missoula, MT 59801

Nebraska

Department of Agronomy
University of Nebraska
Lincoln, NB 68503

Nevada

Knudsen Renewable Resources
Center
University of Nevada
1000 Valley Road
Reno, NV 89557

New Mexico

Department of Animal and
Range Science
Box 31
New Mexico State University
Las Cruces, NM 88003

North Dakota

Department of Botany
North Dakota State University
Fargo, ND 58105

Oklahoma

Department of Agronomy
Oklahoma State University
Stillwater, OK 74078

Oregon

Department of Rangeland
Resources
Oregon State University
Corvallis, OR 97331

South Dakota

Department of Animal Science
South Dakota State University
Brookings, SD 57007

Texas

Department of Range and
Animal Science
Sul Ross State University
Alpine, TX 79380

College of Agriculture
Texas A&M University
Kingsville, TX 78363

Department of Range Science
Texas A&M University
College Station, TX 77843

Department of Range and
Wildlife Management
Texas Tech University
Lubbock, TX 79409

Utah

Department of Botany and
Range Science
Brigham Young University
Provo, UT 84601

Department of Range Science
Utah State University
Logan, UT 84321

Washington

College of Forest Resources
University of Washington
Seattle, WA 98105

Department of Forestry and
Range Management
Washington State University
Pullman, WA 99163

Wyoming

Range Management Department
College of Agriculture
University of Wyoming
Laramie, WY 82071

Canada

Department of Plant Science
University of Alberta
Edmonton 7, Alberta
Canada

Faculty of Forestry
University of British Columbia
Vancouver, British Columbia
Canada

Mexico

Escuela de Zootecnia
Universidad de Chihuahua
Apartado Postal F-28
Chichuahua, Chihuahua
Mexico

International Programs
Institution Technologico de
Estudios Superiores de
Monterrey
Sousal de Correos "J"
Monterrey, Nuevo Leon
Mexico

Universidad Autonoma Agraria
"Antonio Narro"
Buena Vista
Saltillo, Coah.
Mexico

Guidelines for the Level of Education or Training Required

- Post-secondary school. Suitable for a specific job or task. May be satisfied by a shortcourse, workshop, etc. Would probably require less than 1 year to complete.
- Pre-B.S. (certificate or diploma). Suitable for positions with relatively broad duties, e.g., extension positions. Several African universities offer 2- or 3-year certificate or diploma courses in range management.
- B.S. Suitable for management positions, production-system demonstrations, or simple applied research projects. Few universities available in developing countries.
- M.S. Suitable for administrative positions and teaching and research at a relatively unsophisticated level.
- Ph.D. Suitable for research and teaching positions at research stations and universities offering B.S. and graduate degrees. Probably available only at universities in developed countries.

Where graduate training is necessary as a part of the project, there are compelling arguments to provide opportunities for thesis research in the home country instead of in the United States. Dwyer (1983b) listed three major advantages for in-country thesis or dissertation research.

1. The student has an opportunity to learn how to conduct fruitful research under the conditions of his/her home country.
2. The home country benefits from the research that can be applied directly.
3. The results of the graduate students' research contribute to the broader objectives of the project.

Such arrangements should provide for travel to the country for the students' adviser, and for a research coordinator in the host country to provide continuity and advice for the students.

If it is not possible for the students to conduct research in their countries, the research project and techniques used should be relevant to the host country.

Selecting an appropriate U.S. university for graduate training is important in meeting project objectives. Some criteria to consider:

- faculty qualifications — experience and interest in international activities
- support facilities
- similar environment — students interested in tropical pastures should not be sent to universities in arid areas
- favorable academic environment
- past record

In many cases English training is necessary and must be factored into the schedule. The course presented at Georgetown University by USAID appears to provide the students with an adequate background to compete successfully with U.S. students. Some universities also have English training available. For example, New Mexico State University has a special program for Spanish-speaking students. They take intensive English and two statistics courses taught in Spanish the first year. During the second year, the students take regular courses taught in English. With these programs, it is important that students be assigned an adviser and integrated into a department early in the program.

Most universities in the United States do not tailor courses specifically for foreign students. A few have developed special courses for international students and some have incorporated relevant examples into existing courses.

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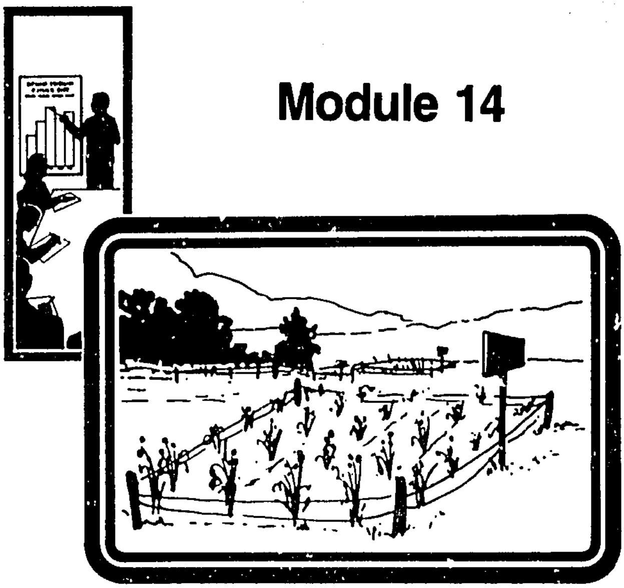
Module 14



Research

All areas of rapid development have been fueled by active and imaginative research efforts. The development of high-speed computers was possible only after years and years of research and development. The so-called "green revolution" in agriculture was possible because of research in genetics, plant physiology and pathology, agricultural engineering, etc.

Much research conducted on plants, animals, soils, etc., applies to rangelands. However, rangelands are unique ecosystems — understanding how each ecosystem's components are related and how each component responds to variations or changes in other components requires research.

Range research in the United States is relatively new. In 1984 the National Research Council of the National Academy of Sciences published a 2,000-page book, Developing Strategies for Rangeland Management. Most of this material was based on research conducted in the United States in the last 50 years.

Range research in the United States is conducted largely by universities and federal agencies. University funding comes from both state and federal sources. Federal range research has been conducted by the research branch of the U.S. Forest Service and by the Agriculture Research Service. The research is usually conducted on research stations where the land and livestock are under the control of the researchers.

Unfortunately, range research for developing countries is spotty and incomplete. In many cases research results are not published in scientific journals and are difficult to find in interim or end-of-project reports. In fact, few developing countries have any type of agriculture or range research organization. Most research is conducted by range workers from other countries, supported by outside funding sources such as USAID, the World Bank, etc. The development of a viable range research organization in most developing countries seems beyond grasp for the present.

Issues

Setting range research priorities for developing countries is difficult because little site-specific information is available. However, since research is expensive and funding in developing countries is limited, research must produce maximum benefits and be aimed at specific problems. There is seldom justification for "basic research," which will not be applied for some time.

Therefore the critical step is identifying problems relevant to development that can be solved through research. The research should be local or regional in nature and should be designed to produce results that are widely and immediately useful. Involve the users of the research — those in the agency (assuming that there is an agency handling range management activities) and the local herders — in setting the priorities.

Long-term Versus Short-term Projects

Range researchers tend to establish long-term research projects to build a database for management decisions. Such studies are necessary because of seasonal and yearly variation in climatic variables and because successional changes in arid and semiarid lands occur slowly (in part because of the low rainfall). Recommendations made after a fairly short-term project may not apply under a different set of environmental conditions.

Unfortunately, however, most development projects are relatively short term and not designed to provide long-term databases. This limits the type of research activities that are feasible in development projects.

Basic Versus Applied Research

Basic and applied research are often discussed as two separate types of research, but they are really part of a continuum. Jacobs (personal communication, 1984) distinguished among four types of research:

1. basic research (academic, scholarly); focuses on understanding relationships and advancing the frontiers of knowledge generally, without particular (or practical) applications necessarily in mind
2. applied research; directed at understanding relationships for the purpose of solving an identified problem, usually under controlled (on-station) circumstances, which may have immediate practical application and benefits for development
3. adaptive research; evaluates applied research results off-station under real-world conditions to determine if results still hold and(or) how they should be modified to be both practical and adoptable by producers
4. demonstration research (implementation or extension); to further test and refine already verified adaptive results over

a still wider diversity of user conditions; an opportunity for potential users to observe on-site applied research and results

Figure 17 illustrates the relationship among these types of research. In some cases basic research may be used right away. For instance, a seeding study to compare different types of seedbed preparation may be applied directly to a large-scale seeding operation. In that case, research that was initially basic can also be considered applied. A study to determine the relative influence of environmental factors on the distribution of rangeland vegetation may be considered basic. However, studies of spatial and temporal variation in vegetation, while fairly basic, might be useful in making decisions concerning livestock grazing.

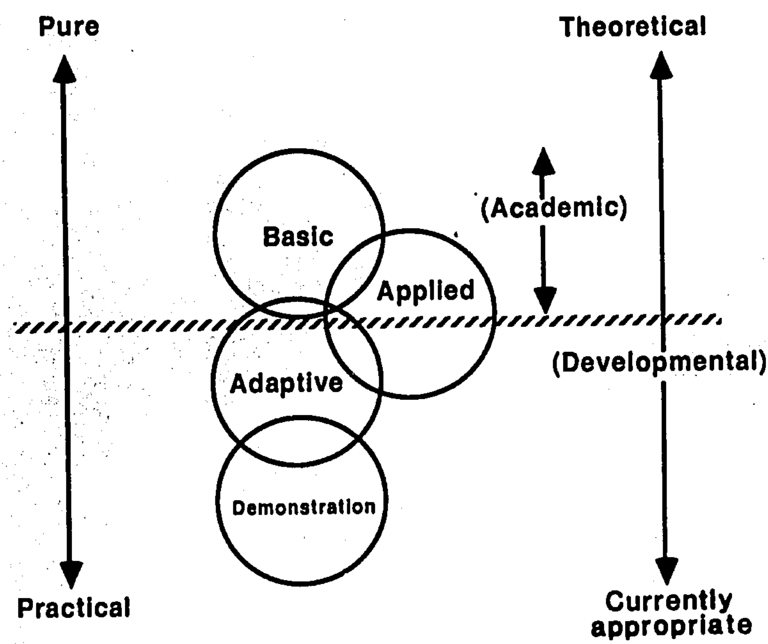


Figure 17. Schematic relationship of different types of research in developing countries (adapted from Jacobs, personal communication, 1984).

In most cases research components in development projects tend toward adaptive or demonstration research. These projects can then be concluded in a fairly short time. In addition, they are more likely to yield something tangible. Governments often wish to have some visible product to show for the money expended. Identify practical problems and direct research toward their solution.

Development of Research Stations

Sometimes it is desirable to develop research stations for carrying out long-term studies. These stations can, with adequate staff, perform many important functions such as developing and testing management practices that are appropriate to the intended socioeconomic environment. The development of a research station is a major undertaking. It is often a complete project in itself, and not simply an objective within a larger project.

Two research stations that were complete projects were the Kiboko Research Station in Kenya and the Kadugli station in Sudan. Experiences at Kiboko underscore the difficulties involved in establishing a research station. It was originally established as a part of an FAO project. However, when the project terminated there was insufficient impetus to keep the station functioning as a research station. So that this effort would not go to waste, USAID awarded a project grant to Winrock International specifically to revitalize the station. It is being run by Kenyan staff with graduate degrees that were obtained at U.S. universities (mainly Texas A&M University). An interdisciplinary staff supports and advises this staff while training is being completed. Initial problems with housing and identification of qualified Kenyan students delayed development of the station. Most of the Kenyan students have conducted their thesis or dissertation research at the station (see module on training and education for discussion of advantages of in-country research for graduate students). Staff associated with the project are optimistic but it still remains to be seen if the station will continue to function without outside funding after the termination of the USAID project in July 1986.

Guidelines for Broad Program/ Development Planning

Not all development projects require research. However, in some cases a research component is necessary to answer key questions related to the overall objectives of the project. Inventory information about the natural resource base is often needed for project planning and implementation. Research into site delineation and vegetation classification, description, and condition may be coupled with inventory efforts.

Often there is a direct link between research needs and demonstration plots useful in extension programs. Research and demonstration activities can often be merged to the benefit of all participants.

Guidelines for Program/Project Development and Design

Since research is costly, carefully evaluate its usefulness before including it in project designs. Research into management practices should ascertain whether such practices will be appropriate in the socioeconomic environment where they will be applied. Several questions could be asked to guide selection of research projects:

- For whom is the research problem or constraint being investigated — producers, policymakers, or simply other researchers? Who decides the value of particular research projects, and why or by what criteria? Research projects should be planned **with** people not **for** people.
- To how many people is the problem or constraint considered to be important? Are the goals local, regional, or national? Do they meet USAID regulations for sponsored development research and implementation?
- Who will be the users or recipients of the results of the research?
- How much benefit will the users or recipients receive if the problem is solved? Quantifiable benefits aid in deciding which problems to tackle first.
- What is the likelihood that the research will contribute to a solution to the problem? This may be evaluated on the basis of short-term or long-term results, capital-intensive or labor-intensive requirements, and low-cost or high-cost inputs, etc.

- Are research tools and personnel to solve the problem readily available? (Problems that can be solved with local resources are likely to have the most lasting impact.)
- What are the expected costs in time and money of solving the problem?
- Why is the proposed research problem or constraint being considered more important than some alternative that might be undertaken with the same resources?
- What is the expected cost of implementing the results if the research is successful? This is an important measure of appropriateness.
- When will benefits begin to be realized by the direct beneficiaries of the research, and who will benefit? In too many projects, the targeted beneficiaries are forgotten in the enthusiasm of implementing the research, and it is mainly the researchers or project implementers who benefit.

A few examples may illustrate the importance of asking these questions. Research to determine optimum stocking for production of meat, milk, wool, or other goods needed by pastoralists may be interesting and potentially useful information. However, if there are no mechanisms for adjusting stocking rate, or interest by the pastoralists or the local government in doing so, then such information may not be very useful. In some cases extension activities to sell the people involved in a particular practice may be necessary before a specific production system is developed, thus creating a catch-22 situation: The local people (or government) will not adopt a certain practice until it has been demonstrated, but the government may not approve of the research or demonstration until it has been proved effective.

A general guideline is to keep the research components fairly simple and straightforward. It is probably not essential to outline a complete research design for a project; however, it is essential to have explicit objectives that can be met within the overall framework of the project.

Consideration of the following questions may assist in the development of effective range research components.

- Are adequately trained personnel available or will they need to be trained as part of the project?
- Can the research objectives be realized during the life of the project or will provision need to be made for extension of the work by local researchers or consultancies by foreign advisers?
- Are suitable research areas available with adequate livestock control?

