Agriculture Technology for Developing Countries

Technical Series Bulletin No. 20

Providing Forages for Ruminant Livestock During Dry Seasons in the Tropics and Sub-Tropics

August 1977

Office of Agriculture
Technical Assistance Bureau
Agency for International Development
Washington, D.C. 20523

PROVIDING FORAGES FOR RUMINANT LIVESTOCK DURING DRY SEASONS IN THE TROPICS AND SUB-TROPICS

Prepared by: Howard B. Sprague

DIVISION OF LIVESTOCK PRODUCTION

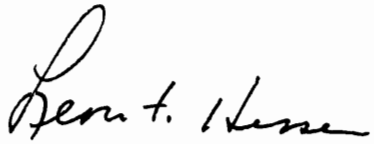
OFFICE OF AGRICULTURE
BUREAU FOR TECHNICAL ASSISTANCE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

PREFACE

Ruminant livestock (cattle, buffaloes, sheep, goats, camels) are exceedingly important in developing countries for producing meat and milk, for providing power and transport, and in doing so by largely utilizing lands, forage plants, and agricultural by-products that are unsuited for direct use by man. The present contributions of ruminants to increasing human food supplies and the quality of human living are judged to be only a small fraction of their true economic potential. This bulletin presents in non-technical terms some practical methods of dealing with one of the major constraints to effective use of ruminant livestock, which is alleviation of the great deficiency in suitable feeds during the dry season of three to ten months per year. The extent of the dry seasons when harvested or stored feeds are needed to support ruminant livestock are illustrated in the world map in Figure 1. of the bulletin.

Much useful information is at hand, or may be deduced from practices in developed countries, that is feasible for application in the tropics and subtropics. The general procedures and practices presented in this bulletin may require substantial modification to be fully applicable to the needs of individual countries.

Additional copies of this publication are available on request.



Leon F. Hesser
Director
Office of Agriculture
Bureau for Technical Assistance
Agency for International Development
Washington, D. C. 20523

OUTLINE

Providing Forages for Ruminant Livestock During Dry Seasons in the Tropics and Subtropics.

I. Introduction
(with maps)

II. Providing Reserve Feed for Ruminant Livestock

A. Semi-desert Regions

1. Adjustment of stocking rates
2. Rotation grazing
3. Suppression of useless and harmful plants
4. Demonstration ranches

B. Savanna Lands

1. Adjustment of livestock numbers to feed supplies
2. Harvest of crop by-products and residues
3. Growing forages in crop rotations
4. Demonstrations of farming systems for savanna lands

C. Wet-Dry Tropics

1. Growing forages in the wet-dry tropics
2. Components of forage production and utilization
   a. Permanent seeded forage plantings
   b. Using crop residues and by-products
3. Demonstration farming systems for the wet-dry tropics

III. Classes of Forages and Their Use as Livestock Feed

1. Definition of forages
2. Hay, and "standing" (uncut) hay
3. Dry stover stored for feed
4. Silage and silage making
5. Green-stover silage
6. Grass silage
7. Fresh-cut green forage

IV. Small Tools and Machines for Harvesting and Storing Forages by Small Farmers

1. For hay making
2. For harvesting thick-stalked crops
3. Silage handling
4. Silage cutters
5. Plastic covers for trench silos

PROVIDING FORAGES FOR RUMINANT LIVESTOCK DURING DRY SEASONS IN THE TROPICS AND SUBTROPICS.

I. Introduction

Ruminant livestock are an important component of agriculture in the tropics and subtropics. They utilize lands that are unsuited for crop production to produce meat and milk for family subsistence, and for meeting food needs of urban populations. Without ruminants, vast land areas would contribute little to the support of man. This support is vital to help keep pace with food needs of rapidly growing populations, as well as to supply the critically essential animal proteins needed to balance human diets for health and vigor.

Ruminant livestock also permit the development of appropriate livestock enterprises on arable lands by contributing to continuing land productivity through use of forages grown in rotations to control soil erosion and to improve soil structure, water supplying power of the soil, and soil fertility. The livestock consuming such forages, provide manures that increase crop yields when used effectively. Ruminant livestock are useful in consumption of crop residues such as straw, stalks and vines, to produce meat, milk, and manure.

Ruminant livestock are major sources of animal power for farming in many countries. In some countries the yearly sale of live animals across national borders is an important source of foreign exchange for countries that produce more animals than needed to meet domestic country demands.

The major classes of ruminants are cattle, water buffalo, goats, sheep and camels. Each class is important in specific countries, but cattle and goats are the most widely distributed. All ruminants are

