IMPROVING LIVESTOCK PRODUCTION THROUGH IMPROVED NUTRITION AND MANAGEMENT

Attention was given in the Turrialba and Baurú meetings to many phases of livestock management, nutrition and feeding practices (Phillips, 1950 and 1953). It became apparent from the discussions at those meetings that four problems, which were of importance to many countries and of substantial current interest, should be selected for further consideration at the Buenos Aires meeting. Two of these relate particularly to the livestock grazing industry, one to the conservation of fodder, and one to nutritional deficiencies. The material in this chapter is, therefore, arranged under four sub-headings, according to the topics upon which governments have supplied information.

National Planning and Management Aspects of the Grazing Industry

Grazing, either on open or fenced permanent ranges and pastures, and on pastures grown in rotation with other crops, is an important aspect of agriculture in most countries in the Americas. This point is emphasized by the figures in Table 13 showing the numbers of various types of livestock in the Americas. It will be seen that the numbers of the cattle and sheep are not only large, but that cattle numbers had increased substantially from the prewar level during the last two decades, while sheep numbers had increased in South America and decreased in North America.

Methods which can be adopted to improve the efficiency of the livestock industry include the improvement of livestock by breeding and selection, the increasing of productivity of grassland and fodder crops, and the addition of measures for animal health. To livestock owners, all these methods call for an increased outlay of funds for investment in their enterprises, but the incentive for such investment will not be found unless the return is at least equal to that which may be obtained in alternative projects. In Argentina, for example, it is said that the return from a farming enterprise is of the nature of 2 percent whereas it is possible to obtain 12 percent for mortgages.

In many American countries, as in other parts of the world, insecurity of land tenure, and in some cases unecomic sizes of holdings, are important factors limiting investment and develop-

ment. Under this general heading, consideration should also be given to duration of leases, private ownership as related to government ownership, grazing permits on public or other lands, and the question of forest grazing on land which has timber resources and value as a catchment area.

TABLE 13 – NUMBERS (IN MILLIONS) OF MAJOR LIVESTOCK SPECIES IN NORTH AND SOUTH AMERICA [2]

Years and Area	Horses	Mules	Asses	Cattle	Pigs	Sheep
North and Central America [1]						
Prewar [1]	18.0	5.5	3.2	100	64	60
1948/49	12.4	4.0	3.5	110	72	39
1950/51	11.0	3.8	3.6	118	79	38
South America						
Prewar [1]	18.2	3.9	2.7	106	30	95
1948/49	18.3	4.4	3.5	132	34	120
1950/51	18.4	4.4	3.7	136	37	123

[1] For the prewar period, the latest estimates up to 31 December, 1939, except for a few 1940 figures, have been used.

[2] From 1952 *FAO Yearbook of Food and Agricultural Statistics* (Vol. VI, Part 1, p. 109)

In view of the importance of the grazing industry, a major question to be considered is the extent to which national planners are at present taking account of the special interests and requirements of the livestock industry.

Under the modern system of land use based on the conservation of natural resources and their improvement, costs are necessarily higher than under the exploitative system. The cheap food era, which was possbile only with uncontrolled exploitation of the natural resources of the producing countries, is being replaced by a period in which there is increasing realization of this fact, and of the urgent necessity to restore the damage which has been done. The next stage will have to be the building-up of the productive capacity of the land to meet the needs of a growing population. The main items of cost in such a program are:

(1) *Interest on the capital invested.* If this is inadequate, money will be invested elsewhere.

(2) *Wages.* These are governed largely by the size of the individual holding, the purpose for which it is used, and the necessity of attracting to this work people of sufficient knowledge to learn and apply modern methods; the wage must be at a level which will compete substantially with that paid in industry.

(3) *Depreciation and obsolescence.* In addition to normal depreciation, as new methods of farming are introduced, equipment will become out-of-date and much will have to be written off, otherwise the work will be done uneconomically, old houses will have to be dismantled and modern housing built to attract skilled labor.

(4) *Rent, taxes, insurance and general contributions.* By virtue of their comparative isolation, rural farmers are called upon to meet expenses in connection with education, holidays and local social activities which are greater than those to be met by people in industrial centers; these should be a charge on the industry.

National planning has one basic purpose, that of creating an atmosphere for efficiency of operation on the individual level. There are several factors which governments need to consider if national planning is to be effective, namely:

(*a*) analysis of future trends, i.e., the relation between population and needs for livestock products, information which must be placed in the hands of producers by 5 or 10-year periods, so that they can make long range plans;

(*b*) examination of the needs for research in relation to critical animal problems, and orientation of the program to meet the needs;

(*c*) provision of technical services to carry new information to the producer; and

(*d*) provision for the orderly marketing of products.

A primary need in national planning is an inventory and classification of naturalr esources, namely, soil, water and vegetation. It would also be important to obtain information on the potential demand and availability of both major and minor plant nutrients which are essential for improvement of grassland and fodder resources to the level required by an efficient livestock industry.

Water is an especially important item in national planning. A major problem is the depletion of underground water stores — an occurrence which is at present a critical problem in the plains of Argentina and elsewhere in the hemisphere. A new technique has been developed in Australia to reduce evaporation of water in open storage through the use of powdered cetyl-alcohol, which, when scattered on the surface forms a thin film, one molecule thick. Water supplies and resources, their use and depletion if not wisely managed, are multiple, and it becomes necessary to

consider and co-ordinate conflicting interests. Some type of hydrological service might well be established in each country to protect existing water sources, reconcile interested users, and formulate plans for use on a national basis, in cases where such bodies do not exist.

Programs of national planning should take into account the balance between the natural, economic and social factors in a given country. For example, in the River Plate region, there has been much improvement in the animals themselves, but no comparable improvement in other aspects of animal production such as the maintenance of soil fertility, pasture management, etc. A need exists for an inventory of human, natural and economic resources, which is lacking in many countries. Only through this will it be possible to determine what resources are available, how they can be used, and which problems require solution. Throughout a considerable part of the Americas there is little relation between research and extension activities, nor is the researcher in many cases thoroughly familiar with the problems of the producer. A great need exists, therefore, for a closer relation between extension, research and the producer.

One fundamental step is the adequate training of capable personnel. Such technicians, who have practical knowledge of the problems, can arrive at their solutions after careful study and analysis and with the help of the people. Only after the producers have adopted the new practices and procedures will the desired progress result.

Information on current developments in a number of the countries in the Americas is summarized in the following paragraphs.

The Government of *Argentina* has taken steps towards making public lands in Patagonia available for sale to those who are actually working on these areas. Some 490,625 square miles are involved in the whole region south of the Rio Negro. The previous history of these lands has been maximum exploitation by lessees under the short-term leases prevailing. Since 1950, new laws have provided not only for private ownership by resident operators, but also for economic operational units, calculated to provide an adequate standard of living based on the number of sheep which can be grazed on a given holding. The Government of Argentina has also had a national program of seed multiplication and distribution since 1948. In the last year, there were some 60 to 70 co-operators in this work.

Chile has in operation a national program to improve, among other things, the livestock industry. The operation is being carried out in three areas under a scheme which can be described as the " Plan Chillán "; this covers the provinces of Maule, Nuble and Concepción. In addition, there is a plan for the southern

part of the Central Zone of Chile, specially for the Province of Cautín, and another for Magallanes. The " Plan Chillán " lays considerable emphasis on pasture management and improvement, soil conservation and the production of seed of introduced species of pasture and fodder plants. New techniques are introduced into farming practice through extension work. In the province of Cautín, while the work is primarily concerned with the conservation and restoration of soils, the establishment of permanent pastures is of great importance under the special conditions of the zone. The region covered by the " Plan Magallanes " is almost entirely devoted to livestock production (sheep); the objective here is to increase this production by the improvement of existing pastures and the establishment of new improved pastures. A reconnaissance soil survey of the country has been practically completed. There is some concern in Chile over the instability created under existing systems of land tenure for those who rent from the State. The Government of Chile has sent a message to the Chamber of Deputies, aimed at modifying existing land tenancy legislation and foresees the possibility of the sale of government lands in the extreme south.

In *Costa Rica*, there is full recognition that agricultural prosperity depends largely on livestock production based on the development and more effective utilization of the grassland and fodder resources of the country. This development will not react unfavorably on the coffee crop which has been the main source of export revenue up to the present; in fact, the indications are that coffee production will be higher if this is integrated with dairy farming. A program is being planned on a national scale and envisages the progressive development of milk, meat, pork and egg production for which there are three inseparable, interdependent and fundamental requirements:

(*i*) inherently productive livestock adapted to the environment;

(*ii*) adequate feed supplies throughout the year equal to the nutritional standards required; and

(*iii*) a standard of management which ensures effective utilization of feed and the maintenance of livestock in a healthy condition.

Since none of these fundamental aspects are of permanent value without the others, the ecological approach has been adopted in full recognition of the relationships between plant, animal and man, and the complete interdependence of the one upon the other. It is realized that, as the program develops, many new problems will emerge which can be solved only by research and some may require facilities not yet available in Costa Rica. How-

ever, the country is developing these as rapidly as possible and is seeking outside assistance, where necessary.

In *El Salvador*, about 685,000 ha., or 32 percent of the land in that country, has been classified as pasture. Of this 17,528 ha. are cultivated, and the remainder is natural range. The variations in carrying capacity have not been determined. According to the 1953 census there were 132,932 draft oxen; 694,498 head of other cattle, 261,252 hogs. 32,858 mules, 3,187 asses, 15,098 goats, 5,453 sheep and 2,243,851 poultry. It is calculated that the people consume on an average only about 27½ lb. of meat, fish and poultry per person, per year. Milk consumption is low. Cheese is made by rudimentary methods in places very distant from fluid milk markets. For many years there has been a considerable migration of cattle and hogs from Honduras and Nicaragua to El Salvador. Some of them continue to Guatemala on foot or by train, and some of the cattle remain for a time, fattening on pastures before entering Guatemala or being shipped to Peru. In 1952, more than 4,000 steers and 30,000 hogs entering the country in this manner remained for slaughter and local consumption.