- Is the socioeconomic structure such that the results of the research can be used?
- Were the pastoralists and potential in-country counterparts involved in planning the research?
- Has an assessment of relevant researchable range problems been made?

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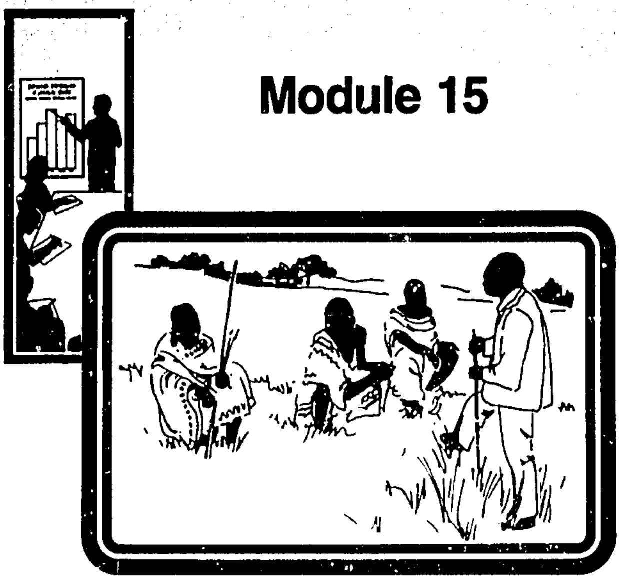
Module 15



Extension

Extension activities are normally considered the link between research results and the producers who use them. These activities involve communicating knowledge or information.

The land-grant university system in the United States has been used as the ideal model for agricultural development by some. In this system agricultural research is conducted by the agricultural experiment stations; the research results are interpreted and dispensed by extension agents to farmers and ranchers. Other government agencies are also involved in extension activities by providing technical assistance to agricultural producers.

The success of American agriculture is often credited to the development of the Cooperative Extension Service. In most states there is an extension office in each county with an agricultural agent, and often a home agent and 4-H leader. The staff of these offices respond to needs and questions of producers in their counties and sponsor training sessions and workshops to provide information on the latest techniques. There is also a staff of specialists, many with Ph.D. degrees, at each land-grant university. These specialists furnish specific information to the county agents and also coordinate training programs.

In developing countries, however, the situation is vastly different. There may be a ministry of agriculture with perhaps a livestock bureau, but almost certainly no agency for range management activities. In most of these countries there is only a limited extension service (which does not address range management). Consequently, range-development projects may need to establish an agency to coordinate extension activities.

Pastoralists and herders need information not only about methods and techniques for improving the efficiency of their operations, but also about government policies. Sandford (1983) contrasted the difficulties in extension work between pastoralists and sedentary agriculturists. Face-to-face contact is much more difficult with pastoralists because of the scattered distribution of people and nomadic or transhumant grazing patterns. Thus extension range activities for developing countries represent a considerable challenge. Traditional types of communication in developed countries such as newspapers, radio, telephone, and television are often lacking. However, in some cases development of a two-way-radio network is possible. Some programs, like the Integrated Program for Arid Lands (IPAL) in northern Kenya, distributed battery-operated radios to nomadic pastoralists. Broadcasts of educational programs on range management practices and market news were quite successful.

Issues

Extension activities might be included in range-development projects because they contribute to:

- interpreting and disseminating the results of research components of projects and other relevant knowledge
- assisting in the development of an agency for planning and coordinating range activities in a developing country (would entail a large training component to provide extension workers)
- assisting in the development of demonstration projects or extending existing technology to local levels (example: developing and training pastoralists in techniques for the establishment of forage reserves throughout one project zone)
- involving pastoralists in the planning process

The extension component in the development project will be influenced by extension programs within the country. If an extension service already exists, it may only be necessary to augment it or to provide additional training or links with other agencies.

Extension activities in developing countries should include more than disseminating technical information. Pastoralists also need to understand government policies regarding grazing, land tenure, control of water, and emergency feed.

Moris (1981) outlined an "information-delivery model" of extension for developing countries. It involves a two-way communication system that becomes an increasingly complex network between the individual family or tribal unit and the national extension office. Information is supposed to funnel down from the top through the network to each family or unit. Feedback on farmer or pastoralist needs and suggestions should flow in the opposite direction. Moris warned that such a system seldom operates in the perceived manner, and admitted that we do not have much data on the effectiveness of such systems.

Establishing an extension network in an area of sedentary, mixed crop-livestock farmers and livestock raisers is much easier than it is for nomadic and transhumant pastoralists. Any extensionist who works with pastoralists will probably need to move with the herders who form his/her client group. Such hardships make it difficult to recruit extension workers.

Another approach for improving communications with herders is to encourage the development of social groupings among the pastoralists (Sandford, 1983). These associations can be used as centers for dissemination of information and various types of management activities (grazing patterns, distribution of vaccines, control of water).

Sandford (1983) listed three major types of herder groups.

- Camping communities. These tend to be small, with only 10 to 50 subgroups. There may be a single spokesperson for each camping group, who aids communication in both directions. Such an individual may want a nominal fee for his services.
- Watering communities. These may be larger than camping communities. They consist of all the families who normally use a common watering point or group of watering points. However, watering communities may not persist during nomadic movement in the dry season. In addition, interests of members of the watering community may be more diverse than those of the camping communities.
- Kinship groups. If groups larger than watering communities are desired, kinship groups or clans may be the only alternative.

Cooperatives and associations are a fourth possibility. They are more formal organizations, and in some cases their development is preferred by governments. In these groups the chief or elder may act as spokesman. Various types of cooperatives — such as livestock and marketing — might benefit the pastoralists to a greater extent than if each family unit operated independently.

Organizing such groups for extension activities has been a part of many development projects. Often social scientists provide guidance for the formation of such groups. However, groups organized by teams that include range and animal specialists will probably be more useful.

Communications theory has developed several approaches for rural development and extension (Moris, 1981). The various approaches might have relevance in the United States, but need to be considered carefully in the environment of the developing country. It is likely that such individuals as "the change agent," "innovator," and "early adopter" have relevance to some societies in developing countries, but certainly not to all.

Thus extension workers need to have some technical background at the level necessary to interact with the herders. In addition, they need enough sociological training so that they understand the social-economic-political structure of the people with which they are dealing.

Language differences can also be a problem for extension workers. Provide language training if the extension worker does not speak the language of the tribes in his district.

Guidelines

- Evaluate the overall goals and objectives of the project with respect to extension components. Can the project objectives be reached without extension components? Can the project objectives be enhanced with the addition of extension components?
- Evaluate existing agencies and ministries in terms of their suitability to administer extension programs. Such programs will be more likely to have a long-lasting impact if they are integrated with an existing agency.
- Identify in-country participants early enough to be trained and spend time on the project. Many people are not suited to extension activities. An effective extension worker is patient, tactful, outgoing, and persuasive.

Extension methods must be modified to deal with changing situations, so strict guidelines cannot be formulated. The following are general guidelines to assist in project design (Child et al., 1984).

- The project orientation and objectives must be considered important by the clients for whom they were designed.
- The extension effort should also be aimed at discovering problems and needs of the clients through individual contacts, group meetings, etc., and not be aimed only at dealing with one perceived problem. The individual problems and needs can be related to overall goals and objectives through problem analysis, resource surveys, government policy, etc.
- Extension programs need to be very flexible because range conditions vary greatly due to drought, disease, etc.

- It is extremely important to involve the local people in any extension activity. Even if it appears at first that the relevant problem is not being handled, with early local involvement it is likely that efforts can eventually be shifted to deal with it. Programs have the potential to interest all members of the group if they include other facets of concern such as family relations, health, education, care of young animals, etc.
- Formal meetings generally are less effective than informal approaches that allow for more participation and feedback. A two-way discussion is usually more effective than a lecture. Use field seminars, tours, and demonstrations.
- It is the responsibility of the extension agent to create rapport, trust, and confidence with client groups. Some techniques and approaches can be learned through training, but some people just have a special talent for extension work. It may be more useful to select trainees based on these skills than on other criteria such as level of education. Knowledge of the local language or dialect and cultural setting is of obvious importance.
- The best kind of demonstration results from concentrating on a few objectives to provide concrete and obvious impact. If extension workers are spread too thin over many projects, none will likely be perceived as successful. When more staff becomes available, other problems may be included.
- Continuity is critical to a successful extension program because it allows the program to grow and develop as experience accumulates. Develop personnel policies and incentives to keep good workers on the job.

Guidelines for Implementation

- Provide adequate transportation for extension agents. Surfaced roads are limited in most developing countries and other roads may be impassable during certain seasons of the year. Knowledge of local conditions can be helpful in negotiating back-country roads. In situations where it is necessary for the agent to travel with herders, it may be necessary to provide hardship pay for incentive.
- Train potential project participants. Some background in U.S. "communications theory" may be useful, but it should not make up the bulk of the training. Considerable training in the social sciences should also be included, as well as language training when necessary. In order to earn the confidence and trust of the local people, trainees should have a broad background in their livestock operations and possess some basic skills. Can they assist an animal in birth? Can they milk the

animal? Can they butcher an animal?

- Provide incentives (salary, housing, etc.) to keep satisfactory extension workers on the job. Make provisions for protecting extension workers from being transferred to some other position within the ministry or relevant agency.
- Formulate extension objectives that have a reasonable probability of being achieved.
- Use appropriate techniques for improved communication in the project area. Radios, mobile units, and radio networks have been used extensively in Botswana and Kenya in early program development. Residential training courses have been useful for reaching scattered nomadic and seminomadic tribes. Demonstration ranches have effectively promoted specific practices to livestock producers and herders. Two-way radios are useful, but local restrictions and regulations should be checked before attempting to establish such a network.

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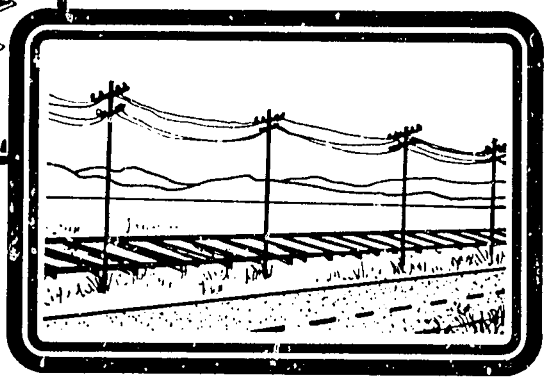
Module 16



Infrastructure Development

A characteristic of a modern society is an interdependence among its components. One of the more obvious interdependencies is between urban and rural areas. City dwellers depend on farmers and ranchers for food and other products from the land; for the farmers and ranchers, city dwellers constitute the principal market. In order for this system to function, it is necessary to have roads, markets, storage facilities, communications for advice on markets and prices, and supply depots.

The framework that allows the system to operate efficiently is known as the infrastructure. Obviously, the more complex the system and its functions, the more intricate the infrastructure will need to be. Infrastructure may be defined as the underlying foundation or basic framework (e.g., roads, telephones, radio, etc.) that provides the links among and within communities. Besides the infrastructure that serves the nation, particular regions, or other large units, there is the infrastructure of the pastoral unit — whether it be nomadic or settled.

Self-sufficient societies, such as subsistence pastoral societies, require a minimum of infrastructure. But the lack of infrastructure also tends to perpetuate this level of existence whether it is desired or not. Therefore, it can be said that the type of development that is based upon an interchange of goods, services, and information among different parts of the national community depends on an adequate infrastructure. It is fair to conclude, then, that development of rangeland as well as that of agriculture in general is closely dependent on, or is limited by, the infrastructure. Often, infrastructure development must precede or accompany production-system developments.

The techniques for infrastructure development are well known. The main questions are how best to fit the infrastructure to the local needs and how best to use it. When planning infrastructure development, every effort should be made to consider the various functions the infrastructure should serve. Compromises will be necessary to accomodate the needs of rangeland development, but should never be made simply because of immediate convenience, low cost, political pull, and the like.

Issues

Infrastructure historically has been developed to fill needs (building a road between urban and rural communities). To a lesser degree, infrastructure has also been used to encourage development (building roads to certain areas to encourage settlement). The question here is how can infrastructure be used to further rational range development? In this section, some aspects of this question will be examined.

On extensive rangelands the infrastructure within a community may be no less important than that connecting it with other communities. The infrastructure includes roads, wells, telephones, and other features that affect the movement of livestock, goods, services, and information (communications).

One of the important influences of infrastructure is its effect on production systems. Subsistence production results if what is produced must be used because little exchange is possible. Under subsistence conditions, simply ensuring a food supply throughout the year becomes a primary objective. (Storage of food is difficult due to long-established traditions, lack of electricity and appliances, and the migratory nature of some pastoralists.) The subsistence production system is not well suited to the annual fluctuations of feast and famine. This system is even less suited to meeting the needs of urban populations or export. Such traditional pastoral systems, however, have provided security if enough animals were available per family, but this may increasingly not be the case because of 1) population increases due to improved medical care and 2) decreases in available grazing lands.

On the other hand, when there is good access to markets and opportunity to buy grains, producers sell animals and the production system gradually becomes a part of a market economy. However, the system that evolves is likely not to be for specialized beef or dairy production. That is because infrastructure is but one of the ingredients necessary for highly specialized systems that depend heavily on market adequacies, credit, and other services that give some assurance of security, especially during drought.

Specialized milk production is difficult and very costly without a good road network (assuring rapid delivery) connected to urban centers. Unless refrigerated trucks and storage facilities are available, production centers need to be near the market. Furthermore, an adequate and regular program for providing veterinary care, artificial insemination, etc., may be necessary. The need for veterinary care is particularly acute if a daily supply of milk is required. This further emphasizes that infrastructure doesn't make things happen, rather it facilitates their happening.

Nomadic movement occurs because the animals must be taken to the feed. If roads were available, feeds could be transported. In some cases this would result in less movement, which would allow intensified production. However, fuel and trucking costs for transporting livestock feeds may be prohibitive in most developing countries.

One of the important considerations in livestock management is the movement of livestock between grazing resources and to market. Also important, particularly in drought, is the transport of feed, water, and even animals. Transporting animals to market could substantially reduce weight losses but may not be economically feasible. If trekking routes are available or are to be developed, then the establishment of feeding and watering places along the way becomes an important consideration. Integration of livestock production with crop production is facilitated by adequate transportation.

Broad Program and Project Development Planning

Infrastructure, as we have seen in the preceding section, is an important variable. It is therefore necessary to evaluate the current infrastructure and its limits before launching range programs. Such knowledge is useful for avoiding impossible tasks and for identifying important infrastructure deficiencies.