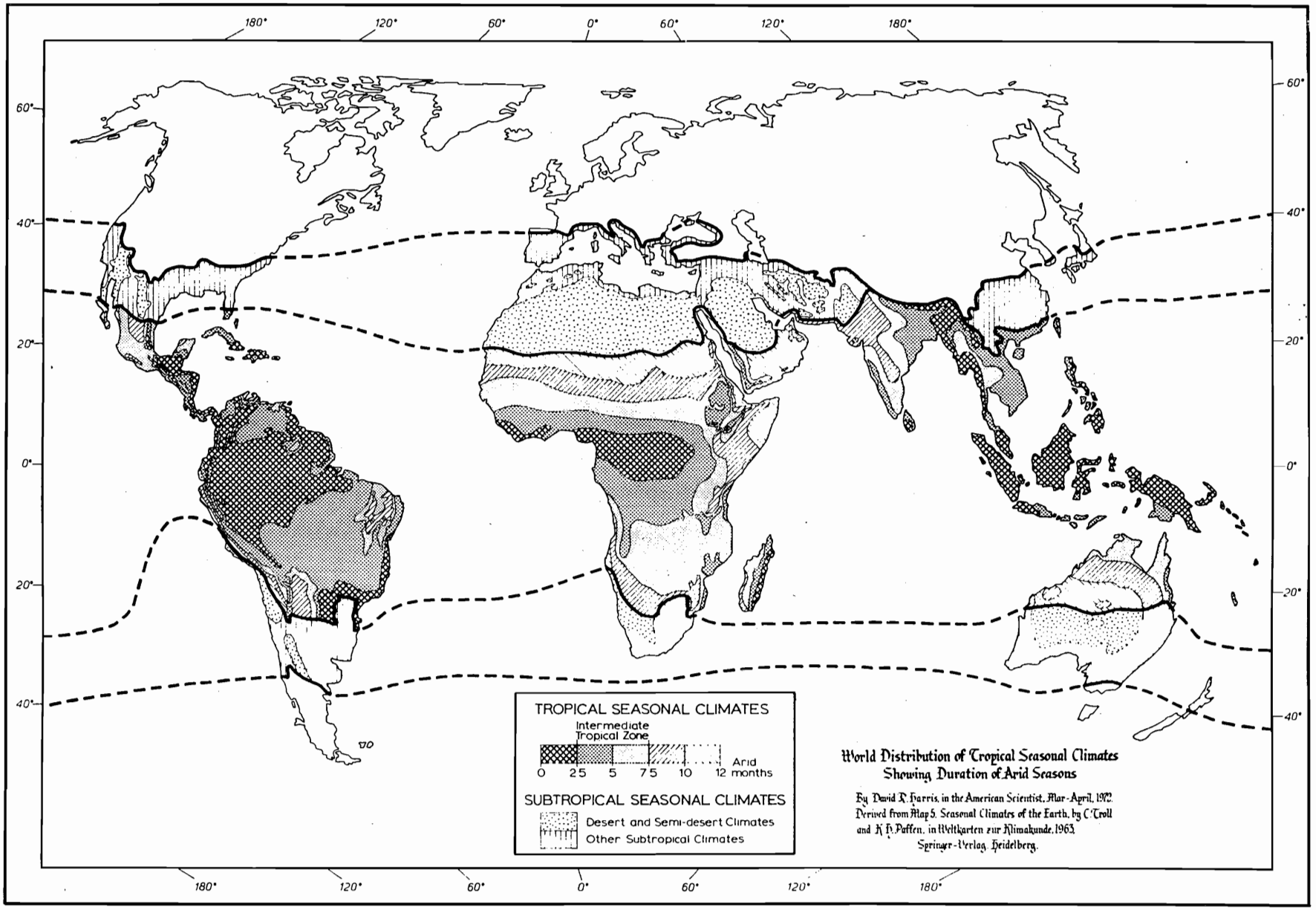
able to meet their nutrient needs from harvested forages such as hay, silage, dried or green plant materials, and crop residues. In most tropical and subtropical regions, efficient livestock production requires regular offerings of a balanced salt-mineral supplement as well as supplies of forages. They may be quite productive without grains and other concentrate feeds, and thus do not compete for foodstuffs suited for human consumption. Pigs and poultry cannot utilize coarse feeds that are well suited for ruminants.

Ruminant livestock enterprises on all land types (ranging from those on semi-desert range lands, to those on intensively cultivated crop lands) require skillful management to be most profitable. Probably the most important weakness in achieving profitability of such enterprises in agricultural systems is the failure to provide a continuing supply of nutritious feed during dry seasons. The average length of the dry season is shown in Figure 1. It should be feasible to rectify this deficiency in year-round feed supply for ruminants, if this requirement is recognized so that it becomes an integral part of ruminant livestock management. It may be noted that this is similar to the requirement for supplying winter feed in temperate zones. The economic benefits should be very substantial. The average birth rates of cattle may be raised from the present estimates of 45% to approach the desired 80% for the breeding herds of cattle; calf losses may be substantially reduced from 35% (toward 10 or 15%), the years needed to produce a marketable full size animal may drop to three or four years from the present five to seven years, and the yearly offtake of marketable animals from the herd increased from the present 10 to 15% to 30 or 40%.