In *Paraguay*, studies under way as part of a national plan to give guidance to the stockmen include the following: the rational use of pasture; introduction of new legume species; establishment of improved pastures; the value of lime and fertilizers for pasture production; elimination of undesirable plants; practices to improve soil structure and moisture; best combination of grasses and legumes in relation to carrying capacity; improvement in the quality of cattle; animal disease control; breeding and management practices; provision of mineral supplements to animals on pastures; and improved handling and transport facilities.

Panama has a national project under way to map and classify all the soils of the country; most work at present is in the region of Chiriqui. While land tenancy studies have been concluded by the Statistic and Census Section of the Ministry of Finance, the results have not yet been analyzed or made available as a help to the livestock industry. Soil conservation is a problem due to various factors. However, in Chiriqui, land contour demonstrations have been established, as also have demonstrations to point out the harm of burning pasture lands.

The *United States of America* has under way a number of activities which relate to the national planning and management aspects of the grazing industry in that country, where grazing may be considered of two major types: A, grazing as a part of the farming enterprise in the more humid or irrigated parts of the country; and B, grazing as a major enterprise in arid and semi-arid portions of the country. Grazing, in these two types of

enterprise, involves the use of more than half of the total land area of the United States. It is practised on 168 million ha. of open permanent pasture or rangelands, 55 million ha. of forest on farms, 28 million ha. of cropland in farms, and approximately 162 million ha. of forested and non-forested rangeland outside of farm boundaries. Of the total land area used for grazing, about 121 million ha. are in federal ownership and about 26 million ha. are owned by state and local governments.

National planning and management, as it affects the grazing industry based on these lands, has concentrated largely on attempts by the federal government to create an atmosphere in which livestock producers can operate efficiently. Such planning involves the national study and analysis of situations or problems within, or affecting, the industry. Needed action may be translated in the form of development orientation, and operation of:

1. research programs;
2. educational facilities involving federal and state extension services and other channels;
3. aids in the form of technical services and financial assistance, where needed to promote wider use of technological improvements in the industry, and to promote conservation of soil and other resources, and
4. rules for the protection of public health, and for the orderly operation of transportation and marketing facilities.

National planning aids the federal, state and local governments in taking those actions which will help the grazing industry to overcome its problems or lessen their effects.

As a phase of such national planning, recent studies of the future needs for agricultural production have been made, based on probable increase in population, trends in consumers' tastes, trends in the use of agricultural products in industry, and changes in total consumption which might be possible with a high level of employment and continued active economy. By 1975, an anticipated increase of between 6 to 8 percent per capita in consumption of agricultural products, and population increase of 32 percent will require an over-all increase in farm production of 30 percent over present levels.

Of major importance to the grazing industry, these studies show that as part of the over-all increase in farm production, there will need to be an increase of an estimated 38 percent in virtually all livestock and livestock products. This is in contrast to a needed increase in all crop production of 24 percent over the 1951-53 level. This lower increase is the result of present production of several major crops in excess of consumer require-

ments. Notable among these is the production of wheat as a food grain. Shifts in production are required to meet the 1975 requirements, most pressing of which is shift from production of wheat as a food grain towards more livestock and livestock products. Such a shift is of significance to the grazing industry and presents several major problems. Associated with the shifts and the need for higher livestock production is another problem — that of obtaining more adequate supplies of high protein concentrate feeds.

To meet the increased needs for agricultural commodities by 1975 will require increased yields per acre of virtually all agricultural commodities except wheat. Nearly all land suitable for agriculture in the United States of America is now in use; a net increase of only 6 percent in the acreage of cropland is probable by 1975. Some land can be used more intensively; other land, in the interests of conservation, doubtless should be used less intensively. As it applies to the grazing industry and use of grazing lands, to obtain these increased needs for livestock production efficiently will require continued efforts to encourage use of present known improved production techniques, and continued research along many lines to increase the output of grazing lands and grazing animals.

The need for attaining greater forage production on pasture and rangelands is another major problem facing the grazing industry. The increased production of forage on pastures and ranges, specially that of the ranges, has not kept pace with the increases in yields per acre of agricultural lands devoted to other crops. An increase of approximately 30 to 35 percent in the yields per acre of pasture and grazing lands would be needed to meet the requirements for livestock production by 1975.

Statistics on labor used in grazing phases of the livestock industry are not available separate from the labor requirements of major enterprises of agriculture. The agricultural industry of the United States of America is estimated to have required 15 thousand million man-hours of labor in 1953 as compared to an annual average requirement of more than 23 thousand million man-hours in the 1910-1914 period. A steady and significant decline has occurred during the past 40 years. Sheep and cattle production, as compared with other agricultural commodities, have always been relatively low consumers of labor. In 1953, they used only slightly more than 1 thousand million hours of labor. Labor efficiency in the sheep and cattle industry has increased, but relatively less than with other major aspects of agriculture. Further increases are still possible.

Soil and water conservation is taken into account a great deal in national planning and operations in the United States of America.

This affects the grazing industry, just as it does other phases of agriculture. As a result of such planning, several significant legislative actions have been taken by the federal government. Legislation establishing the Soil Conservation Service to provide leadership and assistance in a national program of soil and water conservation, and to provide means for the federal government to share with farmers and ranchers the cost of establishing approved conservation practices to be administered by the Agricultural Conservation Program Service has been taken. Recent legislation has provided for both direct and insured loans for conservation work through the Farmers Home Administration of the Department of Agriculture; permission to landowners who establish conservation practices to deduct, as expenses, the cost of such practices, from their income in calculating income taxes; and a national program of soil and water conservation and flood retardation in small watersheds which provides a means for the federal government to share with local units of governments the cost of planning and applying complete watershed treatment programs.

Federal departments administering federally-owned land also give major emphasis in planning and action programs to soil and water conservation, and to the management and improvement of ranges. Since about 121 of the 184 million ha. of public land administered by the federal government is used for grazing, this planning and action influence the grazing industry in a major way.

A shift from government to private ownership of some public lands, such as reported by the Argentine delegation, is being considered in the United States of America. For these areas remaining under public domain, the present policy is, firstly, towards a longer tenure, which is now 10 years and is renewable, and secondly, towards a growing tendency to give the user of the land some responsibility for its care and management, thus, in effect, enabling consideration of the leased land as though it were his own.

Problems such as land tenure, transportation facilities, livestock prices, and others facing the grazing industry are also considered in national planning. Situations are analyzed, and necessary steps of research, education, technical or financial assistance and legislation are taken as needed by federal, state and local units of government. Additional steps may also be taken by associations of livestock producers, or through national meetings attended by representatives of agriculture, industry and government.

The National Foundation Seed Project was established in the United States of America to provide a rapid and improved supply of seeds of hay and pasture crop varieties. This assures that the amounts of certified seed required by farmers are readily available. It was initiated in 1948.

It is considered in the United States of America that continuing attention needs to be given to all of these many phases which concern the grazing industry. One of the major phases essential to national planning on which new work is needed is a national inventory of pasture and rangelands, with specific attention to their condition, improvement, needs and grazing capacity.

Technical Problems in the Use of Grasslands

Much interest was shown in the various technical problems involved in the improvement of range and pasture lands at the Turrialba and Baurú meetings, and the information made available on the work in various countries has already been published (Phillips, 1950 and 1953). A growing awareness of the importance of work in this field was reflected by the large amount of information made available to the Buenos Aires meeting, and which is summarized in this section. The information for each country is presented in sequence to give an indication of the amount and type of work reported for each country.

In *Argentina*, nine major ecological zones are recognized with particular reference to their value for grazing . A publication is in preparation which gives details on the extent of each zone, its climate, soil, vegetation, natural and cultivated forage plants, pasture and feeding problems. In most of the regions, overgrazing has caused deterioration of the soil and vegetation and thus has affected the livestock population. The regions are as follows:

1. Patagonian steppe;
2. western low scrub;
3. Pampean open woodlands;
4. northwestern mountain steppe;
5. central mountain grasslands;
6. Chaco woodland;
7. Chaco parkland;
8. northeastern open woodlands and savannas; and
9. Pampean grasslands.

Two-thirds of the surface of Argentina is arid or semi-arid; the livestock of these regions (sheep, cattle and goats) subsist entirely on the natural vegetation. The prolonged dry period and uncontrolled use of the land have resulted in serious deterioration in the vegetation cover and soil, markedly reducing the carrying capacity; this whole process has led to serious erosion. In order

to cope with this situation, the Ministry of Agriculture and Livestock has initiated a series of studies to regenerate these lands to a condition in which they will maintain an optimal number of livestock, while at the same time ensuring conservation in all its aspects. The studies noted below have been initiated in Patagonia, and will be extended to the north of the country as soon as facilities permit:

(1) Preparation of a manual of the flora of the Patagonian semi-desert.

(2) Study of the vegetation. A map of the vegetation of the Chubut region has been published (Soriano, 1950) which shows the floristic districts, the areas characterized by species or populations that are lacking or rare in adjacent areas. A map has just been completed of all the floristic districts south of the 42nd parallel, which were surveyed by the line transect method.

(3) The effect on the vegetation of elimination of grazing. A network of hare-proof enclosures 1 ha. in size has been set up in vegetation types representative of extensive areas; this system will be extended to the Central Pampa. The changes are being observed using Parker's method (Parker, 1950). Marked increases in density and height of grass and other species have been noted as a result of protection for less than one year.

(4) Ecology of dominant, useful and undesirable species. An attempt is being made to ascertain the characters or mechanisms which give advantage to one species over another. Studies are being made on germination, establishment, root systems and amount and longevity of buried seeds, as well as on environmental factors.

(5) Seeding trials. About 20 indigenous and introduced perennial grass and browse species are being tested in five representative sites. On one site a very palatable indigenous plant, *Bromus macranthus*, was the only species which germinated and grew well in a year when the precipitation was 54 mm. of rain and 16 cm. of snow. In another locality with 500 mm. of rain *Agropyron desertorum* and *A. intermedium* appeared promising.

