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The purpose of the paper is to provide guidelines on basic data gathering necessary for the design and implementation of range/livestock projects applicable to social and environmental conditions encountered in the beef producing areas of Africa.

The paper covers suggested basic data gathering, project planning, development, implementation and administration range/livestock projects.

Work on this paper has been accomplished by staff members of the Office of Development Services, Bureau of Africa in AID's Washington headquarters under the direction of Mr. Princeton Lyman.

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Range Development and Management in Africa

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August 1974

FOREWORD

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RANGE DEVELOPMENT AND MANAGEMENT IN AFRICA

I. INTRODUCTION

A. DEFINITION OF RANGE MANAGEMENT

Range management is the science and art of planning and directing range use to obtain the maximum livestock production consistent with conservation of the range resources.

This definition implies a sustained yield of livestock over a long period of time. It infers the production of the correct kind of meat, wool, hides, etc. to satisfy economic demand. Such a yield is compatible with and can be obtained only by conservation of the vegetation necessary for grazing animals.

It is evident from the definition that range management is closely related to animal husbandry and plant ecology. It embraces other fields of science. Animal husbandry involves animal nutrition, genetics, pathology, physiology, meteorology, and soil science. Each of these fields is vital to range management. The success of the range manager will depend upon his knowledge of the factors involved in animal husbandry and plant ecology and his skill in applying that information.

Among the most vital problems that face both the range administrator and stockman alike are those involving the economics of marketing, producing and investing. A complicating factor is that often the range produces not only forage, but timber and wood. Also, on many ranges game animals are important. Never should the land administrator lose sight of the multiple use principle involved in modern land use planning. Seldom is livestock production the sole problem on land, especially public land. Breadth of vision and training are essential to administration that will result in the maximum returns.

B. PURPOSE AND BACKGROUND

The purpose of this report is to present information for the preparation of range development plans and feasibility studies on range land in Africa.

The problem is immense when it is considered that the total land area of Africa is three billion hectares (about 7.2 billion acres), of which 842 million hectares are permanent meadows and pastures. Range lands, transect several ecological zones with varied problems of use including limited water, fire, and pests, problems of soils and encroachment of bush.

Range forage production presently varies mostly by patterns of past impact by man, domestic livestock, fire, wind and water. Due to the long history of use by wildlife and man and his domestic livestock, much of the range lands of Africa must be considered from a polyclimax standpoint in that cultivation and fire have played important roles in deriving vegetative types of Africa.

The overall objective is to expand present grazing areas and conserve this natural resource in the years ahead, at a rate dependent on the economic development of water and elimination of the hazards of fire, overgrazing, disease, and pests. More specific goals are to:

1. Assess the carrying capacity of the range and formulate plans for utilization of natural resources for optimum development of the range.
2. Provide necessary information on water resources in support of the expansion of range lands.
3. Bring potential range land into production by elimination of constraints such as tse-tse fly, disease bush encroachment, and erosion.

C. METHOD OF PLAN PREPARATION

To provide a sound basis for range development and management, it is necessary to conduct studies to determine needs for selection of appropriate development schemes. The procedures should include several interrelated parts as follows:

1. General Reconnaissance and Field Studies

a. Livestock forage inventory and its relationship to topography, soil and the vegetative community. Interpretation of indicators of forage production conditions and trends, as related to livestock and game use and weather conditions.

Range officers discussing management plan with local cattle producer.

b. Present and potential livestock watering facilities inventory, as related to livestock production potential from surface water probabilities. Where surface water potential does not exist or appear adequate, then determine the probabilities for supplemental groundwater supplies.

c. The apparent situation of livestock producers, their ostensible potential to implement range development projects, livestock producers needs and the local results likely to occur from range development. This should include studies of social and administrative aspects of range development and management, as well as a system of production best suited to local conditions.

2. Design of Range Development Schemes

Projection of appropriate range development schemes from information obtained through the forage and water inventories. Selection of sites for water development and determination of the optimum balance of forage and water the range unit could provide.

3. Selection of Range Development Schemes

Select the pattern of range development schemes which provide the optimum stable livestock production for the logical management unit as related to:

a. Correlating proposed schemes for adjoining areas and finalizing the location of the boundaries of separate grazing schemes or ranches.

b. Finalizing pasture division boundaries within these grazing areas.

c. Compiling maps, charts, tabulations and a summary including cost/benefit information for the project report.

4. Expansion of Program to Adjacent Areas

Outline a program for range development on similar adjacent areas.

A. CONDITIONS AFFECTING LAND UTILIZATION

1. Area Comparison

The size of the area applicable to this type development in relation to the country as a whole.

2. Weather

Description of annual rainfall as to amount, type of storms, distribution, frequency of years with inadequate precipitation for forage production and surface water flows. The daily maximum and minimum temperatures and expected evaporation or loss from surface water storage.

3. Topography Barriers and Elevation

A brief description of topography, natural drainages suitable for water storage, barriers which hinder complete access to forage on the area, including dense bush, by livestock.

4. Soils

An accurate description of soils, particularly from a standpoint of selecting wet and dry season grazing areas, and potential hazards of improper grazing of domestic livestock.

5. Vegetation

A complete description of range sites including soils, range conditions, and trends of major forage producing species, tree or bush canopy.

6. Industry

The importance and relationship of livestock production to other present or potential land uses of the area.

7. Range Forage Management

Wherever dominant climax grasses are maintained in good vigor and density, they produce good forage, especially on the deeper soils. They are preferred and readily consumed by cattle in both the wet and dry seasons and are adequately nutritious (depending on degree of maturity) to provide satisfactory gains.
The delicate balance between good forage producing grasses and low or non-producing "bush" or bare ground is easily upset by the impact of continuous livestock grazing over extended periods of time. This is more serious when grazing follows annual burning of vegetation. Preferred species are the first to disappear under such grazing conditions. There is ample evidence to indicate that good vigor, density and production can be maintained by the forage producing species, where basic non-continuous grazing management practices are employed. Conversely, there is also ample evidence to confirm that range resources could be rapidly destroyed where new permanent water sources are created and used by livestock, without following prescribed grazing management practices.

8. Cattle Land Use Patterns (Water Oriented)

Land use varies from area-to-area; however, the more common practice consists of nomadic herdsmen following the rain with their cattle during the rainy season and retreating back to the seriously depleted ranges adjacent to widely separated permanent water sources for the duration of the dry season. In this process the cattle are dispersed over a large area with no permanent water points for a very brief period during the rains, but during the dry season cattle are concentrated within 9-10 miles of permanent water. Distances of over one hundred miles between permanent water points are typical in many areas during the latter part of the season. Many, or perhaps even most, cattle herds are watered only every third day and travel five to eight miles each way between water and forage. From a situation of forage supply without water, it shifts to another difficult situation of finally having available water, but little or no forage for cattle within walking distance of permanent water.

9. Trends in Land Use Patterns

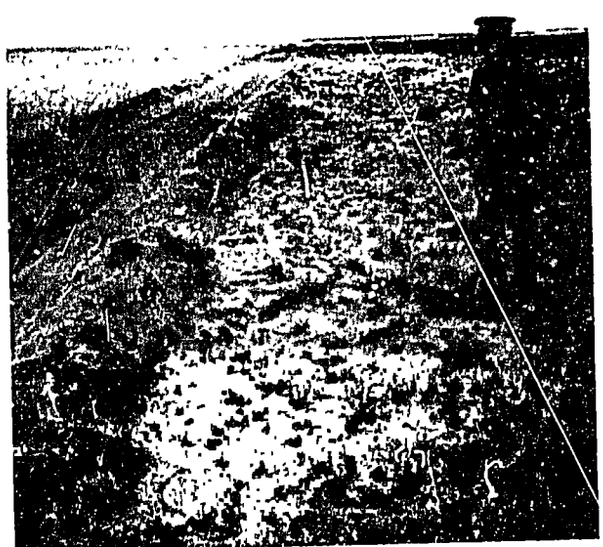
The present grossly inadequate permanent water supplies permit only inefficient and damaging range use. Past programs of disease controls, and consequent larger number of animals, have surpassed the development of additional permanent water supplies. Continuing damage is occuring to more acreage of range land adjacent to permanent water points recently developed. At the same time a great portion of the area, in the absence of water supplies, is greatly underutilized. The problem becomes one of livestock distribution rather than one of total overstocking. Water development correlated with range use planning could do much to eliminate this problem.

Completed firebreak.

10. Use of Fire

Large volumes of forage which cannot be currently utilized, except for a brief period during the wet season, is burned annually. The purpose of this burning is both to eliminate pests such as ticks and snakes and the accumulation of unused dry grass, which covers the fresh green forage the next wet season, and to keep bush species from further invading the grasslands. Uncontrolled burning also occurs on areas which are vitally needed as dry season grazing by livestock owners. These fires are caused by hunters, beekeepers and farmers burning crop residue and weeds. Annual burning creates a vegetative cover which is fire tolerant in both grass and tree species. The fire tolerant grass species are normally not the most palatable and nutritious grass species. Where fire control is practiced and management employed, the less fire resistant species quickly increase to the desired level. Fire should be used then as a tool at set intervals (4-5 years) for control of bush. The proper sequence should be prevention of burning in the first few years of a deferred rotational grazing system followed by controlled burning on blocks for bush control. Fire has and should continue to play an important role in economical bush control.

Constructing firebreak which will also serve as access road and boundary for grazing blocks.



Effective prevention of burning forage by firebreak. Fire stopped by the firebreak.

11. Water Development and Management

A great need for planned water development and management for stabilized livestock production exists. Most of the stock water ponds, both natural and those constructed to date, go dry shortly after the seasonal rains stop. Those which have been successful in holding water for the longest periods through the dry season, are those which are the deepest and conserve water with the least surface evaporation and loss through percolation. Storage sites should be located on water courses with adequate flows to fill. Unfortunately, most of the reservoirs are subject to heavy silting and should be designed with silt traps which are periodically cleaned with heavy equipment in order to maintain the reservoirs holding capacity.

There is great need then for developing water points according to an overall plan that can be managed for stable forage production and which will provide a dependable source of livestock water when and where it is needed to meet the grazing schedule in the range management plan. The location of these water points should be within reasonable proximity to areas producing suitable livestock forage, and the water supply should be sufficient to maintain a cattle herd in balance with the forage supply.

Nomadic and semi-nomadic herdsmen tend to experience more difficulty in maintaining pumping and storage equipment at bore holes, than they do at surface catchments. To that extent, they tend to prefer reservoirs to bore holes if the reservoirs can provide the water when it is needed. Reservoirs can provide adequate water if properly located, designed and constructed and the herdsmen maintain good water discipline.

There is also a need for temporary water storage facilities in areas designed to be "wet season grazing areas" in the management plan so as to extend the period of grazing for a reasonable time in these areas, beyond the date when the rains stop.

Therefore, through careful planning of wet and dry season grazing areas coupled with required water supplies, full utilization of ranges may be made through supplying permanent water on dry season areas, which is usually expensive, and temporary water on wet season areas, which is usually less expensive.

Range officers in field camp in Northern Kenya developing management plan for range water development project.

Inlet into reservoir with rock and wire gabeon from silt trap

Under present nomad cattle production system many calves become too weak to make the long trip to water. The only water received is that carried long distances to them.

Local cattle producers with range management officials discussing controlled utilization of watering points. Local producers sampling quality of water.

Range officers planning period of use of water stored in reservoir.

Range officers planning wet and dry season grazing of development area.

B. LIVESTOCK PRODUCERS OF THE AREA

1. Background Information

Information from studies of present social structure, relationship and outlook of the people presently producing livestock on an area should be closely examined to assist in designing the most feasible type of range development such as private ranches, group ranches, cooperative ranches or grazing reserves. This kind of examination and study will enable the local cattle producers to increase production and become economy minded with the least disturbance to the social structure.

2. Basis of Livelihood

Nomadic and semi-nomadic cattle production is characterized by little more than subsistence level economic patterns.

The basis of livelihood for pastoral people is grazing of cattle, camels, sheep and goats. Cattle owners frequently own no camels except for milk or pack animals and few if any sheep and goats. Camel owners rarely own cattle, but frequently own large numbers of sheep and goats.

These typical nomadic and semi-nomadic people tend to be good herdsmen, and their system of stock raising characterizes land use in much of Africa. It has evolved over centuries,. under conditions over which they have had little or no control, other than to seek systems of survival for themselves and their livestock.

3. Aptitude for Livestock Production and Resource Maintenance

The apparent interest of African livestock operators to perpetuate the range resources, if given a reasonable opportunity, is commonly documented by several indicators. For instance water and grazing areas are commonly reserved by tribal agreement for utilization during the dry season. Self-imposed restraint from grazing reserved areas eliminates the need for control fences between management pastures, which is normally the most expensive necessity of range improvements. This is a distinct and tremendous advantage in directing substantially higher proportions of available range development funds into development of stable livestock watering facilities.

The primary task of the livestock operator up to now, has apparently been one of surviving through short-range planning alone, in competition for forage and water with others. Often fully aware of the situation, he is obliged to carry on without a community-wide long-range program.

The nomadic herdsmen often lacks formal education and money, but he does have the very important interest, attitude, aptitude and natural skill in many tasks necessary for successful livestock production.

4. Source of Range Managers

Experience in the past has shown range administrators originating from a traditional background of livestock production tend to be outstanding. Every effort should be made to obtain students for enrollment in local degree or diploma level schools from pastoral backgrounds for participant training for higher degree levels in foreign countries such as the USA.

5. Occupants of Grazing Areas

The system of land tenure varies considerably in African states, not only from one state to another, but within one state and this, in turn, reflects on the type of occupants utilizing the land.

In general, nomadic and semi-nomadic pastoralists occupy state-owned land or land held in trust for tribal groups. This type of land is usually the more arid areas which are not suited for cultivation. However, some form of right of occupancy usually is recognized through prior use. Every consideration should be given to groups holding prior use rights when developing range for increased livestock production. Various methods have been used with success. Examples are the ranching associations in Masai land of Tanzania and the group ranches in Kenya where groups or associations are registered and title to the land is issued to the group. Grazing reserves established through legal procedures and grazing permits issued to livestock owners have been established in Northern Nigeria,

North East Kenya and Southern Ethiopia. Careful consideration should be given to planned land use and right of occupation of new areas opened up—such as areas cleared from tse-tse fly (refer to maps). Land use planning for proper utilization of natural resources will insure an economic benefit which can be maintained over a long period of time. Careful consideration should be given to the possibility of utilizing the human resources available—beef production. This will help develop the human resources and achieve a more even income distribution among local cattle producers. On the other hand, developing para-statal or government operated ranches—which are usually more expensive to develop and more costly to operate in terms of increased beef production—is in direct competition with local cattle producers for forage and water.

A careful census should be made of people occupying an area together with the number and types of livestock owned by them prior to development of an area. This information is essential to plan proper stocking of the area following development.

C. FARM LAND

Land use planning should precede range development and areas suited for more intensive agricultural purposes should be designated as such. Where established villages and farm land exist, enclaves should be cut out of development projects to allow for expansion and grazing of the village livestock. Where fragmented farms are in an area more suited to livestock production, compensation should be paid and the farmed area reseeded to grass or allowed to revert to grass under natural conditions. Where possible on ranch development and grazing reserves, occupants should be encouraged to diversify their activities to more fully utilize the available human resources.

D. COMMUNITIES AND AMENITIES

In the past nomad cattle producers have utilized permanent villages for sale of milk and livestock and purchase of the few essential items required by them; however, few, if any, of the normal amenities, such as schools and medical facilities are available to them. When nomads or semi-nomads settle on developed ranches, or grazing reserves, it then becomes possible to extend these facilities to them.

The African pastoralist has long been subjected to cattle taxes for which he received very few government-provided amenities in return. The establishment of permanent dwellings should be planned on range development projects in connection with domestic water supplies and farm land (if possible) and access to markets, schools, and medical facilities.