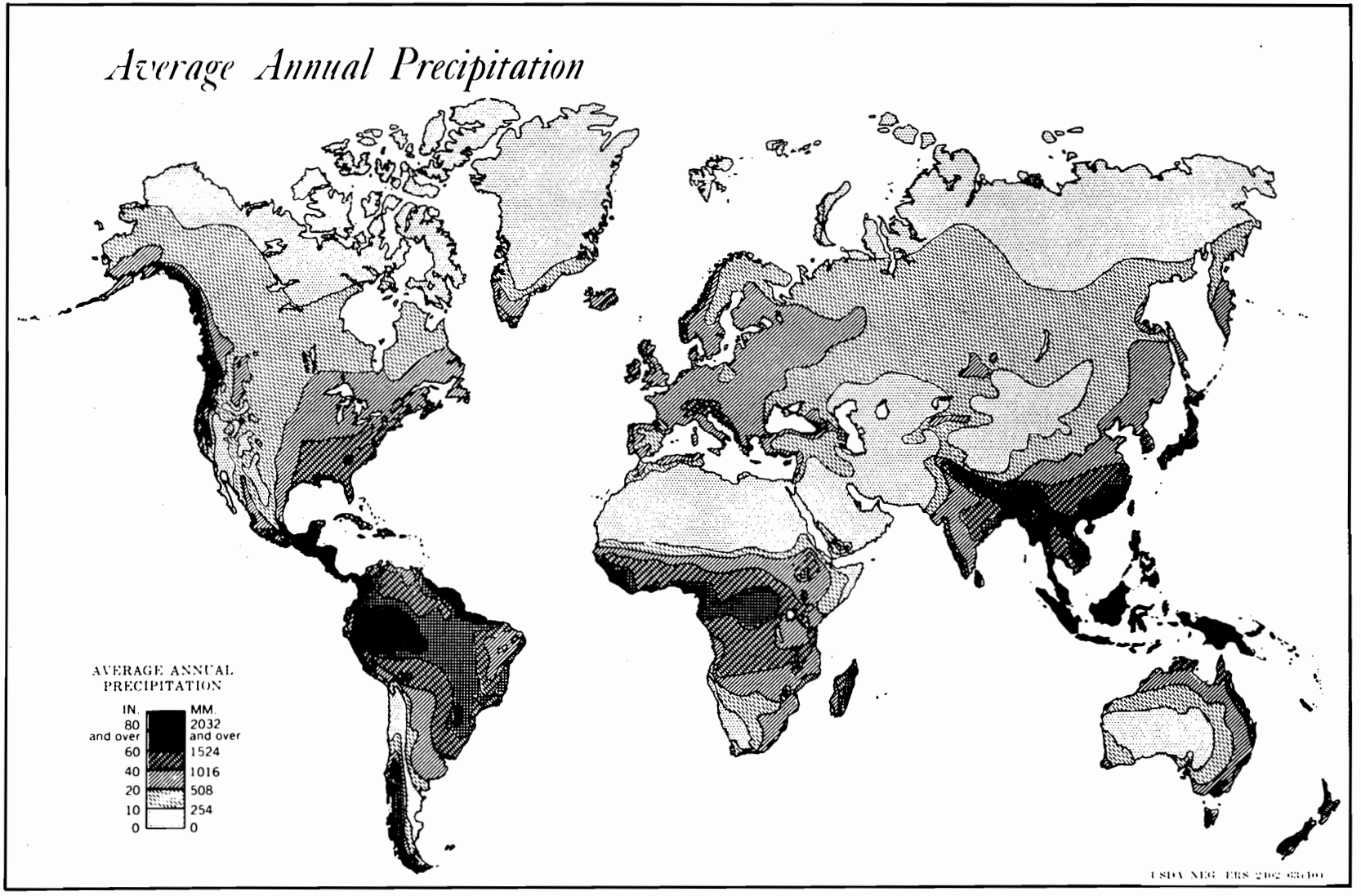
Comparable improvements may be achieved for goats, sheep, buffalo and camels.

In general, productivity of ruminants may become enough more efficient, so that 1/3 to 1/2 as much feed will be needed under good management, to produce each kilogram of meat. Yearly milk flow may be greatly increased in amount and duration. The common cycle of producing weight gains in the season of rains, followed by losses from deprivation and starvation in the prolonged dry season, can be overcome by ensuring year-round feed supplies. When adequately fed, the control of animal diseases should become more effective, and the husbandry of the livestock can be well organized to meet needs of the breeding herd, of the young stock, of the lactating animals, and of those being grown for market or local slaughter. With the breeding herd maintained in healthy condition, it will become possible to institute livestock improvement programs in indigenous herds by selection of superior dams and sires and controlled breeding to propagate the superior stock.

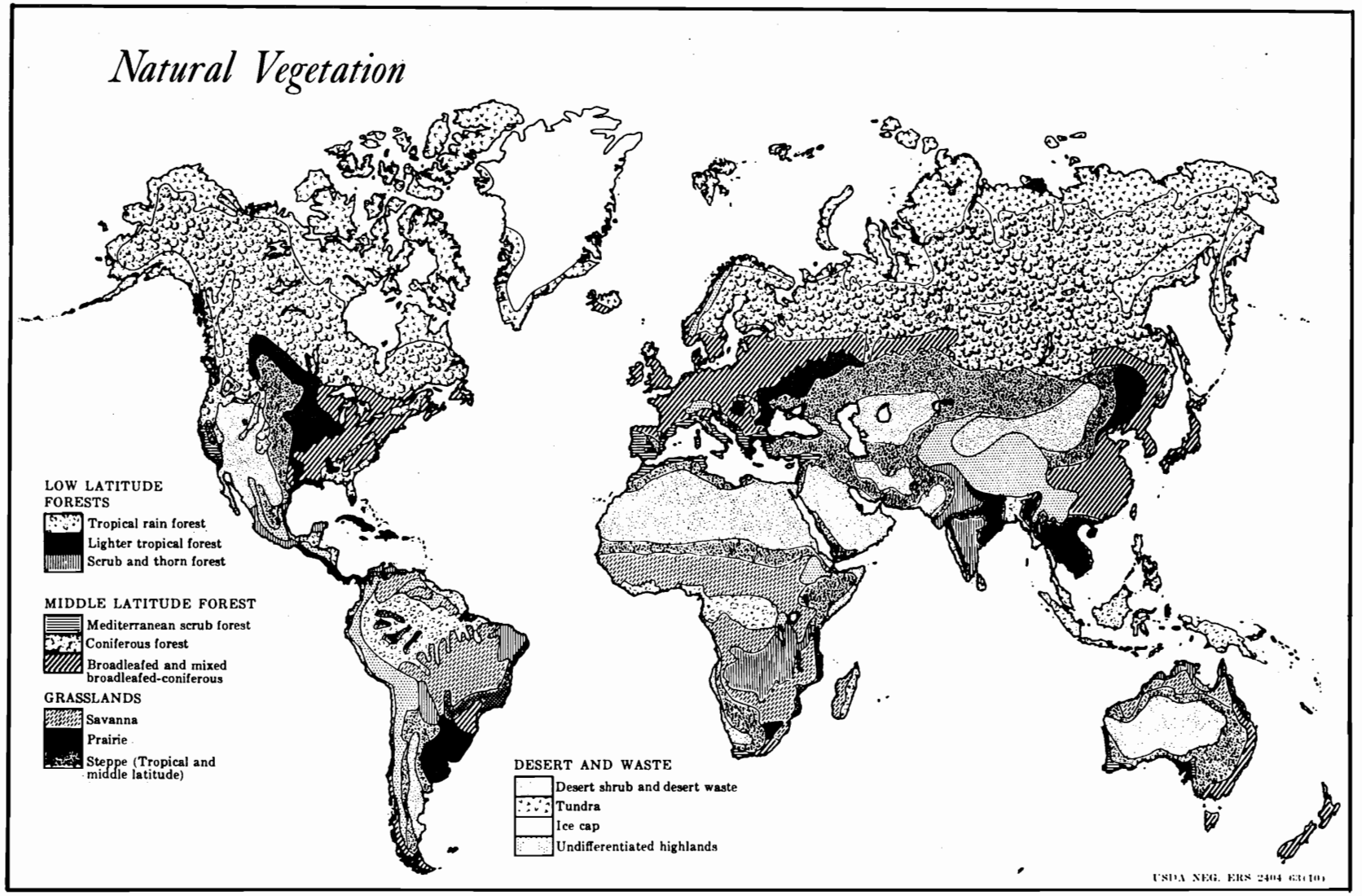
The average length of the dry season when little new vegetative growth occurs, is shown in Figure 1. The total yearly rainfall is indicated in Figure 2, and a strong correlation may be noted between total rainfall and the duration of the dry season. Figure 3. shows the distribution of natural vegetation zones. It is obvious that ruminant livestock enterprises cannot be fully productive by depending solely on native vegetation. However, it is possible for man to intervene in all climates to insure a more adequate and uniform supply of forages for ruminants.