Action has been taken by Argentina during recent years to make adequate quantities of seed of adapted and improved species and strains available to farmers. This includes the planning and co-ordination of work in progress at the various experimental stations of the Ministry of Agriculture and Livestock; in 1954, there

were 27 forage crop improvement projects under way, apart from the work concerned with the multiplication of seed of new forage varieties and introductions. A special experimental station at Anguil was created to work primarily with the improvement and management of forage species. Improved strains of forage plants available to date in Argentina include:

Plant	*Strain*	*Remarks*
Alfalfa	General San Martin FAV	Resistant to stem nematode
Alfalfa	Nemasint FAV, synthetic variety	Resistant to stem nematode
Alfalfa	Selección Pergamino MAG	Resistant to root rot
Alfalfa	Magnif, M_1 and M_5	Resistant to stem nematode
Barley	Negra de Manfredi MAG	Resistant to aphids (*Schizaphis graminum*)
Barley	Gautrache Araucana MAG	
Bromus carthaticus	Selección Angel Gallardo	
Bromus carthaticus	Selección Pergamino MAG	
Oats	Santa Fé, No. 3	
Phalaris tuberosa	Selección Pergamino MAG	
Ph. tuberosa	Selección Castelar MAG	
Ph. tuberosa x Ph. arundinacea	Hibrido Castelar (synthetic allopolyploid)	
Ph. minor	Selección Pergamino MAG	
Ph. minor	Selección Castelar MAG	
Perennial rye grass (*Lolium perenne*)	Selección Pergamino MAG	
Black sorghum (*Sorghum almum*)	Magnif 504 MAG	
Sudan Grass (*Sorghum sudanense*)	Oliveras Paraná MAG	
Sweet Sorghum (*Sorghum saccharatum*)	Oliveras Carcaraña MAG	
Vicia sativa	Selección Pergamino MAG	

The superiority of the new selections has been verified in regional trials. These varieties are now being multiplied for introduction into cultivation on a large scale; several are already available to farmers in limited quantities. In addition to the above-mentioned types work is in progress on other species including *Phalaris arundinacea*, *Dactylis glomerata*, *Vicia* and sweet clover.

In view of the interest expressed in hardy types of oats for winter fodder, it should be noted that such types have been developed in Argentina; it is considered that these may be of use in countries with a warm climate, since they are resistant to yellow rust (*Puccinia coronarium*). A need is recognized in Argentina to organize seed exchange between the various countries in Latin America, particularly for those plants which grow well and are valuable forage species in a certain region, but which do not mature seed under the environment of the country.

In *Chile*, work is under way in the cold climate of Magallanes, where the Ministry of Agriculture and Livestock is planning to establish eight demonstration centers. The type of grassland dominated by " coiron " (species of *Festuca* and *Stipa*) has deteriorated greatly owing to excessive grazing by sheep. The palatable soft grasses are often eradicated by continuous summer grazing on the higher lands. On the other hand, the coarser bunch grasses are grazed in the winter and with too heavy grazing may be eliminated. This occurs on the lowlands which are used in winter. The heavy winds cause " blow-outs " as a result of the depletion of the soil cover by this method of management. These pastures are being improved by protecting them from grazing for one year. Seeding of suitable areas with grasses and legumes is also practised, using *Agropyron elongatum. A. intermedium. Festuca elatior*, alfalfa (Ranger and Rhizoma), and in some parts *Dactylis glomerata.* Seed of indigenous species of *Elymus*, which promises to be of value for re-seeding, is being multiplied.

Overgrazing and rabbit infestations have led, in some cases, to the formation of large sand dunes which may move at a rate of up to 5 km. per annum. *Elymus arenarius* and *Ammophila arenaria* are used for their control, together with complete protection from grazing by all animals for at least 5 years. Similar results have been obtained with these species in the part of Tierra del Fuego belonging to Argentina.

Following the report of the Baurú meeting, the Government of Chile has taken action on the biological control of the rabbit through the use of the myxomatosis virus. In Australia and other countries, the virus has been transmitted by an insect vector such as the mosquito; in Tierra del Fuego, it is spread by direct contact of one rabbit with another. This action is having a marked effect in reducing their numbers. A similar problem exists in the Argentine part of Tierra del Fuego, north of the Rio Chico, where rabbits have been increasing rapidly in numbers. The hard winter of 1954 greatly reduced the rabbit population. The spread of myxomatosis from the Chilean part of Tierra del Fuego is also having its effect.

An experiment is being conducted in the Magallanes region of Chile to improve the carrying capacity of the range land covered by Mata negra (*Verbena tridens*) and Mata verde (*Chiliotrichum diffusum*). As a result of the mechanical elimination of these unpalatable species, and reseeding, the carying capacity of the experimental area has, in two years, increased 80 times (from one animal per 20 ha. to 4 animals per ha.). Rainfall in this area approximates 250 mm. per annum.

The following tabulation shows the present status of land development in Chile:

Total area of country	74 177 000	
Area usable for agriculture	29 000 000	(39%)
Area under agricultural rotation ..	5 903 200	
Irrigated area	1 342 000	
Area under cultivation.....	2 536 898	

Of the area under cultivation, 1,285,700 ha. are in annual crops, 141,198 ha. in fruit trees and 555,000 ha. in fallow land. There are pasture lands, as follows:

On land not subject to rotation	6 800 000
On unwatered land under cultivation	3 107 000
On irrigated land under cultivation	733 000
Total	10 640 000

Experiments in progress indicate that the carrying capacity of the irrigated artificial pastures may be greatly increased by the use of superior species, proper fertilizers and control of grazing by the electric fence. It is also believed that the 430,000 ha. of irrigated natural pastures could, with advantage, be plowed up and sown to superior mixtures which would greatly raise livestock production.

Some years ago, Chile began to prepare a soil map and now only a few areas remain to be surveyed. This map shows not only the soil types but also gives climatological data, and furnishes a sound basis for planning the pasture work in the different zones of the country. The chief problems are prolonged dry periods in spring, summer and autumn and low temperatures in winter; these, added to bad management and a gradual deterioration in soil fertility, are resulting in the disappearance of the most valuable species and their replacement by unpalatable species and weeds.

Artificial pastures which have, until recently, been based almost exclusively on alfalfa, red clover (*Trifolium pratense*) and perennial rye grass (*Lolium perenne*) have shown a lack of resis-

tance to adverse conditions of soil and climate. Prolonged investigations have now shown that the following pasture species are of value to the dry zone: *Sanguisorba minor*, *Trifolium incarnatum*, *Phalaris tuberosa*, *Festuca pratensis*, *Arrhenatherum elatius*, *Eragrostis curvula*, *E. lehmanniana*, *Dactylis glomerata*. These species are planted in pure stands or mixtures, according to the possibilities shown by the soil map of Chile.

Ladino clover (*Trifolium repens* var. *giganteum*) has given excellent results on soil with medium to heavy texture on which alfalfa and red clover did not do well. Tall oat grass (*Arrhenatherum elatius*) is adapted to the Andean Precordillera and the coastal terrace lands, on light soils which are largely covered with poor annual species.

The species of pastures and fodder crops which are grown on the dry and irrigated artificial pastures are indicated in Table 14.

TABLE 14 – AMOUNTS OF PASTURES OF VARIOUS TYPES IN CHILE

Type of Pasture	Irrigated Land	Dry Land	Total
Alfalfa	100 000	3 000	103 000
Arrhenatherum elatius	—	6 000	6 000
Dactylis glomerata	2 000	246 000	248 000
Red Clover	190 000	135 000	325 000
Holcus lanatus	—	121 000	121 000
Lolium perenne	6 000	10 000	16 000
Trifolium incarnatum	—	5 000	5 000
Mixtures	5 000	300 000	305 000
Others	—	16 000	16 000
Total	**303 000**	**842 000**	**1 145 000**

Parallel to the pasture program in Chile for some years there has been in operation a plan for forage seed production under the Ministry of Agriculture and with the co-operation of the farmers. There are at present about 3,000 ha. in seed production, yielding enough seed of the different species to meet the country's needs.

In *Colombia*, with the exception of a few ranges, the usual practice is to maintain the livestock under extensive pasture conditions without any particular management. The cattle graze throughout the year on swards formed by Para, Guinea, India and Yaragua grasses. To sustain an animal, 1.6 ha. are required. It is felt that improvements in pasture management, including seeding and the use of the pastures in the young stage, might

improve the nutritive condition of the animals. The use of the mowing machine is advised to favor the growth of legumes, to eliminate weeds, and to maintain the pasture in a short and more palatable condition; these steps should help to increase the carrying capacity per unit area.

In *Costa Rica*, several productive species are now well established including, the following:

Grass		*Species*
Bahia	—	*Paspalum notatum*
Carpet	—	*Axonopus compressus*
Elephant	—	*Pennesitum purpureum*
Gamalote	—	*Paspalum conjugatum*
Guinea	—	*Panicum maximum*
Imperial	—	*Axonopus scoparium*
Honduras	—	*Ixophorus unisetus*
Kikuyu	—	*Pennisetum clandestinum*
Molasses	—	*Melinis minutiflora*
Para	—	*Brachyaria purpurascens*
Yaragua	—	*Hyparrhenia rufa*

As the pastures are at present deficient in legumes, a concentrated effort is being made to discover types which can be established and to maintain a grass/legume mixture for the production of balanced herbage with a higher protein and mineral content. Some of the promising indigenous legumes are being collected and and tested as pure species and in mixtures with grasses.

Work in progress indicates that, in the highlands (temperate zone), Kikuyu grass with white or subterranean clover (*Trifolium subterraneum*) makes excellent pastures, and that in the intermediate zone (8,752 to 17,304 ft.), Molasses grass (*Melinis minutiflora*) blends well with white clover (*Trifolium repens*). In the lower lands of Guanacaste, mixtures of Yaragua (the dominant grass in this area) can be made with tropical Kudzu (*Pueraria javanica*), velvet bean (*Stizolobium deeringianum*) and Alsike clover (*Trifolium hybridum*).

Strains of common grasses are being tested for higher production of better quality herbage, and the effects of fertilizers and animal manure on the yield and composition of herbage are being observed. Laboratory facilities have been provided at " El Alto " for the analysis of samples of herbage cut at different stages of growth and under different systems of treatment and management.