On rangelands, roads are almost invariably the most important infrastructural element. They should not only link population centers, but should be distributed so as to reach the primary grazing regions. Additionally, they should permit ready movement within each major grazing region. The same is true for telephone communication.

Several categories of information should be included in an assessment of the existing infrastructure.

- roads — distribution, quality, and passability year-round; obstacles
- population centers and facilities — meeting halls, hotels, electricity, fuel, markets, and other features important in range programs
- safe water and food for human consumption
- telecommunications — distribution and reliability; difficulties
- radio — location of stations and coverage

- electricity — source and coverage
- other sources of energy — type, location, and coverage
- important water sources — oases, rivers, lakes
- major trekking routes — location and stations for feed and water
- places available for meetings, training, etc. — locations and facilities available
- medical facilities nearby

In order to determine additional infrastructure needs, identify areas and populations that are not being served adequately. Priorities can be set after a detailed analysis of population, number of animals, potential productivity, and likely economic and social benefits has been made.

In the development of a national program, the selection of specific project areas is of prime importance. These project areas generally constitute a geographical region with a number of affinities such as a similar climate, common migratory routes within the region, ethnic and(or) language similarities among the people, and the possibility of meeting essential common needs within the region through complementary land use.

A good example of such an area is that of the northern region of Somalia served by the Northern Rangeland Development Project. The area is big enough to include the migratory movement of most of the pastoralists in the region. Although the climate is generally dry there are some areas where rainfall is high enough so that supplementary feeds can be grown. During colonization the people were exposed to a British administration and a number of practices (including grazing reserves) were introduced. A substantial part of the region has good roads and marketing facilities. The most practical means for communication throughout the region is by radio.

Infrastructure development must be carefully integrated with the development project plan. Some of the more common infrastructural developments are discussed below.

Water Development

Special attention must be given to water development. It is around watering places that people and animals gather under most grazing systems. It is the place where disease-control measures can be most easily implemented. It is also a good place to give out information, check on problems, and assess animal conditions, herd structure, and composition. (Besides these positive aspects, wells are also a feature contributing to overgrazing, as discussed in module 2.) These wells and other watering places need to be maintained. Because they are a strategic part of the pastoral infrastructure they should be easily accessible by roads. Just as water resources should be located to facilitate control of animal distribution in grazing-management schemes, it may also be possible to lay out the roads in such a way that they mark boundaries of grazing areas.

Activities Requiring Central Gathering Points

Activities that require gathering points include meetings, technical assistance (including veterinary services), dipping, and marketing, all of which require means for relatively easy access. Particular attention should be given to ensure easy marketing as a way of augmenting the income of the pastoralists and controlling animal numbers. During the project-planning process, deficiencies of the current marketing system should be identified and changes recommended to facilitate the process (see module 17).

Migration and Trekking Routes

Migration and trekking routes are generally well established. They should be studied for possible improvement — especially for reducing animal deaths and weight losses. Trekking to market may require the provision of water supplies and reserve areas for grazing. Again adequate access is essential.

Assessment of Forage Conditions

Collecting information on forage conditions is an activity that should be a regular part of any range program. A network for measuring rainfall could be useful. Such continuing assessment requires a road network adequate to permit the sampling, and could also be facilitated by telephone or radio communication.

Integration of Livestock and Crop Agriculture

In most countries there are some areas, which due to more rainfall or irrigation, are suitable for cultivated forages or crops. The cultivated forages may be used for hay or as pasture, and crops could produce residues of considerable value as animal feed. If pasture and crops could be integrated with the range grazing-lands, productivity and security could be substantially increased. Grazing pressure on rangeland might also be decreased, and, with a more balanced source of animal feed, livestock would be ready for market at an earlier age.

Drought

The calamity of severe drought cannot be avoided. However, much can be done to mitigate less extreme droughts. Two possibilities are especially important — transporting feed to the starving herds, or transporting selected animals to places where grazing is available. Roads are critical to either operation.

Technology Selection

The technology employed for infrastructure development should advance the range management objectives and the welfare of rangeland peoples. There are a number of considerations.

Simplicity

Complex equipment and structures are difficult to maintain and repair. Regular wells that require manual work may be preferable to engine-operated pumps. Windmills may be preferable to gas or electric engines. Roads should be built for easy maintenance. In general, simple things that can be fixed easily and immediately are best.

Low Cost

This relates closely to simplicity, but it also means that over-investments in arid and semiarid rangelands should be avoided. There are too many risks. Returns per unit of land are generally low for arid and semiarid lands. Cost/benefit ratios seldom favor improvements with a high cost per unit of land in developing countries, even when ammortized over long periods (30 years).

Durability

Though costs need to be low, durability is also critical. This does not mean, however, that roads need to be covered with asphalt. Shale or gravel can also create a durable surface. All infrastructural improvements should be such that they require as little maintenance and future investment as possible.

Use of Local Labor

Involving people in infrastructure development is preferable to bringing in machines to do the job. It is a learning experience for the workers and may help to create an interest in maintaining what has been built. And, of course, the income that they earn may be important to them. Using large machines is no doubt faster, but it doesn't provide experience that may be helpful in the future.

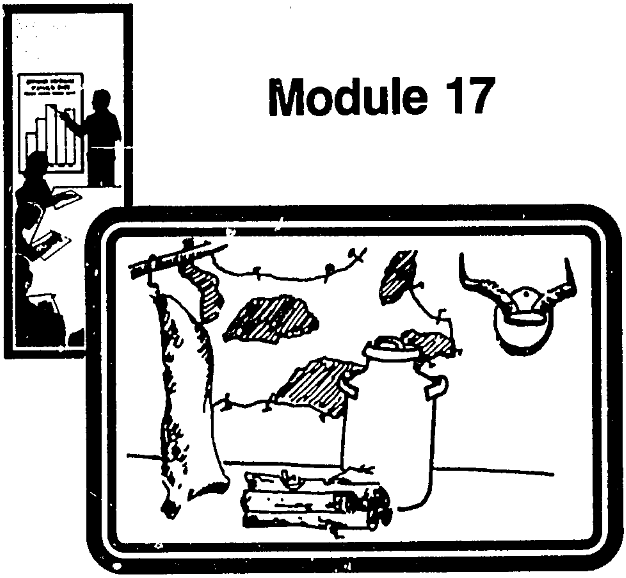
Use of Local Resources

Too many projects use manufactured goods — even manufactured goods that have to be imported. This leads to excessive costs and great difficulties in maintaining the installations. Therefore, the rule should be that any technology employed must be based on the use of local resources wherever possible. If this cannot be done, maybe the technology should be changed. Still, there are some things that often cannot be found or made locally — for example, how many developing countries manufacture telephones, telephone wires, and radios?

Acceptability of a Technology to Local People

Acceptability is critically important. This is one of the reasons why local people should be participants in the planning and execution of projects. For example, in one African country the government and a foreign donor made a series of installations for water. The pastoralists, however, did not like what these installations did to their grazing patterns and asked the government to close them. A lot of money could have been spent for a better purpose.

Module 17



Marketing Rangeland Products

Many think that the only products of rangelands are those derived from domestic animals — meat, milk, hides, and wool. These are the main products, but not the only ones. Wild ungulates (hoofed mammals) in many places, especially in Africa, do provide meat and hides, but are also an enormous asset to recreation and tourism whether for hunting or simply for viewing and photographing. Rangelands also produce timber, firewood, resins (like gum arabic), medicinal plants, honey, minerals, and water. In many places water may be the most valuable product (although the land owner or leaseholder does not often get the benefit). Recreational fishing is good in some rangeland streams.

This module addresses marketing of animal products because it directly affects the welfare of the range people and of people in general, and indirectly affects the use of range resources. Game cropping is discussed in another module.

Although much is known about marketing in developed countries, little of it is useful where traditional self-sufficient systems prevail. Western experience cannot be generalized to developing countries, especially in Africa. It is therefore essential to know the local situation before launching marketing-development programs. The importance of this is emphasized by the fact that even with substantial investments and care in execution, livestock-marketing projects by the World Bank and others in Africa have not met expectations.

Issues

The issue of marketing range livestock becomes increasingly important as the human population grows. Growth of the urban population in particular impels governments to seek to increase production on rangelands through better marketing. This can be a most difficult task due to traditionally inadequate marketing of animals in regional or national markets, inadequate infrastructure, etc.

Attempts at improving livestock marketing are generally concerned with getting more livestock products to the market, reducing costs, and improving quality. In addition these attempts often involve processing, e.g., sausage making or freezing. It is important to note that these kinds of objectives have practically nothing to do with the land resource, except to the extent that they might help to remove more animals from the range. Generally not even supplementary pastures or herd structure are improved through marketing. Hence, the benefits would be limited to more money in the pockets of the producer and savings for the consumer.

Marketing is not simply a selling process; it is a process for exchanging goods or services for mutual benefits. If the potential seller has no desire for or need of certain goods (which may be represented by money), he has no incentive to sell. Also, if he is offered too little for what he has to sell, he will be reluctant to part with his product. Selling a product, of course, also means that the owner loses the use of that product. Since many traditional African pastoralists have few external needs, they may have little interest in selling animals that might otherwise be considered ready for the market. If they do not have a surplus they will be even more reluctant, unless they feel they could live better by exchanging some animals for other food staples such as grains. Similarly, if inflation rates are high, animals will be retained longer than normal.

The decision to sell is further complicated by other factors. Perhaps the most important is that the number of livestock reflects the owner's status or prestige. And from a practical viewpoint the owners sometimes feel that numbers by themselves constitute security against drought. Besides that, the animals facilitate complex lending arrangements, pay for brides, etc., all of which contribute to security, status, and power. For these and other reasons, marketing arrangements do not necessarily balance production with demand as is widely assumed.

Successful marketing may demand fundamental alterations in the production system, such as changing the time of marketing, and age and condition of the marketed animals; the practice of milking lactating females; and even what species is grown. For example, shifts toward more emphasis on production have in some places accompanied a transition to a market economy. Whatever these changes in the production system are, they may or may not be sustainable, favor improved condition and trend of the range vegetation, or increase the stability and security of the range people. Understanding these relations is vital and is an area where more research is needed.

That is, marketing strategies where "production" is for the market affect the management of arid and semiarid rangelands and therefore influence their condition and trend. And because improved management and range conservation are basic to long-term production, marketing systems should contribute to that aim, or at least not add further to the range problems.

Marketing systems should not upset practices and arrangements that provide security during drought. Moris (1981), for example, mentions the disillusionment of Maasai pastoralists with marketing systems after they shifted from mixed-species herds to predominately beef production in response to earlier market conditions. They discovered that the market could not absorb their excess sales of cattle during drought; many of their cattle died. The emphasis on cattle rather than a combination of animals with different capacities to survive in drought increased their vulnerability to drought. Unless counter-measures such as forage conservation are taken, dependence on one type of livestock will continue to be a problem when the market cannot absorb surplus animals, particularly during drought.

Program and Project Development Planning

It is essential to first try to understand the human needs and trends in relation to local marketing conditions. Economic assessment based merely on the more obvious economic criteria is not likely to be satisfactory. A good starting point is to find out what, if anything, is wrong with the existing marketing system, and what might bring changes.

Demand

In some countries, demand is substantially greater than supply. This elevated demand may result from local needs or exports. Not infrequently, the demand is artificially high due to government intervention to keep prices low to favor the consumer. Producers generally react to low prices by reducing supplies. Therefore it is necessary to know approximately what the actual demand is for each kind of product, and for what quality and where, etc. In making the estimates, try to anticipate changes in demand.

Supply

Price is the most obvious of the factors influencing supply. Certainly if the price is too low, production will not increase. However, as we have seen, many other aspects are involved, especially the interest that livestock people may have in selling.

Since the precise causes for low supplies will vary, it is important to identify the multiple influences.

Some of the questions that ought to be considered:

- Is the prevailing price, whether set by the market or by government, at a low level? If the price is held down by the government, how is this influencing activities at the producer level?
- What are the ways in which animal products are brought to the consumer? What are the costs in the various steps, including weight loss through trekking?
- Is access to markets (through whatever means) adequate? If not, where are the deficiencies?
- Are traders doing a good job in finding and bringing animals to market? Are their costs or profits excessive? If costs are high, could they be reduced significantly by better roads? Are producers at a disadvantage in price determination?
- Are the local people on a monetary economy?

It is easy to conclude that significant deficiencies exist in the marketing system after making only a cursory examination. However, only a thorough investigation can tell whether or not these conclusions are valid.

In order to better identify and understand deficiencies that may be linked to production, answer this question: What are the dressing weights (carcass) and ages of the various species brought to market? The data should include information on the median, mean, and range, or even better yet, the frequency distribution of different weight classes. From an analysis of this type, much can be determined about the conditions under which these animals have been raised. This could lead to probing the causes of the results observed. For example, if most animals are marketed at an age exceeding that which could reasonably be expected, an explanation should be sought in the field, and consideration given to correcting the problem.

In developing the overall picture of land use and productivity, seek answers to the following questions.

- Is movement to market concentrated in certain parts of the year or distributed evenly? Are these movements associated with rainfall or forage growth? Is selection of animals for sale based on weight, age, degree of fattening, sex, or what? Are there more animals available that could be sold to an advantage? Is building up herds as insurance against total loss in case of drought an important factor limiting animals marketed?

- Are animals bought directly off the range to be taken to market or are they first sold to intermediaries for further growth or fattening? If so, with what results? If this is not done, why isn't it? If it is done, at what weight and age?
- What is the potential for animal products other than meat?

The answers to the above and other related questions should give some clues as to how well the commercial objectives complement the production systems and to what extent, if any, marketing is contributing to production.

Questions intended to explore traditions or other motivations that may influence readiness to sell include the following:

- How important are animal numbers to position (status) in the community? Does this apply to all animal species? How common are practices designed to give "security" to the individual family such as "lending livestock"? Are livestock important as bride price or for other festive occasions? How may drought-security provisions influence selling behavior?
- How is selling, or not selling, influenced by needs or demands of pastoralists for other goods (food staples and health, for example)? What goods are in demand: foods, clothes, etc.? Is the demand regular or irregular? How do diet and sources of the food available influence attitudes toward selling? How many kinds of animals and how many of each are required to meet the food and other purchase needs of the pastoralists per year? Is there any variation in sales in relation to size of holdings or to species kept? If so, how do size and composition of herds vary?

Assessment of the situation along these lines should give an idea of the problems that might need to be resolved in order to actually improve the services that marketing can provide. It should then be evident that a marketing problem requires a collaborative effort among range managers, consumer specialists, anthropologists, economists, and others for research or other activities that may be necessary. Also, it is to be hoped that the information would lead to caution about seemingly easy solutions such as introducing auction sales that have weighing scales. At this stage it is critical to find out what the pastoralists think the marketing problems are and what should be done about them.