The Average Duration of the Dry Season in the Tropics and Subtropics



Average Annual Precipitation



Natural Vegetation Zones

II. Providing Reserve Feeds for Ruminant Livestock

The provision of supplemental forages during the dry seasons in semi-arid and sub-humid regions continues to be a crucial problem. The characteristic procedure of moving stock to other grazing areas is generally futile because all other grazing lands in the region, generally on dry ranges, are universally overgrazed and devoid of additional feeds. The relief provided by moving marketable cattle toward market, generally occurs after all grazing lands have been denuded by excessive stocking.

A. The semi-desert regions generally receive less than 20 inches of rainfall, and the rainless season may continue for six to ten months. The common practice is for herdsman to seek ungrazed areas after local grazing lands are exhausted; within feasible travel distance from stock watering points. Since access to semi-desert range lands often is uncontrolled, and thus open to all flocks and herds, such feed supplies are soon exhausted. The resulting situation is one of gradual deprivation, with animals continuously losing weight until the following season of rains and renewed plant growth. Methods of providing forages to sustain livestock during the dry season are needed to reduce or eliminate weight losses and to maintain the productivity of the breeding herd. The following practices are widely useful.

1. Adjustment of Stocking Rates: There must be adjustments in total number of animal units on the available grazing lands, to keep the stocking rate within the forage supply on the lands available. Grazing lands should be allocated in large blocks to the groups of herdsmen who normally occupy the area, and these grazing rights should

be denied to all other migrant groups. The using herders should be given exclusive control and use of the lands allotted to them, so that they will benefit from good management practices and suffer the consequences of improper management. Under this arrangement, the productivity of range lands measured in terms of liveweight offtake per year, may be progressively improved yearly, if the stocking rates do not exceed the forage (grazing) capacity of the allotted range. Governments should undertake these restrictions on grazing use, by providing the authorized herders with appropriate technology on forage production and on animal husbandry as well as counsel on marketing to keep livestock numbers in balance with forage supplies. Government intervention and authorization on rangeland use is a prerequisite to productive utilization of these natural resources.

2. Rotation Grazing: Standard grazing practices should provide for division of the range lands into four or more large blocks, so that grazing of each may be on a rotation basis. Depending on the length of the season without rains, enough grazing areas should be reserved for use in the dry season so as to insure a year round supply of feed. When supplemental feeds can be stored as hay or silage, or when crop residues and by-products can be made available, the areas of grazing lands reserved for dry season use may be reduced. Also rotation grazing practices should protect at least one-fourth of the total grazing land for growth and seed production of the forage plant species each year. This practice permits natural reseeding and strengthening of the forage plant cover. Such periodic resting should reverse the commonly observed degradation of range lands.

The goal is to put livestock productivity on range lands on a 12-month basis instead of three or four months growth period that now prevails. The benefits should be greatly expanded under careful management that fully recognizes the nature and limitations of feeds produced on range lands, and that seeks to maximize the yearly off-take of livestock.

3. Suppression of useless and harmful plants: Overgrazed range lands are degraded by the encroachment of brush and scrubby tree growth and unpalatable or noxious herbaceous plants; and the decline in abundance of forage grasses, legumes and other edible plant types. The undesirable or useless plant species should be removed by grubbing, or use of herbicides, as labor becomes available. Grazing management to permit strengthening of desirable forage species by controlled grazing and natural reseeding will reverse the degradation process. As unwanted vegetation is removed, there will be opportunity to introduce new forage grasses and legumes from regions with similar conditions of soil and climate, that are likely to persist and spread to increase feed production. Rather remarkable progress is feasible; substantially above the traditional productivity of the native semi-arid lands. There are at least five superior perennial grasses and two forage legumes known that are adapted to semi-arid conditions.