E. ETHNIC GROUPING

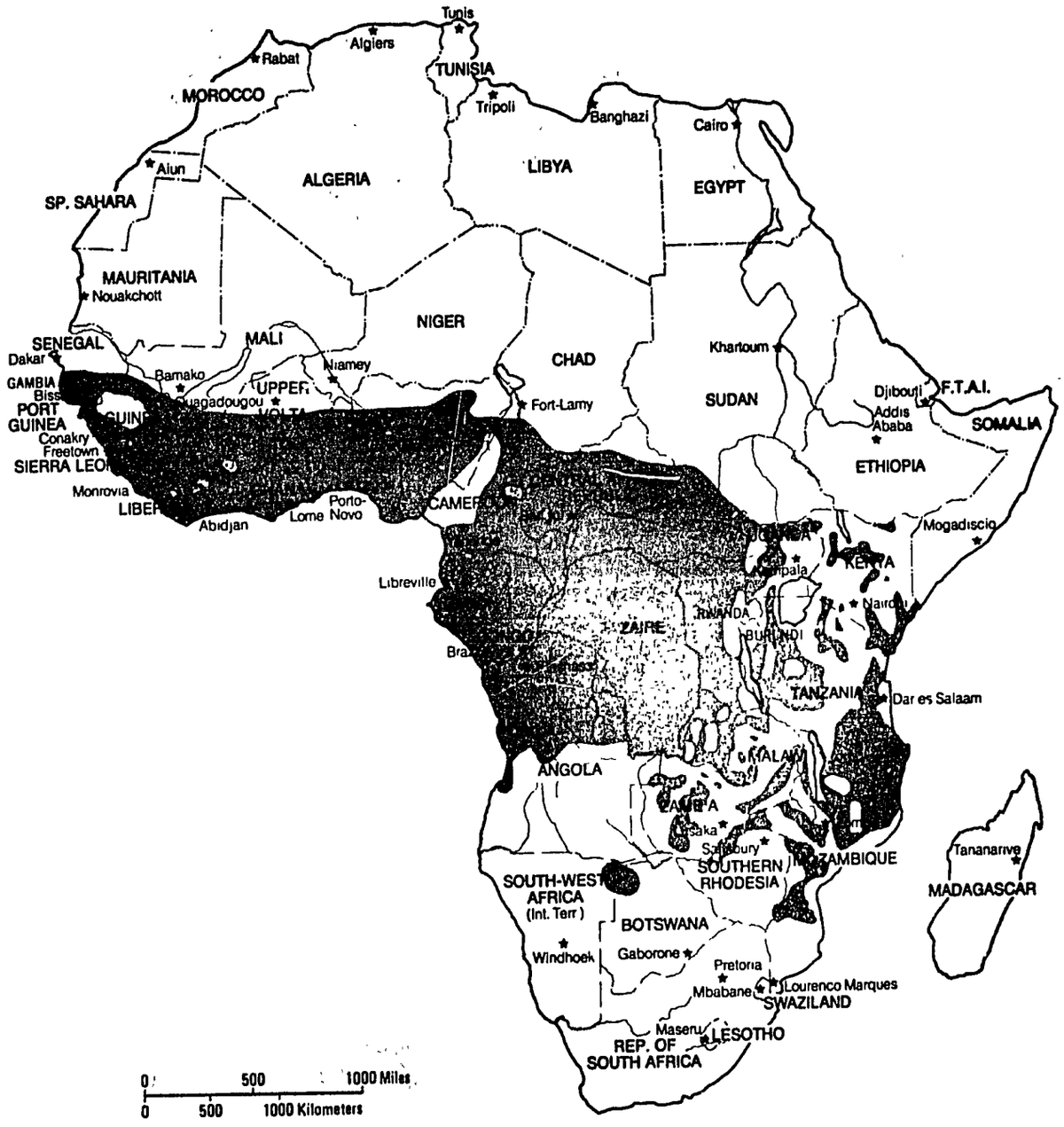
Although attempts are being made by most African states to break down tribalism, strong tribal ties still exist in most nomadic or semi-nomadic cattle producing tribes. Often there is little or no allegiance to government, and in some cases, there is hostility. Where possible, development should be made on land where there is undisputed right of occupancy or title to the land. Administration of lands where there is dispute over grazing or water rights is often quite difficult. In many cases land use disputes will cause breakdown in administration and management.

Most areas have well recognized tribal rights, which can even be broken down further to recognized clan or family rights to a given land tract.

Usually the dry season grazing areas have recognized tribal rights to existing water, while wet season grazing areas with little water have no rights or mixed grazing rights without well-defined boundaries. Therefore, the ownership of water is usually the key to right of occupancy. In planning development projects provisions should be made for fees to be charged in relation to water provided rather than for grazing rights.

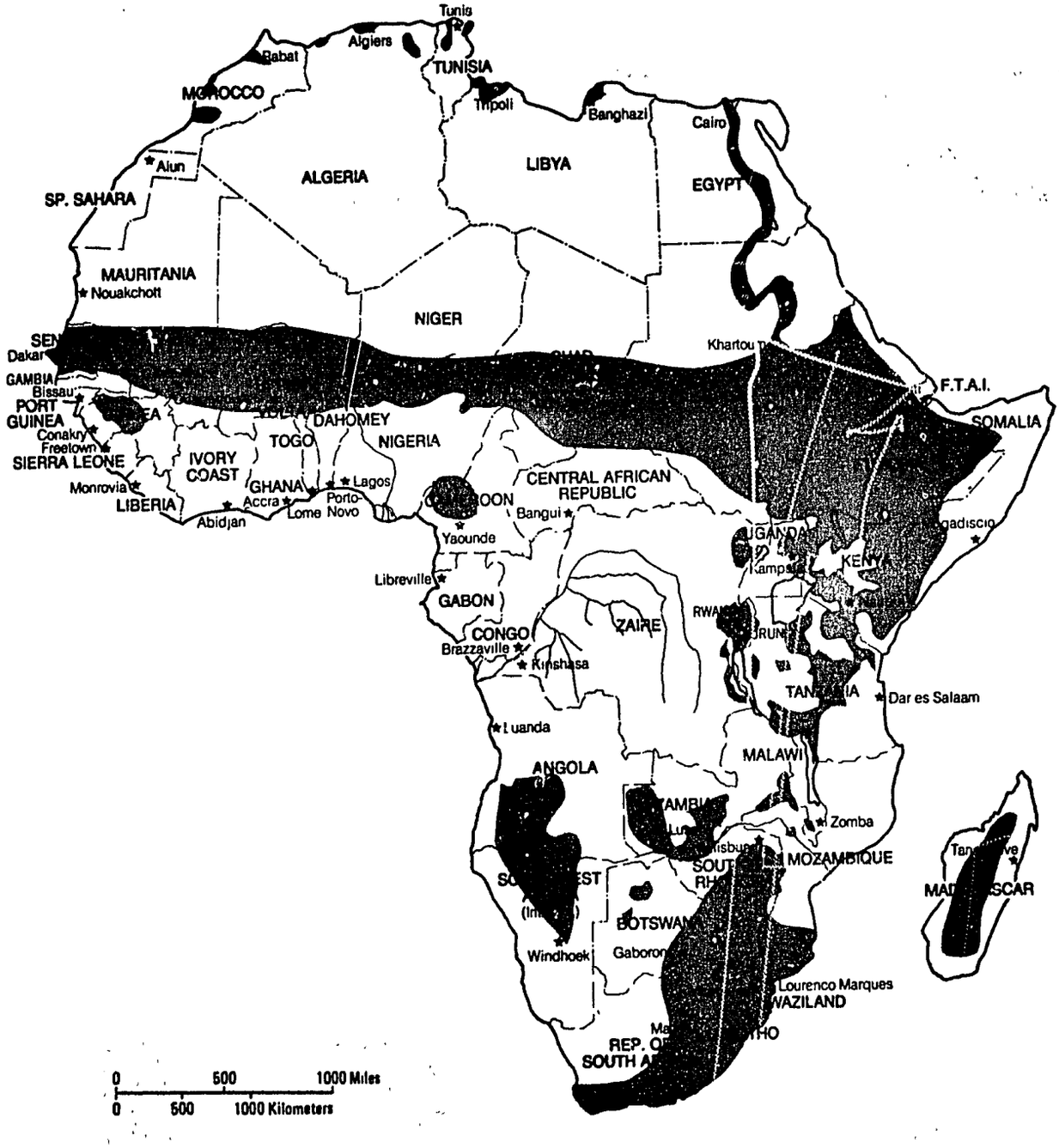
Map 1

DISTRIBUTION OF TSE-TSE FLY



Map 2

MAIN CATTLE PRODUCING AREAS



F. LIVESTOCK ON THE AREA

1. Cattle Census

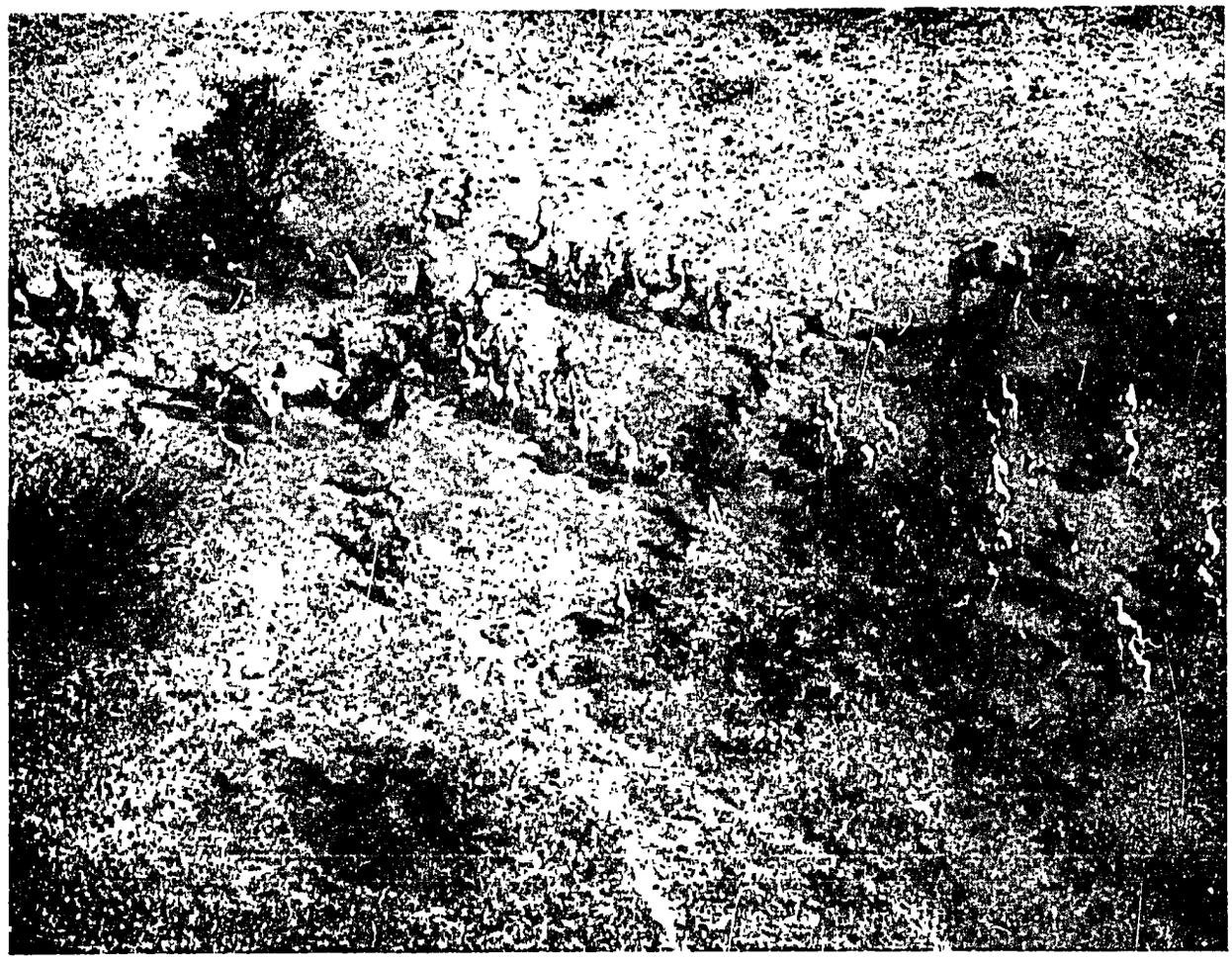
An accurate livestock census is essential in order to determine the base from which projections can be made of future production in determining economic feasbility of a range development program. Accurate census figures are also needed to determine carrying capacity of the area in relation to degree of present use of forage produced for a known number of animals. This gives the range planner a basis for recommending the number of animals suitable to the area's production potential.

Several methods have been employed—with varying degree of accuracy—in determining livestock populations for an area. In order to obtain an accurate estimate, two counts a year (one in wet season and one in dry season) should be made, particularly where seasonal migrations occur.

A count of the animals treated under the Rinderpest Vaccination Program provided a fairly accurate estimate of their number.

Another reliable method is by the use of aerial photography. This method was used by Watson in his North East Province of the Kenya Livestock Census in 1969. Aerial photography is especially practical as a large area can be covered in a relatively short time.

Aerial census of livestock. Cattle concentrated near stock pond.



Aerial census of livestock. Goats and camels in the photograph.

Boran cattle originated in Southern Ethiopia but have been improved through selection of superior animals.

2. Livestock Records

An accurate record of livestock owned by each producer should be maintained. This record should show classes of livestock by sex and age groups as well as numbers born, deceased and sold. These records are necessary in order to assess long-term benefits obtained from range development and improved animal husbandry.

3. Breeds and Quality

The selection of the most economical breed to produce is extremely important in the long-range development program. A detailed description of breeds of animals owned by local cattle producers with information as to their genetic ability to produce economically under improved nutritional and husbandry levels is necessary in order to plan a herd improvement program through selection and culling or introduction of new genetic stock. Rates of gain, age of maturity, size of animal and quality of carcass are quite variable among African breeds produced under similar conditions. The introduction of exotic breeds through importing bulls to achieve increased production is possible; however, extreme caution should be exercised in introduction of exotic breeds where nutritional levels and health standards are inadequate.

Ankole cattle with crossbred Boran and Angus offsprings from a cattle improvement program in Uganda.

Branding cattle for identification Record keeping cards are maintained on each animal with record of innoculations and calves produced

East African Shorthand Zebu with crossbred Sihawal offsprings from a cattle improvement program in Kenya. Note size of offspring in relation to dam

G. CORRELATION WITH OTHER USES

Products from range vary as much as range sites, climate, and vegetation. Management plans should consider all possible types of production from range lands.

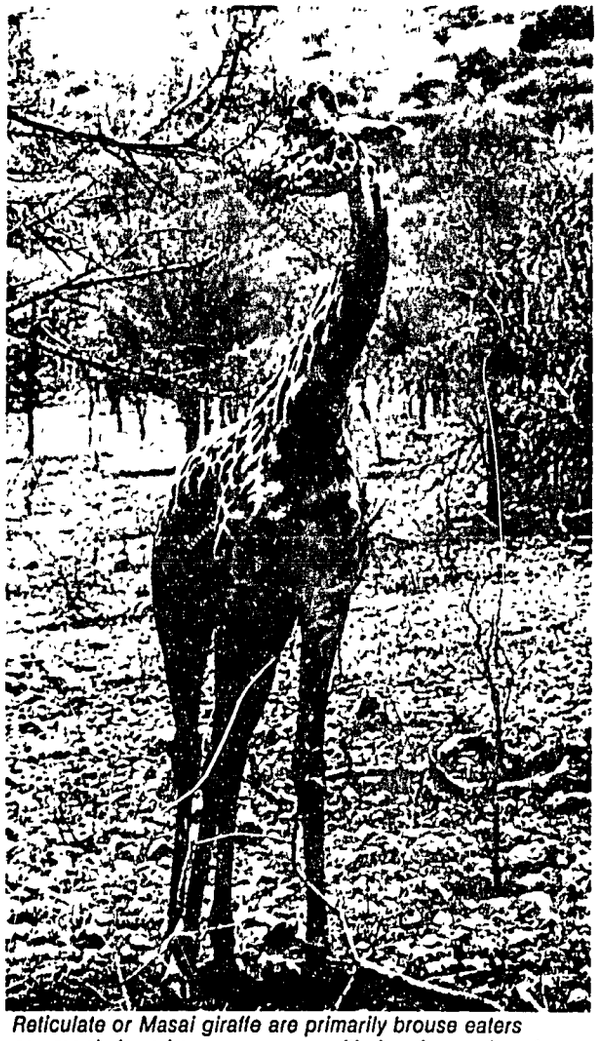
The development and management of range animals not only improves the habitat for domestic animals, but also for wildlife through providing additional water, control of fires and prevention of erosion and excessive runoff. With the exception of predators and possible spread of disease by wildlife there is no reason for not having abundant game species present on range lands.

Wildlife is becoming an important revenue earner in parts of Africa through tourism and hunting. African ranch owners are becoming aware of the economic potential from wildlife. Professional hunters and safari units are leasing hunting and camping privileges from ranchers for sizeable amounts of money.