Criteria for project selection include importance of problems, similarity or representativeness of problems, interest of people, interest of government, possibility of cooperation among agencies involved, likelihood of success, etc. The observations and questions relating to program development are equally applicable to project development. In project formulation, however, it is essential to identify with more precision what is to be done, how it can best be done, and what it takes to do it.

The analysis preparatory to project formulation should therefore clarify exactly where the deficiencies lie. Some things to identify:

- deficiencies in infrastructure (roads, telephone communications, etc.) and the presumed effects of these deficiencies on the functioning of market systems
- inadequate demand due to low income, poor distribution of consumer market, etc.
- inadequate market structure (purchasing, distribution, sales mechanisms) and their effects on costs
- fluctuations in production (and supply) and causes
- conditions influencing incentives for selling (price; high weight losses; factors that discriminate against production; need for security, status, etc.)
- inadequacies of production systems (orientation toward milk production, lack of stratification, lack of culling, lack of supplementary feeds, poor grazing control, etc.)
- effects of drought on supply, quality, and price
- consumer preferences and how they can be met
- kind of animal husbandry that complements range and forages
- range and forage grazing systems

Determine what actual benefits could be achieved by the actions proposed, and what the priorities should be. If increases in production or changes in quality are anticipated, make sure that the consumer demand for the additional products is there. Changes in marketing strategy at the level of local markets might be required. For example, some years ago in Benin meat quality was improved through better grazing management. It then became necessary to build a more attractive and sanitary meat market to appeal to the clientele who were interested in better beef. The principle this illustrates is that marketing is a chain. Strengthening one link may not be enough because usually there is more than one weak link. A new chain is likely to be much too costly and inefficient in the early development stages. For this and other reasons, marketing projects on livestock need to be long term, cost effective, and carefully planned.

Keeping costs down is imperative. For an illustration see Moris' (1981) account of the Maasai range project — and the folly of markets that are not economically sound.

The usefulness of integrating marketing within other project activities cannot be overemphasized and is again illustrated by Moris (1981). In other words, besides asking, "How can the overall efficiency of the marketing system be improved?" also ask, "How can marketing contribute to the desired change in the production system?"

Identify the potential links between a proposed marketing system and other agencies or institutions early and make sure that these groups will cooperate. Marketing is dependent on both demand and production, so include both producer and consumer groups.

Technology Selection

The technology for improving marketing should:

- Be simple and easily understood. Generally this means that the new technology will not be vastly different from what exists.
- Stimulate progressive but gradual changes. Investments to promote marketing have proved risky. Learning from experience can vastly reduce the risks and improve performance in the long run.
- Increase participation of pastoralists while maintaining security. No sensible pastoralist (or rancher) is going to risk his security for temporary (and perhaps questionable) gain.
- Be widely acceptable. Know what the risks are if some proposed action goes strongly against special interests or the community.
- Favor more efficient production and increased income. This is absolutely essential to any producer accepting a new practice.
- Encourage better land use. The effective productivity of most arid and semiarid rangelands is less than it could be. Unless grazing can be better controlled, productivity will only decrease. For example, moving young animals to finishing areas or supplemental feeding during a feed shortage can reduce risks and increase production.
- Be largely self-sustaining. Governments in developing countries too often involve themselves in projects that have large sustaining costs. Marketing ought to pretty well pay for

itself, as it is a service for just about everyone. Developments in technology, installation, etc., that preclude a self-sustaining organization should be avoided. The consumer as well as the producer should pay his/her fair share.

- Provide technical advice and incentives. The government's main responsibility should be to provide the necessary technical advice and possible incentives to the producer. These should provide tangible results to both producers and consumers.

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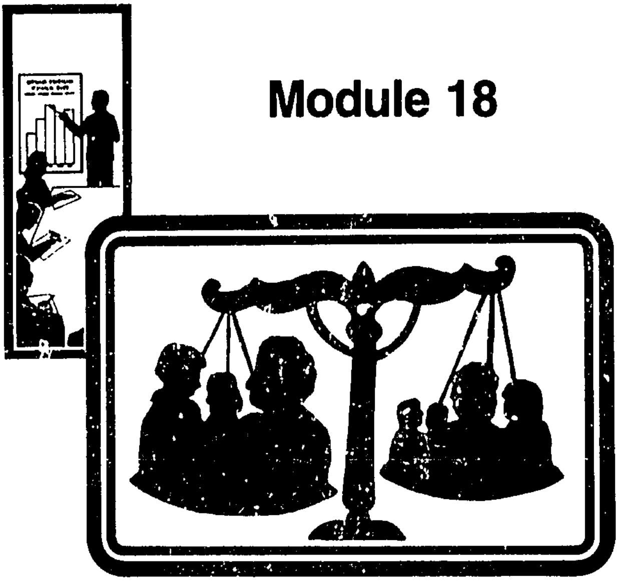

Module 18

Agency and Personnel Selection for Development Activities

Successful integrated project planning and implementation require program continuity. To achieve this, more energy and care should go into identifying contractor requirements and selecting contractors and personnel that can see the program through to completion. Although this may require designing long-term projects (10 years or more) the accumulating knowledge will strengthen the development process.

There has been a strong tendency to change consultants, institutions, and even whole planning teams between each step in the planning-and-implementation process. Changing personnel and institutions during a development program disrupts continuity in background thinking and program conceptualization. Sometimes changes and new ideas are required, but the effects are frequently disastrous because each new contractor disregards what has gone before.

Agency Selection

After a project has been designed and approved by the host-country government, and a donor is willing to fund the project, the next step is to select the appropriate agency to implement the project. A description of the scope of work in a request for proposal (RFP) is critical, as is a carefully considered listing of personnel and qualifications required. (This information can also be included in the project design paper.) Such attention to detail helps to make the selection process successful.

For range-development projects it is essential that all competing agencies and firms be evaluated on the basis of their expertise and background in range management. The lowest bidder will not necessarily provide the best performance.

The following guidelines are suggested for the selection of contracting agents.

- Provide continuity in agency and personnel through all phases. The practice of offering multiple requests for proposals and accepting the lowest bidder often works against continuity. Such procedures often result in bringing in new planning teams for project papers and others for implementation. Different contractors may have different philosophies and different staff strengths.
- Select the most appropriate agency or firm at the start of the project and keep it until the project is completed, even if

there are several phases. Changing agencies between phases disrupts the project and reduces efficiency.

- Use contractors with in-house expertise in the major disciplines required for a particular project because they are more likely to be able to support the project throughout its duration. Home-office staff with both international and professional experience can provide the needed flexibility and balance to meet unforeseen opportunities and problems that so often arise in development activities.
- Use host-country contracts if possible.
- Use private and voluntary organizations (PVOs) when appropriate.

Personnel Selection

Personnel should also be kept on the project as long as possible. If personnel changes are necessary, a period of overlap will ensure continuity. Host-country governments should also encourage continuity by providing counterparts. Specific requirements should be written into the project design for selecting project personnel. The following guidelines are suggested for the selection of personnel.

- Select staff carefully. Of course, personnel with range training and experience in developing countries is essential. Often it works well to combine an older, experienced worker with a younger, inexperienced person interested in international development. This procedure provides a mechanism for a younger person to obtain experience while contributing to the project. The same principle could be applied to host-country nationals who have the necessary education, even if a donor must pay them a salary during the planning period.
- Include a rural sociologist or an anthropologist (according to specific needs) in most range-development projects. This individual should at least have some appreciation for range management since it is unlikely that he/she will have any formal training in the discipline. The social scientist should work closely with the range management adviser to ensure integrated planning and implementation.
- Include monitoring and assessment in all range-development projects. Personnel with background in these aspects should be included in the project team if there is no agency in the host country. However, it would be preferable to develop such capabilities in the host countries (see module on assessment and monitoring).

- Encourage qualified nationals to participate at every opportunity — even if this involves the expense of paying for a replacement to assume their regular duties while they assist with the planning job.
- Involve the local pastoralists and livestock owners in the planning process, particularly during the area- and project-specific planning. The best way to achieve this is if the planning team early on establishes a rapport with these people.
- Encourage contractors and planners to visit and work with the targeted population during the project-development phase. This should enable planners to have enough contact to establish rapport with local pastoralists and agriculturalists and to understand the local situation. Only from such rapport can these "people of the land" be effectively involved in the planning process (White and Tiedeman, 1985, pp. 1-10 and 78-86). The planner or contractor who is not known by the local people cannot hope to elicit their cooperation and involvement in project implementation. Sandford discusses this question of involving local people at length and provides many guidelines for building a successful relationship (Sandford, 1983, pp. 232-241, 247-250, and 275-276).

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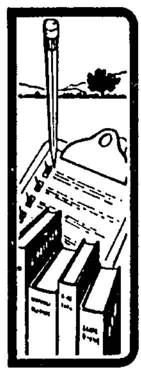
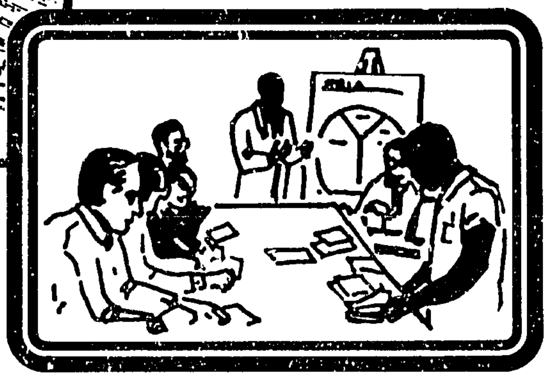
SECTION III



GUIDELINES FOR PROGRAM PLANNING AND DOCUMENTATION

Module 19



Program Planning

Many people and agencies concerned with the use, development, and management of renewable natural resources in the Third World are dissatisfied with past projects on the arid and semiarid rangelands. Many projects dealing with crop and animal production in these fragile environments have been counterproductive. They have created more severe and complex problems than they were initially intended to solve: Famine repeatedly ravages these regions as though nothing constructive had been attempted.

Many international agencies and organizations have tried to suggest ways to increase the effectiveness of development and management projects in rangeland areas. The consensus is that many of the causes of the problems are rooted in the unanticipated interactions between traditional and social factors, and the development interventions. Among the frequently mentioned observations and recommendations:

- A critical need exists to improve the way projects are planned for arid and semiarid areas regardless of whether that planning deals specifically with rangeland resources or with other development activities within these areas.
- Successful rangeland projects require a long-term commitment, 10 years to 25 years.
- The amount of time (number of budget cycles) committed to a specific project must ensure building of adequate in-country capability and full transition to management by the host government.
- More time and funds must be provided for planners to establish a rapport with and learn from the local people who will become the beneficiaries of the projects.
- Project planning must be based on a good understanding of indigenous societies and their traditional resource use and management systems.
- Planners must develop a greater empathy for and understanding of the people who are a part of these systems.
- The pastoral and agricultural people affected by these projects must be participants from the outset.
- Project conceptualization and design teams should always be multidisciplinary and include experts in the humanities and social sciences in addition to resource economists and biologists.
- Qualified range management experts are equally as important as agricultural officers, human-health people, livestock officers, and veterinarians on the mission staffs of donor agencies and on planning teams in arid, semiarid, and subhumid regions.

- Project benefits will generally be greater and more lasting if realized through training and assisting national experts to do their own situation and problem analysis, project design, implementation, and follow-up.
- Interventions must start from "where the people are" and build on traditional management, often in small increments.
- More attention needs to be given to projects and actions that prepare the ground for successful development/management interventions.
- Program elements must be carefully coordinated by the host government for continuity and compatibility, both within and among the activities of various donors.
- Conception of or desire for a project on the part of the host government is not alone sufficient reason for its planning and implementation.
- Whether with donors or country participants, carefully establish accountability; reward those who guide projects to the realization of objectives.
- Preparation of staff should always be a prime concern.
- Consistency of action in resource development is essential and highly dependent on adequate documentation, problem analysis, and well-oriented planning.

The objectives of this module are to 1) develop an improved understanding of the planning process among those concerned with renewable natural resources and human development in Third World nations and 2) offer some guidelines for planning that will increase the lasting benefits from rangeland development and management in these countries.

Planning Defined

A plan is "a method for achieving an end; a detailed formulation of a program of action." The act of planning requires that one "devise ... the realization or achievement of" a goal or objective (Conant et al., 1983). The first step toward becoming a good planner is to know the discipline in which you are planning. The second step is to understand what a plan really is and the process by which it is devised. The planning process, in summary, consists of the following: 1) setting goals; 2) analyzing situations, problems, and needs; 3) creatively thinking through alternative actions; 4) evaluating possible side effects; 5) selecting and sequencing the best options; 6) executing the planned sequence of options; 7) monitoring progress and side effects to ensure attainment of project objectives; and 8) follow-up to ensure host-country assimilation of the new procedures.

Planning Units

The words "planning units" can be interpreted two ways — in the institutional sense of the government or corporate organization that handles the function of planning, and in a geographic sense as the area included within one integrated plan for development and management. We shall first cover the geographic sense.

The way you define the geographic extent of a planning unit directly determines the objectives and the information that is feasible to acquire. It also affects whether or not the project succeeds.

Establishment of Geographic Planning Units

It may be easier to appreciate the importance of proper location of the boundaries of geographic planning units if the guidelines are stated in terms of the consequences of wrong placement.

- If the unit's boundary does not match traditional boundaries between established social organizations, it may be difficult to implement all plans developed for the unit and local people may have little interest in the project.
- If the unit's boundary does not follow natural watershed boundaries, complications in the use or allocation of resources may result.
- If the boundary for planning purposes does not match political boundaries, jurisdictional disputes can be expected.
- If planning boundaries do not coincide with established uses, implementation problems will arise.
- If all planning is done within small, highly specific areas for limited purposes, integrated planning may be impossible and serious errors may be made in resource allocation. Adverse impacts in other areas of resource use and management may result.

Multinational planning. While multinational planning for large regions may be feasible to draw nations together in their thinking as they deal with common regional problems, these efforts are often extremely costly. They may serve to focus public and international attention on problems and to attract funding for the essential and more detailed project designs and implementations. However, the individual Third World nations rarely have the number of capable staff and agencies available to handle the responsibility for this level of planning. In many respects this level could be considered an unwise drain on limited professional manpower when viewed in relation to realizable benefits.

On the other hand, some international rangeland problems require multinational attention and agreement. Some examples are disease and pest control, famine relief, transhumant and nomadic livestock movement where settlement of these populations is not the solution, water development, training, and information exchange. Drawing multinational planning groups together under the direction of United Nations agencies such as the Food and Agriculture Organization (FAO) can, in instances like these, be an effective mechanism for regional planning. An example of such is the FAO planning of a program for the ecological management of arid and semiarid ranges (EMASAR). This unifying program is now supported by over 90 national and multinational projects on rangeland problems. Another very successful multinational program is the Desert Locust Program of FAO, which has been successful in avoiding a major, devastating outbreak for nearly one-quarter of a century.