4. Stop all uncontrolled burning of rangelands. Yearly burning may provide temporary acceleration of new growth of forage at the beginning of the rainy season, but the accompanying effects are harmful. Burning damages some sensitive forage species; it volatilizes and loses all of the nitrogen and sulfur in the burned vegetation; and

increases the runoff and loss of rainfall that would otherwise permeate the soil profile. There often may be a useful role for occasional controlled burning as a management practice, when it is handled so as to have maximum effect on suppression of brush and inedible plants, and to provide opportunity for seeding improved forage grasses and legumes that are adapted to the local climatic and soil conditions. The common motive of herdsmen to burn as a rescue operation for starving livestock, should be replaced by concern over elimination of overgrazing, by culling and marketing of excess stock, by reservation of selected range areas for feed in critical dry periods, and by temporary movement of herds to farming areas where other forages may be made available.

5. Demonstration ranches. The semi-desert rangeland areas are ecologically very fragile, and livestock husbandry must emphasize human survival above all other factors. The current management practices have made very little use of technology developed in other similar ecological zones (such as portions of the semi-arid southwestern U.S., and of Australia). Innovations must be tested cautiously to avoid hazards of failure. Indigenous herdsmen without specific control of any land areas are unlikely to voluntarily modify traditional practices. Such individual innovations as providing new wells without relating these to the total needs of man and his livestock, have been disastrous, since the resulting concentration of stock caused complete degradation of the surrounding grazing lands.

It is recommended that demonstration ranches be established in selected localities, to apply the entire package of improved technology and to evaluate the net economic benefits. The areas selected should be

geographically distinct to obviate the need for fences, and large enough to accommodate the diverse yearly forage needs of the indigenous herdsmen. The herdsmen who operate on the ranch should be granted exclusive rights to the demonstration rangelands and in return should receive counsel and assistance in carrying out long range management practices. The objective should be to conduct an open program on how best to manage livestock enterprises on semi-desert range that will increase net income and greatly reduce the impact of erratic rainfall that is characteristic of such regions. Such demonstrations are needed to convince both governments and herdsmen that much better ways of handling these natural resources may be invoked than the traditional neglect that has prevailed.

These demonstration ranches also should be used as training institutions for development of nationals who will become capable of extending these management practices to other rangeland areas. A small staff of qualified expatriate professionals should be provided for an initial three to five year period to establish the ranch and perfect training procedures that are appropriate.

B. Savanna lands average 20 to 40 inches of yearly rainfall. Rainfall is generally limited to a period of four to five months followed by dry seasons of seven to eight months duration. The growth of native forage plants may be limited by infertile soils as well as by extended dry seasons. In the savanna regions, there is usually an intermingling of "dry land" farming on more favorable soils, with grazing on infertile lands unsuited for cropping. The ratio between areas of soils

favorable for cropping to those that are naturally infertile, varies greatly from region to region. As the technology is perfected for soil improvement of such infertile soils, they may be converted from grazing to crop production. Livestock enterprises in the savanna regions may be oriented to permanent grazing lands, or to forms of livestock production that are compatible with local cropping systems. Areas of land that are unsuited for tillage because of steep slopes, soil erodibility, stoniness, shallow soil depth, etc., that are intermingled with arable soils, should be developed and utilized for grazing livestock enterprises. (Note *)

1. Adjustment of Livestock Numbers to Feed Supplies. The opportunities for production and utilization of forages to support ruminant livestock during the long dry season are substantially greater in savanna zones than in semi-desert regions. The amount of forage produced on native grasslands may be substantial, and forage growth may be enhanced by soil treatment and the introduction of more productive species of forage grasses and legumes. Forage management practices should insure animal productivity on a year-round basis, instead of weight gains only in the season of rains. The following elements of more profitable management of savanna lands include the following:

There should be an adjustment in numbers of ruminant stock that will limit the total livestock population to the total supply of feeds available for the full year. It is assumed that grazing animals will subsist on native grasslands during the period of rains and active

*See: Technical Series Bulletin No. 19. "Combined Crop/Livestock Farming Systems for Developing Countries of the Tropics and Sub-Tropics".

plant growth. However, there should be sufficient harvested feeds stored to meet feed requirements for the long dry season. Some use may be made of grasslands that are reserved for grazing after forage plant growth ceases. However, additional harvested feed supplies are needed to permit maintenance of a larger herd with sufficient nutritive feeds to prevent serious animal weight losses and to permit the breeding herd to calve normally and to maintain milk production until the following period of rains.

Harvested feeds may be produced in several ways: (1) native grass may be cut and made into hay toward the end of the rains, while the forage is still green. This hay should be collected in stacks or bales on larger holdings both for protection and to facilitate feeding at a later dat e. Hand cutting of grass will suffice where cutting machines (mowers) are not available. If the forage is dry when stacked, the hay may be stored in relatively large stacks, compacted, with rounded tops to shed water in the event of occasional late rains. Such hand tools as sickles for cutting, and pitch forks for handling dry hay are low in cost. For larger holdings, harvest may be made with tractor mowers and rakes.

2. Harvest of Crop By-Products and Residues. In areas where crops are grown on arable lands (intermingled with grazing lands), there are opportunities to harvest crop by-products and residues, and native weedy growth along field borders and roads, for storage as livestock feeds. For example, the non-fruiting tillers of millet, sorghum or maize may be cut as soon as head formation has occurred on the fertile stalks, and collected for storage as dry fodder, or made into silage. Also, the vines of groundnut harvest or harvests of other food grain

legumes may be saved for livestock feed. Crop farmers may negotiate with herders to provide such feed, or the crop farmers may use such feed to carry the family subsistence herd (mostly goats) through the dry season, with greatly improved milk production and growth of meat animals. The volume and kinds of crop residues and by-products will vary greatly from region to region, but all such feeds should be collected and stored for use in the dry season.