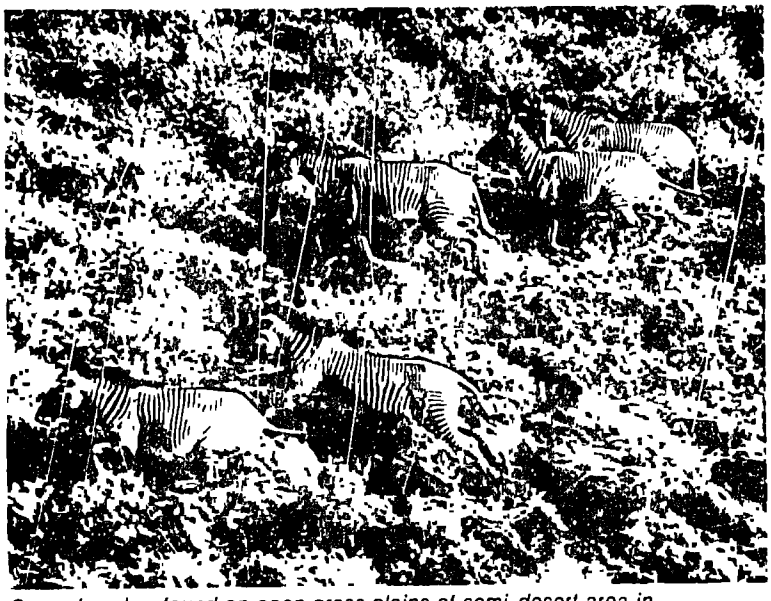
Development of a range area not only provides an improved habitat for wildlife, but also provides access roads and tracks into areas previously not accessible for hunting and tourism. The nomadic and semi-nomadic cattle producers of Africa are largely responsible for the plains game population that now exists in Africa. Cattle producers are not usually hunters of game animals for meat, whereas most sedentary farmers are hunters and have almost eliminated game in the areas occupied by them.

Poles, wood and charcoal are also valuable products which can be obtained from much range land in Africa. Managed charcoal making operations should be considered in range development programs for clearing bush to the desired density and species. Planned cutting is necessary in order to insure that adequate trees of the desired species are left for shade and soil protection. Careful control of charcoal making operations must be exercised to prevent starting grass fires. Charcoal can and should be a valuable export product where control in production is exercised. However, several African countries are attempting to halt charcoal exports because of indiscriminate cutting and burning which is seriously damaging the habitat.

The commercial production and harvest of game animals for human and pet foods has been studied in several African countries. The regular controlled offtake of non-productive game animals is just as important in wildlife management as it is in domestic livestock production. At present the major constraint to harvesting game is lack of efficient and sanitary means of processing the meat at an economical cost.

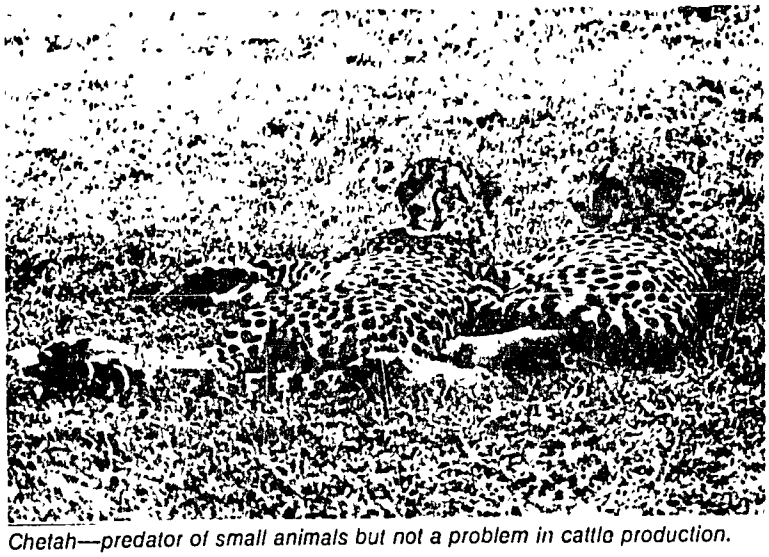


Reticulate or Masai giraffe are primarily brouse eaters commonly found on range areas with Acacia species of bush and trees.



Grevey's zebra found on open grass plains of semi-desert area in Northern Kenya.

Cape buffalo common on higher rainfall range areas or flood plains adacent to lakes and rivers. Can be a problem in destruction of fences and spread of disease to cattle.



Chetah—predator of small animals but not a problem in cattle production.

H. OWNERSHIP OF LAND

The land tenure of range lands is extremely important from the standpoint of available credit for development and the repayment of cost of development, and operation and maintenance of the land by the beneficiaries. Several systems are now employed by African states such as:

1. Grant of Title

Grant of title to individuals or groups where development loans are made to the individual or groups who are responsible for paying cost of operation and maintenance, and principle and interest on the development loan. It requires considerable business ability on the part of the producer to operate under this system.

2. Long-Term Lease

Long-term lease by individuals, groups, cooperatives or companies, whereby the lessee pays a nominal lease fee to the government. The lessee pays cost of development, and operation and maintenance of the range land. This system requires special credit as no mortgage can be placed on the land for collateral. Also a high degree of skill in business management is required.

3. Grazing Reserves

Grazing reserves with grazing permits issued livestock producers. Government maintains title to the land and pays cost of development operation and management and regains this cost through charging fees to permit holders and through increased revenue generated by the project.

4. Government or Para-statal Ranches

Government or para-statal organizations own and operate the developed ranches. The cost of development operation and maintenance is recovered through revenue generated by the sale of livestock and livestock products.

III. RANGE DEVELOPMENT PROJECT INVENTORY AND PLANNING

A. DEVELOPMENT PLANS

Range development plans should be prepared for each ranching or grazing unit prior to beginning implementation of projects. These plans should provide a basis for estimating herd projections. The required number, size, and location of facilities to be constructed should be planned and cost estimates developed. The plan should also include estimated operation and maintenance costs and estimated benefits to be received from development from which benefit/cost ratios and internal rates of return can be calculated.

B. RANGE MANAGEMENT PLANS

The details of each management plan, including both written and graphic sections, are intended as reference and working tools for the range manager. They serve as a record of condition and trends of the range before initiating management and the treatment and trends under applied management.

Management plans serve as a means of recording the number of livestock supported on the grazing area under recorded precipitation over a period of time. From these records the range manager can more accurately adjust numbers of animals to the annual forage production for the range unit.

Standard range photo-grid plots should be established with rain gauges to give accurate recordings of rainfall and vegetative trend.

Where invasion or increases of non-desirable bush or trees is a problem, the management plan should include a plan for resting blocks to be burned for economical control of the non-desirable plants.

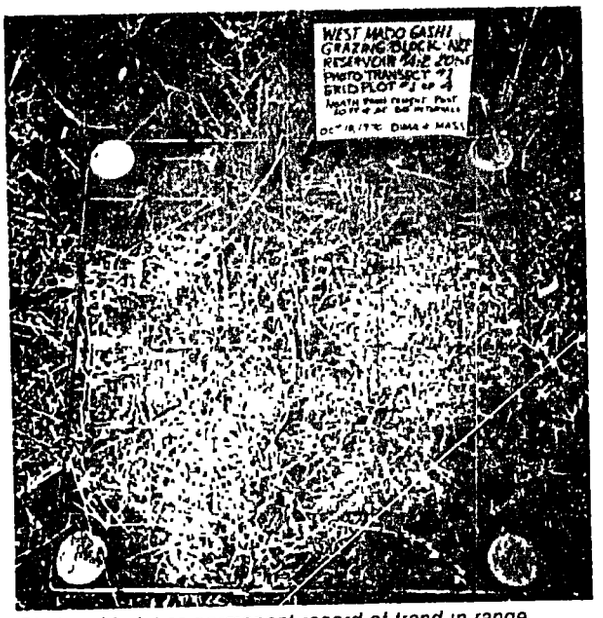


Photo grid plot as permanent record of trend in range condition under management plan.

C. SUMMARY OF INVENTORY DATA

1. Cattle Forage Inventory

Several systems of forage inventories are employed throughout the world. One of the more widely used systems is that of range sites and condition classification.

A range site is defined as an area capable of producing essentially similar vegetation when in top or climax condition. A range condition class is an expression of the present production in terms of potential production. Soils are one of the major factors to be considered in describing a range site.

Soil depth is important from the standpoint of water storage and nutrients available to the grass root system.

Climatic conditions. Climate is one of the major factors influencing vegetative communities. Precipitation, temperature, humidity and air movement are the primary factors of climate which influence plant growth.

Precipitation. Precipitation is the major factor influencing plant growth in Africa. With the exception of high elevations, low temperature is not a limiting factor as in many areas of the world. Thus, plant response is in direct relationship to available moisture. Precipitation is normally in the form of rain, with hail being common at elevations above 5,000 feet. The pattern of whether precipitation is single or bi-modal is important from the standpoint of length of wet and dry seasons. Single precipitation patterns normally have a longer, more harsh dry season than do bi-modal. West Africa experiences a single precipitation system while East Africa has a bi-modal system. Precipitation in the arid and semi-arid areas of Africa tend to be storms of high intensity, short duration and covering a relatively small area in strips or narrow bands as frontal systems move across an area. More general storms covering a larger area and of longer duration and lower intensity are more common for higher rainfall areas. Precipitation is entirely dependent upon moist air masses moving inland from coastal areas in both East and West Africa.

The air masses move inland, with the frontal system being the active area of thunderstorms and rainfall, then recede back to the coastal areas as wind currents change and high pressure systems from the continent cause a shift in the direction of air movements. In West Africa the air flow from the Sahara usually carries considerable dust and extremely low humidity at which time day temperatures are quite low and occasionally freezing temperatures occur. As winds and dust diminish, temperatures gradually increase to 90-120 degrees Fahrenheit depending on elevation and distance inland.

Poor range condition—bare ground with annual weeds and invasion of bush.

Fair condition, perennial grasses, low vigor, low density with bush invasion.

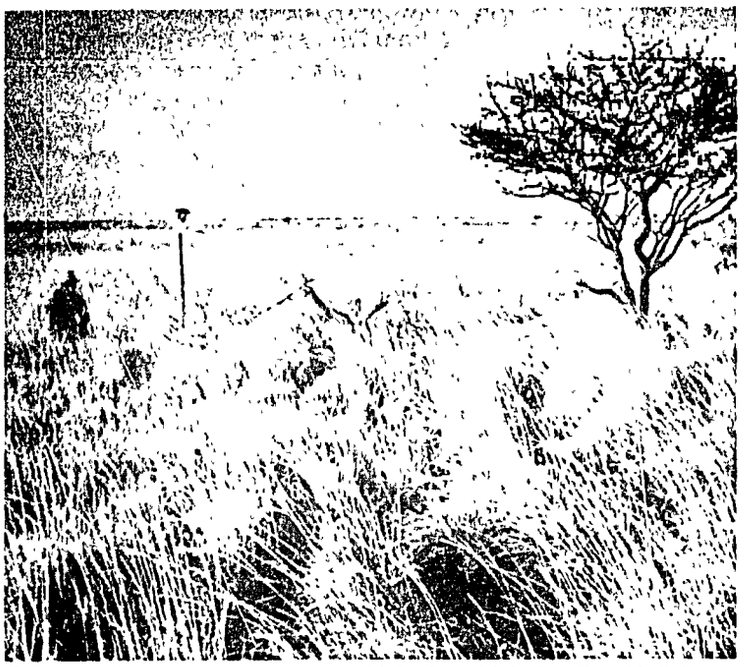
Low fair range condition—mostly annual grass with perennial grass in protected areas from grazing livestock. Invasion of bush species.

In East Africa daytime temperatures are moderate (ranging from 70-85 degrees Fahrenheit) during the two rainy seasons. Normally a short cool season follows the rainy season where temperatures are in the lower elevations. This cool season is the result of cloudy skies with little or no precipitation. Temperatures gradually increase during the dry season with highs of 90-115 degrees Fahrenheit. Dry seasons in East Africa are not as harsh as those of West Africa because dry seasons are shorter in duration, temperatures are not as high and humidity is relatively higher.

Soil texture is important for water penetration and water holding capacity which reflects available moisture for plant growth. Soil stability is influenced by soil texture. When soils are subjected to trampling by animals, conditions are created which lead to greater danger of excessive wind or water erosion.

Clay soils may be unsuitable for grazing by livestock during the rainy season because of muddy conditions.

High fair condition—perennial grasses, moderate vigor, high density with limited bush encroachment.



Good condition—perennial grasses, high vigor, high density with little or no bush encroachment.

Line transect to determine plant composition and density.

Slope is important from the aspects of access by livestock, runoff of precipitation, and erosion.

Position and elevation are important from the standpoint of receiving additional available moisture from runoff from adjacent areas (flood plains).

Exposure is important from the view of evaporation through exposure to the sun's rays (north or south facing slopes).

Range condition and trends are important parts of range analysis to obtain an index of the condition and apparent trend in condition of the vegetation and the soil stability.

One standard method of determining range condition and trend is the pace transect. This provides data on plant cover, plant composition, plant vigor, present degree of utilization, soil stability and related items.

Plant composition is important from the standpoint of quantity and quality of forage produced.

Plant vigor is an indicator of the current trend in range condition. Also the number of young plants of both desirable and undesirable plants is an indication of trend.

Length of seedstalk is one index of measuring plant vigor. These measurements are compared to standards from a similar area where plants are known to be vigorous.

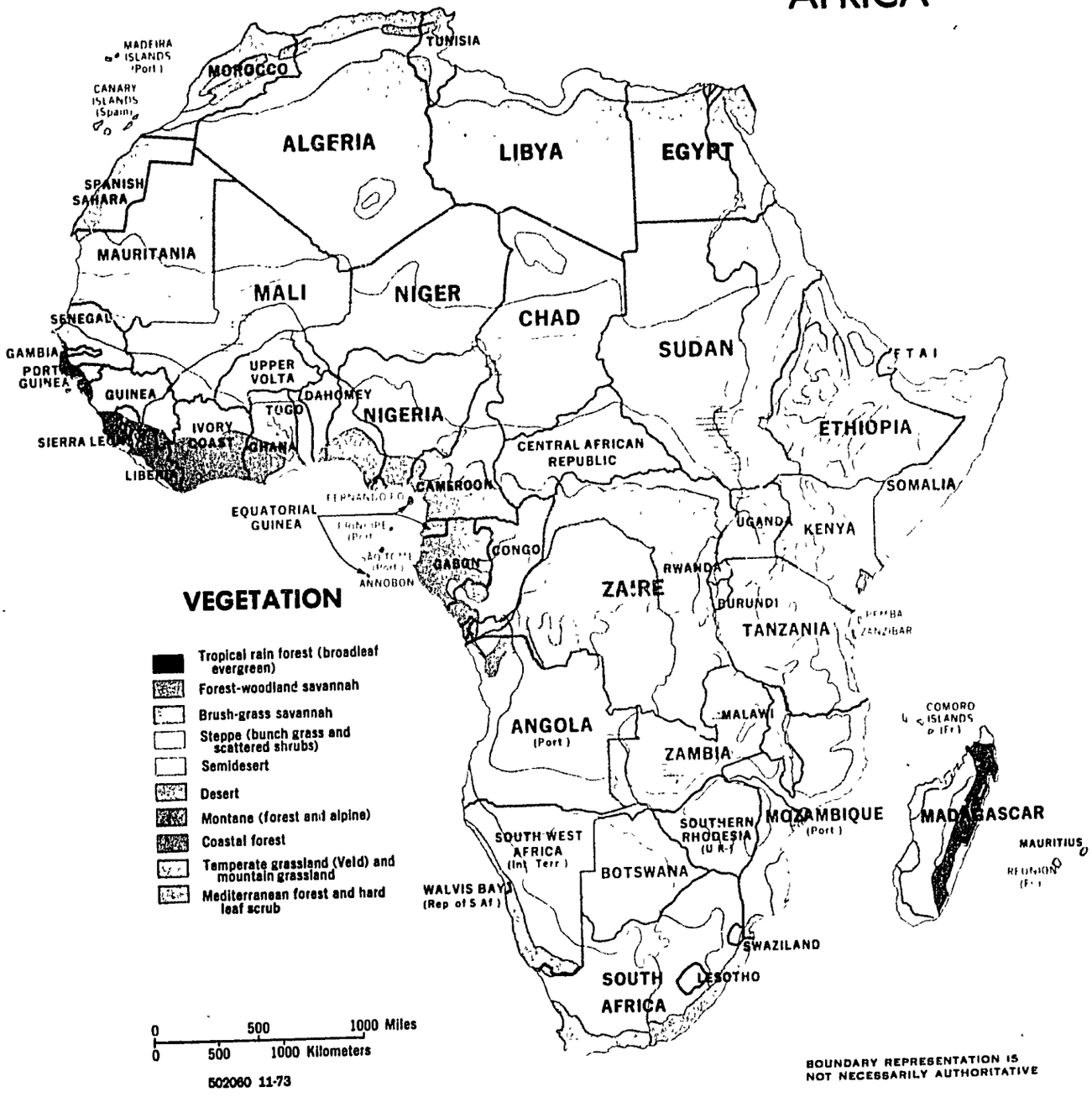
Plant cover or density is important from the view of forage production and soil protection. Plant cover or density is calculated from the number of hits on the pace transect.

Amount of current erosion and susceptibility of the soil to erosion is estimated. From this information, limitations of utilization can be determined.

Another method of determining range condition and trends is the "clip quadrat method" in which random sample plots, one meter square, are clipped to ground level and actual air dry measures by species made and recorded. These measurements are made to serve as a basis for estimating and stratifying forage production on the different condition classes of soil types or range sites.