National-level planning. Similarly, national-level planning can either drain resources or ensure that they are rationally allocated. Careful and informed national-level planning can 1) produce comprehensive, integrated programs; 2) establish priorities; 3) provide the basis for interministerial cooperation in development; and 4) establish the framework and assign responsibilities for planning the individual projects.

Area-specific planning. Development and resource-management projects are usually specific to a defined area within a country. The information needed for planning is much more detailed and comprehensive — the level of detail is normally compatible with scales of 1:50,000 to 1:30,000 (occasionally larger). Depending on the problems to be addressed, information may be required on vegetation, soils, landforms, physical developments and infrastructure, land use, social structure, demographics and migratory routes, and on animal populations, marketing, husbandry practices, and movements. In extremely arid rangelands in Third World countries where resource values are low, or in areas where the government does not have the capacity or need to work with this level of detail, intensive assessment of landscapes at a scale of 1:250,000 or 1:200,000 may provide all the information needed for area-specific planning for extensive production systems. In this connection, it is often helpful to decide ahead of project design whether a low, moderate, or high level of intervention (inputs of capital, labor, and technology) will be feasible in view of the characteristics of the human-animal-resource ecosystem.

Planning Institutions

This section discusses the second definition of a planning unit, the administrative organization of planning. Regardless of the institution or organization responsible for project planning in developing nations, there is almost unanimous agreement on the primary cause of low benefit to dependent peoples from many range, agricultural, and animal projects. It is the failure 1) to acquire adequate knowledge and to understand the traditional management, social organizations, and values of the indigenous society and 2) to use this information and understanding in designing development/management projects. To avoid these failures, any planning organization or unit should include qualified staff in anthropology and(or) sociology and resource or land economics.

There are two aspects of the institutional or administrative structure for planning: 1) the organization and assignment of authority and accountability for rangeland resources within the country and 2) the organization and responsibility for planning. The way in which these questions are resolved affects how donor nations must interact with the host government in planning and the effectiveness with which programs and projects on range development and management can be carried out. Rarely will a country have a single agency, or even a single ministry, to which the donor can go to discuss the full spectrum of rangeland problems and needs. Therefore it would be desirable, wherever the donor can create the opportunity, to encourage the formation of a ministry or a single agency responsible for rangeland resources.

But caution, it has not worked to give this responsibility to a department dedicated to another discipline, such as animal husbandry or forestry. On the other hand, there is strong precedence for successful rangeland-resource departments organized within ministries of agriculture or natural resources. Even the formation of a separate ministry in countries where rangelands constitute a major part of the resource base would not be unreasonable. In any case, the existence of a range agency centralizes the responsibility for this resource and greatly simplifies working with donor governments on integrated rangeland projects.

Similarly, if the planning functions of the host government are performed by separate agencies or ministries, the work of renewable resource development and management is severely complicated. Vitally important steps can be overlooked or forgotten in the implementation stage simply because of the separation of planning from the agencies accountable for the management and the condition of the resource.

The answers to two questions on institutional organization of governments determine how effective donor nations can be in helping to develop and manage rangeland resources in Third World countries. The first question is, "Where does governmental responsibility lie for the development and management of rangeland resources?" and the second is, "How is the government organized to handle the planning functions for the development and management of renewable natural resources?" Regarding the first question, if responsibility is not fixed in a single agency that has rangeland resources as its **primary responsibility and function,** it will be much more difficult for a donor nation to plan and implement a successful project. Furthermore, the project will probably not survive the withdrawal of the donor regardless of its initial success. This problem is more thoroughly discussed in the module on policy and institutional development.

The answer to the second question, on how the planning function is handled within the host government, will largely determine whether or not the philosophies of integration of planning with implementation can be successfully adopted. Many emerging governments have copied the idea of a separate ministry or agency for planning. For a developing nation, this has some serious drawbacks. The greatest one is the difficulty of achieving the smooth integration of planning with implementation and project follow-up. The concept of evaluation and monitoring as an integral, driving force of planning, implementation, and follow-up will also be difficult to apply through a separate planning agency. These disadvantages are substantial and difficult, if not impossible, to successfully deal with where planning and action functions are in two separate agencies. If power plays develop between the agencies, as they often do, the necessary interagency coordination essential for a successful project will require master diplomacy and very close monitoring to achieve.

In addition, the organizational separation of planning and action almost always results in duplication of professional expertise. The reservoir of trained professionals with enough experience to handle planning is generally inadequate to allow this luxury in most developing nations. Rangeland planning without professional competence in range science and management usually leads to shallow planning, implementation problems, and unanticipated side effects. To avoid these problems in a situation where the two are separate, trained professionals have to handle the dual role of planning and management if area-specific programs are to succeed. Also, the isolation of planning from implementation requires a higher level of effective communication between the planning and the implementing organizations than commonly occurs even in the industrial nations, let alone in an inexperienced, developing nation.

By establishing the responsibility for planning within each ministry, this critical function is generally placed in the hands of the most experienced and capable personnel in the country. This arrangement also has the advantage of being able to involve some of the same people or the same supervisors in the implementation of the project — that is, liaison between planning and implementation is reasonably assured. The agency has to prove the quality of its planning by making it work. When expertise from multiple disciplines is required to plan a project, form an interdepartmental working group within the agency or draw on consultants.

The only time a single national-level planning group would be useful is when it is formed expressly to develop a comprehensive national plan for the integrated development of natural resources.

Even here, however, the most economical way to achieve this goal is through an interdepartmental working group. Members of such a group could be drawn together from each ministry or agency, returned to their regular work when the national plan is accepted, and reformed when the plan needs to be updated. With this approach, the high costs of permanently maintaining a special bureau are avoided. A side benefit of the approach is the greater ministerial and agency support for the national plan because each was a party to its conception and design.

The Planning Process

Based on the kinds of direct problems and side effects observed from past planning efforts, regardless of the donor or planning agency, the most important change that could be made in the planning/design process is to emphasize the preplanning functions and ensure that a social anthropologist and appropriate natural resources experts familiar with local conditions make up the planning team. This team should be involved in the national plan and preparation of the initial list of problems, needs, and potential development projects. If the team then proceeds with area-specific or project planning, maximum efficiencies are obtained. The presence of a social anthropologist on all planning teams, starting with this initial effort, would probably prevent the initiation of unsuitable projects by adding critical technical advice on human needs, project feasibility, and potential side effects. It would also help with the social and cultural understanding of the environment in which projects would ultimately be planned and executed, and would provide this information at the right time. In many instances such team participation would result in activities to improve the understanding of the indigenous society and its culture and traditions, or to provide educational and extension support on which an eventual management project could be built. This approach would define and clarify the starting point from which any development or improved management effort must begin better than resource-management experts have traditionally done when working alone.

Guidelines for Project Planning in Rangeland Areas

Levels of Planning

The goals and objectives of planning are determined by the level at which it takes place — the government level or the program level.

Government level. At the government (or first) level, management is involved with formulating national plans (for developing and managing resources or for encouraging economic development). The major concerns at this level are policy-making, setting national goals and objectives, short-term planning for allocation of resources (financial and human), setting priorities on development options, organizing for accomplishment, and reviewing operations to evaluate performance. The operational aspects of this level may deal with political, legislative, and executive management; with development of guidelines; and with setting the stage for integrated planning and management at the area-specific level. This corresponds essentially to the broad, overall, or comprehensive planning function identified by Child et al. (1984, p. 218). It provides a framework within which the next level of planning is done and approximates the Country Development Strategy Statement (CDSS) used by USAID. Sandford (1983, pp. 47-60, 255-294) discusses the planning and support functions in the government management of development projects (so this is not repeated here).

Program level. At the program and project (or second) level, planning could more appropriately be called "design." Here the concern is with working out the details of a specific operational plan within the guidelines set forth in the national plan. This parallels essentially the area-specific planning of Child et al. (1984).

In the design or area-specific planning phase, it is helpful to delineate three areas of activity (Child et al., 1984, pp. 176). The first is preplanning, which covers things that must be done before beginning the actual design or development. Examples of important concerns in the preplanning phase are the setting of project goals and objectives, assembly and analysis of relevant information, preparation of a situation statement, identification of problems and perceived needs, specification of new information needs, and identification of the traditional social, cultural, and economic environment in which projects will be carried out.

The second area is the acquisition of the additional information specified during preplanning, and the third is the actual design phase. Here, especially, the repeated application of problem analysis and decision-making principles leads the planner through the design, specification, and sequencing of elements for implementation. These ordered elements become the resource development or management program/project which, when successfully carried out, should achieve the goals and objectives, solve the problems and fill the perceived needs, and contribute to goals set in the national plan.

Putting Plans into Effect

In implementation the emphasis shifts from thinking, analysis, and design to the doing or action mode, but the former planning elements are not totally set aside. This action phase emphasizes the functions of staff recruitment and organization, supervision, logistics, fiscal control, quality and performance control, program or project direction and monitoring, and usually some fine-tuning or redesigning of the initial plan.

Monitoring should involve post-completion assessments to ensure that all viable goals and objectives of the project are attained, that an effective transition to complete operation by the host government is effected, and that unanticipated side effects do not go unnoticed. This module will deal only with that level of planning called "design" and with implementation.

Issues

There are three central issues with which we are concerned. First is integrated planning versus single-purpose, isolated planning (Child et al., 1984, pp. 209-212). Second is coordinated planning that ensures a smooth transition between projects and a planned sequencing of projects within a development program. Third is a planning procedure that always looks at the side effects of and interrelationships among projects that may create problems in other areas.

Planning for relatively narrow or limited projects that are "completed" without specific concern for project follow-up or for interrelationships with other projects in related areas is not compatible with the requirements for sound ecological resource development and management. Three examples are 1) a project on livestock that may be comprehensive as regards animal health, husbandry, and marketing but only deals in a limited way or not at all with grazing-land practices and inter-relationships with agricultural cropland; 2) resource-assessment projects terminated without communication with the planners through which follow-on projects in resource development and management will be designed; and 3) a borehole program to locate and develop water without planning to manage the use of the water or the vegetation and soil resources associated with its use.

This module proposes an approach to integrated planning that will ensure that adverse side effects that may arise are considered in advance, and that ameliorative measures are designed.

Guidelines for Broad, National-level Planning

Comprehensive problem analysis and resource planning will help to ensure compatibility among projects. Such highly generalized planning usually meets the needs for the broad administrative/management functions of government, while still providing an important framework for area-specific resource assessment and planning (Child et al., 1984, p. 218). Both levels of planning are necessary to achieve the goals of integrated resource development and avoid the adverse side effects of isolated project planning.

Staffing for National-level Planning

The requirements for success in national-level planning are an information base generated at scales of 1:200,000 to 1:250,000, and a multidisciplinary planning staff. The staff should include a qualified social anthropologist, experts in renewable and non-renewable natural resources, and a resource economist. One of their most important tasks is preparing a series of situation statements and problem analyses of each major geographic planning unit in the country.

Situation Statement and Analysis

The situation statement and analysis should summarize the traditional systems for resource use and management for each subregion of the country. It should particularly focus on how to prepare the way for the main project thrust. This exercise will provide essential background for project conceptualization and, for example, show where additional research, information gathering, or education-extension work should be done prior to the design of specific projects.

The results of these interventions should be worth the effort and cost as long as national planning is looked upon as an umbrella within which area-specific projects will be developed. When considering the possibility of national-level planning, objectively answer the question, "is the government organized, structured, and staffed to participate in developing a coordinated national plan and to carry out such a plan when it is developed?"

Experience has shown that the answer will frequently be negative. If this is the case, the deficiencies must be corrected before work can proceed.

Guidelines for Area-specific Design and Implementation

Project Design and Implementation as a Unified Effort

Although projects are designed and implemented by the donor agency through separate contracts, this need not necessarily be so. In some instances, a combined design and implementation project would have many strong advantages. Three important reasons for emphasizing the intimate relationship between designing a plan and putting it into effect are:

- It would have an impact on members of the planning agency to know that they would have to prove their plan by successful implementation.
- Continuity is essential — of philosophy and concepts as well as between program elements. Each phase needs to flow smoothly into the next.
- Planning and design do not stop abruptly when intervention begins. If managerial or operations monitoring is being carefully and systematically done, redesign will be continuous!

Development as a Process

Speaking of area-specific development plans, Sandford (1983, pp. 264-267, 270-272) discusses an important concept of planning that he calls the "process approach" to planning in contrast to the widely understood "blueprint or project approach." In the developing-nation situation, the process approach has many distinct advantages. It draws planning and implementation together into one continuous sequence of events with numerous adjustments along the way.

> ... A "process" approach is a managerial orientation which assumes considerable uncertainty and is characterized by flexibility, by learning by innovation, and by continued openness to redesign and adaptation to changed circumstances.
> (Sandford, 1983)

What better describes the need and the working environment in a developing nation? Most people have no problems with the process approach when they are dealing with broad programs.

Yet when implementing the separate elements of those programs, the typical planner insists on setting the plans inflexibly in concrete and following the "blueprint" as though it guaranteed outcome and appropriateness of technological interventions. The process approach may even be preferable in North America and other technologically advanced regions of the world. Development is a process involving many surprises, and imaginative redesign is necessary throughout the establishment of an intervention and beyond.

Role of Problem Analysis in Planning

Careful information gathering and thorough problem analyses ensure a look at the situation through the eyes of the people affected, and so help to prevent most of the side effects of ill-conceived projects. Unfortunately, rarely is sufficient time spent on this. Too often it appears that many projects are conceived mainly in response to the desire of a host ministry for financial support in a specified area. While it is important that the host country approve all projects, a good analysis of problems and their causes is also critical for current and future orientation. This is underlined by the fact that many well-planned projects have fallen short of goals that should have been attainable even in a developing nation. Such failures also indicate a lack of careful monitoring (and adjustment of the project). However, the more thorough the planning, the fewer the adjustments required.

Problem analysis is not something done once at the initiation of planning and laid aside. It is a tool to be used throughout the development phases. Its first use, in preparing the situation statement, is in generating a clear and concise characterization of problems, perceived needs, and opportunities. As each viable project is identified through this process and designed, the principles of problem analysis are applied repeatedly.

When undertaking rangeland resources planning in developing nations, three situations may be encountered. 1) The situation may be satisfactory by existing evaluation standards; 2) the situation may be undesirable (i.e., a deviation from standards — a problem, deficiency, or need exists); or 3) an opportunity may exist to benefit the ecosystem.