3. Growing Forages in Crop Rotations. New technology for maintaining productivity of arable lands for crop production, involve the growing of adapted perennial forage grasses and legumes in rotation with crops. (See Technical Series Bulletin No. 13. TA/AGR "Seeded Forages for Grazing and for Harvested Feeds in the Tropics and Sub-Tropics"). A mixture of selected grasses and legumes may be grown for about two years (in a five-year rotation), and that forage may either be grazed or harvested as hay for dry season feeding. The value of this feed can be fully exploited by sale to livestock herders for use in the dry season; or the farmer may purchase livestock to feed and subsequently market. The net value of this feed should equal the value of the tilled crops that are displaced, and there should be a bonus value in the substantial contribution to soil productivity and subsequent increased crop yields that are virtually cost free. This system is conducive to more stable crop production in years of limited rainfall, and has the added advantages of reducing the abundance of weeds, insect pests and disease damage in cultivated crops.

4. Demonstrations of Farming Systems for Savanna Lands.

Government intervention will initially be necessary to demonstrate the beneficial advantages of combining the various practices to produce feasible and profitable systems for feed production in support of livestock enterprises suited to each region. It is proposed that such intervention be made by establishing a demonstration crop/livestock farming system, in which local herdsmen and farmers of a community participate under the direction of competent specialists, and with initial guarantees to protect the participant producers against unusual losses. The government should ensure timely delivery of all essential inputs for successful production, and provide assistance in marketing the salable livestock and their products.

One such demonstration should be conducted in a representative region of a specific country that agrees to cooperate, for a minimum period of three to five years after the demonstration is fully implemented. The specific arrangements should recognize the social and economic conditions that prevail as well as the technology deemed applicable. A successful project in a single country may serve to stimulate other countries in the geographic region to establish their own demonstrations.

C. Wet-Dry Tropics. These climatic zones average 40 to 60 inches of rainfall yearly, but have dry seasons of five to seven months when there is light rainfall. Some of the lands in the wet-dry tropics have been cleared of native tree growth and are utilized as grazing lands. In other regions of the tropics, such lands are still occupied by native trees and other woody growth.

1. Growing forages in the wet-dry tropics. There is a need to produce and harvest forage to support ruminant livestock during the dry season, to maintain animal growth and weight gains, as well as to support reproduction and milk flow of the breeding herds and flocks. Feed production may come from (a) permanent planting of forages on cleared land (particularly land classes not suited for cropping); (b) forages grown in crop rotations; and (c) crop residues and by-products.

Some forage may be grazed during the rainy season, or cut periodically as growth permits for feeding green to livestock. During the rainy season, harvested forage may safely be stored as grass silage. Good quality hay may be made successfully from forages grown on grasslands when harvest occurs at the beginning of the dry season, so as to facilitate field drying prior to stacking.

2. The following components of forage production and utilization may be noted:

(a) Forages on lands unsuited for cropping virtually all forage (whether grazed, cut and fed green or cured as hay) in the wet-dry tropics is the result of man's efforts, in clearing and establishing forage plantings. However, there are considerable areas of land classes that are not suited for intensive crop production because of steep slopes or erodibility or shallowness, stoniness, etc., and this land should be utilized permanently for perennial forages, or for tree crops. Since these lands are usually intermingled with areas suited for tilled crops, farms containing both kinds of lands should be developed as combined crop/livestock farming systems. Certain perennial species of adapted grasses and legumes are well suited to the wet-dry tropics, wherever

such lands are cleared of native woody growth. See Technical Series Bulletin No. 13. TA/AGR, "Seeded Forages for Grazing and for Harvested Feeds in the Tropics and Sub-Tropics".

Where desired, such perennial forage plantings may be made with low growing species suited primarily for grazing, and other plantings of taller growing species may be made for utilization by either grazing or as harvested feeds (hay or silage). The successful production of forages must serve as the basis for profitable livestock enterprises, and the size of the livestock operations should not exceed the yearly potential for total forage production. Livestock numbers and their yearly feed requirements should be brought into balance with the estimated production of feed on the land areas available, so that feed supplies will not be a limiting factor in productive ruminant livestock enterprises.

(b) Perennial forages in crop rotations. Many of the soils in the wet-dry tropics are relatively infertile in the natural condition, but may be greatly improved by treatments with lime to reduce excessive soil acidity and the high toxic aluminum content, plus substantial initial treatments with phosphate (finely ground rock phosphate is acceptable), combined with moderate fertilization with other mineral fertilizers. The inclusion of perennial forages in the crop rotation on arable soils is an effective way of replenishing soil organic matter to the depth of the forage plant root system. Such replenishment is quite useful in increasing crop production for several years after growth of the forages in the rotation, through increase in water supplying power of the soil profile, and in maintaining high contents of soil nitrogen

and mineral plant nutrients. The perennial forage legumes, when well inoculated with appropriate strains of root module bacteria, are capable of providing sufficient soil residual nitrogen to greatly reduce (or even eliminate) any need of the succeeding crops for nitrogen fertilizers for as much as two years. It is important to select those species of forage legumes and grasses that are adapted to the soils and climate of each area, to achieve the foregoing objectives.

"Standing or uncut hay." This is feed consisting of a growth of a perennial forage grass -- legume mixture that completes growth just before the onset of the dry season when soil moisture supply is exhausted, and is left standing. This crop is then grazed directly by livestock as needed during the dry season. It is not actually "hay", since it is not harvested and stored, but it may fill the same role as hay in feeding livestock during the dry season. To avoid tramping losses, the standing hay fields should be grazed a small piece at a time, restricting the grazing animals to a limited area until all standing forage is consumed.