It is considered that one of the fundamentals for successful livestock production, namely " a standard of management which ensures effective utilization of feed and the maintenance of stock

in constant good health " is the most difficult part of the program to achieve because it embraces simultaneously the management of both grass and animals. This depends very much on those who carry out the daily routine tasks and many have not yet acquired the necessary skill in modern methods of pasture and livestock management. In helping to overcome this difficulty the extension service, established in 1948, and now having over 60 officers at 32 centers, has been most useful.

At the " El Alto " animal research center and at " El Capulin " research covers different methods of grazing, varying intensities of defoliation, use and effects of fire for grass control, and the conservation of surplus grass as hay and silage. Suitable farms are being used for the demonstration of practices and the need for concentrates and mineral mixtures is being studied. A soil survey of the country is now well advanced and this is being followed by research into mineral deficiencies which may be reflected in deficiencies in the forage and in animal health and production

In *El Salvador*, technicians of the Ministry of Agriculture and FOA (recently re-named International Co-operation Administration) are conducting experiments to compare Para, coastal Bermuda Pangola and other grasses for fattening steers. Also, on account of the very high price of corn, root crops are being tested for the feeding of swine.

In *Panama*, laboratory and field facilities have been established for investigations and demonstrations of pasture problems, but sufficient personnel is still lacking. Plants used for pasture improvement include: *Pueraria javanica*, *Panicum barbinode*, and *Hyperrhenia rufa*.

In *Paraguay*, in the work of STICA, a number of species have been found of special value. An indigenous species, *Paspalum guenoarum*, (*P. rojasii* — pasto rojas), has given excellent results, being superior to *Hyperrhenia rufa* (Yaragua) or *Chloris gavana* (Rhodes grass) in the maintenance of a uniform level of production throughout the year; seed production is also good. *Avena strigosa* var. *glabrescens* is proving valuable for winter grazing. Among the legumes, two indigenous species of Vicia (*V. selloii* and *V. graminea*) are promising, and introductions of *Vicia obscura*, *Trifolium repens*, *T. Hirtum* and *T. pratense* have shown good behavior. At present, improved pastures are based on the use of *Paspalum guenoarum*, *Chloris gayana*, *Hyperrhenia rufa*, *Pennisetum purpureum*, *Panicum maximum* and cereal rye.

In *Uruguay*, trials are being conducted at " La Estanzuela " on the effect of mineral fertilizers and inoculation on the yield of legumes. A pasture fertilized with 1,760 lb. of superphosphate per ha. produced 17.5 tons more green weight per hectare than

the control; more than half the vegetation was composed of native clovers and fine grasses, while the control plots contained species of *Stipa* and weeds. Similar results were obtained on a mixture of alfalfa and rye grass L.E. 284 (*Lolium multiflorum*); the degree of response to the fertilizer was related to the proportion of alfalfa in the mixture.

In all soils a favorable reaction to phosphatic fertilizer was found which was not the case for lime. In these cases the hyperphosphate was more economic than the use of lime and superphosphate. In alkaline or neutral areas superphosphates or similar fertilizers should be used.

The experiments with fertilization and rotation have shown that it is more convenient to use phosphatic fertilizers on legumes which precede cereals rather than directly on cereals not preceded by crops which increase organic matter content and improve soil texture.

Experiments on pastures have shown that both quality and production increase after the application of phosphorus.

In trials initiated in 1948 on a crop rotation of fertilized alfalfa (2 to 4 years) with wheat, maize, oats and flax, the yield of wheat was doubled as compared with the control plots. The integration of crop and livestock husbandry constitutes a decisive factor in preventing any further decrease in cereal yields, even on lands which have been in continuous crop production for 50 years. Experimentally it has been shown that this procedure has resulted in the recovery of the productive capacity of the soil.

In the Forage Crop Department at " La Estanzuela, " trials are in progress on the pasture value and seed production of the following grasses and legumes:

Agropyron elongatum	*Dactylis maritima*	*Phalaris arundinacea*
A. intermedium	*Festuca elatior*	*Trifolium pratense*
Arrhenatherum elatius	*Lolium multiflorum*	*T. procumbens*
var. *tualatin*	*L. perenne*	*T. repens*
Bromus carthaticus	*Lotus corniculatus*	*T. subterraneum*
Dactylis glomerata	*Medicago sativa*	

A special service has been set up in Uruguay for the multiplication and distribution of various grasses and legume seeds. In the year 1954/55, the production by the station at " La Estanzuela " of seed of forage plants for intensive multiplication in subsequent years was as follows:

Italian rye grass (*Lolium multiflorum*)	22 050 lb.
Vicia	11 025 lb.

Rye (for grazing)	13 230	lb.
Red clover (*Trifolium pratense*)	3 307	lb.
Alfalfa	880	lb.

In *Jamaica*, pasture research is closely related to work on livestock breeding, husbandry and nutrition. The officers dealing with the different sections work together as a team and so ensure that the work has a practical application and that the economics of the industry will be considered. There are three stages:

A. A search for new species or varieties to give greater carrying capacity and for a grass which will supplement the other grasses during periods of dormancy or reduced yield. Drought-resistant strains are required. A wide range of species and varieties has been introduced but so far only very few have shown promise. Most of the legumes have given very disappointing results.

B. Establishment of observation plots for promising types, to make recordings of chemical tests, weights, leaf/stem ratio, growth behavior and fertilizer requirements. The results obtained are used in selecting varieties for further tests, not to determine their potential value as pasture species.

C. Planting several acres of the best grasses for pasture trials. These are fertilized and yields are recorded. The steers used in the experiments are weighed through the trials to determine their yield of beef per acre. Trials on management and comparisons with other grasses are also made. The first year is used to develop the technique of pasturing the species to the best advantage and the actual trial begins after this.

The following are some of the results obtained in the pasture trials:

(*a*) The native flat grasses predominantly *stenotaphum secundatum* have been tested for six years to determine feeding value and management. Yields could be increased appreciably by subdivision, mowing, rotational grazing and the application of fertilizers, but they are still too low for economic production and the response to treatment too small to cover the costs. The carrying capacity is 3 to 5 acres per steer. Liveweight increases of up to 1 lb. per head per day were obtained, but these were still uneconomical. This species is the chief grass in the undeveloped upland pastures. Because of its limitations, attention is now being directed towards Pangola grass (*Digitaria decumbens*) and Coastal Bermuda grass (*Cynodon dactylon*).

(*b*) Feeding trials have been conducted for six years on Napier grass (*Pennisetum purpureum*) with promising results. Twelve steers were maintained on 9 acres and gave an average increase of about 2 lb. per head per day for 9 months during the growing season. During the past two years, enough fodder was cut to make silage for the time of shortage. An undesirable character of this grass is its long resting period in the autumn and winter months. Experience has shown the need of grazing for no more than 4 days at each time of pasturing. Eighteen pastures are necessary for the best rotation. Napier grass requires heavy application of fertilizers. When the grass is cut, it lasts for only 2 to 3 years, whereas it can be maintained for 6 years when pastured. A trial is in progress at present to work out the ratio of acreage of Pangola and Napier grasses necessary to provide fodder throughout the year; both grasses have different resting periods and complement each other.

(*c*) In 1950, Pangola grass was introduced and has so far been the most promising species. Liveweight increases of 2 to 2½ lb. per head per day have been obtained during periods of good growth. Extensive feeding trials have been made to compare Pangola with Guinea grass (*Panicum maximum*) and Coastal Bermuda, as well as studies of methods of management and response to fertilizer. Pangola has about 24 percent dry matter compared with 16 percent in Napier grass, and it is much more leafy.

(*d*) Research on Guinea grass is in progress at the dairy cattle breeding center. This is the best grass for the coastal plains. It is difficult to pasture in such a way as to maintain maximum production. When properly managed, a higher milk production has been obtained. Eighteen pastures are necessary for proper feeding and to maintain the pastures themselves in good condition. One hundred and fifty cows, dry stock and heifers are maintained on 230 acres (about 0.8 acre per cow). The land is irrigated and the average daily temperature is between 85° to 90°F. (29.4° to 32.2°C.). The yield per acre is approximately 7,000 lb. of milk (5 percent butterfat) in 305 days with twice daily milking. Pangola grass is now being grazed at this station, and has not so far increased the yield of milk as compared with Guinea.

In the *United States of America*, the mapping of the soils and determination of the conditions of pasture and range land, based on the botanical composition, are an integral part of the technical assistance extended to co-operators in the grazing industry in soil conservation districts. Soil maps and land capability information

are used for conservation planning of the crop land and tame pasture areas. Plans for correct management of range land are based on site and condition inventories supplied to the land operators. Agencies administering federal grazing land also map these and determine grazing capacities in order to be able to advise on the improvement of these lands for the grazing industry. Substantial progress is being made in the mapping and determination of the productive capacity of privately and publicly owned land in soil conservation districts. A national inventory of all pasture and range lands is urgently required, with particular reference to their potential composition, ecological status, present condition, productive capacity and possibility for improvement.

Research and demonstration programs for grassland management in the United States of America are conducted primarily by the Agricultural Research Service, the Forest Service and the Soil Conservation Service of the Department of Agriculture, the Bureau of Land Management of the Department of the Interior, and the state agricultural experiment stations.

In the work of the Agricultural Research Service, most of which is co-operative with the states, the state experiment stations generally furnish office, laboratory, greenhouse and field facilities. Centers provided primarily by federal funds include Plant Industry Station, Beltsville, Maryland; Regional Pasture Laboratory, State College, Pennsylvania; Northern Great Plains Field Station, Mandan, North Dakota; U.S. Range Livestock Experiment Station, Miles City, Montana; Central Plains Experimental Range, Nunn, Colorado; Southern Great Plains Field Station, Woodward, Oklahoma; and the Jornada Experimental Range, Las Cruces, New Mexico. At the Pasture Laboratory, excellent laboratory, climatic control chamber, and greenhouse facilities are provided for fundamental work in physiology, nutrition, genetics, pathology, and soils phases of grasslands. Extensive land facilities are required for range management studies in the Great Plains. For example, at the Southern Great Plains Experimental Range there are approximately 4,000 acres involving 60 different pastures varying in size from 60 to 200 acres. On the Jornada Experimental Range there are 105,000 acres, including 18 different pastures. The Central Plains Experimental Range includes 30 pastures totaling 9,500 acres. At Mandan, North Dakota, and Miles City, Montana, the acreage involved is 1,200 and 1,800, respectively. In the humid regions land required for pasture experiments is much less, with individual pastures usually varying in size from one-half to 4 acres. Small plot studies involving plots about 6 x 20 ft. in size are conducted at a number of locations.