Map 3

AFRICA


MADEIRA ISLANDS (Port)
CANARY ISLANDS (Spain)
MOROCCO
TUNISIA
ALGERIA
LIBYA
EGYPT
SPANISH SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
ERITREA
SENEGAL
GAMBIA
PORT. GUINEA
GUINEA
UPPER VOLTA
DAHOMEY
TOGO
NIGERIA
SIERRA LEONE
IVORY COAST
GHANA
LIBERIA
CENTRAL AFRICAN REPUBLIC
ETHIOPIA
SOMALIA
CAMEROON
FERNANDO PO
EQUATORIAL GUINEA
PRINCIPE (Port)
SAO TOME (Port)
ANNOBON
GABON
CONGO
UGANDA
KENYA
RWANDA
ZAIRE
BURUNDI
TANZANIA
PEMBA
ZANZIBAR
COMORO ISLANDS (Fr)
ANGOLA (Port)
MALAWI
ZAMBIA
MOZAMBIQUE (Port)
MADAGASCAR
SOUTHERN RHODESIA (U K)
SOUTH WEST AFRICA (Int Terr)
BOTSWANA
MAURITIUS
REUNION (Fr)
WALVIS BAY (Rep of S Af)
SWAZILAND
LESOTHO
SOUTH AFRICA
VEGETATION
Tropical rain forest (broadleaf evergreen)
Forest-woodland savannah
Brush-grass savannah
Steppe (bunch grass and scattered shrubs)
Semidesert
Desert
Montane (forest and alpine)
Coastal forest
Temperate grassland (Veld) and mountain grassland
Mediterranean forest and hard leaf scrub
0 500 1000 Miles
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Locating clip plots to determine pounds per acre forage production on a grazing block.

A basis for estimating bush and tree canopy density is by measuring the basal area of bush canopy at sample sites with an angle gauge. The plotless cruising technique is then used to determine shrub and the canopy density. Forage production and bush density are then stratified in condition classes of range sites. From this information average pounds per acre of forage production can be determined for each of the several condition classes of each soil type or range sites. This information is eventually utilized in determining stocking guides.

The dominant preferred perennial forage species are recorded for each soil type or range site. These species are referred to as "key forage species". They are considered as indicators of downward trend in range condition when they become less frequent than normally expected for the site.

Other less desirable species of grass and forbs tend to replace the dominant preferred species under continuous heavy grazing. These species are referred to as "increasors".

Finally with continued improper range utilization and downward condition trend the area becomes denuded or invaded by annual grasses and perennial bush and tree species. These are referred to as "invaders".

Range sites are normally given names of local soils or conditions such as "red desert sand bush", "black cotton soil flood plain", "open heavy grey-brown soils" or "shallow lateric soils open bush".

Range condition classes are an expression of potential production and classified as a percentage of potential production as follows:

Excellent	—	81-100% of potential
Good	—	61- 80% of potential
High Fair	—	41- 60% of potential
Low Fair	—	21- 40% of potential
Poor	—	0- 20% of potential
Very Poor	—	- 00% of potential

TABLE 1: EXAMPLE OF SUMMARY OF RANGE SITES AND CONDITION CLASSES

		CONDITION CLASSES (UNIT: ACRE)				
Range Site	Total Acreage	Good	High Fair	Low Fair	Poor	Very Poor
Red Desert Sand	100,000	10,000	30,000	20,000	30,000	10,000
Black Cotton Flood Plain	50,000	30,000	10,000	10,000	—	—
Open Heavy Grey-Brown	80,000	20,000	40,000	10,000	5,000	5,000
Shallow Laterite Open Bush	40,000	—	5,000	5,000	10,000	20,000
TOTAL AREA	270,000	60,000	85,000	45,000	45,000	35,000
PERCENT OF TOTAL AREA	100	22	32	17	17	12

From clip quadrats and occular estimations an estimate is made of the pounds of forage produced for each condition class of range site. A summary is made of this information:

TABLE 2: EXAMPLE OF SUMMARY OF RANGE FORAGE PRODUCTION BY SITE AND CONDITION CLASS

		POUNDS FORAGE PER ACRE BY CONDITIONS				
Range Site	Total Acreage	Good	High Fair	Low Fair	Poor	Very Poor
Red Desert Sand Bush	100,000	1,000	650	390	100	—
Black Cotton Flood Plain	50,000	1,500	1,000	600	150	—
Open Heavy Grey-Brown	80,000	800	510	300	80	—
Shallow Laterite Open Bush	40,000	500	325	200	50	—

The range planner is then able to determine the number of animal unit months the range area is capable of supporting. This is a calculation of the acres of each range site condition class multiplied by its present range forage production per acre. The total forage production is then divided by the pounds of forage required for one animal unit for a period of one month. These calculations are then recorded by each range site and conditions class as animal unit/months which the area will support as follows:

TABLE 3: EXAMPLE OF SUMMARY OF ANIMAL UNIT MONTHS BY RANGE SITE AND CONDITION CLASS

		ANIMAL UNIT MONTHS				
Range Site	Total Acreage	Good	Fair	Fair	Poor	Total AUM
Red Desert Sand	100,000	5,000	9,750	3,900	1,500	20,150
Black Cotton Flood Plain	50,000	37,500	5,000	3,000	—	45,500
Open Heavy Grey-Brown	80,000	8,000	10,000	6,000	200	24,400
Shallow Laterite Open Bush	40,000	—	810	500	250	1,560
TOTAL	270,000	50,500	25,760	13,400	1,950	91,610

This gives the ranching area of 270,000 acres a carrying capacity of 7,630 animal unit years or 35 acres to the animal unit.

2. Bush and Tree Canopy Density

As previously mentioned the bush and tree canopy densities are recorded for each site and condition class at the time of making the forage inventory. These recordings are summarized by range site and condition class:

TABLE 4: EXAMPLE OF SUMMARY OF RANGE SITE BUSH AND TREE CANOPY

(UNIT: ACRE)

Range Site	Total	0-5%	6-20%	21-30%	Over 30%
Red Desert Sand	100,000	0	20,000	30,000	50,000
Black Cotton Flood Plain	50,000	45,000	5,000	—	—
Open Heavy Grey-Brown	80,000	65,000	15,000	—	—
Shallow Laterite	40,000	20,000	15,000	5,000	—
TOTAL AREA	270,000	130,000	55,000	35,000	50,000
PERCENT OF TOTAL AREA	100	48	20	14	18

In the event tree and bush canopy density exceeds 25-30 percent, it becomes a barrier to livestock access to forage species. The carrying capacity for the site and condition class must be reduced corresponding to the percent of the area occupied by bush. However, growth form of the bush must be considered, thus the range planner must exercise judgment as to the percentage forage production is discounted. The recording is more valuable to serve as a guide to the bush and tree canopy density response to management treatment.

3. Geology and Groundwater Resources

Geological surveys are available for most of the African states. They provide considerable information about soils and the possibility of surface and groundwater development on the study area. Soils maps are often included as a part of the geological survey, also location of existing spring, perennial flows in rivers, and possibility of obtaining groundwater. They usually indicate where perched water tables may be found at shallow depths as well as the principal acquifier of potential groundwater supply. Information is given as to depth to the principal acquifier and quality of water in terms of saline content (PPM of dissolved salts) as well as expected yields in gallons per hour from pumping of bore holes. The approximate extent of fresh and saline water acquifiers is mapped in many instances.

In the event no groundwater information is available a groundwater survey should be initiated if groundwater is required as a major source of livestock water. These investigations should be made by correlating test holes with geology of the area. Information should be obtained as to depth to water, quality of water, probability of dry holes, and probable yields of water. From this information, the feasibility and cost of providing livestock water from underground sources can be determined. In general, groundwater sources of sufficient quantity and quality are much more expensive than surface water storage. This is particularly true when cost of operation and maintenance are considered. However, groundwater sources are more dependable in drought years.
Where both groundwater and surface water supplies are feasible a combination of the two systems is satisfactory. The surface water should be used as the major sources for livestock and groundwater from bore holes will be used for domestic and emergency needs only.

4. Surface Water Hydrology

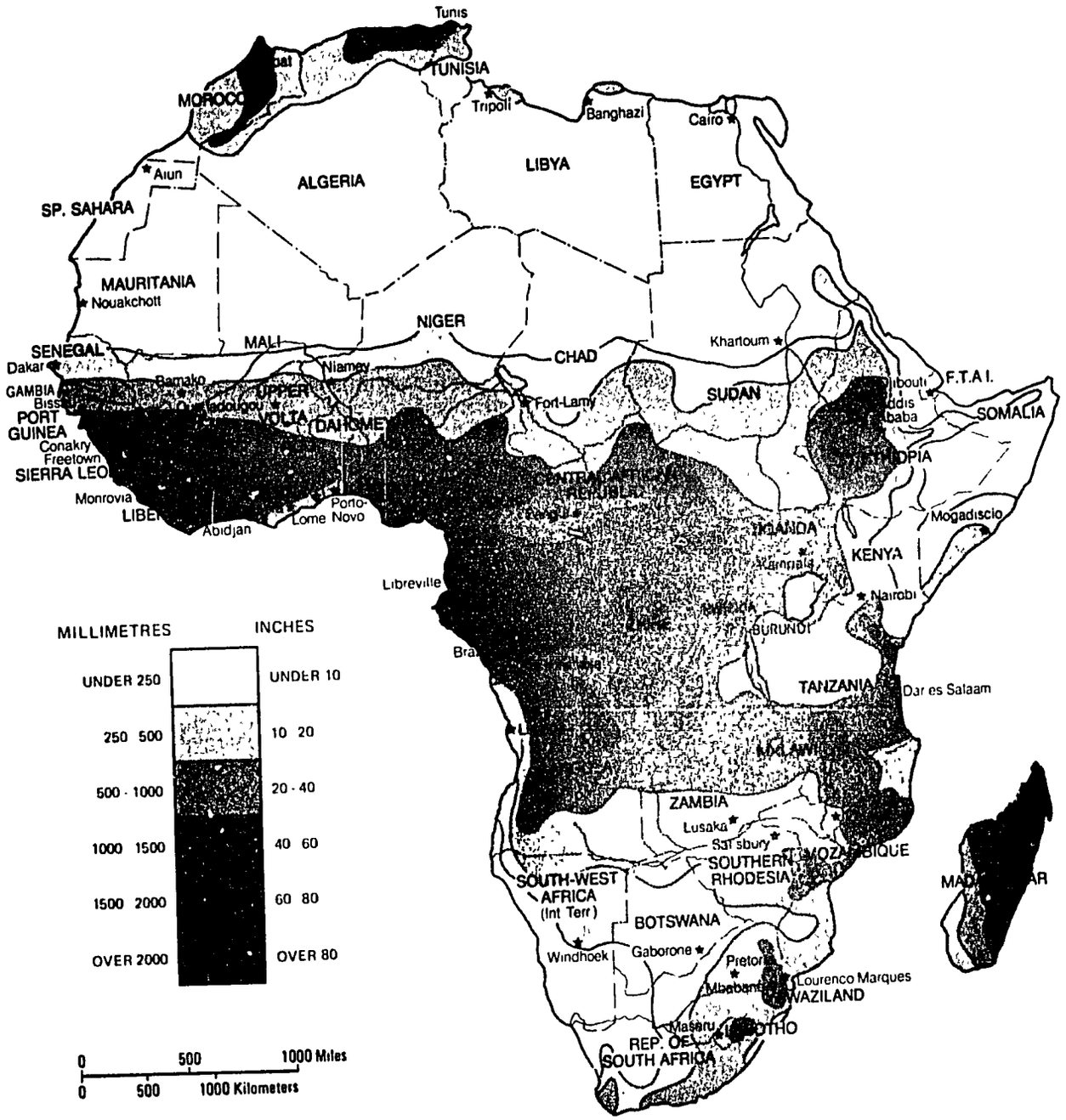
Surface water hydrology is extremely important in determining the feasibility of providing livestock water by surface storage. Even though an area receives limited rainfall (10-14 inches), it does not preclude the possibility of developing sufficient livestock water through surface storage.
Normally livestock producing areas are remote from towns or cities of any magnitude, and little or no hydrological data is available for the area under consideration. Therefore, hydrological investigations are necessary prior to completion of a development plan for the area.

A good example is the North East Kenya Range Water Development Program where an average annual rainfall of 10-14 inches occurs. Hydrological investigation was conducted by the USAID range water development team prior to planning surface water storage for livestock in the area. The hydrologic investigations carried out for this project area include estimating: (1) direct runoff from rainfall, (2) water requirements for livestock, (3) sedimentation, and (4) flood flows. Apparently no stream gauging has been done on small watersheds in or adjacent to the study area. Since no stream gauging records are available, the methods used for estimating direct runoff were taken from the Hydrology Guide for Use in Watershed Planning.[1]

[1] Hydrology Guide for Use in Watershed Planning: National Engineering Handbook, Sec. 4, Supplement A, U.S. Dept. of Agric., Soil Conservation Service.

Map 4

AVERAGE ANNUAL RAINFALL



a. Analysis of Rainfall Records

Long time rainfall records (1931 through 1968) are available for Garissa (mean annual rainfall of 12.7 inches) and Wajir (mean annual rainfall of 11.3 inches). These gauging stations are approximately 70 miles from the study area. While they definitely have similar climatic conditions as those in the project area, the rainfall records (1955 through 1968) for Mbababala and Habaswein, which are adjacent to the project area were considered more representative and analyzed along with the same period of records for Garissa and Wajir and the results used in estimating potential runoff. For analytical purposes, all calculations were based on an Antecedent Soil Moisture Condition II [2] in which 1.75 inches of rain, in a period of five days preceeding and/or including part of any particular storm, was used as the antecedent rainfall. In other words, only that part of any particular storm that remained after fulfilling the requirements for Condition II, was recorded as having a potential, considering other hydrologic conditions for producing runoff.

All storms, having a potential for runoff after meeting the requirements for Antecedent Moisture Condition II, were tabulated by months (March-April-May and October-November-December) for the four respective rainfall gauging stations. This analysis, based on thirteen years of records, indicates that the rainfall is sufficient, in this project area, to fill the proposed surface reservoirs at least eight out of ten years. This does not mean, however, that in the other two years the reservoirs will have no water. The records indicate that some rain will fall during these years (extended dry periods which may last as long as 30 months) but the runoff will not be sufficient to fill the reservoirs—possibly only half filling in some instances. The reservoirs will then not have enough water to carry the livestock through to the next rainy season and the livestock will have to be moved to other adequate water supplies or suffer considerably. To meet this emergency situation, alternate water places, such as in the Golana Gof and deep boreholes are planned within the grazing area.

The analysis also indicates that there will be enough runoff for two years out of the eight years of sufficient rainfall to fill the reservoirs during both the March-April-May and October-November-December rainy periods. During the remainder of the eight years the reservoirs will fill during either one or the other (equally distributed) of the two rainy periods.

The rains usually come from scattered thunderstorms rather than solid fronts. This uneven storm distribution often results in certain areas receiving heavy rains and others, a few miles away, receiving very little or none. However, during the course of any normal rainy season practically every area receives some rain. Because of this uncertainty in distribution and the sometimes extended dry season, the deep (30 feet) reservoirs which are to be constructed in the "dry season pastures" will be built to hold enough water to carry the planned number of livestock for 12-15 months, once they are filled, without additional runoff.

Larger reservoirs are not needed because they would have more water (at least 80 percent of the time) than can be utilized by the livestock as planned in the Range Management Scheme.

The estimated mean annual rainfall for the project area is 10-12 inches, with higher averages occurring in the West Mado Gashi grazing unit. The estimated monthly potential evaporation from open water is 7-9 inches.[1] Because of these high monthly evaporation losses and low rainfall, it is imperative that all reservoirs be constructed under designs that will minimize this loss.

[1] Compiled from data available to December 1966 by T. Woodhead (East African Agricultural and Forestry Research Organization).

[2] Antecedent Soil Moisture Condition II refers to the degree of wetness of a watershed at the beginning of a storm, and for Condition II, the soil is neither nearly dry nor nearly saturated, but average or in good plowing condition.

b. Analysis of Hydrologic Conditions

Hydrologic Soils Groups [2] and land use and land treatment classes were used to determine the hydrologic conditions of the project area.

(1) Hydrologic Soil Group

The characteristics of the two major hydrologic soil groups found in the project area are as follow:

Soil Group "B". Mostly sandy soils with above average infiltration after thorough wetting.

Soil Group "C". Soils containing considerable clay and colloids with below average infiltration after presaturation.

TABLE 5: EXAMPLES OF ACREAGES OF HYDROLOGIC SOIL GROUPS BY GRAZING BLOCKS

Hydrologic Soil Group	Mado Gashi (West)	Mado Gashi (East)	Kalalut	Total
B	101,480	282,400	432,000	815,880
C	269,370	538,300	121,600	929,270
TOTAL	370,650	820,700	553,600	1,745,150

Since neither agricultural soil maps nor soil surveys are available for the project area, the hydrologic soil groups were classified on a reconnaissance basis.

(2) Land Use

For hydrologic purposes, all of the land use is classified as native range. Acreages in manyattas, roads and tracks are considered too small to be treated separately.