The "standing hay" may be produced on land areas utilized for seeded pastures (Technical Bulletin No. 13) or as forages grown in crop rotations (Technical Bulletin No. 19), using those forage grasses and legumes that are suitable for the average rainfall of the region (Technical Bulletin No. 14, pages 61 and 78). (Technical Bulletin Series, Office of Agriculture, Bureau for Technical Assistance, Agency for International Development, Washington, D. C. 20523). Where rainfall permits more than a single crop of forage, the earlier growth may be grazed, or harvested as grass silage. The later growth made toward the end of the season of rains, terminated when the soil moisture is

exhausted, may then be a standing crop of dry forage to be grazed as needed during the dry season.

(c) Using crop residues and by-products. Crop resudues and by-products may provide significant supplemental feeds in the wet-dry tropics, wherever substantial crop production occurs. For example: (1) sugar cane tops and leaves may be collected and made into patatable silage by the addition of molasses from the sugar mills; (2) green stover of maize, sorghum and millet from which grain has been removed, may be similarly pr served as silage; (3) wheat straw, rice straw, and rice grain polishings may be stored dry and fed as supplements to other stored feed; (4) the meal or cake from extraction of oil from oilseeds (cottonseed, soybeans, groundnuts, sesame, etc.) is high protein feed of excellent nutritive quality for ruminant feeding; (5) the vines and stems of groundnuts, and all food grain legumes; (6) the plant residues from most vegetable crops are excellent feeds when fed green; and the unsalable bananas and plantains may be fed successfully; and (7) cotton gin wastes may be stored dry, and converted into useful ruminant feed by fine chopping and blending with oilseed cake or meal and molasses to produce nutritionally balanced feed. Such crop residues and by-products are often wasted for lack of knowledge or initiative in using them to contribute to support of livestock enterprises. The greatest value of these potential feed stuffs is their utilization in dry seasons when perennial forage plantings are making little or no growth. The animal manures produced from such feeding practices should be collected and spread on crop lands to fully exploit the income potential of livestock conversion of crop resudues and by-products.

3. Demonstration farming systems. Since the combined crop/livestock types of farming systems indicated in the foregoing sections are now rarely followed in the wet-dry tropics, and because the several components of the most suitable systems must be combined with some care to ensure profitability, it will doubtless be necessary for the government to establish and operate demonstrations to prove to local farmers and herdsmen the economic advantages and feasibility of systems that are formulated to fully capitalize on available technology. Demonstrations should be under the direction of qualified specialists (probably expatriates at first), and by accorded governmental sponsorship and financing, even though local farmers and herdsmen should actually carry out the operations on the demonstration area. In most cases, external financing will be essential to operate a demonstration system for an initial period of three to five years. Such Demonstrations should be a national activity, and not undertaken as an international regional effort. The combined social, economic and political factors are so different from country to country, that attempts to have a single demonstration serve more than one country have very questionable usefulness.

III. Classes of Forages and Their Use as Livestock Feed

1. Definition of Forages. Forages may be defined as any fibrous plant materials provided to ruminant livestock as feeds. These include range and native plants grazed by livestock, pasture plants, harvested plant material in the form of green plants or hay; dry cereal grain straw (grain removed), grain stover preserved as silage, and fine-stemmed grasses, legumes and other herbaceous plants preserved as "grass silage".

Such forages are well utilized by ruminant livestock (cattle, buffalo, goats, sheep, camels) by reason of the unique digestive systems of ruminants, in contrast to pigs and poultry that are not capable of digesting such feeds.

The chemical composition of such forages varies widely. The fiber content usually exceeds 20% by dry weight; there is a variable content of digestable carbohydrates and fiber; the fat content is rather low, the protein may be as low as 4% in straw, dry stover, and dry range plants or as high as 20% in legumes and young grasses; and the nutritionally important minerals (calcium, phosphate., magnesium and essential "trace" elements) may range from very low in dry standing grass on rangelands and dormant pasture and in straws and dry stover, to high levels in most legumes and young grass herbage, and in the growing points of browse plants.

2. Hay. Hay is the dried plant material from fine-stemmed grasses, forage legumes and other herbaceous plants, harvested and stored for feeding ruminant livestock.

Plant materials are cut, sun-or-air-dried to bring moisture content down to 20% or lower and then stacked in compact piles with rounded tops to shed any rains that occur. The hay plants should be harvested while the nutrient content is high and total yields per hectare are approaching a maximum for the season. In general, grasses should be cut for hay as soon as heads appear; legumes when blooming begins. The hay crop should be sun dried as rapidly as possible and promptly gathered and stacked when dry to preserve as much green color as possible, since such color is indicative of higher feed value.

Leaching by rains rapidly reduces nutritive value. Storage in stacks built to shed rainfall is generally the most feasible method of avoiding such deterioration. In feeding hay, it should be distributed in small piles on hard ground or in feeding bunkers for the daily ration, in such supply as to meet daily feed requirements of the livestock without wastage. Livestock should not be allowed to feed directly on hay stacks since that method results in much wastage from tramping by animals.

3. Dry stover stored for feed. The mature plants of millet, grain sorghum and maize, from which grain has been removed, may be harvested and stored for feeding in the dry season. Such stover should be cut promptly after the grain is removed, while most of the plant leaves are still green, to conserve its feed value. A brief period of field drying is desirable to avoid spoilage, and this may be accomplished by cutting each stalk near ground level and stacking these upright in shocks for a short period until drying is complete. The dried shocks may then be moved to a place where the forage can be protected from animals, but convenient to the feeding areas to be used in the dry season. All handling of stover should be designed to save the leaves, since these have higher feed value than the stalks. In feeding, any stalks not consumed the first day may be chopped or shredded and offered to stock again. Smaller ruminants have difficulty eating very coarse materials.