In the Forest Service program a network of 15 major experimental ranges or field laboratories forms the backbone of research

on management and improvement of range lands for maximum production of forage, livestock and livestock products. One or more of these field laboratories is located in each of seven major native vegetation types of the western and southeastern United States of America used for grazing by livestock. Each of these, in addition to providing centralized locations for field research, provides demonstration in grassland management and improvement.

The Soil Conservation Service assists farmers and ranchers in approximately 2,650 soil conservation districts in the United States. These districts cover four-fifths of the farm and range lands in the country, including more than 90 percent of individual farms and ranches. The basic purpose of the program is to assist bringing about adjustments in land uses and treatments and in the use of water and forage resources, establishing a permanent and balanced agriculture, and reducing the hazards of floods and sedimentation. This purpose is served by the development of a well rounded, co-ordinated program of soil, water and plant conservation and land use. The program involves making conservation plans for individual farms and ranches, assisting groups of landowners in improving facilities for the use and disposal of water, work with soil conservation districts and on watersheds and other use areas; and the application and maintenance of all known adapted conservation practices and treatments on the different kinds of land in accordance with their needs and capabilities as shown by detailed land capability surveys. Approximately 2,500 technicians are specifically employed to help farmers under the Soil Conservation Service program.

Emphasis on research in grasslands is placed on development of superior varieties, improved cultural, production and management practices, and better methods of seed production. Basic studies of plant diseases, physiology, breeding behavior, and other factors of forage plants related to their improvement and culture are stressed. Research is under way on species and species combinations to meet the wide variety of climate, soil, and use conditions throughout the country; methods of establishment, culture and management to provide the most economical and stable returns with various species and under different conditions; methods of weed and brush control in pasture and ranges; measures for the control of hazards to stands and production such as diseases, insects, unfavorable weather, and misuse by man or the grazing animal, and methods of harvesting and preserving forage for subsequent use in adverse or stress periods. Closely coupled with the demand for improved varieties has been the need for rapid increase of seed of new varieties in sufficient volume for general use on the farm.

It is not feasible to list all significant accomplishments in the

grassland improvement program and the following are merely indicative of the progress from recent studies in the United States.

Spectacular increases in yield are being obtained in improved pastures and ranges through the use of more productive species combinations, improved varieties, renovation, adequate fertilization, better grazing management, and other techniques developed by research. Increases in production of 4 to 6 — fold are not common. From this research program have come deep-rooted, tall growing, productive grasses and legumes such as brome grass (*Bromus inermis*), Ladino clover (*Trifolium repens* var. *giganteum*), and alfalfa for the northern part of the East; orchard grass (*Dactylis glomerata*) and Ladino clover for the middle latitudes; tall fescue (*Festuca arundinacea*), Ladino and crimson clovers (*Trifolium incarnatum*), Bermuda grass (*Cynodon dactylon*), Dallis grass (*Paspalum dilatatum*) and Bahia grass (*Paspalum notatum*) for the South, and crested wheat grass (*Agropyron cristatum*) and other wheat grasses for the West. Notable among improved strains of these species are: Lincoln brome grass; Pilgrim white clover (large type similar to Ladino); Dixie crimson clover; Ranger, Buffalo, Atlantic, Williamsburg, Narragansett and Vernal Alfalfa; Coastal and SuwaneeBermuda grass; Nordan crested wheat grass.

Birdsfoot trefoil (*Lotus corniculatus*) is becoming increasingly important as a legume in hay and pasture. In many areas, it has given better stand survival than Ladino clover and the bloat problem is less acute. At the Dixon Springs, Illinois, station, after two successive dry years, birdsfoot was one of the few pasture legumes which survived and it produced over 3 tons of dry matter per acre. Lambs fattened on this pasture for early market sold in June for $ 29.50 per cwt. Lambs on pasture grass alone did not fatten and were sold the following autumn, after feeding, for only $ 20.00 per cwt.

Dallis grass (*Paspalum dilatatum*) is one of the most important perennial pasture grasses in the South, but its usefulness is limited by its total susceptibility to the ergot fungus. Because of this susceptibility, seed supplies of Dallis grass are limited and there is danger of ergot poisoning of livestock. The Mississippi station is making good progress in the development of seed producing and ergot-resistant strains. Progeny from a Dallis grass x *Paspalum malachophyllum* hybrid have proved to be highly resistant to ergot.

Fundamental taxonomic, physiological and ecological studies are contributing to the understanding of factors responsible for range deterioration or improvement, of relationships between climatic variation and plant growth, and to the development of improved grazing practices.

Research on range measurement techniques seeks to develop methods for the appraisal of grazing capacity, the relative condition

and trend, and other features of range lands essential to evaluation, management and improvement of such lands. An objective method for determining range condition has recently been developed by technicians of the Soil Conservation Service.

Pasture renovation by thorough working of the sod, fertilizing and seeding to produce tall growing species mixtures, such as orchard grass-Ladino clover, brome grass-alfalfa, or Bermuda grass-clover, greatly increases total production and distribution of production. Research has shown that renovation can more than double production from unimproved pastures. The quality of forage is improved by the introduction of nutritious grasses and legumes and by fertilization.

Dryland seeded pastures decrease in productivity, even though maintaining stands, as they become older. The Wyoming Station (co-operative USDA) learned that crested wheat grass (*Agropyron cristatum*), Russian wild rye (*Elymus junceus*), and western wheat grass (*Agropyron smithii*) respond to severe renovation as well as to applications of nitrogen. The degree of response, however, is directly related to the amount of spring moisture. The combination of renovation and fertilization gives higher production than either fertilization or renovation alone. In years of low amounts of spring moisture the increased production does not pay for the cost of applying fertilizer, but with ample rainfall a new gain of more than $ 15.00 per acre above the cost of the fertilizer and its application is obtained.

An awakening to the fact that species with high yielding potential will respond to relatively large applications of fertilizer and that plant feeds applied to pastures will give as economical returns as such applications on cultivated crops has been a big step forward in pasture improvement. Coastal Bermuda grass (*Cynodon dactylon*), fertilized with 200 lb. per acre of nitrogen, has produced over 700 lb. of beef per acre. Species such as Ladino clover and alfalfa are potash-loving plants, and recent studies have shown greater response to potash than to phosphate on many soils. In some of the range areas of the West, sulphur and nitrogen have given outstanding results.

Research on mountain meadows by the Colorado station now suggests the possibility of producing " super hay " which may take the place of costly protein supplements in winter feeding. Controlled irrigation and the application of 480 lb. of nitrogen per acre produced hay containing 2,400 lb. of crude protein per acre. If further feeding tests prove to be satisfactory, it may be possible for ranchers to set aside areas of their meadows to raise the high protein hay and thus avoid the necessity of buying protein supplements.

The importance of knowing the reaction of all types of forage plants to fertilization is shown by studies at the Oklahoma Station

where it was found that the influence of fertilization on the quality of protein varies in different plants. With Sudan grass (*Sorghum sudanense*), although the yields were greatly increased by fertilizers, the relative amounts of the principal amino acids remained essentially the same. On the other hand, fertilization of alfalfa brought about a substantial variation in the leaf/stem ratio and, since the composition of the leaf and stem protein differs, the composition of the whole plant is affected by fertilizer treatments.

The irrigation of pastures in humid areas is a comparatively recent development but recent research has shown that supplemental irrigation plays as important a part on pastures as it does for cereal or row crops. The Indiana station found no difference in animal daily gains on irrigated and non-irrigated pastures, but a heavily grazed irrigated Ladino clover-brome grass pasture produced about 500 more sheep-days per acre for the grazing season than did a similar non-irrigated pasture.

During an exceptionally dry pasture season the North Carolina station found that supplemental irrigation increased milk production 35 percent, total digestible nutrient yield 109 percent, days grazed 70 percent, and carrying capacity 100 percent. It is pointed out, however, that only high yielding, well fertilized pastures can be irrigated profitably.

The Massachusetts station has reported that, by applying adequate potash, increases of 30 to 80 percent in hay production were obtained for the first 3 harvest years. Although liberal amounts of potash fertilizer were applied 3 times each year, the grasses studied removed 79 to 94 percent of the application during the 3 years.

Perennial and annual weeds result in approximately 9% reduction of potential forage yield on the 1,200 million acres of pasture and range lands in the United States of America. Research has shown that a 20 to 60 percent increase in forage production will result from the chemical control of weeds on infested pasture and range lands.

Recent results on salt-desert-shrub winter ranges in Utah and ponderosa pine ranges in Colorado continue to confirm that moderate grazing (50 percent or less of current production of desirable native range plants) plus other good grazing practices improve the forage cover, nearly double the income, and control undesirable range plants.

Development of methods for managing and improving range grazed by herbivorus big game animals and correlation of this use with grazing by livestock is being studied. General principles applying to intensity of range use by livestock also apply to range used by big game animals. Big game and livestock use, in common, many of the same plants and range areas, but the degree

of competition varies with animal and plant species, and season and intensity of use. All of these factors must be considered in determining optimum stocking for either game or livestock, and in manipulating the forage supply through management.

Research on grazing influences shows that grazing of lands useful also as timber producing lands or watersheds (catchment areas) may require additional consideration of the grazing practices or timber harvesting practices for optimum production of timber, water and forage. Research on the relation of grazing to rodent population has shown that grazing practices may influence these populations and, in turn, the impact they may have on range grazing capacity.

An intensive series of studies in Colorado and New Mexico showed that as ranges improved in condition as a result of conservation management the green feed season is lengthened, calf crops are higher, calf ages are more uniform, individual cow and calf weights are heavier, and the gross yield of beef is invariably increased. The average of all ranches studied showed that those in poor condition produced 405 lb. of forage and 8 lb. of beef per acre. Potentially similar ranches with their range in good condition produced 1,026 lb. of forage and 14 lb. of beef per acre, an increase of 253 percent in the forage yield and 175 percent in beef production.