Problem analysis is a systematic way to ensure that decisions will be sound and rational — based on carefully analyzed facts. In summary, the process involves identifying situations that need correction or improvement, identifying cause(s) of the deviation, specifying and analyzing of alternative action(s), analyzing problems that may arise from each alternative action, and finally, deciding to select those alternatives with the fewest adverse side effects. Each such alternative is a building block for a sound plan of action (figure 18).

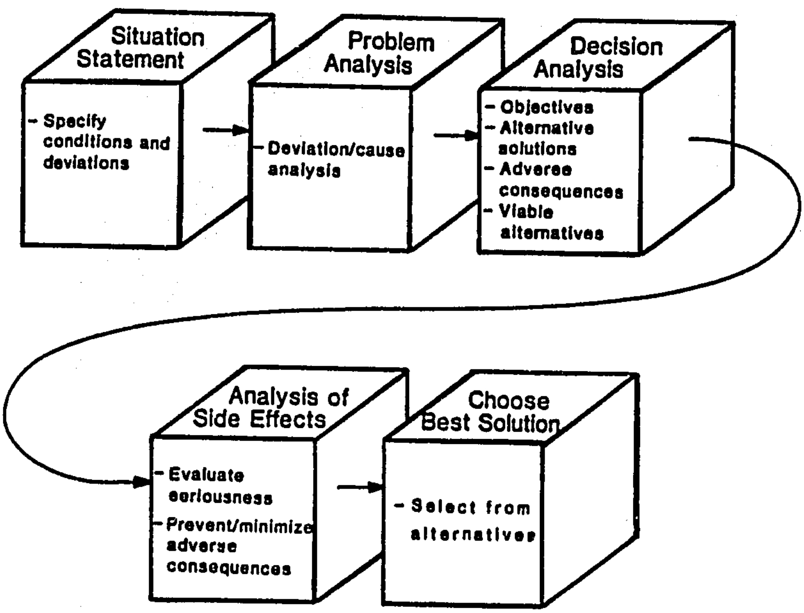


Figure 18. The role of problem analysis in the selection of management alternatives, which become the building blocks of a sound management plan.

The procedures of figure 18 are progressively applied at each major step through the outline for planning and implementation (table 2). When unanticipated events occur during implementation, the procedures are reapplied to devise interventions or to fine-tune the plan. This process is thoroughly explained and illustrated by Kepner and Tregoe (1981).

It may help to understand the relation of problem analysis to development planning. An easy way to achieve this is to compare the basic ways people think, how they handle problems and how this fits in the planning context. This comparison is summarized in table 2.

Table 2. Comparison of the ways people think and handle problems with the four fundamental steps in planning (adapted from Kepner and Tregoe, 1981).

The ways people think — questions that people respond to	How people handle problems	Steps in developing building blocks of a plan
What is happening?	Clarify and specify the situation	Appraise the situation, deviations, and opportunities; separate concerns; list and prioritize
Why?	Determine cause and effect	Analyze problem/ opportunity
What to do about it?	Choose best alternative	Make rational decision, produce a building block for the plan
What will the result be?	Anticipate/predict results	Assess results, interrelationships, and side effects of action; cycle back to decision process if needed.
		Define and sequence acceptable actions, or building blocks, to produce plan

Examination of figure 19 may help in understanding the rather complex interrelationships among different kinds and levels of planning and the processes necessary to design and effect a good plan for rangeland resources development and management. In its broadest outline, the planning process should be looked upon as covering the major steps outlined in table 3.

Planning Systems Compared

The country-development strategy statement routinely prepared by USAID is somewhat comparable to the things done under the first "preplanning" caption in the outline of table 3.

Development of USAID's project identification document (PID) matches the "identify candidate programs/projects" caption under "analyze national or regional problem" in the initial preliminary planning. The project paper of USAID is the same as the results from the "action program planning" in table 3. This table shows many parallels with the present USAID approach to planning but it highlights three major contrasts: 1) It places greater emphasis on the preplanning functions, both at national and at area-specific levels; 2) it emphasizes the inseparability of planning and implementation; and 3) it places much greater emphasis on a follow-up effort that often starts during implementation, assuring attainment of project goals and objectives.

Table 3. The sequential steps in planning and implementing rangeland developments.

Preplanning

1. Assemble and evaluate existing information
2. Encourage and advise host government in interventions only they can do (Sandford, 1983, p. 271)
   - set policy guidelines for rangeland areas
   - set country goals and objectives for rangeland development
   - devise budgeting, procurement, and accounting procedures suitable for rangeland areas
   - establish education, extension, and research priorities for rangeland areas
   - assess and allocate available technical/professional manpower
   - project amount of host government finance and capital expenditure available for rangeland development
3. Describe and analyze situation
   - physical
   - biological
   - socioanthropological
   - economic
   - political
4. Analyze national or regional problem
   - set broad program goals and objectives
   - identify candidate programs/projects
   - set priorities
   - specify new information needs

Table 3. (continued)

New Information Acquisition and Evaluation

Action Program Planning (for Candidate Area Defined in Preplanning)

1. Local preplanning
   - incorporate new information
   - refine situation statement and analysis
   - redefine problem statements
   - fine-tune problem definition
   - set area-specific goals and objectives
   - define strategies
2. Project planning
   - analyze problems and decisions
   - identify and design facilitating actions
   - identify and design direct actions
   - sequence and schedule
   - hire staff
   - work out logistics
   - establish budget

Implementation of Plan

1. Check and confirm sequence of actions
2. Arrange logistical support
3. Recruit, assign, and train personnel
4. Arrange cooperation
5. Execute plan (facilitate and direct action elements)
6. Monitor project management functions
   - logistical plan
   - cooperation
   - performance schedule
   - quality of performance
   - budget and fiscal plan
   - unanticipated side effects
7. Redesign or adjust plan and modify implementation

Follow-up

1. Monitor impacts on resources, humans, and animals
2. Assure goal and objective attainment
3. Assess effectiveness of project
4. Ensure continuity/transition to next program phase

In planning rangeland projects, it is important to treat development as a process and not just a project. Planning (design and redesign) is a continuing process and one of the greatest assurances that programs will have a lasting beneficial effect on the recipient peoples and nations. When this is done, a huge step is made toward use of the "process approach" recommended by Sandford (1983) for development projects in the Third World.

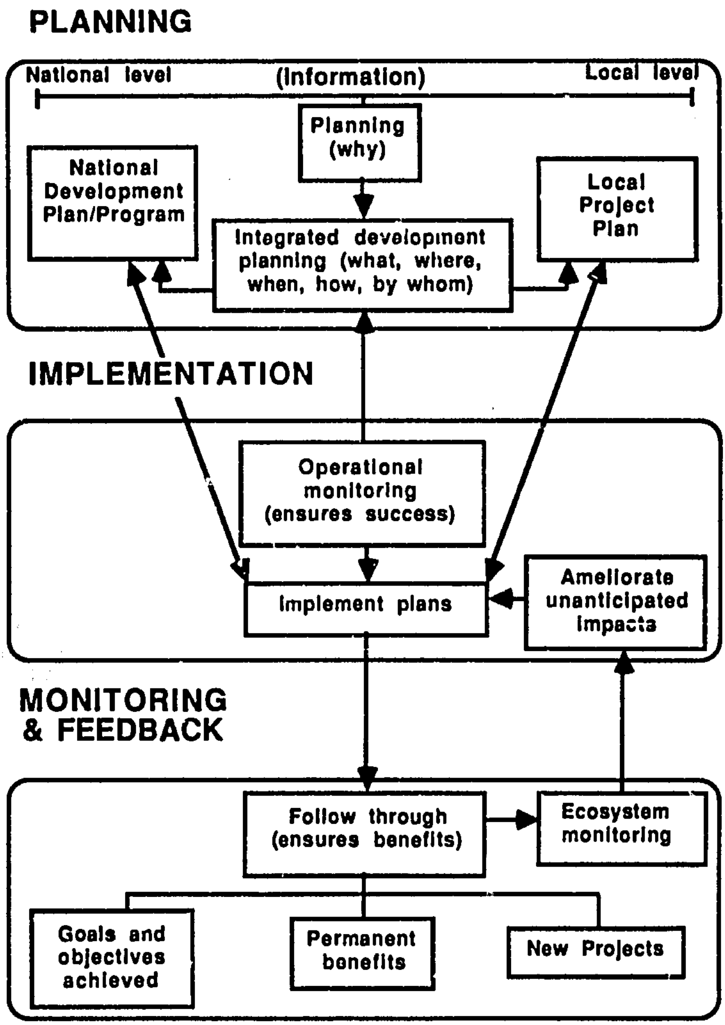


Figure 19. Interrelationships among different kinds and levels of planning that are essential for development in arid and semiarid rangelands.

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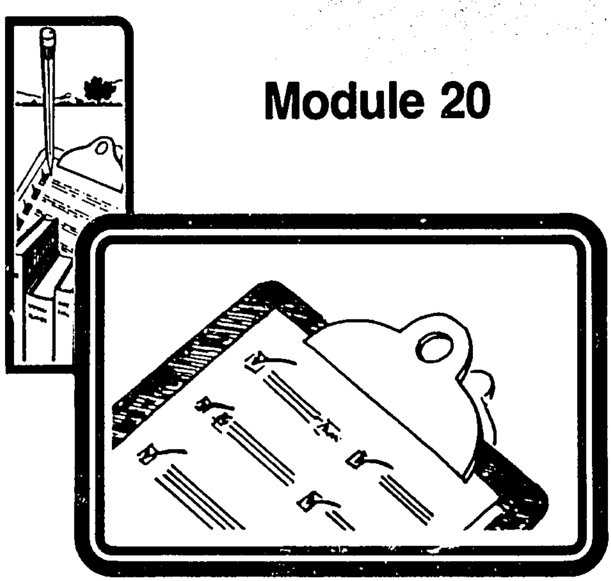

Module 20

Assessment and Monitoring

Assessment and monitoring are essential to the integrated planning process but have often not received adequate attention. For example, resource inventories and ecosystem assessments are rarely a continuing part of projects in rangeland areas; the assessment of social and anthropological factors and the description of traditional management schemes are not customarily a part of rangeland resource analysis; and ecosystem monitoring is rarely included in plans for project implementation in developing countries.

Planning as a Process

Rangeland resource development and management in the Third World is a continuous process, not something that can be compartmentalized into discrete boxes. Assessment and monitoring are essential elements in the process of planning and implementing new interventions. They drive and guide the perpetual redesign, redirection, and creative improvisation until the goals and objectives of the project are achieved. (See box for some useful definitions.)

Role of Assessment and Monitoring

In the preplanning phase neither assessment nor monitoring are involved — the emphasis is on assembling and evaluating the existing information. If more information is needed, however, assessment would be planned during this phase. Remember that preproject planning, properly done, could lead to the decision not to proceed with the project.

Assessment should be the first task in the planning or design sequence, whether plans are being developed at regional, national, or local area-specific levels. Assessment and planning should be very closely coordinated, even though they often take place at different times. Additional gathering, evaluation, or reinterpretation of data may become necessary as planning progresses because not all information needs can be anticipated.

Traditionally, assessment projects initiated by USAID have not been linked to the planning of specific programs and projects. This is probably because an assessment project makes a neat package for purposes of advertising a request for proposal

Assessment. Assessment is a complex reiterative process of information acquisition for decision-making. It is thoroughly explained in the context of development planning and design by Child et al. (1984, pp. 169-204). Conant et al. (1983) summarize a number of technical facts and viewpoints on resource assessment. These authors treat the assessment of soils, plants, and wildlife but omit any mention of domestic animal assessment and monitoring. They do, however, cover many important aspects of the human component of the ecosystem and offer suggestions on assessment methodology.

Managerial monitoring. Managerial monitoring is the responsibility of the project leader and is used to keep track, check performance, or regulate and control the activities under a program/project plan. This type of monitoring is intended to ensure the attainment of prestated goals and objectives and is as important as ecosystem monitoring in development projects.

Ecosystem monitoring. Ecosystem monitoring is concerned with the biotic and abiotic elements of the system, particularly with the impact of consumers on the stability, quantity, and quality of primary production and the net effect on human and animal life. Child et al. (1984, pp. 197-198) briefly summarized ecosystem monitoring in the context of development planning and implementation.

Remote sensing. Remote sensing is simply acquiring information without contact (as from an airplane or satellite). It is a tool of great potential value, as well as some risk, in both assessment and ecological monitoring; it has some value as an input into the decision-making process. It is not true that remote sensing involves only highly sophisticated technology. It includes traditional as well as sophisticated aerial photography, and aerial images created by various electronic sensing systems. The data or imagery processing is by visual as well as computer-assisted means. This whole field was comprehensively summarized in relation to developing country applications in Conant et al. (1983, pp. 34-41, 254-261, 348-357, 468, 473). Do not overlook the need for ground truthing, which validates remote-sensing results.

(RFP); because it is thought that involving multiple contractors ensures the lowest project cost; and because few donors involved in resource development realize that planning, intervention, and assessment form a continuum. The tendency has been to segment everything into project units because this is thought to make them easier to manage.

Monitoring has largely been limited to intermittent progress reviews (generally by an independent team) and post-project reviews (usually by consultants retained for the purpose). The donor agency should always play a major role in these reviews, which fall into the category of managerial monitoring.

Ecosystem monitoring, which has the even more important function of charting the impact of the project on the resource, on the presumed human recipients of the benefits, and on the economy of the country, has traditionally been omitted entirely. Little awareness is evident of possible adverse side effects from certain kinds of "development" projects.

Recently there has been almost universal agreement by people experienced in international development that the two largest factors preventing the attainment of project goals and objectives are 1) planners for rangeland resource development and management have not sufficiently understood and taken into account the human, social, and anthropological aspects of the indigenous society; and 2) planners have assumed that traditional management is bad or nonexistent, or have failed to adopt its techniques.

Guidelines for Assessment and Monitoring

The single most serious issue is getting donor agencies, and many natural resource specialists, to accept the "process concept" in preference to the customary "discrete project concept." Development is a process that progresses slowly, often not according to expectations. It is a series of steps, with frequent loops back to redirect, revise, or try again. This looping process requires continual assessment and monitoring throughout planning, design, implementation, and follow-up.

Big schemes that seek to leap forward rarely succeed in the long run, although in the short term they can absorb huge amounts of money and human resources and give the impression of success. Development activities frequently produce unanticipated impacts — economically, socially, and environmentally — that have extreme and irreversible consequences. Had early planners thought more about assessment and monitoring, these consequences might have been avoided or their adverse impacts reduced.

The second issue concerns the importance of 1) starting development activities that build upon existing management strategies, 2) understanding and involving the indigenous people who are directly affected by development, and 3) agreeing to move forward at a reasonable pace to achieve development and economic growth. All three of these essentials depend on the quality and timeliness of assessment and monitoring.