(3) Land Classification

The land classes are based on hydrologic considerations not on forage production and are classified as follow:

Good—range that has more than 75 percent of the area with plant cover and is lightly grazed.

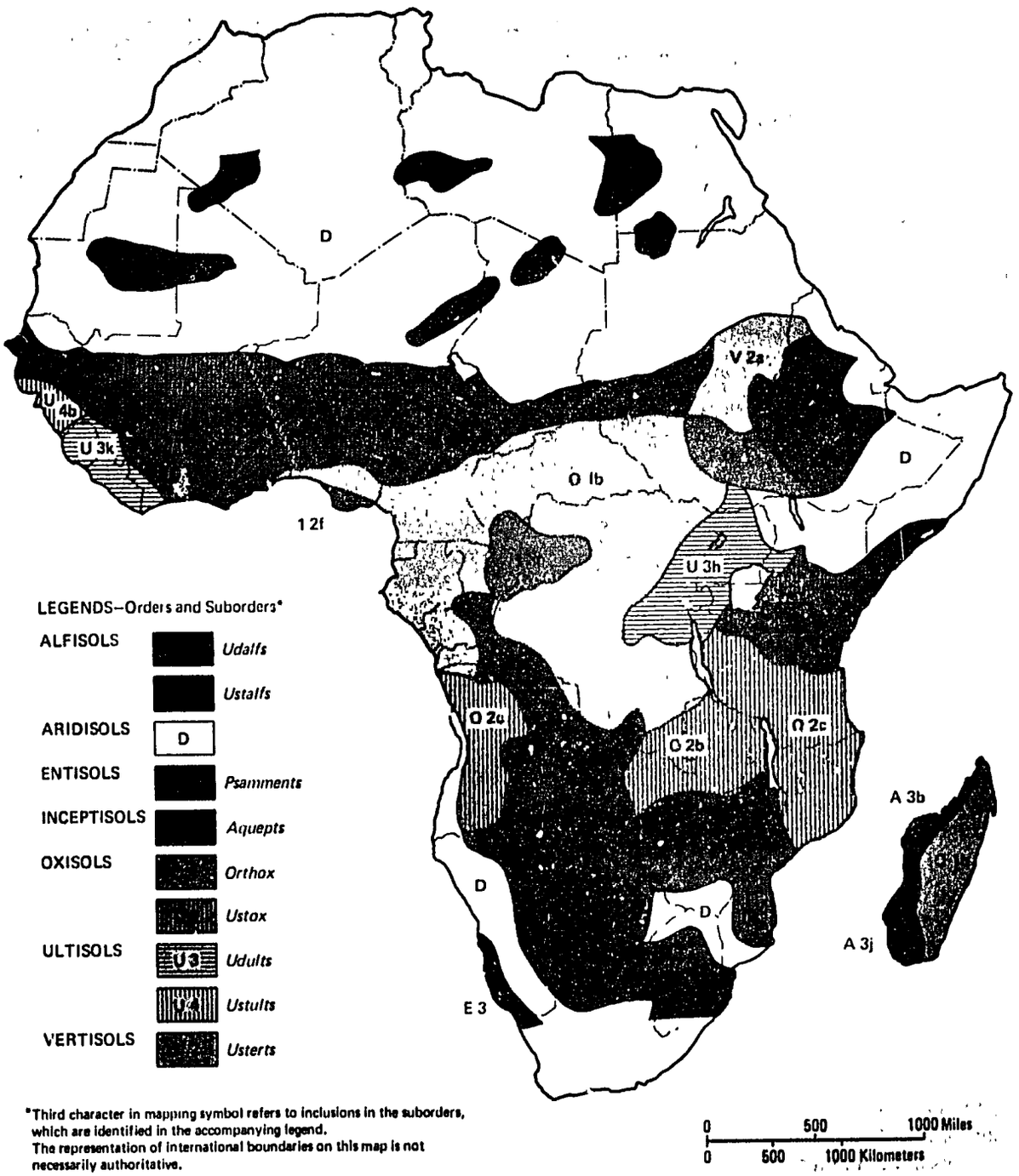
Fair—range that has between 50 and 75 percent of area with plant cover and is moderately grazed.

Poor—range that has less than 50 percent of the area with plant cover and is heavily grazed.

[2] Hydrologic soil groups are a group of soils having the same runoff potential under identical storms and cover conditions.

Map 5

SOILS OF TROPICAL AFRICA



*Third character in mapping symbol refers to inclusions in the suborders, which are identified in the accompanying legend.
The representation of international boundaries on this map is not necessarily authoritative.

TABLE 6: EXAMPLE OF ACREAGES OF LAND CLASSES ON AREA PLANNED FOR BEEF PRODUCTION BY GRAZING BLOCKS

(UNIT: ACRE)

Classes	Mado Gashi (West)	Mado Gashi (East)	Kalalut	Total
Good	211,500	268,700	291,100	771,300
Fair	81,750	260,400	212,000	554,150
Poor	77,600	291,600	50,500	419,700
TOTAL	370,850	820,700	553,600	1,745,150

More than 50 percent of the range land is in the poor-fair land condition class. With better management and protection as set forth in the range management scheme, it is estimated that almost 85 percent of the area should be in the fair or good land condition class by 1980. Much of the improvement will be in the badly eroded area adjacent to the Golana Gof.

(4) Analysis of Runoff [1]

Precipitation curve numbers. Each combination of a hydrologic soil group and a type of vegetative cover (hydrologic soil cover complex) has been assigned a corresponding runoff curve number (RCN). The RCNs as developed for the hydrologic soil-cover complex in the Hydrologic Handbook for Use in Watershed Planning are assumed applicable to the project area (similar to many areas in the western part of the USA) and will be used in determining direct runoff.

The higher the RCN, the greater the amount of runoff to be expected from a given storm.

TABLE 7: RUNOFF CURVE NUMBERS BY LAND USE, LAND CLASS AND HYDROLOGIC SOIL GROUPS

(UNIT: RCN)

Land Use	Land Class	Hydrologic Soil Group B	Hydrologic Soil Group C
Natural Range	Good	61	74
	Fair	69	79
	Poor	79	88

c. Water Requirements for Livestock

(1) Present Sources

In estimating the required development necessary for supplying future demands for livestock water, the present supply must be inventoried for the area. The present man-made reservoirs, boreholes, shallow hand dug wells, springs, stream flow and natural depressions must be considered, and their potential for supplying water at the required period of time an area is to be grazed assessed.

Normally, permanent water supplies required on dry season grazing areas are limited to boreholes, deep reservoirs, and permanent streams and springs. However, much of the required water supply can be met on wet season grazing areas by utilizing natural supplies such as streams and shallow depressions. In most instances, it is advantageous to extend the period of grazing time on the wet season grazing areas by construction of shallow ponds for surface storage, and shallow hand dug wells in water bearing stratas in stream beds.

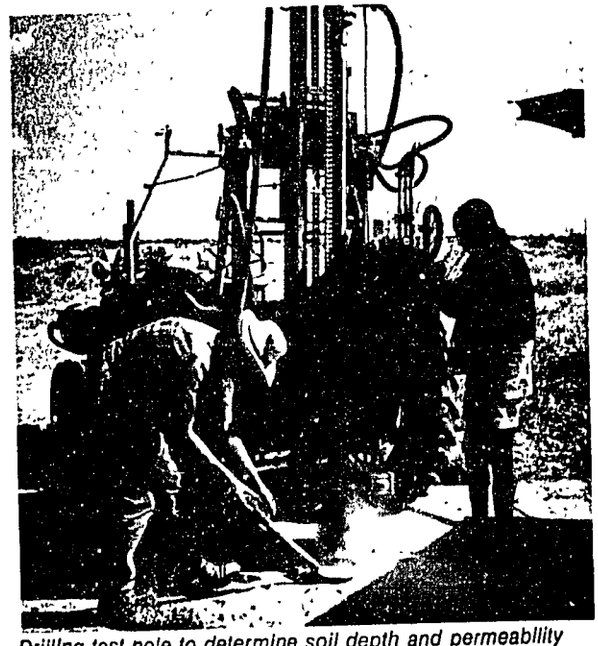
[1] Runoff—precipitation curve numbers express the relationship between the amount of direct runoff and the amount of rainfall occurring under a given antecedent moisture condition.

(2) Future Sources

Requirements are based on the assumption that the average animal consumes one gallon of water daily for each 100 pounds of body weight. The average expected body weight for improved animals in a development project is about 700 pounds under a cow-immature steer operation and about 800 pounds for a growing or fattening ranch. Therefore, 7-8 gallons of water is required daily for each animal in a development project. As an example, on the North East Kenya Project 54,000 cattle are expected on the first development area where a cow-immature steer production will be in operation. Daily consumption will be about 7 gallons per day for each animal for a period of about 150 days during a normal dry season and six weeks extension of grazing on the wet season grazing areas. To meet this requirement 86 reservoirs containing about 240 million gallons of water are needed as a minimum. Of this total approximately 65 percent or 154 million gallons will be available for livestock, and 35 percent will be lost through evaporation and seepage.

In order to minimize evaporation losses, the reservoirs should be constructed as deep as practical (considering soils, location and water requirement) and with the least surface exposure possible. Where possible construction should be at right angles to the prevailing winds. The embankment from the excavation should be used as a dam where increased depth can be achieved or to serve as windbreaks from prevailing winds and barriers to livestock and wild animals. The design should provide the most protection and keep evaporation losses to a minimum. Depths of 25-30 feet are required in the cattle producing areas of Africa to provide livestock water during the dry season over and above evaporation and seepage loss. Depths of 12-15 feet are adequate to provide temporary water storage during and for a six weeks period following the rainy season on pastures used as wet season grazing areas.

Planning location for water development in order to balance forage with water requirements.



Drilling test hole to determine soil depth and permeability in water reservoir site investigation.

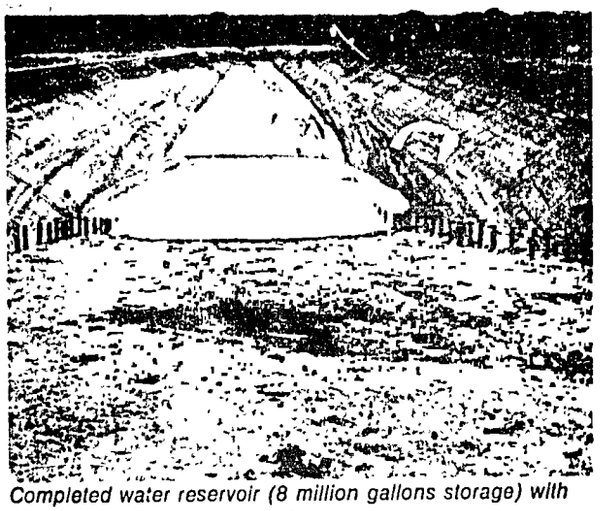
Seepage losses should be kept to a minimum by drilling test holes prior to construction in order to assure adequate depth of non-porous materials. It may be necessary to investigate several alternative sites before satisfactory soil depth are found. Areas with relatively shallow soils for pond construction should be considered as possible wet season grazing areas.

Design of ponds should be planned to have the least earth surface to water contact as possible. Square pits or ponds have less earth to water contact than do rectangular (long, narrow) ponds. Less seepage loss occurs in relation to gallons of water stored from a square barrow pit than from a rectangular barrow pit.

Evaporation loss in relation to depth of reservoir is extremely important in providing livestock water during the season the water is required for use. The effective volume of water available for livestock use is in direct relation to feet of evaporation loss versus depth of water storage.

Factors critical in designing permanent water supplies are location in relation to possible catchment of sufficient runoff, soil permeability in relation to seepage losses, depth in relation to evaporation losses, and design in relation to surface exposure and water exposure to soil.

Boreholes equipped with pumps based on their potential output should be considered as emergency sources where ponds are possible or as major supplies on sandy areas where surface storage is not feasible. However, cost per gallon of water delivered for livestock consumption may cost four to five times as much as surface storage.



Completed water reservoir (8 million gallons storage) with fenced access ramp for livestock.

Aerial view of completed dam for livestock water. Dam has been seeded to grass to prevent erosion.

Controlled access to water eliminates trampeling damage to a structure by livestock.

Windmills have only limited potential use in that their pumping capacity is only 150-200 gallons per hour when in top operating condition and can only be expected to operate 8-10 hours per day for a maximum delivery of two thousand gallons. Conventional cylinder type pumps driven by diesel engines can deliver up to 1,000 gallons per hour for a ten-hour period of pumping or 10,000 gallons per day. As a comparison on the North East Kenya Project one reservoir can support 4,000 animals per day while cylinder type pumps producing 10,000 gallons from a borehole can support only 1,400 head per day.

Pipelines for distribution and delivery of water to a grazing area require sufficient elevation for gravity flow or the water must be force pumped. Distribution systems may be practical to keep livestock concentrations away from major supplies, however, supplies dependent on long pipelines (over 2-3 miles) are quite expensive and should be considered as a last resort.

Development of springs and shallow hand dug wells in stream channels can provide a limited source of cheap water for livestock consumption and should be considered as a possible source of supply. In many instances, these sources have been exploited by local cattle producers; however, with development additional amounts of water may be obtained.

(3) Estimating Sedimentation

The relief is generally flat, with slopes of less than one percent in most of the cattle producing areas of Africa. The length of slopes varies considerably but is generally long with drainage systems not well defined.

The levelness of the land helps prevent erosion from becoming a serious problem where the vegetation is in poor condition. Where slopes are steeper and grazing presssure heavy, serious erosion occurs. However, most is sheet erosion from overgrazed areas.

Mechanical measures to prevent erosion are uneconomical and not practical. The most effective means is improvement of vegetation to protect the soil and retard runoff, thus reducing soil losses to an expected level of five tons or less per acre per year.
Experience has shown ponds must be fenced with controlled access for livestock to prevent the soil from continuously being disturbed and washing directly into the pond. Livestock and wildlife should be allowed to enter and water only on one side. To minimize erosion on the entry side its slope should be no steeper than one foot vertically to six horizontally (6 to 1 slope). A sediment pool should be constructed to catch silt at the entrance of the pond This sediment pool will probably need cleaning every 3-4 years. The design of the sediment pool should be based on an estimate of soil losses from the watershed. One method is Musgraves probable soil loss equation as follows:

$$E = F \times S^{1.35} \times L^{0.35} \times P^{1.75} \times C$$

where E = probable soil loss in tons per acre per year, F = soil factor, S = slope in percent, L = length of slope, P = rainfall, C = cover.

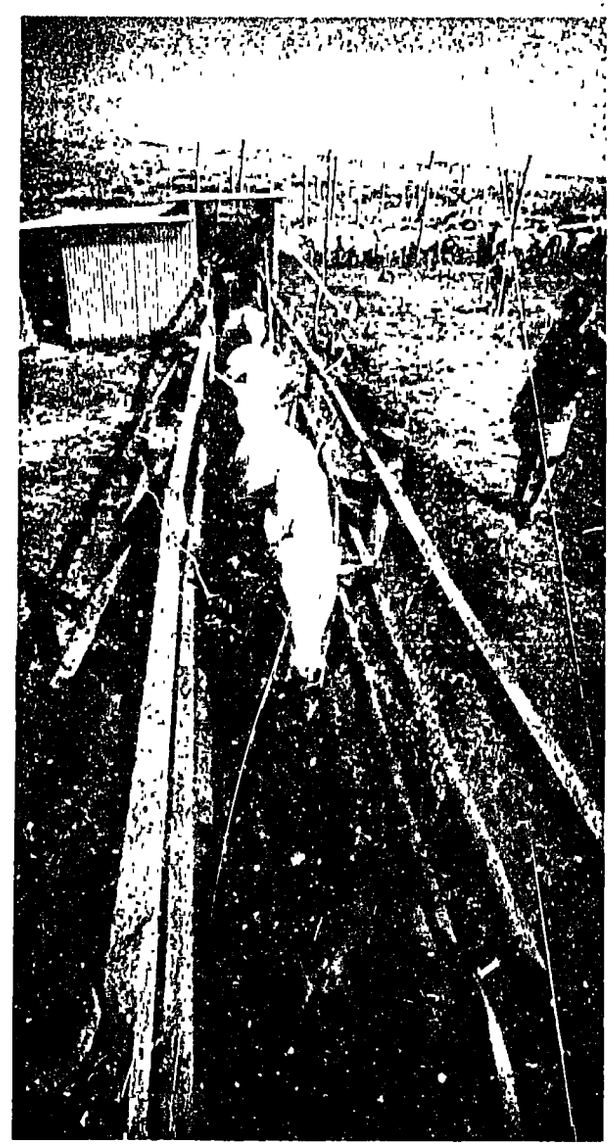
(4) Estimating Flood Flows

In general, precipitation in drier cattle producing areas of Africa falls in the form of widely scattered local thunderstorms, the path of which is normally about 5 miles in width and produces local runoff for short durations.
The lack of accurate rainfall gauging stations in or near the area normally make determination of area mean rainfall by the Thiessen method impractical. Therefore, the planner must utilize other methods of determining stream flows. One practical method which can be employed is to take a cross section profile of the drainage from the previous high water trash mark. The normal flow of drainage ways with grass and bushes and one to two percent slope is about five second feet. The quantity in second feet equals the area of cross section times the rate of flow of five. Emergency spillways should be designed to carry this flow with a 25 percent safety margin plus three feet of free board on the dam above expected peak flow.
Large streams with flows of long duration should be avoided or off channel structures with controlled diversions installed. Also, stream beds carrying high loads of sand and gravel should be avoided because of silting problems.
Dams with storages above ten acre feet should be designed by a competent engineer, especially where property damage and loss of life are possible in case of structure failure.
Where possible desilting areas should be fenced and protected above the entrance storage in order to allow sufficient growth of grass to slow the movement of water and cause the silt load carried by the water to be deposited in the desilting area rather than in the reservoir. The protected area also serves as a measure to prevent possible headcutting and gully erosion from the reservoir.