After 20 years of federal range management under the guiding principles of the Taylor Grazing Act, the major destructive uses of the public grazing lands have been eliminated. An outstanding example of the results of effective range management has occured on the Nipple Rim area of Colorado Grazing District No. 6. A detailed study indicated that over a 13-year period from 1937 to 1950, with range use in accordance with grazing capacities and proper seasonal use, the downward trend of forage values and ecological plant succession occurring prior to managed grazing had been stopped. An upward trend was being maintained in quality and quantity in forage. An outstanding increase in abundance, vigor and distribution of grass species in all range types was the earliest significant response to proper management. In some places grass increased at least tenfold. The protective cover developed by increased vegetation has had a marked effect on reducing surface run-off of water and increasing percolation. Litter and humus are building up, raw draining channels are becoming sloped and covered with perennial vegetation, and head cutting of gullies has been slowed or stopped.

The Nebraska station compared lactating cows on an irrigated Ladino (*Trifolium repens* var. *giganteum*) — brome grass (*Bromus inermis*) pasture with a comparable group in dry lot. The pasture saved 5 lb. of hay, 35.9 lb. of silage, and 4.1 lb. of grain per

cow day and these savings amounted to $ 114.00 per acre for the grazing season.

A federal forage crop improvement program in the United States of America is divided into research projects devoted to breeding, and cultural work in each of the following fields: (*i*) soybean; (*ii*) alfalfa; (*iii*) clovers (*Trifolium* and *Melilotus* sp.), (*iv*) grasses, (*v*) lespedeza (*Lespedeza* sp.) lotus (*Lotus* sp.) and southern legumes, (*vi*) pasture and range production in humid areas, (*vii*) pasture and range investigations in arid and sub-humid areas, and (*viii*) foundation seed production. Federal workers are encouraged to conduct fundamental studies on methods of breeding, cytogenetics and other pathological and physiological investigations, directed toward assisting or stimulating applied breeding breeding work at state experiment stations. Many federal personnel are located at state agricultural experiment stations and their programs are supported to varying degrees by state funds. Although the type of federal program conducted at a given location varies with needs and conditions these programs are initiated on the premise that federal personnel have regional responsibilities and consequently any breeding work should be directed towards the region in which they are located. Regions will generally involve several states or more restricted areas depending on climate, soils and the species involved in the program. Active co-operation among state-supported grass and/or legume breeding programs and the co-operative state-federal programs mentioned above is encouraged. Co-operation is realized through conferences and the exchange of reports and experimental material, and by virtue of the fact that federal workers are located at state experimental stations.

At the present time breeding work is in progress in the United States of America with the following legumes:

Alfalfa (*Medicago sativa*)	Soybeans (*Glycine max.*)
Lespedeza cuneata	Sweet clover (*Melilotus sp.*)
L. stipulacea	*Trifolium incarnatum*
Lotus corniculatus	*T. pratense*
Lupinus sp.	*T. repens*
	T. subterraneum

The main grasses that are receiving attention include:

Andropogon gerardi	*Bouteloua curtipendula*
Agropyron cristatum	*B. gracilis*
A. intermedium	*Bromus inermis*
A. trichophorum	*Bromus carthaticus*

Buchloe dactyloides
Cynodon dactylon
Dactylis glomerata
Elymus junceus
Eragrostis sp.
Festuca arundinacea
Lolium multiflorum
Oryzopsis hymenoides
Panicum virgatum
Paspalum dilatatum
Paspalum notatum
Pennisetum glaucum
P. Purpureum
Phalaris arundinacea
Phleum pratense
Poa pratensis
Sorghastrum natuna
Sorghum halepense
S. sudanense
S. vulgare

Plant introduction is basic to, and forms the initial step in, grass and legume breeding. There are at least two principal reasons for this emphasis on plant introduction. Firstly, a considerable portion of the livestock industry in the United States of America is based on legumes and grasses introduced from other countries. All of the 40 to 45 major legume species and approximately two-thirds of the 80 or so major forage grasses used on improved pastures were introduced into the United States from foreign lands. The range land of the great plains and western intermountain states consists primarily of native species, but thus far introduced grasses have been used more extensively in re-seeding abandoned farmland and deteriorated range than have the native species. Naturally, there is a good expectation that new introductions can result in bringing other valuable species to the farmers and ranchers of the United States. Secondly, the large number of forage species together with limited personnel and financial support, means that concentrated breeding work cannot be devoted to each and every species. At the present time breeding work with some important grasses and legumes is very limited and many species are not receiving any attention whatsoever. Introductions provide an avenue for isolating superior strains in the absence of organized breeding programs.

Interspecific hybrids have been obtained between *Paspalum dilatatum* and *Paspalum malachophyllum* which have given rise to Dallis grass segregates that are immune or highly resistant to ergot (*Claviceps paspali*). Johnson grass (*Sorghum halepense*) — sorghum (*Sorghum vulgare*) hybrids have led to the production of perennial sorghum types and sweet Johnson grass lines. Selection work is continuing with the ergot-resistant Dallis grass lines while seed of the experimental Johnson grass-sorghum hybrids was to be distributed for testing in 1955. Hybrids have also been obtained by crossing *Lolium multiflorum* and *Festuca elatior* and *Lolium perenne*. These hybrids are sterile, but results suggest that it should be possible to restore fertility by utilizing colchicine. The objective of these programs is the production of fescue strains

which are vigorous and palatable. Many other examples could be listed here, including a wide variety of crosses among species of *Poa* and *Dactylis*. In addition, some work has been done with *Agropyron-Triticum* hybridization but in common with similar programs in other countries, most of this work has been directed towards wheat grass improvement. Continuation of this work will emphasize the development of forage types. Other *Agropyron* hybrids, especially *Agropyron-Hordeum* and *Agropyron-Elymus*, are in the process of being examined for possible economic utilization. A natural hybrid between *Oryzopsis hymenoides* and *Stipa viridula* has been increased and is being evaluated in regional tests.

Interspecific hybridization in the leguminosae has been discouraging. Hybrids have been difficult to obtain and where crosses have succeeded, the resulting hybrids either fail to develop or are highly sterile. Nevertheless, interspecific hybridization in the legumes present some fascinating possibilities and should be expanded. Thus, it has been possible to transfer the low coumarin genes of *Melilotus dentata* to *Melilotus alba*. The cross between *Melilotus alba* and *Melilotus dentata* is successful, but the resulting hybrid seedlings are deficient in chlorophyll and do not develop beyond the cotyledon stage. Hybrids have been grown to maturity, however, by grafting them on to stalks of normal plants. The culture of these hybrids has provided a source of low coumarin that has been incorporated successfully into sweet clover breeding programs.

After a new variety has been developed serious problems may arise in producing satisfactory supplies of breeder and foundation seed to initiate a substantial increase of certified seed for farm use. Until recently some rather promising varieties were developed which eventually passed out of existence because of the lack of sufficient seed stock.

In 1948, the National Foundation Seed Project was established in the Forage and Range Section of the U.S. Department of Agriculture with the express purpose of facilitating the multiplication of seed of improved forage crop varieties. In this program breeder seed of accepted varieties is allocated to seed producing states where foundation seed is grown under government contract. Production goals for a given variety are determined by estimates of possible seed usage in the regions where the variety is adapted for forage. Varieties must be recommended to the planning committee of the National Foundation Seed Project by a regional forage crop technical committee and this recommendation must be supported by evidence of superiority. The planning committee includes two representatives designated by each of the four regional forage crops technical committees, two from the International Crop Improvement Association, two from the American

Seed Trade and four from the U.S. Department of Agriculture. This project provides a means whereby promising varieties can be increased rapidly and the seed made available to farmers interested in using them. At present there are five alfalfa varieties, three red clover (*Trifolium pratense*) varieties and one sudan grass (*Sorghum sudanense*) in the project and there was a good possibility that an orchard grass (*Dactylis glomerata*) variety would be added in 1955.

Through the allocation of breeder seed to regions that are well equipped and suited for seed production, it has been possible to bring about a rapid increase in the available supply of certified seed. The progress in building seed supplies of Vernal alfalfa under the auspices of the Foundation Seed Project will serve as an example of what planning can do to shorten the time between the release of a new variety by an agricultural experiment station and the time when seed is available to the consuming farmers. Vernal was approved by the planning conference of the Foundation Seed Project in February 1953. Foundation seed fields were established in Utah and Washington in April of that year. At the same time, 10 lb. of stock seed were planted in California for certified seed production. In six months there were 7,888 lb. of foundation Vernal from a 31-acre field in Washington and 6,400 lb. of certified seed from California. The foundation seed was allocated by the planning conference of the Foundation Seed Project to states interested in producing seed of this variety. As a result of this co-operative effort, approximately two million lb. of certified Vernal alfalfa seed was made available in 1954 — 18 months after the initial plantings were made with breeder seed. In 1955, an estimated six million lb. of certified seed was produced. This rapid increase of certified seed contrasts sharply with the slow increase that was possible prior to the initiation of the Foundation Seed Project. Certified seed supplies of Ranger and Buffalo alfalfa can be cited as further evidence of the program's value In 1949, the production of certified Ranger seed was 1,101,250 lb. while in 1953, there were 27,160,000 lb. of certified seed. The increase in Buffalo alfalfa was from slightly over 300,000 lb. in 1949 to almost nine million lb. in 1953.

A grassland problem of particular concern to Argentina, Brazil, Paraguay and Uruguay is the lack of winter-growing species in the natural pastures of Northern Argentina, Southern Brazil, Paraguay and Uruguay. There is generally adequate grazing in these natural pastures in the spring, summer and autumn, but the winter period is critical. Cattle which gain up to 440 lb. from spring to autumn may lose half of this gain in weight in the subsequent winter, and it usually takes 4½ to 5½ years for steers to reach a market weight of 1,100 lb. Research on indigenous

and exotic species suitable for winter grazing would, in association with fodder conservation programs, contribute greatly to the solution of the problem.

Conservation of Fodder as Silage and Hay

In tropical regions where there is a marked variation in growth between the wet and dry seasons, conservation of forage constitutes one of the important means by which the shortage of grazing in the dry season may be offset. In other areas, such as the one mentioned at the end of the previous section of this chapter, livestock producers are more interested in the possibility of provision of winter grazing, but also have a definite interest in fodder conservation to supplement winter grazing and to meet emergencies.