4. Silage and silage making. Silage is any plant material that is preserved in moist condition under anaerobic (air excluded) conditions

that fosters rapid fermentation to produce natural organic acids which effectively prevent any further change in plant composition. Well made silage has nearly all of the nutritive value present in the crop plant material that is ensiled. It is generally palatable to livestock, and will keep indefinitely when properly made and stored.

In developing countries, the most convenient storage structure usually is a trench dug in a well drained location on soils of medium texture (not sands), where the silo can be easily protected from all animal traffic, but convenient to a feeding location. The trench may be two to four meters wide, two to three meters deep, with one end open at ground surface level for effective drainage in case of rains. The bottom of the trench should slope gently from the closed end to the open end. The length of the trench should be such as to accommodate the amount of feed to be preserved in this manner. Plant material to be ensiled should be chopped to lengths of two to five cm., both to ensure firm packing to exclude air and to facilitate consumption by animals. The chopped material is built up from one end to about 40 cm. above the sidewall of the trench, and thoroughly tramped, or packed by other means, to provide a solid mass. The filling should begin at the closed end of the trench and the packed mass filled each day should be covered with a polyethlene plastic cover (2 mil. thick), with the edges covered with soil to help exclude all air. This cover should be extended to include each new day's harvest added to the trench. Polyethlene sheeting suitable for sealing a trench silo, may be used for several years if carefully handled to avoid perforations.

Silage cutters may be quite simple and inexpensive, where hand labor is available for power. The essential features are a flat topped table or bench on which green material is laid, with a cutter or chopper positioned at the end to cut off pieces of plant material pushed across the table or bench. For larger volume operations, power driven silage cutters may be purchased.

(a) Green stover silage. Stalks of pearl millet, grain sorghum, maize, etc. from which grain has been harvest ed, should be cut promptly while leaves are still green, and chopped into short pieces for filling a trench silo. Since grain has been removed, the stalks and leaves are relatively low in quickly fermentable substances. Where molasses from sugar cane processing mills is available, the blending into the chopped material of 50 kilos of molasses per ton of stover will enhance desirable fermentation of the silage, increase the feed value and make the stover more palatable to livestock. Whenever stover is low in moisture at time of harvest, water should be added as the plants are chopped, so that the plant material may be firmly packed in the trench to exclude air.

The tops and leaves of sugar cane may be made into silage by chopping and preserving as silage. The blending of molasses into this feed as it is chopped, is useful where molasses is readily available. Elephant grass (napier grass, Pennisetum purpureum) and pearl millet (cat-tail millet) also may be cut and ensiled satisfactorily. During periods of adequate rainfall, elephant grass and pearl millet will make rapid regrowth if cut with a stubble height of 20 to 30 cm., so that a new crop may be harvested every three to four weeks.

(b) Grass silage. Whenever rainfall seriously interferes with

hay harvest of fine-stemmed grasses and legumes, the alternative procedure is to make grass silage. This practice is particularly useful in the wet-dry tropics where much growth is made during the rainy season. Forage in excess of that needed by grazing animals should be harvested at a nutritious stage of growth and preserved as grass silage. Quite often such forage is excessively moist when cut and taken directly to the trench silo. The practice of permitting field wilting for a few hours has the merit of reducing weight of the crop to be transported to the silo, and of increasing the feeding quality of the preserved silage.

Such forage should be chopped at about the same length as stover, to permit solid packing in the silo. The addition of molasses as the forage is chopped, at the rate of about 50 kilos per ton of green crop, also is highly desirable in making palatable nutritious grass silage. Grass silage may very well become the predominant form of stored forages in the wet-dry tropics, insuring adequate livestock feed during the dry seasons.

7. Fresh-cut green forage. The practice of cutting green forages daily and transporting this feed to animals held in stalls or corals, or tethered, is useful where lands are not fenced for grazing, and where forage may be collected from cropland, roadsides, non-arable areas, etc. When produced on a large-scale such feed may be machine chopped in the field as harvested, and transported daily to feeding stations. For small scale operations, common to small farms, the forages are hand harvested and transported and fed to family livestock without chopping. An alternative used in some regions,

is to tether individual animals on forage producing areas, and to move animals as the feed is consumed.

IV. Small Tools and Machines Needed for Harvesting and Storing Forages by Small Farmers in the Tropics and Sub-Tropics

1. For hay making. A sickle or scythe is needed for cutting, a hand hay rake for collecting, and a pitchfork for moving the harvested forage. For larger scale operations, tractor drawn mowers, rakes and balers are commercially available.

2. For harvesting thick stalked forages such as millet, grain sorghum, or maize, a corn knife or machete with heavy blade 30 to 40 cm. long is needed.

3. A silage fork is essential for effective handling of chopped silage. A typical silage fork is shaped like a scoop, but the scoop is replaced by heavy closely spaced tines.

4. Silage cutter. For small operators, a simple silage cutter consisting of a bench or table, with a cutting knife at one end may be used to chop green forage into lengths of two to five cm. The forage is hand fed to the cutting knife. For larger operators, power driven silage cutters are comercially available.

5. Plastic cover for trench silos. A satisfactory cover which is impervious to air should be used to cover the top of the trench silo as soon as filled. This plastic is usually polyethlene, that is thick enough (2 mil.) to be used several years without deterioration when protected from perforations from sharp objects and livestock tramping. The edges of the cover over the trench should be covered with soil (compacted) to exclude air during the initial period of fermentation of the ensiled plant material.