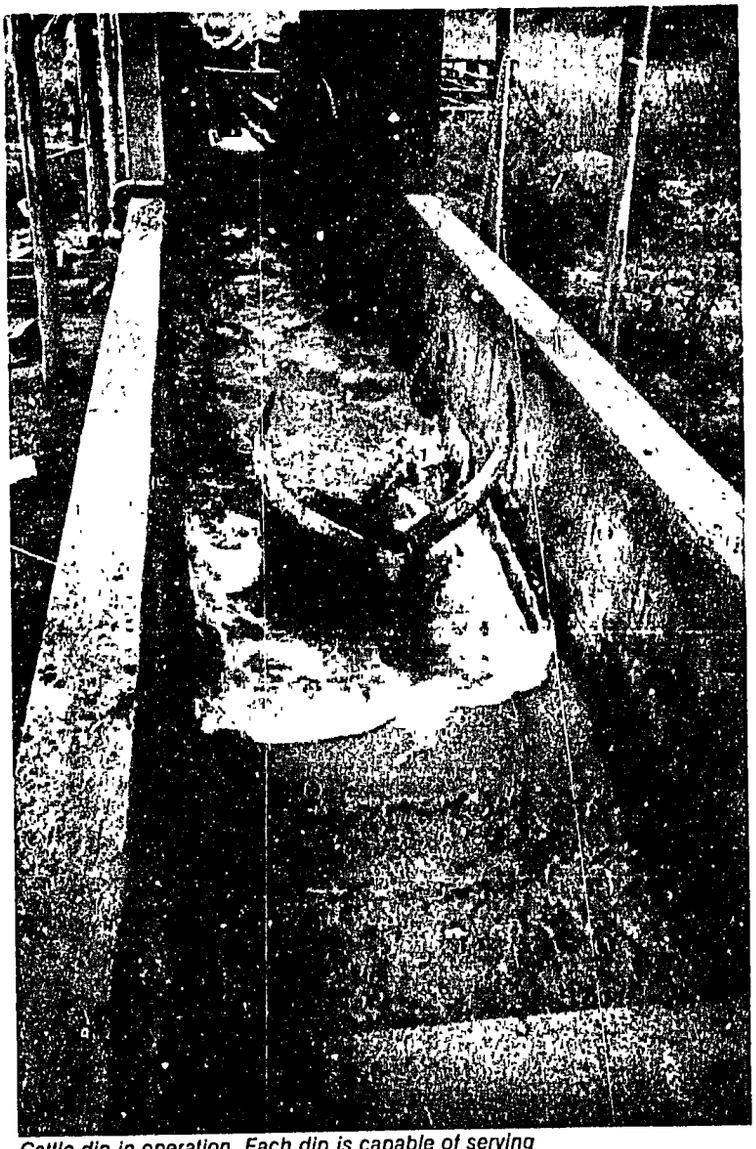
(5) Existing and Planned Structural Improvements

The existing and planned structural improvement of a range development area should be mapped and constructed as a part of the overall development for the area which will enable the range manager to implement the grazing management plan for the area. Each structural improvement of the area should be designed and located in accordance with the purpose it is to serve. Permanent water developments should be designed for use on dry season grazing areas and temporary water developments on wet season grazing areas. Distance between water developments should be planned to allow maximum proper utilization of forage on the area. Zebu type animals can utilize forage 2½ to 3 miles from water satisfactorily. This allows a spacing of five to six miles between water developments on large grazing blocks or one water development can serve an area approximately six miles by six miles square. Access roads into an area being developed should be planned as a part of the overall development of the area, in which they will later serve as firebreaks and boundaries of grazing units. Fencing of African range units is not normally recommended as a first phase development practice, since livestock are normally herded during the day for protection against predators and stock thieves. Adequate control of movement of the livestock can be achieved by the herders. In some instances fencing of perimeters may be necessary in order to prevent trespass grazing. However, other measures of control should be carefully considered prior to initiating construction of expensive fencing. Special purpose fencing of areas may be feasible such as night grazing paddocks, or improved pasture areas for special purposes.

Stock handling facilities and dips or spray races should be planned as a part of all major developments for a range area. Crushes are necessary to insure adequate animal health programs are carried out. Dips or spray races are normally required as a protective measure against tick-borne dis-



Cattle spray race in operation. Spray races require less dip fluid but require the operation of a motor and pressure pump.

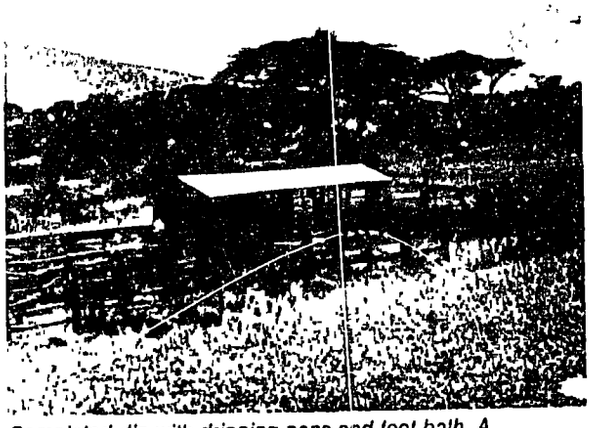


Cattle dip in operation. Each dip is capable of serving 5,000 head in a dipping program where animals are dipped once a week.

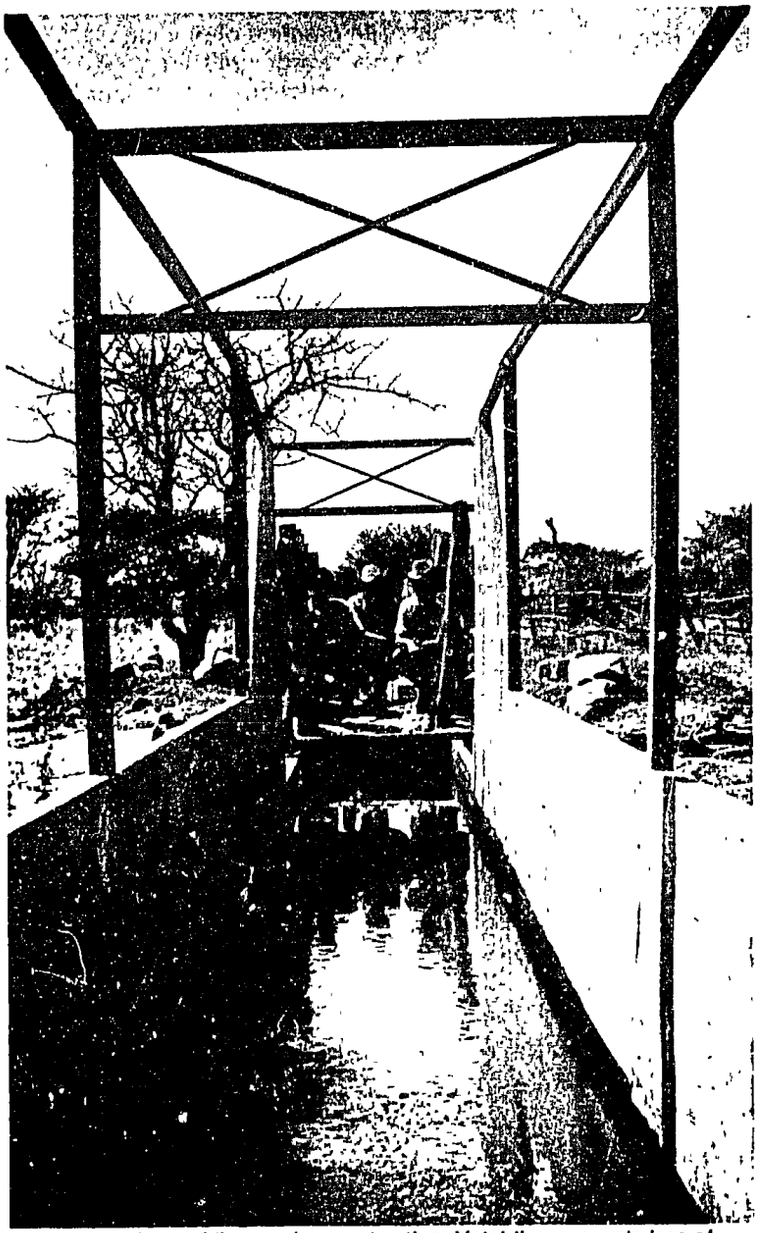
eases and mechanical damage to the animal from biting ticks. The practice of dipping offsets one of the major arguments of nomad cattle producers for annual burning of range areas.

Elaborate design and expensive construction should be avoided in development of African range areas as development costs have a direct bearing on the economic viability of a ranching unit. Unfortunately, mechanical or chemical control of undesirable bush species in Africa is not economical under the present livestock economy. Therefore, control must be limited to management practices such as controlled burning.

In areas being cleared of tse-tse fly, total clearing to destroy the fly habitat is possible; however, cheaper and more economical means must be found. Shear clearing of barriers around a block area to be cleared of tse-tse fly by aerial or ground spray methods is practical under present known methods where the size of the block area cleared is large enough to offset the high cost of shear clearing the barrier.

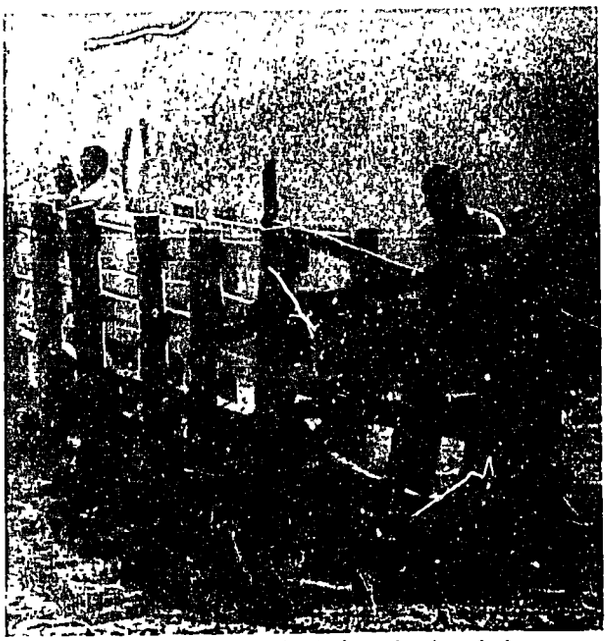


Completed dip with dripping pens and foot bath. A cattle crush is also attached.



Cattle dip with metal liner under construction. Metal liner prevents loss of fluids through cracks in walls of vat.

Vaccinating cattle against Foot and Mouth Disease, type SAT 2.



Cattle crush for branding and veterinary treatment of livestock.

(6) Non-Structural Improvements

Plant protection has largely been recognized as the most effective and economical method of preventing both wind and water erosion. Management systems should provide for sufficient plant cover to remain on the soil for protection against wind erosion and impact from rain drops. Plant stubble remaining on the soil acts as millions of tiny retarding structures to decrease the movement and consequent runoff of precipitation from a watershed. Many minute channels are left in the soil by the normal process of annual decay and replacement of its root system by plants. This is particularly true of the plants such as grass with fibrous root systems. These minute channels are important in increasing the water intake rate of a soil. Plant residue protects the soil from the direct force of the wind and sun which in turn reduces evaporation from the soil surface. Plant materials leached into the soil and organic matter from decomposed plant material improve the soil structure and tilth and increase water intake and holding capacity.

Thus, the manipulation of livestock on range area becomes the key factor in controlling degree, season and length of grazing of plants by animals. The control of grazing on an area is tailored to the needs of the area to be grazed. Thus, the management plan calls for a system of use of range areas which will allow plants to remain vigorous and reproduce themselves, while at the same time protecting the soil which they are dependent upon for nutrients and moisture. Areas in low range condition respond rapidly to management whereby preferred species are allowed to reproduce themselves and regain their importance in the species composition. Also plant density will increase to the desired amount increasing forage production per acre and providing adequate soil protection.

Range reseeding or introduction of improved species is not recommended (except for special purposes) cn large tracts of African range lands. The management and proper utilization of present and potential native forage production in range areas of Africa could utilize available manpower and capital resources to develop necessary water and physical faciilties for many years, without expending manpower and capital on increased production through introduction of improved species and mechanical treatment such as range pitting, contour furrowing, terracing and water spreading.

Management systems should consider controlled burning as a means of economically controlling invasions or increases in undesirable bush or tree canopy. Burning as a control measure should only be practiced on areas where grass density and vigor have recovered to the point of providing ample fuel supply to produce a hot fire to achieve the necessary kill of undesirable bush species. Controlled burning then should be practical as a treatment in a rest rotation grazing system.

Improved range condition and consequent increased forage production per acre increase the available forage for conversion into beef by livestock owners. This increased production of beef means increased income for producers. The operation of grazing management systems are relatively inexpensive when compared to benefits through increased grass and eventually beef production; whereas increased production through mechanical treatment can be expensive and questionable as to its cost/benefit ratio.

D. RANGE MANAGEMENT SYSTEMS

1. Applying a System Tailored to the Environment

The management system must take into account the highest possible production of beef, while at the same time, conserving or improving the environment available for cattle production. This implies utilizing forage to the proper use level and at the same time allowing plants to produce satisfactory leaf growth for manufacturing a good supply which can be utilized by the plant for root development and reproduction by seed or vegetative means. In other words a plant must have a reprieve from grazing animals periodically to allow its physical functions to occur if the plant is to survive and compete for available space, soil moisture and nutrients. High vigor and adequate reproduction can only occur where plants are allowed to complete these necessary physiological processes.

In most instances, the desirable forage species are the most palatable to grazing livestock and are selected by grazing animals first. The preference of these species by animals cause higher utilization and consequent lessening of their ability to compete with less desirable species. If this process is allowed to occur over a period of time the plant composition will be altered and the less desirable species will become dominant. Thus, a system must be designed whereby grazing blocks are periodically rested or deferred during the growing season to allow desirable plants to be maintained or increased in the plant community.

Factors limiting the time and season of beneficial grazing of livestock on a range site must also be considered in planning a system of use. Soils may limit the use of certain range sites during the rainy season because of muddy conditions. Thus, such a range site should be considered as a dry season use area. Permanent water supplies may be difficult to obtain by surface storage or groundwater supplies. Thus, the area should be considered as a wet season grazing area where temporary water supplies can be developed by surface catchments during the rainy season.

Biting insects such as flies and ticks may be a problem on wet areas or flood plains during the rainy season. Thus, these areas should be considered for use immediately following the rainy season when insects are less numerous. Most grass species are palatable and nutritious during peak growth periods; however, many species become less palatable and nutritious after maturity. Range sites producing dominant forage species which are not palatable and have little or no nutritional value after maturity should be considered as wet season grazing areas, or in the case of flood plains as soon as the area is dry enough for livestock to enter, immediately following the rainy season. Systems should be designed to coincide as nearly as possible with that practiced by local cattle owners. Considerable investigation of the practices carried out by local cattle owners should be conducted before finalizing a management plan. In most instances there are valid reasons why cattle producers follow a grazing pattern on an area. These factors must be considered and solutions found if the system of grazing is to be satisfactorily altered to increase livestock production.

2. Grazing Treatment and Cattle Management

Grazing treatments may vary slightly from a bi-modal rainfall to a single rainy season area. However, the same basic principles are involved. The key to each management system consists of accomplishing two steps:

Step. 1. Graze livestock in the wet season areas when rainfall has produced green forage and a water supply to support the livestock. This is usually in the March/April and October/November period in a bi-modal rainfall system, and June/July period in a single rainy season area. Other areas designated as dry season area are deferred during this period.

Step. 2. When livestock have remained for the prescribed period of time or run short of forage and water on the wet season grazing areas they are moved to dry season grazing areas. Forage and water supplies have been reserved for use during the dry season or seasons. Livestock are removed from wet season areas which are allowed to rest until the next prescribed use period. Examples of treatments possible on single and bi-modal rainy season areas can be seen on the following pages. During the introduction of a rotational grazing system, the system should not be complicated and should allow the most beneficial use of the area with the least movement of livestock. In most instances, the four pasture systems on single rainy season areas and the five pasture systems on bi-modal rainy season areas prove to be the most satisfactory. These systems give more flexibility in altering the grazing treatment to allow for controlled burning where necessary or carrying a block as reserve forage for utilization in the event rainfall fails to occur during the expected period.