In either type of area there are special problems related to silage crops adapted to growth and conservation in these areas, to legumes which may be used in silage to increase the protein content of the ration, to efficient methods of harvesting, to the use of preservatives in silage making, and to feeding practices when silage is used. The costs of harvesting and of feeding silage must also be taken into account in relation to the advantages gained through more adequate feeding. Much interest was expressed in this subject at the Baurú meeting and participants in the Buenos Aires meeting were, therefore, asked to present new information on the developments in their countries. That information is summarized in the following paragraphs.

In *Argentina*, silage production and preservation in farm practice includes the use of maize, alfalfa, sorghums and grass/legume mixtures. The types of silos used vary with the zones of the country and the character of the subsoil. Temporary silos of the stack type are commonly used where there is a relatively impermeable clay subsoil. Trench silos are used in dry or well drained soils and the material may be stored for many years as an emergency fodder reserve. Tower silos are rarely used apart from certain dairy farms. It is essential to mechanize the harvesting and transporting of the green material to reduce the cost of the operation. Crops to be ensiled should have a high yield per unit area and silage quality is higher if the crop is free of weeds. Efficient use of pastures in Argentina often involves making of feed reserves, such as silage, during the lush periods. For example, in the Province of Buenos Aires there are two production peaks in alfalfa during the year, the more important in the spring and the other in the autumn. Production reaches the lowest level during the winter. Thus, storage of surplus forage during the spring is essential if a constant number of animals are to be fed more or less

uniformly during the year from a given land area. Variations in protein content of several crops used for silage in Argentina are shown in Table 15.

TABLE 15 – PROTEIN CONTENT OF VARIOUS SILAGES IN ARGENTINA*

Crop	Stage of Growth	Crude Protein	Digestible Protein	Moisture	Digestible Protein in Dry Matter
		..... Percentage			
Mixture of alfalfa, whiteclover, and rye grass *Bromus catharticus* and *Phalaris minor*	Grasses and legumes blooming	5.35	1.29	52.10	2.69
Mixture of alfalfa and *Bromus catharticus*	Blooming	4.65	1.65	73.41	6.20
Alfalfa	Blooming	7.35	2.73	67.40	8.37
Weedy cut of Alfalfa	Blooming	5.58	2.75	67.10	8.35
Sweet Sudan	Ripe grain	1.97	0.45	82.25	2.53
Sweet Sorghum		2.92	0.85	75.50	3.46
Silybum marianum	Before blooming	2.59	0.71	83.00	4.17
Peas (plants and pods)	Green grain	3.84	2.35	69.00	7.58

* Analysis made by Ing. Agr. M.A.L. Reichart

In *Chile*, there are great variations in climatic conditions, both from high to low altitudes and from the north to the south of the country. In the irrigated valleys many tower silos had been built with government credit, but there is now some question as to whether pastures with cool season species, properly fertilized, may not make silage unnecessary. Silos are of particular value in the cold climates with long winter seasons; it is, however, always desirable to attempt to produce pastures particularly suitable for winter grazing before undertaking the making of silage.

In *El Salvador*, the principal problem in the production of cattle is their maintenance during the severe part of the dry season extending from January through April. During this period the cattle suffer severely from lack of forage and water, often becoming very emaciated and sometimes dying. There are abundant rains from May to October and light rains from October to January. While it is a common practice to move cattle from the highlands to the fertile lowlands during the dry season, some progress has been made in the use of silos to store a part of the green forage during the rainy season to feed the animals during the dry season. As part of a campaign started by the Agricultural Extension Service in 1948, agents help in planning and filling the silos and

return for the opening of new silos to advise the farmers on the use of silage. Guinea grass (*Panicum maximum*), Yaragua (*Hyperrhenia rufa*), Para (*Panicum purpuroscens*), elephant grass (*Pennisetum purpureum*), corn, sorghum, pigeon peas (*Cajanus cajan*) and frijol criollo (*Phaseolus* sp.) are being used. The legumes are always used with grasses such as sugar cane tops, and sorghum. Trench silos are commonest because of their low cost. Beginning with one silo in 1948, the number built has increased each year until 1954 when 39 were built, making 111 in all. It is believed that there are an equal number which have not been supervised and counted by the Extension Service, There is no longer a prejudice against the use of silage and dairymen and consumers no longer suffer from a marked shortage of milk during the dry season.

No silage is made in *French Guiana.*

In *Panama*, the crops used for silage include: maize, sorghum, beans, kudzu (*Pueraria javanica*), *Crotalaria*, Guatemala grass (*Tripsacum dactyloides*), Para grass (*Brachyaria purpurascens*), Guinea grass (*Panicum maximum*), imperial grass (*Axonopus scoparius*) and Yaragua grass (*Hyperrhenia rufa*). The best months in which to make silage are October and November, towards the end of the rainy season.

The *United States of America* had, according to the 1950 census, 680,000 silos, 90 percent of which were tower silos and the remainder chiefly trench silos. The average capacity was 103 tons. Crops ensiled include maize (73 percent of all silage), grass crops (9 percent) and sorghum (of great importance in the dryland areas of the Great Plains and the South). Attempts made to self-feed silage from the base of tower silos have not been entirely successful; some degree of mechanization has been successful in top unloaders and bottom unloaders. Extraction of silage from trench silos is efficiently effected by means of hydraulic manure scoops to load the material into wagons or trucks for transport to the livestock. Many operators are self-feeding silage from the trench by means of a movable barrier at the face of the silage.

Results published by the U.S. Department of Agriculture (Shepherd *et al.*, 1954) have shown the increased efficiency of making the alfalfa crop into silage rather than hay; about 12 percent more milk per acre can be produced. When the hay suffers damage by rain, about 28 percent more milk was produced due to greater retention of the leaves in the crop. The result has been a higher content of total dry matter, protein and carotene in the silage than in the hay, with equivalent demands on motor and manpower.

The use of chemical preservatives is now receiving considerable attention in the United States of America, Recently a commercial

product named " Kylage " has become available, produced under patent rights and similar to a German product " Kofa. " It consists largely of a mixture of calcium formate and sodium nitrate.

In many parts of the United States, silage made from hay crops is being used to supplement pastures during periods of low rainfall in the summer, thus providing a more uniform level of feeding and leading to increased livestock production.

The making of hay is very difficult under tropical conditions. However, it is of such potential importance that efforts should be made to develop the special techniques which may be necessary. Such methods might be based on the utilization of the great heat of the sun's rays, while at the same time ensuring protection for the herbage against their direct influence, to prevent loss of carotene. The storage of baled hay through a rainy season frequently presents special difficulties in the tropics. In studies of hay making and the use of hay, three problems should be considered:

(1) the need to cut the grass while it still has considerable nutritive value;
(2) the prevention of deterioration in baled and stacked hay due to molds; and
(3) the undesirability of excessive cutting of grasses which may eradicate them and favor weeds.

Relatively little new information on these problems or on ways of solving them is available.

In *Argentina*, there is no research specifically on hays or haymaking. Hay produced in irrigated zones is green, leafy and of high quality; hay from dry zones is poor in quality, many leaves are lost in handling, and the color is poor. Eight cuts are obtained from some irrigated land and three or more cuts from dry land, with a yield 5,500 lb. to 7,700 lb. per ha. per cut. Both the old-fashioned and more modern methods of cutting, loading and transporting are used. Alfalfa is practically the only hay crop. The effect of unfavorable weather during the haymaking season may be reduced by the use of modern farm machinery. The use of round bales practically prevents damage by rain in the field.

Haymaking, particularly of alfalfa, is most important economically in *Chile*. The methods already noted for Argentina are practised. In the colder southern part of the country, alfalfa is replaced by red clover, but the crop is frequently damaged due to variable weather conditions. Oats are used for hay in the extreme south.

In *French Guiana*, conditions are most difficult for haymaking,

particularly in the lowland areas which are accessible only in the dry season. It is not yet known whether baled hay of these swamp grasses will keep free of mold during the wet season.

In *Paraguay*, haymaking is a problem due to heavy rains and overheating of the stored material, and the whole subject requires detailed study.

In *Uruguay*, good hay can be made consistently only in mid-summer. Dews are heavy at other seasons of the year. Alfalfa is the main hay crop.

Nutritional Deficiencies in Livestock

An FAO Agricultural Study, No. 5, prepared by Allman and Hamilton (1948), brought together information from various parts of the world on the nature and incidence of various kinds of nutritional deficiencies which had been observed in various types of livestock and poultry. This Study provided the main basis for discussion at the Turrialba meeting, at which some new information on the occurrence of deficiencies in the Americas was presented, and further information was forthcoming at the Baurú meeting (Phillips, 1950 and 1953). Additional information was discussed at the Buenos Aires meeting, and an attempt has been made in the compilation of Table 16 to list the countries in which various types of deficiencies have been observed in the Americas. Obviously, this constitutes a very generalized approach, but it does indicate the scope of the problem. Some general observations, also some details concerning occurrences of deficiencies in various countries, which will be of interest to nutrition workers, are summarized below:

General Considerations

Energy shortages are not uncommon even in some sections of the most advanced countries where the level of economic development is low. They are often found in the semi-arid grazing areas, and in grazing areas characterized by dry and wet seasons, owing to inadequate feed reserves for the dry season.