The third issue involves the concept of "doing for" versus "helping to do." Much of the resource assessment and monitoring that has been done has been completely planned and carried out by outsiders, and then left behind: "Done, here it is!" As a result there are countless resource analysis results that are lost on the shelves. Many are complete in some respects (even overdone) and critically deficient in others. One of the best ways to correct this situation is to educate and train locals to plan and carry out assessment and monitoring for themselves.

These issues can only be addressed if donor agencies budget sufficient funds and time for the necessary assessment and monitoring. Rangeland resource development requires a long-term commitment to projects (10 to 25 years) and a flexible budgeting and funding structure that allows response to unforeseeable developments along the way.

Guidelines for Broad Development-program Planning

Resource assessment looks at the vegetation-landform-soil systems, human and cultural factors, animal factors, economic factors, political factors, and the infrastructure and institutional framework. It provides information on characteristics, distribution, extent, current condition, interrelationships, and problems. Monitoring focuses on changes, impacts, and results — including unanticipated side effects.

For program planning the analyst or data processor moves toward smaller map scales and more refined levels of generalization and for project planning toward more detailed information generally, but not always, at larger map scales. Essentially the same categories of information are needed in both instances.

Guidelines for Program/Project Design and Implementation

Although presented in the context of area-specific planning, many of these guidelines also apply to broad development planning. The only difference is that broad planning requires less detailed information.

Some Key Guidelines

Rely on existing information rather than new inventories and assessments.

The assembly and analysis of existing information is one of the most frequently neglected and underbudgeted functions of planning and design. The major reasons for this are the diverse locations of depositories, lack of indexing, and loss of key items known to have existed (Child et al., 1984, pp. 174-175). Funds must be budgeted to analyze what information is available. Merely organizing and updating existing information may be adequate, particularly for national-level planning.

In most developing nations the use of some remote sensing is essential because of the great distances, difficulty of travel, and shortage of professional manpower.

Donor nations with inventory, assessment, and monitoring needs cannot afford the luxury of other alternatives. Key questions regarding the use of remote sensing are: How will remote sensing be used as a tool in inventory, assessment, and monitoring? What systems or elements of systems will be used? Where, when, and how will imagery be acquired? To what extent will electronic data analysis supplement visual interpretation? Will systematic aerial reconnaissance be used for verification of image interpretations, human settlement, and animal census and distribution? Who will do the remote sensing? Who will pay for it? Can you afford the lag time to acquire it? Will the military confiscate it for military reasons?

Remote sensing is relatively easy — don't make it more complicated than it is. It does, however, require a high level of knowledge as a resource ecologist, soils expert, etc., because the analyst must know what to expect in the project area. Even then, ground verification is a must, and the determination of accuracy of interpretations and proportions of omission and commission errors is strongly recommended.

In gathering supporting ground data, some statistical cautions are appropriate. A frequent error made in assessing resources in developing nations is measuring at unnecessary levels of accuracy and precision. In many cases a simple subjective score would be adequate. To help resolve this problem, ask a few questions. What are the consequences of the decisions to be made from the data? Are they irreversible? Can the course of action set in motion by the decisions be changed or corrected? If so, much lower precision levels are tolerable. Will decisions deal with large differences or fine and complex inter-relationships? If the former, carefully scored data may be adequate and much more cost effective. In many cases people cannot use statistically refined data, and so its collection is unnecessary. The number and kind of parameters examined are also a function of the subsequent decision process and its consequences. Be aware that the risk of "overkill" is great.

Long years of training visual-image interpreters shows that, given all the apparent qualifications of knowledge, visual acuity, and reasoning ability, only about one in five become truly accomplished, accurate interpreters. Somewhere near the same ratio probably will hold where computer-assisted interpretation is used because this refinement can never be divorced successfully from the human interpretive skills that are the result of extensive ground-sampling experience.

Establish an in-country resource-assessment facility with a remote-sensing laboratory instead of building a reliance on foreign-contract facilities and expatriates.

Key questions are: What determines the point at which a country should develop its own facility? How sophisticated should the facility be? How might it function to the advantage of the country? These kinds of facilities require reliable power sources and air conditioning, which many developing nations cannot provide. Equipping, staffing, and maintaining such facilities is expensive and technically demanding. Most of the needs of developing nations can be met from visual interpretation of either satellite imagery or aerial photography;

many service agencies provide state-of-the-art materials at reasonable cost. Most countries should plan to use these facilities, or regional laboratories where available, in preference to setting up their own facilities.

Small microcomputers are becoming available with software for analyzing satellite- and aircraft-scanner data. Given a dependable and stable power source, these may replace mainframe computers, which must be kept in air-conditioned rooms.

Given quality imagery, in-country personnel who have one of the required disciplinary specialties can be trained to do visual interpretation. They should not attempt to add computer-aided sophistication until they are skilled at visual interpretation and ground verification. The best course of action is to grow into eventual sophistication -- one step at a time, with advice and guidance from experts.

The SPOT Image Corporation (France) has made satellite imagery with 20-m and 10-m ground resolution available. This, together with microcomputer capabilities, will likely revolutionize resource assessment and monitoring in the developing world. The visual product is expected to be almost as good as small-scale, high-flight aerial photography. This offers great advantages to countries where it is difficult to obtain aerial photography at sufficiently frequent intervals or at exactly the right season for many vegetation-analysis problems.

Establish an information base that can be used.

Key questions are: Will the data be summarized and used in the conventional mapped, tabular, and narrative form with map overlays as appropriate to need? Or will a geographical information system be developed and used for information management — storage, retrieval, reduction, analysis, and summarization? Will there be a permanent natural resources information archive and library established in-country to ensure that information remains readily available and is not lost? Computerized information systems are exciting concepts and every developing nation would like to have its own, and of course the computer system required to handle it. Unfortunately, few developing nations can maintain the physical environment required to dependably operate such a system. Few people have become proficient enough at querying such a system to consistently obtain the required information and get it to its ultimate user, even among resource management agencies in the United States! Yet, everyone — with a little training — can read maps, well-designed tables of data, and narrative explanations; draw their own interpretive overlays; and make inferences and reach decisions based on this information.

Paralleling the concept of a computerized information system is the critical need for a central library and storage facility. Development of such should begin with the preplanning assembly of existing information; all new data and maps should be channeled into this archive for safe keeping and ready access.

Determine the scope, quantity, and detail of information that is to be provided.

Key questions are: Is the information for national or regional planning or for area-specific planning? Will it be used for many planning needs or only for immediate single-purpose needs? There are three common errors in determining the scope and level of detail. The first is failing to assemble all available information, particularly that in foreign languages. This leads to poor quality of work, unnecessary duplication, failure to take advantage of social anthropological information, and eventually to attempts to plan with inadequate knowledge of traditional management.

The second most common error is an information overkill that results from not answering the questions, "How much information is needed, what will be done with it, and who will use it?" The third error is failing to plan for liaison between assessment and monitoring teams and planning teams from the outset of the program. A good assessment job may be done but the information will not be in the form planners need. This is a serious problem when expatriates do the assessment/monitoring work and are not funded to help potential users of the information.

Determine who will do the assessment and monitoring.

Key questions are: Will it be an expatriate or consulting group, qualified country nationals, or a combination of expatriates and nationals? If the last, where will the authority for leadership lie and what will be the levels of participation by expatriates and country personnel?

Even though it will be a slower route, the ideal situation is for the assigned nationals to assemble and analyze existing information and to do the assessment. They should initially have access to the advice and guidance of qualified expatriates. These expatriates should be advisers and helpers, not the prime doers! If the nationals do the work, they will understand it, have confidence in it, and use it — with continuing guidance and help when needed.

Ensure communication between assessment/monitoring personnel and planning/implementation personnel.

Key questions are: Will some of the assessment team become members of the planning team or will they go on to other assessment projects? If the latter, how will liaison with planning be assured and how will monitoring be handled?

The best way to provide liaison between assessment and planning is to carry key assessment personnel into planning. If assessment and monitoring are done by a permanent team that moves from project to project, it is essential that a small group that will be on the planning-and-implementation team be assigned to participate on the assessment-and-monitoring teams. The "counterpart" who briefly drops in once a day to check on progress is a waste of funds and manpower.

Base legends and information-classification schemes that are presented on maps on structural, floristic, and phytosociological (plant community) criteria.

Key questions are: What vegetation-classification criteria will work best in what parts of which developing countries? What landscape features should be mapped for greatest usefulness? Should existing or potential vegetation be mapped?

Interpretations of vegetation should be done on the basis of existing vegetation, not on the presumption of what is the "climax" or potential vegetation for each site. This makes the task ideal for use of remote sensing because the sensors see only what is there, not what someone presumes, or even knows, might be there in a few hundred or thousand years. (If a map of potential vegetation is essential, a qualified plant sociologist can prepare an interpretive overlay once the basic resource assessment of existing vegetation, soils, and landforms is done.)

Learn from the literature and people of the area to prepare for the interpretation of assessment data.

The key question is: What is the best way to do the interpretation work for rangeland assessment?

Analysts should learn as much as possible from the literature, local people, and ground travel (with remote-sensing imagery in hand), about the plant-community types that occur in the area and the relationships between these plant communities and the soil and landform conditions with which they are normally associated. Low-elevation aerial flights (with imagery in hand) can be a fast way to develop initial interpretive skills.

Systematic aerial reconnaissance can provide information on human and animal populations.

Conant et al. (1983, pp. 376-384) and Child et al. (1984, pp. 59-86) have provided excellent guidelines on human and animal populations.

The techniques of systematic aerial reconnaissance (Gwynne and Croze, 1975; Milligan, 1982) are highly developed. This is one of the most efficient ways to quickly and reliably obtain information on animal populations and human habitation in the arid and semiarid regions of the world. Data thus obtained can be a basis for ground observations and interviews in developing demographic and other kinds of essential data.

Use internationally accepted classification schemes when mapping soils, landforms, and land use for rangeland resource analysis.

The key question is: How should these features be treated when mapping for rangeland resource assessment?

The continental soil maps from FAO, along with local soil and geological maps where they already exist, provide a good starting point for soil examination. Study these maps and reports for information on vegetation-soil relationships and land-use suitabilities in regions where rainfall is sufficient to sustain dependable crop production. Soil mapping should be done at a level as close as possible to the level of vegetation mapping, i.e., if specific vegetational communities are mapped then soils should be mapped at the soil-series level. If the project area does not have significant agricultural potential, mapping of soils could be reduced to mapping of the geologic structure (soil-forming materials). This is often suitable for nationwide assessments at scales of 1:200,000 and smaller.

By all means map soils and vegetation at the same time to help the vegetation analyst and the soil surveyor achieve reasonable parallels in mapping intensity and to resolve relationships between vegetation and soils during ground verification and legend-development studies. If this work is done separately, disparities between soil and vegetation maps and data result.

Landform mapping should be based on a small number of macrorelief classes that reflect elevational relief, complexity of drainage patterns, and smoothness or angularity of slopes together with landform classes that are ecologically significant in terms of the microenvironment for vegetation and soil formation. The important thing is the landform and macrorelief patterns that affect vegetation and soil development and management.

A simple legend should also be developed to map those existing land uses that have changed the vegetation and character of the landscape, i.e., agricultural cropping, urban-industrial development, mining, and infrastructure where the scale permits. It is not the intent of such a legend to reflect potential land uses.

Use multiple-purpose, rather than single-purpose, surveys and assessments where possible.

The key questions are: Can a thorough ecological assessment for multiple-purpose applications be justified? Is it practical to attempt?

Historically, resource assessment has tended to be single purpose — range-site surveys for rangelands, soil surveys for agricultural development, and timber-type and volume surveys for forestry. The problem with this approach is that there is little or no complementarity among the separate assessments. The total cost in areas with multiple-use potential is very high. In addition, this approach usually overlooks land-use interrelationships and side effects and may fail to provide essential information for projecting environmental consequences. On the other hand, integrated resource assessments provide information on all major components of the ecosystem. By taking advantage of this information, future supplementary studies will be conducted with greater efficiency and substantial savings.

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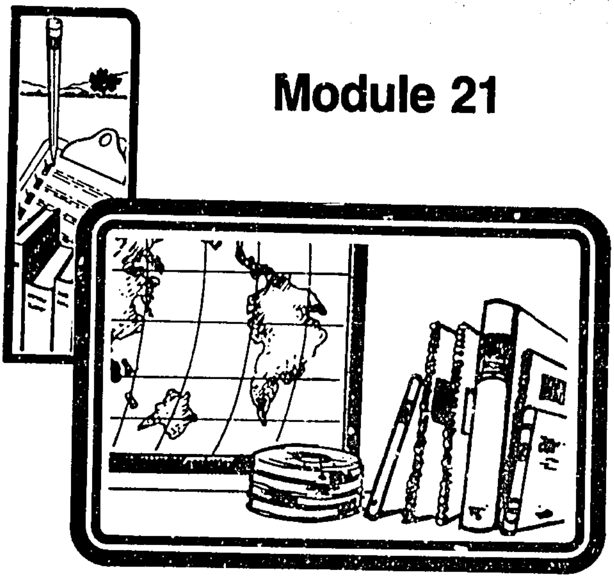

Module 21

Documentation Centers

Outside consulting firms commonly perform resource assessments for developing nations, usually in separate projects for forestry, rangelands, agricultural development, and land-use planning. In some cases these foreign experts have local counterparts, but the expatriate is nearly always in the lead position. However, it is both desirable and cost effective to establish a national center that is responsible for natural resources evaluation, considering the advantages of integrated resource assessment (Child et al., 1984) and of the national government doing its own integrated resource surveys. Rapid technological advances in this area and the requirements of monitoring also favor the centralization that such a center would provide.

In addition, few developing nations have provided a proper documentation center or archive for information on natural resources. As a result many valuable items have been lost or cannot be found in the time allocated for the literature search in project planning and design. Not only is this a tragic loss, but contractors are repetitively going through the same expensive exercise of locating documents, or worse yet, doing without the information or developing it all over again. A national documentation center for natural resources would make the essential information more readily available to all users.

With the growth of technology for information acquisition and management, a decision about the scope of a documentation center's activity is important at the outset. Whether to have separate centers for documentation and evaluation or a combined center is an important issue.

Issues

Evaluation Center

If a country has only a small and occasional volume of resource-evaluation work, it would be logical that each ministry or department be responsible for all evaluation in its discipline. The work could either be contracted out or done in-house with regular professional staff plus temporary or consultant help. In this case an evaluation center would be expensive and unnecessary.

On the other hand, if the work load is large and steady, a single government center to handle assessment and monitoring is a logical and cost-effective choice.