Beyond these two steps the responsibility of the livestock owner is to utilize physical facilities provided in the prescribed manner to reduce cost of maintenance and follow prescribed animal health and husbandry programs to insure maximum output of beef from the area. Areas having limiting factors which dictate the utilization of blocks in the dry or wet seasons offer the range planner less flexibility in designing a rotational grazing system. The problem becomes one of balancing forage available for utilization during both seasons of use. However, development costs may be considerably less in that only temporary watering points are required on the wet season areas.

This system of designated wet and dry season blocks, with required development for their utilization may be a more economical method of initial development and management in African states where capital for development is a limiting factor.

A second phase development and management system could be initiated when the ranch or grazing reserve has achieved a firmer financial status. This second phase development consists of additional physical developments to permit more intensive range management and animal husbandry.

IV. PROJECT ADMINISTRATION

A. ADMINISTRATION OF GRAZING UNITS

1. Grazing Reserves

Various attempts of administering grazing reserves through government police actions have been made throughout Africa, most of which have been unsuccessful because cattle owners resent the enforcement of grazing practices without their consideration or involvement. However, administration involving appointed or elected leaders of the cattle producers show much promise of success. In this type of administration, government technicians act as advisors to a grazing committee composed of elected or appointed representatives of the cattle owners. The committee is responsible for carrying out the proper utilization of facilities such as water development, control of burning, and the management plan. The committee has the responsibility for insuring that members adhere to the proper stocking rate and seasonal grazing use of pastures.

The grazing committee is responsible for requesting and utilization of government assistance in carrying out the planned management and livestock production on the developed areas. The committee is obligated to impose fines and penalties as prescribed in the program on its members who fail to adhere to or refuse to comply with these regulations. It may call upon local government officials for police action if necessary.

Self-imposed discipline on water utilization is strong in most cattle-producing tribes. This characteristic can be utilized as a means of introducing self-imposed management of a new development area.

Example I

SINGLE RAINY SEASON

Three Pasture Deferred Rotational Grazing

TREATMENT

PERMANENT WATER ALL PASTURES

A GRAZE DURING WET SEASON, JULY–SEPTEMBER.

B GRAZE DURING THE LATE DRY SEASON, APRIL–JUNE

C BURN IN JUNE THEN GRAZE DURING THE EARLY AND MID–DRY SEASON, OCTOBER–MARCH.

TREATMENT	PASTURE	GRAZING SEASON: APR–JULY	AUG–NOV	DEC–MARCH	YEAR
A	1				1st
B	2				
C	3	BURN			
B	1				2nd
C	2	BURN			
A	3				
C	1	BURN			3rd
A	2				
B	3				

REPEAT SEQUENCE

Example II

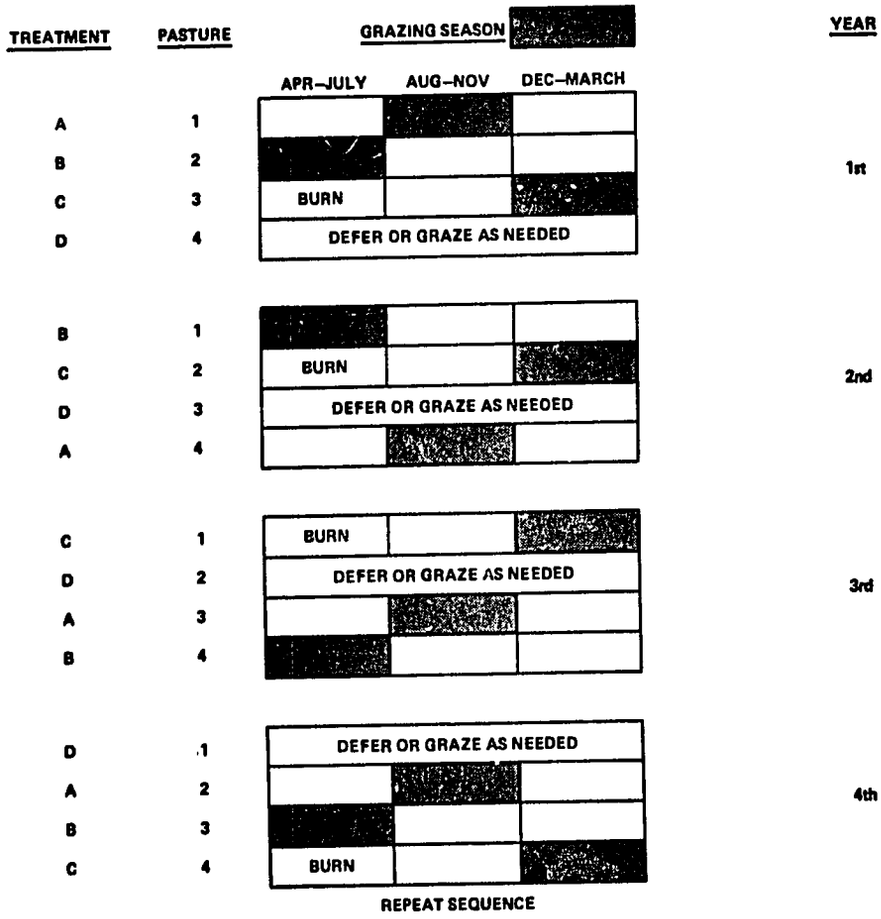
SINGLE RAINY SEASON

Four Pasture Deferred Rotational Grazing

TREATMENT

PERMANENT WATER ALL PASTURES

A GRAZE DURING THE WET SEASON, JULY – SEPTEMBER.
B GRAZE DURING THE LATE DRY SEASON, APRIL – JUNE.
C BURN IN JUNE THEN GRAZE DURING THE EARLY AND MID–DRY SEASONS, OCTOBER – MARCH.
D TREAT AS DESIRED, DEFER OR GRAZE WHEN FORAGE IS NEEDED.



Example III

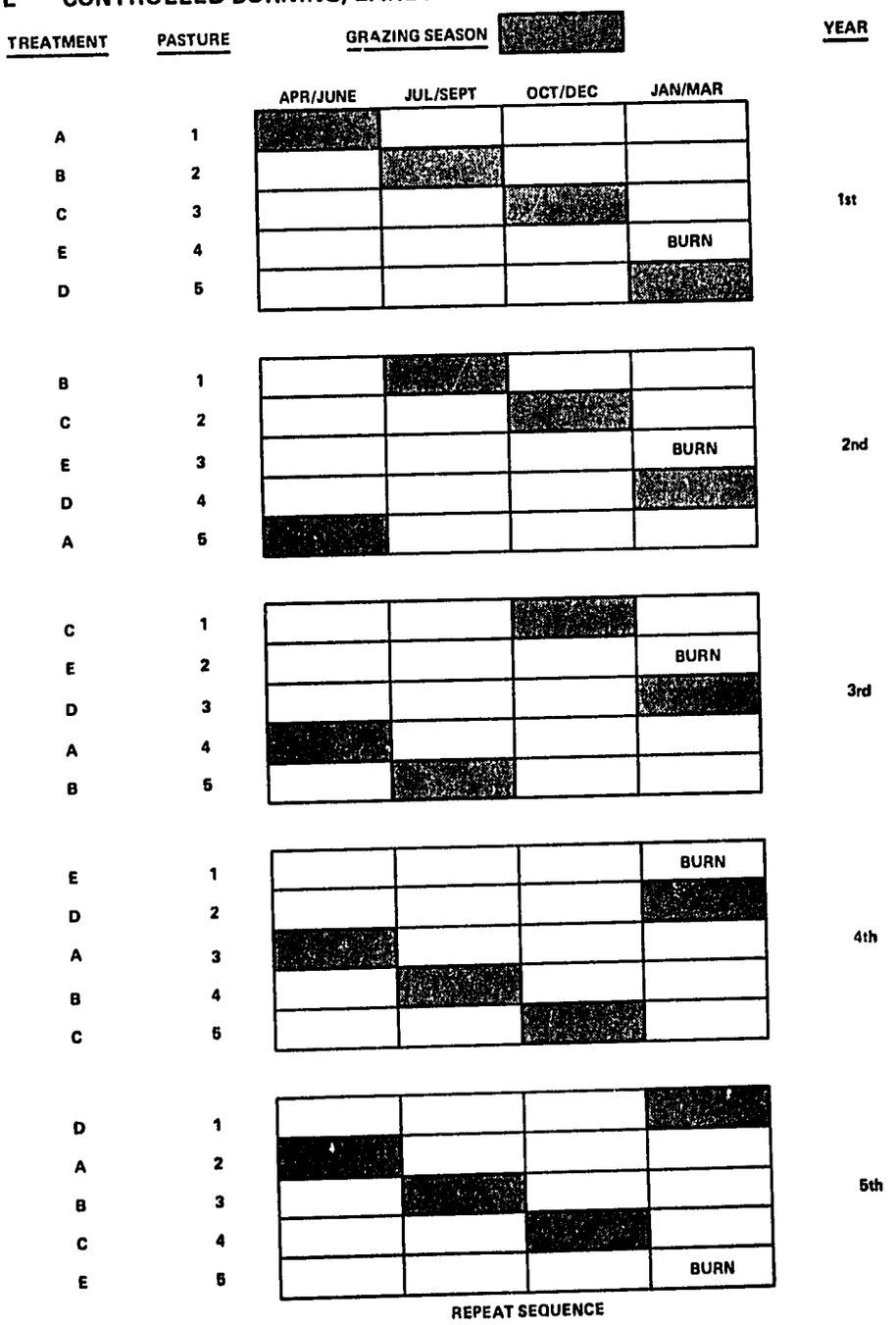
BI-MODAL RAINY SEASON

Five Pasture Deferred Rotational Grazing

TREATMENT

PERMANENT WATER ALL PASTURES

A GRAZE DURING LONG WET SEASON, 15 MARCH–15 JUNE.
B GRAZE DURING LONG DRY SEASON, 15 JUNE–15 SEPTEMBER.
C GRAZE SHORT RAINY SEASON, 15 SEPTEMBER– 15 DECEMBER.
D GRAZE SHORT DRY SEASON, 15 DECEMBER– 15 MARCH.
E CONTROLLED BURNING, EARLY MARCH.



Example IV

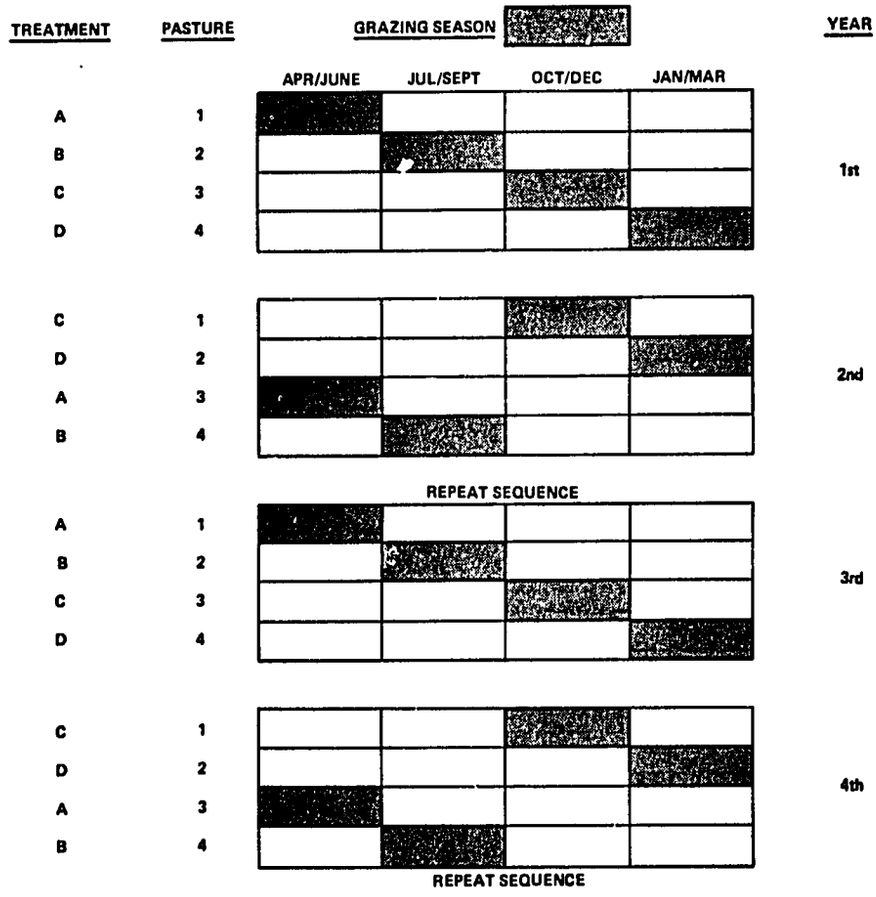
BI-MODAL RAINY SEASON

Four Pasture Wet and Dry Season Grazing

TREATMENT

PERMANENT WATER REQUIRED DRY SEASON

A GRAZE DURING LONG WET SEASON, 15 MARCH – 15 JUNE.
B GRAZE DURING LONG DRY SEASON, 15 JUNE – 15 SEPTEMBER.
C GRAZE DURING SHORT WET SEASON, 15 SEPTEMBER – 15 DECEMBER
D GRAZE DURING SHORT DRY SEASON, 15 DECEMBER – 15 MARCH.



2. Group or Ranching Associations

A formal committee which is recognized as a legal body should be organized. Powers to obtain necessary credit for development and maintenance must be vested in the committee. The committee in turn must have power to assess members fees on a basis of percentage of cattle owned for repayment of development and maintenance costs. Members should be registered and given a recorded right to run their allocated number of livestock, or be required to decrease numbers to prescribed levels or allowed a percentage of increased numbers in the event of increased carrying capacity.

3. Cooperative and Company Ranches

Normally cooperative or company ranches should have a paid manager responsible to the board of directors for the management and operation of the ranch. The livestock are cooperative or company property and are managed as a ranch unit. Government assistance should be available for planning and implementing a ranch management and development plan. Continued assistance in an extension type program should be made available to the ranch manager for implementing the grazing plan, livestock health improvement programs, and marketing assistance.

4. Government and Para-statal Ranches

Managers are normally responsible for the day-to-day operation and management of government or para-statal ranches. Technical assistance should be available to the ranch manager for planning and implementing a development and management plan as well as a continued extension type assistance in animal health and improvement programs and marketing assistance.

5. Private or Individual Ranches

Private or individual ranches require a fairly high degree of managerial skill on the part of the owner. However, government technical assistance should be made available to assist the ranch owner in developing a ranch plan in which range management and development are an integral part. Extension type assistance should be made available to ranch owners in follow-up on range management, animal health, animal improvement and marketing information.

B. GOVERNMENT ASSISTANCE

In order to provide the above technical assistance to cattle producers in African states, one of the initial steps in first phase development should be training of adequate local staff to follow through on the future range planning and development as well as provide extension type assistance in range management, animal health, animal improvement and marketing information. Where infrastructure such as countrywide veterinary programs, marketing facilities, and transportation systems are not adequate for an orderly movement of livestock to consuming areas, government must provide this infrastructure from government revenue or nominal charges to the livestock producer to cover cost of services rendered. This requires organization within the Ministry of Agriculture of African states to provide these necessary services. Divisions of the Ministry involved with this assistance are range management (extension, bull production, artificial insemination); veterinary services (national disease control programs, quarantine, parasite control, and animal health extension type programs); marketing services (market facilities, stock routes, holding grounds, and market information).

C. ADMINISTRATION OF CONSTRUCTION AND MAINTENANCE OF RANGE IMPROVEMENTS

In most African states available contract services are inadequate or too expensive to provide construction and maintenance of ranch developments. In the event contract services are available from the private sector they should be utilized; however, technical aspects of the development should still be under the supervision of a government engineer.

The field administration of the engineering, construction and maintenance staff should be the responsibility of the chief agricultural engineer in cooperation with the ranch owners, or range office on the project. All aspects of engineering involved in the survey, design, layout and supervision of construction and maintenance should be under the supervision of the engineer. He should have the authority to inspect all materials, equipment, and workmanship in development. He should furnish all instructions and information regarding design plan and specification that may be necessary and to point out to the construction and maintenance crew disregard of any of the provisions of the design plans.

Plans and schedules for maintenance of improvements on a specific ranch or range area should be planned jointly and correlated with the ranch manager or range committee who will provide recommendations annually for the maintenance needs to be provided by government equipment and staff.

Cost of development and maintenance should be paid by the beneficiaries either in the form of direct payment or in the form of grazing or water fees paid annually on a per head basis to offset cost of development and maintenance over a long period of time. Caution should be exercised in government development and maintenance programs whereby government eventually becomes overburdened with responsibility for expensive maintenance and operational programs with little or no direct revenue generated from the activity.

TABLE 12 HERD COMPOSITION BASED ON 100 MATURE COWS

FEMALES		MALES	
Age	No.	Age	No.
5-15 (mature)	100	5-15 herd bull	4
4-5	8	7-8	7
3-4	10	6-7	7
2-3	12	5-6	7
1-2	17	4-5	8
	147	3-4	9
		2-3	10
Calves [1]	30	1-2	16
			68
		Calves	30

[1] Calves born during the year are not included in total herd number.

TABLE 13 AVERAGE DEATH LOSS OF CATTLE PRODUCED UNDER NOMADIC OR SEMI-NOMADIC SYSTEM

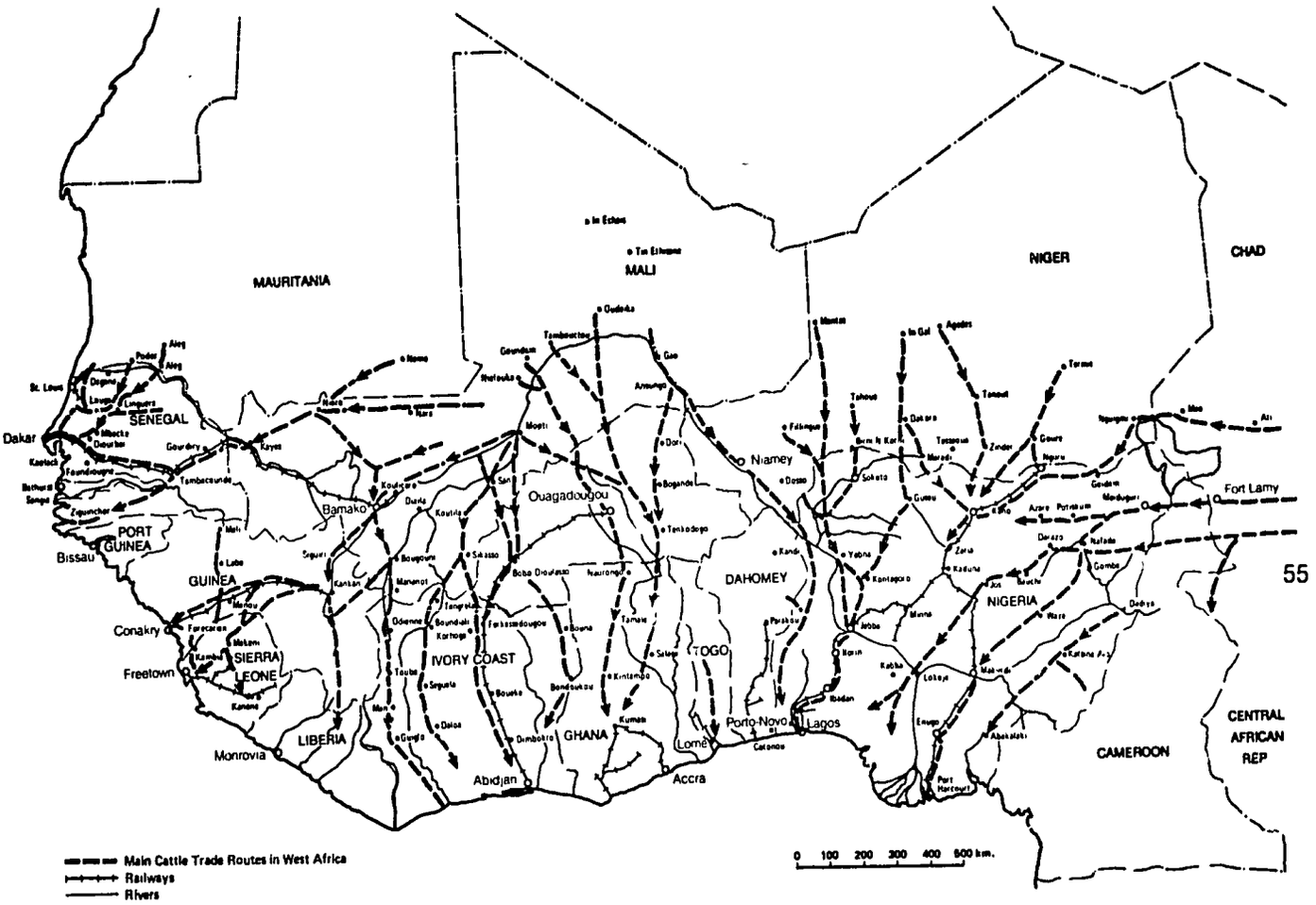
FEMALES		MALES	
Age	Percent	Age	Percent
5-15	8-10	5-15 bulls	7-9
4-5	5-8	7-8	5-8
3-4	5-6	6-7	5-8
2-3	8-10	5-6	5-8
1-2	10-20	4-5	5-8
0-1	30-55	3-4	5-8
		2-3	8-10
		1-2	10-20
		0-1	30-55

TABLE 14 AVERAGE DEATH LOSS OF CATTLE UNDER SYSTEMS WHERE AFRICAN RANCHES ARE DEVELOPED AND DISEASE CONTROLLED

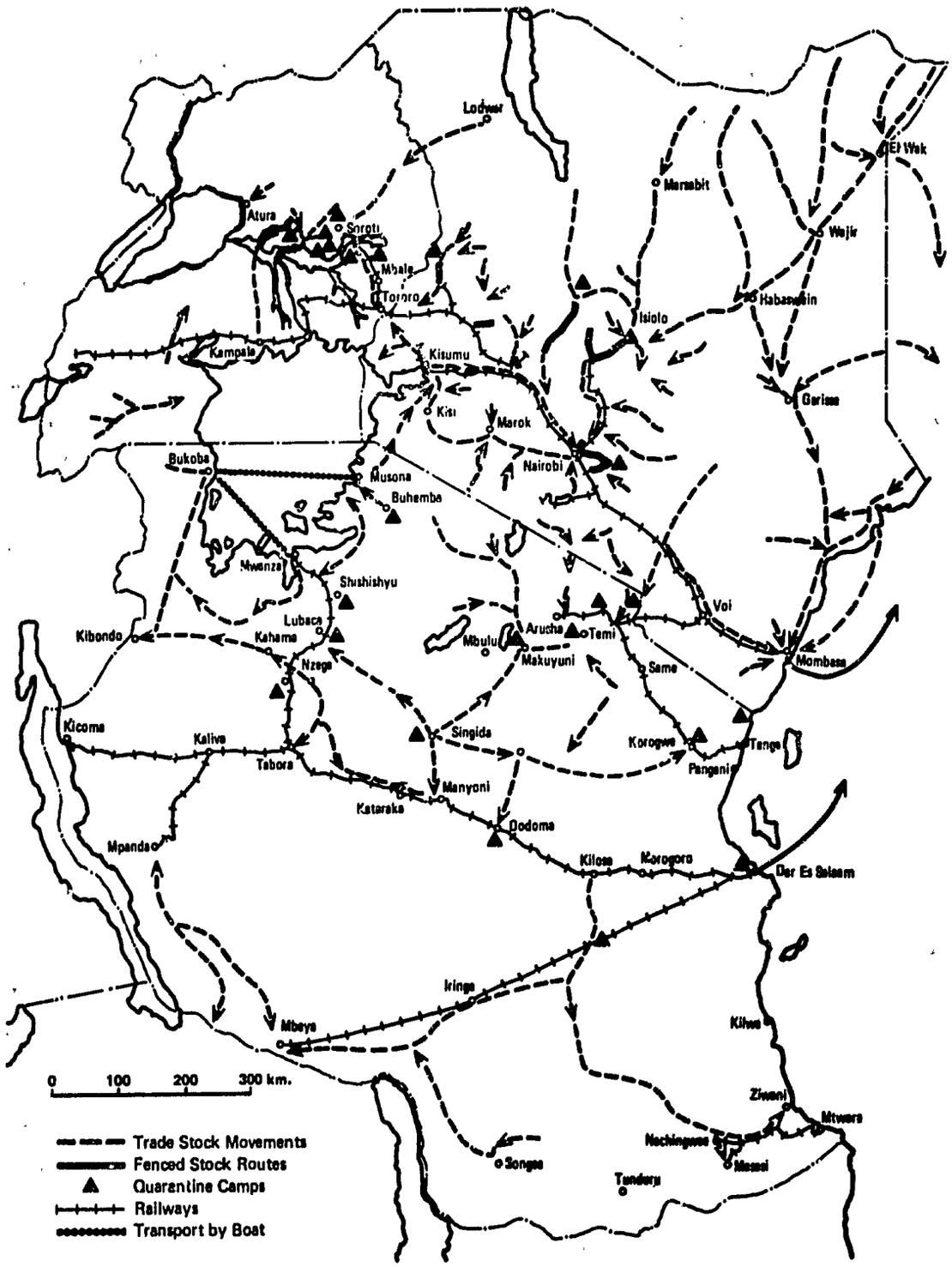
FEMALES		MALES	
Age	Percent	Age	Percent
3-10	4	3-6 bulls	5
2-3	3	3-4	3
1-2	7	2-3	3
0-1	10	1-2	7
		0-1	10

Map 6

MAIN STOCK ROUTES WEST AFRICA



Map 7
MAIN STOCK ROUTES EAST AFRICA

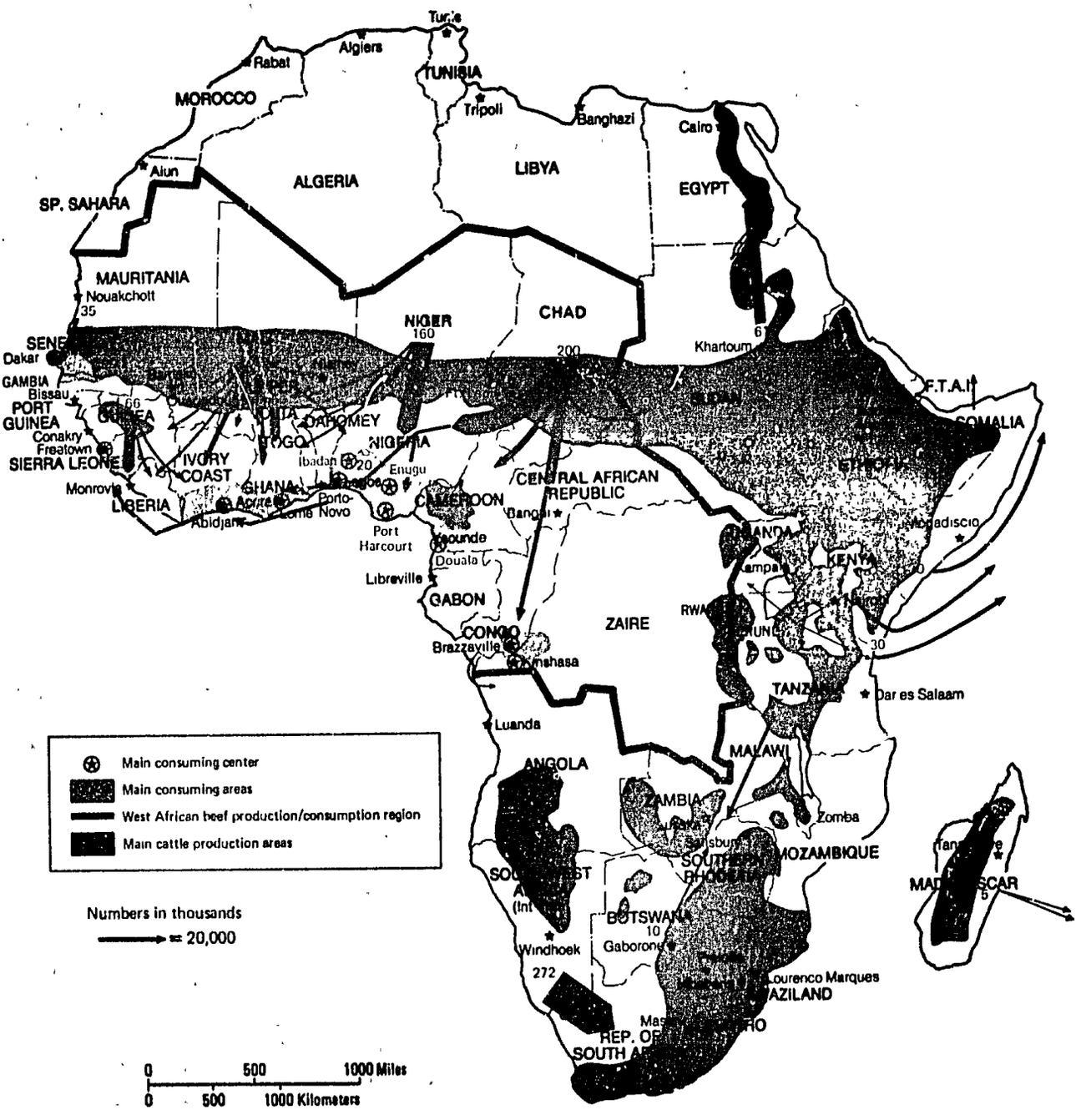


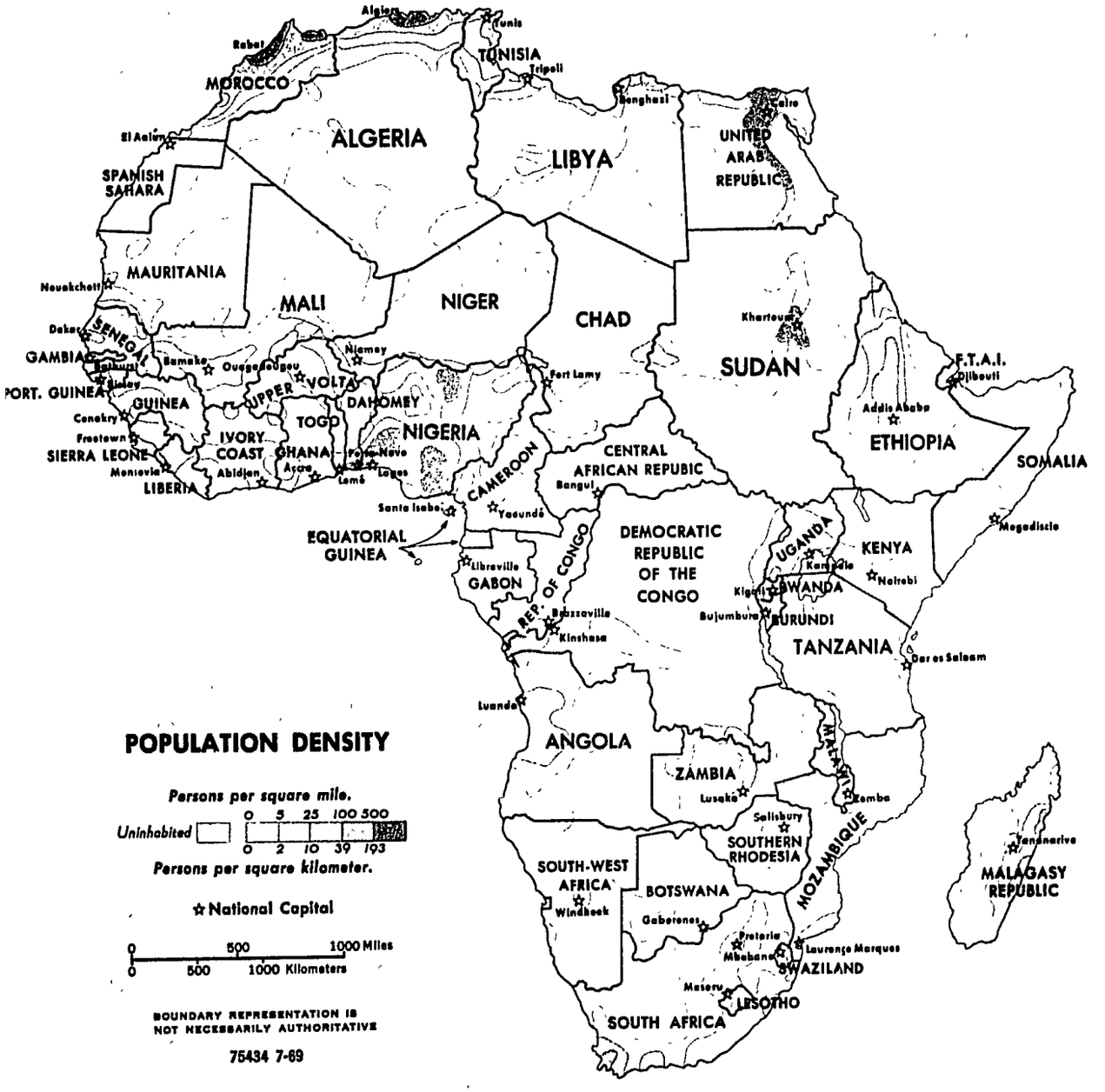
Map 8

RAILWAY LINES AND BOAT SERVICES

Map 9

ECONOMIC GEOGRAPHY IN SUB-SAHARAN AFRICA



Map 10

AFRICA