Consider the high cost and technical requirements of remote sensing in resource evaluation, and a national or regional center becomes more viable. Although some remote-sensing equipment and technical capability is essential for each discipline, it would not be economic for each department or ministry to have its own full-blown remote-sensing center. When you think about the normal professional manpower and financial situation in most developing countries, the case for a central facility becomes even stronger.

The importance and potential growth in the use of remote-sensing technology among the developing nations is tremendous. They already, for example, account for the sale of between 35% to 50% of the Landsat imagery used in the world.

Unfortunately, attempts to create a center of this type will likely meet some bureaucratic resistance simply because separate facilities are traditional. Another argument for maintaining separate facilities is that during an integrated assessment there would still be some specialized kind of information each discipline could contribute that would not be found in a common evaluation center.

Some professionals argue that the integrated, ecological approach will be more expensive and produce too much information they don't need. Yet when good, new information is provided in a timely manner, a need and use for it often quickly appears.

Another issue in the development of an evaluation center involves the question of whether it should be national or regional. Steps have already been taken, for example, to establish regional remote-sensing laboratories in Burkina Faso and Kenya. There is a partially effective facility in Nigeria and a high level of capability in India and Indonesia. Other facilities exist or are being discussed.

Wherever a country has access to a regional remote-sensing center, the terms of its availability, scope of services offered, and costs, etc. should be thoroughly investigated. It is better not to develop a national center for resource assessment (including remote sensing) until it is demonstrated 1) that the regional facility will not meet the country's needs, 2) that a continuing need exists, 3) that a center is of sufficiently high priority to compete for financial and manpower support, and 4) that there is a sufficiently large cadre of trained resource analysts to provide a stable staff for the national facility.

Documentation Center

A documentation center is needed immediately in almost every developing nation. An important issue is how it will be set up to handle the large mass of information it will be expected to keep readily available to users. Coordination with large libraries, such as at universities, needs to be worked out so that there is no unnecessary overlap.

One solution is to establish the documentation center at the national university, but this could require some functions not normally handled by libraries. Some accessions in the natural resources areas would have to be handled as rare books and maps, which indeed they are. The options for accessing and indexing are the traditional labor-intensive card file or a computerized indexing system. The next step could be a completely computerized geographic information system (GIS), a possibility that is exciting but presents many serious operational challenges.

The United Nations Environment Programme (UNEP) is setting up a GIS to handle its Global Environmental Monitoring (GEMS) data. It will be operated out of England, which solves the problem of maintaining a controlled environment for the sensitive computer hardware in a developing country.

A multinational facility would not meet the needs of any single country for a natural-resource-information depository, because it is not likely that many countries would entrust highly detailed data to an open, international facility. The individual nations will, however, be able to call on this facility for some kinds of information important to their work.

Combined Versus Separate Centers

The question of whether or not a resource-evaluation center should be combined with a documentation center is subject to serious debate. There are advantages both ways, but few precedents for the combination.

It follows that the group that generates multipurpose resource data and information should be the custodian of same. Thus, combining a resource-evaluation center and a resource-documentation center into one administrative unit is logical and probably cost effective. Centralizing the responsibility for training, operational resource evaluation, and a documentation center into one administrative unit will even out the otherwise sporadic work load that is characteristic of operational evaluation and monitoring.

If the documentation center becomes part of a national or university library, it is probably a bad idea to include the evaluation center under the same administration. But if the two centers are combined, they should be organized within a ministry concerned with natural resources.

Guidelines for Development and Implementation

Many of these guidelines apply both to institution-building and training and to implementation of resource assessment and monitoring. (Similarly, guidelines in the section on resource assessment — for example, on remote sensing and the functioning of a resource-assessment team — are equally appropriate to this module.)

Evaluation Center

Guideline. Two options exist for training staff for the evaluation center, regardless of its initial scope. The first option is to train staff on the job. Trainees would obviously have to meet some basic educational requirements. Scientific and technological requirements for this field are very high, including proficiency in one or more natural resource disciplines; some degree of proficiency in remote sensing is desirable.

The second option is to send potential staff to a national or a foreign university for formal training in the required disciplines.

A potential third option, of course, would be to combine the two. Given prior professional training in one of the renewable-natural-resource areas, option one is most attractive and functional for resource-evaluation training. The on-the-job training could be preceded by or interspersed with shortcourses in remote sensing and resource-evaluation techniques. This latter could be a mix of training methodologies and would not tie up valuable manpower in advanced, formal education while the development program moves ahead.

Guideline. The evaluation center should emphasize effective service. It should perform, or provide leadership for, evaluation-and-monitoring projects, provide shortcourse training in all service activities, and function as an archive and information center.

The importance of all these items is self-evident. The only one that is subject to debate is whether or not the center should actually assess and monitor projects, or merely provide training, advice, and guidance.

Aerial photographs, satellite images, and data tapes should be archived and indexed in the center when they are no longer being used on a regular basis by other national agencies. Because of the historical value of these items for detecting change, they should be retained indefinitely. Originals should not be checked out of the center unless the agency that originated them needs them temporarily. If photo negative files are maintained and state-of-the-art reproduction facilities are available, it would be easy to provide copies of photos and images at user expense.

The facility should have high-quality reproduction facilities for both written material and maps. Color-copy capability is desirable for maps, some illustrations, and photographic materials. Many accessions will be "last and only copy" so they should be reproduced for use or made available only in the center.

Since this is a national, not a regional program, it is best for the center to actually conduct evaluations for their clients — the natural resources and planning ministries, departments, and agencies. This will ensure better quality control on performance. It is simply a matter, given adequate funding, of assembling a quality staff and then training and fielding evaluation crews. As the work load increases, more crews will be put in the field and as work drops off, crews will be laid off or diverted to liaison with planning and implementation teams or to other work in the ministries.

Involving staff on resource-evaluation crews in training exercises is a superior way to screen and prepare them for greater responsibilities in planning and management. The value of this approach has been proven by application among resource-management agencies in the United States. After about 1 year of experience, have each crew member prepare a comprehensive plan for a small area on which he has done the evaluation work. If the crew is involved as a unit in these exercises, members will also get valuable training in team planning.

Your goal should be to eventually replace the present practice of contracting out the resource assessment and monitoring to consulting firms and international agencies.

Documentation Center

Guideline. The initial function of a documentation center should be to assemble, index, and make available publications, reports, and maps relating to natural resources within the country.

An experienced librarian will be required for initial acquisitions and organization. Technical staff in the various resource specialties must be involved in document selection. In many cases accessions may have to be created by photocopy, but originals should be acquired wherever possible. The accessions should include publications, maps, and reports on resources and on development-and-management plans and projects. Initially nothing should be destroyed or culled. Current and past project files and libraries are a good source of accessions. All must be consolidated in the center and if personnel of any project need day-to-day access they should be provided copies; the originals, where they exist, should go into the center. A small library staff must be trained so the collection can be maintained and kept current.

An ideal option is to train staff for the documentation center on the job. The Mali Land Use and Inventory Project carried out by TAMS and the GRM stands as a highly successful example of this training option. A documentation center was established, accessions made and indexed, and a small staff trained through the periodic on-site guidance of a capable library-science consultant.

A tight security system and check-out and inventory-control system is essential if the facility is to survive and provide needed services.

House the facility in a carefully engineered, fire- and waterproof building that can be secured against the ravages of insects and other destructive vermin. Air conditioning may be desirable if practical and affordable.

Make a serious effort to locate and secure copies of all colonial government studies and maps of natural resources; donor-agency reports and special studies of natural resources; inventory maps and tabular data; and scientific studies on renewable and nonrenewable natural resources — especially on plant taxonomy and ecology, geology, soils, and water resources. In many cases copies of reports on adjoining countries will be equally valuable. For additional sources see Conant et al. (1983).

A Combined Facility

Guideline. The timing of activities and the level of sophistication of facilities and services provided are important to the success of a resource assessment, monitoring, and documentation center.

The sophistication of the evaluation services and the storage-and-retrieval technology that is implemented in a documentation center can make or break development programs in a developing nation.

The options are 1) to do it all in one major step with complete, state-of-the-art technology, 2) to start with a modest level of technology in both areas, or 3) to start with a documentation center that will assemble and catalog existing resource information and then grow into the full combined facility. Only options 2) and 3) are viable for most developing nations. Of these the third would usually be preferred because it is less costly in terms of initial outlay and allows time for training the staff. This can be effectively done by using ongoing projects to train a cadre of resource analysts and documentation specialists who will eventually staff the facilities.

Guideline. First, establish a national documentation center.

The problems surrounding the quest for existing information on natural resources in every developing country are so great that initially the most beneficial development activity would be the permanent funding of a documentation center. It would be ideal for multilateral support because it would be used by all donors and all projects. It should encompass more than just rangeland resources. The cost of the facility and staff would not be so great as to detract from other high-priority projects in the relief of human misery. The availability of accessions could be made worse if taken from present custodians and put into a central facility that then was abandoned. Many past projects in library support have started with support that then dried up. Lack of adequate support in the case of a documentation center would make the resource-development database unavailable, and the total project would be a waste of resources.

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Author Biographies

R. Dennis Child is a range scientist who for the past 14 years has had experience with range ecology, range-livestock research, range-forage resources, production-system modeling, and natural resource planning. He began his career as a faculty member at Colorado State University where he taught courses in range and natural resource management and became adept at developing computer range-planning procedures. Before becoming a coordinator with Colorado State's regional-resource-analysis program, Dr. Child spent 2 years as the program's computer programmer. For the past 8 years he has served as a range scientist for Winrock International. He is presently a program officer and serves as the project manager for the range management program in Kenya, where he spent 3 years from 1980 to 1983 as the project's range ecologist. On the project, he led studies to determine the use and limitation of rangeland plants under different grazing-management strategies and served as deputy chief-of-party his last year there. Other international experience has included training-project studies in Mexico, a tropical grassland course in Costa Rica, and a review-team mission to study the rangeland resources of the Hashamite Kingdom of Jordan. As project leader for the Southern Forest Range and Pasture Program, he conducted regional surveys of forage resources. Dr. Child is experienced in the fields of agroforestry and farming-systems and has worked with evaluations of diets of goats grazing upland hardwood sites.

Harold F. Heady is the noted author of the range management textbooks, Rangeland Management and Range and Wildlife Management in the Tropics. In addition he has authored 140 other publications in the fields of range management and grassland ecology. He received his Ph.D. in plant ecology from the University of Nebraska. In 1984 he retired from the University of California at Berkeley after serving as a distinguished professor of range management since 1951. From 1977 to 1980 he was the assistant vice-president for agricultural and university services and associate director of the agricultural experiment station. From 1974 to 1977 he was the associate dean of the college of natural resources. Dr. Heady has had extended range management consultancies with the Food and Agriculture Organization of the United Nations in Saudi Arabia and in Malawi. He has had short-term consultant assignments on range management problems with the University of Nairobi, Bureau of Land Management, U.S. Forest Service, Department of State, and the governments of Australia, Israel, Kenya, Kuwait, Malawi, Mali, Mexico, New Zealand, Rhodesia, South Africa, Tanzania, Uganda, and Saudi Arabia. Dr. Heady has been an invited speaker to many international symposiums including those held in East Africa, Mali, Chile, Mexico, and South Africa. He is a charter and life member of the Society for Range Management.

Roald A. Peterson is an internationally known range ecologist with broad experience in pasture and fodder crops, livestock production, soils, and plant genetic resources. He began his career by working for 8 years in range research for the U.S. Forest Service. The next 7 years he spent as a pasture specialist for the Interamerican Institute of Agricultural Science in Montevideo, Uruguay, where he organized, directed, and taught international courses on pasture and range management and livestock production for five countries. From 1961 to 1979 Dr. Peterson worked for the Food and Agriculture Organization of the United Nations (FAO). From 1961 to 1970, as chief of the pasture and fodder crops branch in Rome, he directed as many as 75 technical-assistance field activities in diverse countries and helped develop an international program on plant genetic resources; from 1970 to 1974, as chief of the crop and grassland production service, he directed programs on pasture and fodder crops, fruits and vegetables, field crops, industrial crops, and seeds; from 1974 to 1979, as manager of a livestock-development project in the Dominican Republic, he emphasized an integrated research program on pastures and livestock that was influential in the establishment of a national center for livestock research, a goat experiment station, and a center for criollo cattle. With FAO, he served on missions in Turkey, Colombia, Somalia, and Mongolia. He is currently Adjunct Professor, Department of Agronomy, University of Arkansas, Fayetteville. Dr. Peterson received his Ph.D. from the University of Minnesota in plant ecology, speaks Spanish fluently, and understands Portuguese, Italian, and Norwegian.

Rex D. Pieper received his Ph.D. in plant ecology from the University of California, Berkeley. For the last 20 years he has served on the faculty of New Mexico State University teaching a broad range of subjects: range analysis (18 years), introduction to forestry (12 years), range plants (3 years), and advanced range ecology (4 years). Since 1966 he has been the advisor to all of the foreign undergraduate students studying range science, with approximately 20 students each year. In his capacity as a professor he prepared the syllabus, Measurement Techniques for Shrubby and Herbaceous Vegetation, published for the range analysis class. For 4 years Dr. Pieper taught a 9-week course for international students on range management and forage production. He has been the project leader for numerous rangeland studies that included protected ranges, wooded rangelands, desert grassland ecosystems, ecology, and control of pinyon-juniper forest lands. He has received both distinguished teaching and research awards and has been an invited lecturer in Australia, Mexico, and Brazil. For 5 years he has been on the editorial board of the Journal of Range Management. Numerous large corporations have used his expertise as a consultant in the field of vegetational analysis and grazing evaluations.

Charles E. Poulton has a broad background in range management and has considerable experience in planning and monitoring rangeland development in an international setting. He began his career in the U.S. Forest Service where, in a 7-year period, he served in seven states in research and administration, and as a district ranger. From 1946 to 1970, he served on the faculties of the departments of range management at Montana State University, the University of Idaho, and Oregon State University. In 1970, he was the director of the Environmental Remote Sensing Laboratory at Oregon State University and in 1973, he left to accept full-time employment with the Earth Satellite Corporation. In 1974, he became director of the range and resource ecology division where he directed projects in Brazil, Iran, Ghana, Tanzania, Gabon, Mali, and North America. He joined FAO in 1976 to become a senior officer for rangeland resources, pastures, and fodder crops. He made significant contributions toward the development of rangeland resources while working out of Rome. From 1978 to 1981, he developed and implemented training programs on remote sensing and land-use analyses while working on a NASA-Ames research contract through Air View Specialists. He has authored over 85 publications, contributed to seven books, and developed 13 training modules. Dr. Poulton received his Ph.D. from Washington State University from the botany department, with a major in ecology.