Protein deficiencies, particularly qualitative deficiencies, are also responsible for slow growth rates, lowered milk yields and other troubles in many areas. Such deficiencies are apt to be found, for example, during the long dry season which characterizes much of the Pacific slope. Such deficiencies may be remedied by the use of protein-rich concentrates, or by the adoption of systems

TABLE 16 – MINERAL EXCESSES OR DEFICIENCIES CAUSING NUTRITIONAL PROBLEMS IN THE AMERICAS*

Country	Bone Diseases	Boron	Calcium	Ca/P imbalance	Cobalt	Copper	Fluorine, Excess	Iodine	Iron	Magnesium	Manganese, Excess	Molybdenum	Nitrate	Phosphate	Pica	Protein	Selenium, Excess	Sulphur	Zinc
Antigua (British Leewards)			×					×						×					
Argentina			×				×		×	×				×					
Bolivia								×											
Brazil				×	×	×		×						×					×
Canada					×			×					×	×			×		
Chile			×							×							×		
Colombia			×											×					
Costa Rica		×			×			×				×							×
Ecuador								×									×		
Guatemala	×							×											
Guiana, British			×		×		×					×		×					
Guiana, Dutch						×				×	×								×
Haiti			×		×			×	×	×				×					
Honduras			×	×										×					
Honduras, British															×				
Jamaica			×						×					×					
Mexico					×		×										×		
Nicaragua			×		×			×						×					
Panama			×																
Paraguay			×					×						×					
Peru						×		×						×			×		
El Salvador	×		×																
Uruguay			×						×					×					
U.S.A.			×		×	×	×	×	×			×	×	×		×	×	×	
Venezuela			×											×					

* In addition to conditions involving specific minerals, reports of lack of vitamin A have been reported from Jamaica and Chile, urolithic conditions in Haiti and Argentina, lack of vitamin E in Jamaica and lack of vitamin D in Chile and acetonaemia in Argentina.

of forage production which ensure either adequate grazing or an adequate supply of stored feed during the dry season.

Improper balance between energy supplies and protein still remains a problem in many areas, since such rations are often wasteful owing to inefficient utilization of the total feed supply.

The use of antibiotics in animal nutrition is a relatively new phase. Study of them has been intensified owing to conditions created by highly specialized production systems and by the need

for greater efficiency owing to increased costs of production. They have received particular attention in the United States of America. Other problems are perhaps worthy of higher priority in countries where intensive systems of livestock and poultry production are not yet in general use. The same may be said of hormones which are also receiving considerable attention in attempts to find treatments that will increase the efficiency of livestock and poultry production. At the same time, developments arising from research in these fields should be watched carefully to see where they may find effective practical application.

Much of the work on nutritional deficiencies has been related to mineral deficiencies. In this connection it is becoming more generally recognized among animal husbandmen that the mineral content and availability to plants of the minerals in the soils have an important relationship to the health of animals fed on plants grown on those soils. Also, studies of the signs of mineral deficiencies in plants are making available information of much importance to the livestock producer by enabling him to foresee from observations on the plants the deficiencies which may occur in his animals. However, such information cannot replace precise data on the mineral content of feeds and on the specific requirements of the animals.

The need for specific vitamins varies with the kind of animal. But for all, it can be said that good quality green roughage or pasture will take care of most needs. Thus, more attention should be paid to pasture improvement and management, and to better ways of conserving forage for use during non-growing periods. Ruminants, in particular, due to microorganisms in the rumen, have the ability to synthesize certain vitamins. But even non-ruminants do better if they have access to natural feeds in variety.

Care is necessary in considering the deficiency problem for several reasons. Bone chewing and other signs of apparently depraved appetite may be due to general upset, to deficiency of protein and to generally ill-defined hunger, which finds its outlet or expression in this way. The trouble may be temporary and connected with such things as the coming of new teeth in a young animal. It is, therefore, important to ascertain the true cause of depraved appetite with great attention to detail and then to remedy the trouble in the most direct and economical way.

The economics of combatting a deficiency should also be considered. Frequently, it is more economical to provide the minerals which are lacking through the drinking water or in the form of palatable licks, rather than by a direct application to the pasture.

The interconnection between minerals should also be considered. If, for example, an animal receives too little molybdenum, copper

might build up to toxic proportions. The complete copper-molybdenum story is not yet fully worked out, and it seems as though sulphur in some specific form may enter into the final picture.

The general status of the soil, including its acidity or alkalinity, may also affect not the amount but the availability to the animals of certain essential mineral elements. Similarly, minerals in the drinking water of the animals may have an effect, not only on the palatability of the water itself (thus seriously limiting normal water intake), but may affect the appetite and health of the animals and, in addition, have a bearing on mineral imbalance.

Further, it is not enough to ascertain all these things relative to improved nutrition, nor merely to publish the information in scientific, or even popular, journals. The message must be carried to the producers themselves, so that they can put the practices into common use. Search should be made for intelligent, willing co-operators to demonstrate in each community the value of the findings. Such work, and related activities in the extension of knowledge of improved methods of livestock production, opens up a whole new field for trained animal husbandmen in many countries, and one which is basic to increasing the supply of animal proteins. The problems will not be easy of solution in many areas since a chief stumbling block will be the price structure for saleable products, compared with the increased cost of obtaining the product. The stockmen should be shown, for instance, that even with no change of milk or meat prices, by adopting the improved nutritional practices, only half the number of cows will need to be milked; or that beef production per acre can be increased. It is essential, therefore, to show the producer how to increase his income, and, at the same time, keep prices within the reach of the consumer.

Observations in Countries

A type of avitaminosis in ruminants resulting from the continuous ingestion of *Cynodon hirsutus* and *C. dactylon* is rather common in *Argentina*. The HCN liberated from these species in the rumen of the animals seems to destroy the microorganisms which synthesize the B complex vitamins. The situation is aggravated following the first frosts. Affected animals have responded very favorably to injections containing a mixture of aneurin, nicotinic acid, riboflavin and adenine.

Urolithiasis is reported not to exist in some zones in Argentina, but there have been sporadic outbreaks, mainly in sheep, in certain parts of the Buenos Aires province, and in Patagonia, North of the Santa Cruz river. Grass tetany, principally in cattle, is re-

ported as occurring frequently throughout the livestock grazing area. Types of pasture giving rise to the illness are oat, wheat, barley, etc., especially when the environmental conditions favor consumption of forage with a high moisture content.

In addition, hypomagnesemia and acetonemia are reported to occur in dairy cows, as well as various non-specified vitamin deficiencies. In limited areas, a lack of iodine and cobalt affects cattle and goats; the former is deficient in certain valleys of the Province of Salta. The need for cobalt has been recognized in restricted areas of the Province of Buenos Aires, and perhaps in certain parts of Patagonia. The wool of sheep in these latter areas is characterized by brittleness which can be remedied by small doses of cobalt.

While species of *Astragalus* known to have a facility for concentrating selenium in their tissues are found in Argentina, no clinical symptoms of selenium toxicity in animals have been reported, nor was selenium found in the analyses of these plants. Also, no cases of iron deficiencies are known.

In Argentina, the appearance of " anteque seco " is reported to be related to deficiencies of phosphorus and manganese in the native pastures. Affected animals reacted favorably to mineral supplements at the rate of 5 g. of sodium acid phosphate (Na_2HPO_4) and 0.2 g. of manganese sulphate per head per day.

In *Brazil*, information has been recorded concerning the State of Piaui, where it has been most dry for three or more years, showing that many diseases described, as Broca, Oca, Mal da Ponta, Mal do Chifre, etc., all have the same syndrome. It has been suggested that all have a common cause in a nutritional deficiency; the area may be deficient in zinc, copper and probably cobalt. Post mortem examination and analysis of livers and spleens of cattle indicate a copper deficiency. Incidentally, heavy internal parasitism adds to the picture of malnutrition.

In a study of infertility of cows made in the State of Minas Gerais clinical observations included hypophosphorosis. Particularly near the Municipio de Pará in the eastern part of the state, groups of cows were encountered in which several years had passed since previous calving. Most of these cows were extremely emaciated, walked rigidly, had perverse appetites and low milk production. When bone meal was offered to these animals it was consumed avidly.

The ruminant (cattle) disease, commonly known as " Chorona ," " Pela Rabo ," " Rabugem " or " Toca, " occurs in the Zona da Mata of the State of Minas Gerais at altitudes above 1,370 ft. Striking emaciation is characteristic of all the conditions described by different names. Recovery is spontaneous upon removal to new pastures. Lack of copper or cobalt or both is attributed to be the

cause, or perhaps plant toxicity. Since copper sulphate medication produced fair results, it is believed this is a metabolic disease.

Congenital goiter is frequent in Minas Gerais State, especially in calves. Mineral supplementation or tincture of iodine treatment resolves the problem.

Deficiencies of Vitamin A and D have been reported in the North and Central Zones of *Chile*; lack of vitamin A in cattle, together with deficiencies in calcium and magnesium; and avitaminosis and mineral deficiencies in fowls in the southern zones. Specific local deficiencies have not yet been determined, although it is possible that they exist. Forage, both natural and introduced, in the various zones of the country, is being analyzed with a view to determining its mineral and vitamin content.

In *Ecuador*, numerous cases of osteoporosis and osteomalacia, indicating a Ca/P imbalance, have been reported; goiter in sheep has been reported at 8,230 ft. Sulphur may be lacking, as had been indicated by improvement observed following its administration in sulphurized salt blocks. The main experimental work being done is concerned with methods of overcoming the deficiencies, and so far the best results at lower elevations appear to come from injections of phosphorus calcium gluconate.

In *El Salvador*, the animal scientists are getting some of their answers from the plantsmen. Agronomic studies indicate that forage grasses are not only deficient in nitrogen, but also in trace minerals such as manganese, cobalt and zinc. The addition of these fertility elements to the soil materially improved plant growth. Iodine is lacking, as evidenced by goiter in humans and hairlessness in young pigs. However, data on which to base conclusions are meager, not only on stock feeds, but also on soils.

Reports from *Guatemala* indicate a number of areas deficient in one or more of the essential minerals, as determined from blood serum studies. Because the problem is complex and time consuming, no other actual research has been carried out. However, a practical solution has been successfully arrived at through the use of a mineral mixture that contains all the required elements. Continued observations show that goiter is a real problem in the Guatemala highlands. In humans, both potassium iodine and potassium iodate effected marked reduction of endemic goiter.

In *Haiti*, no direct relationship has been established between soil and plant composition and animal nutrition problems. Nevertheless, it is reported that, in a general way, Haitian soils are high in calcium and deficient in phosphorus and potassium. Animals suffering from a lack of potassium have been observed in a considerable area between Declay and Cap Haitien on the north coast, and in the drainage area behind Hinche (Papaye Breeding Station) in the north central region. Other areas reported as

calcium deficient are found around Kenscoff and behind Miragoane; on the other hand, at Anse a Pitre, a calcium excess is reported in the soil. Salt areas (and thus highly alkaline) have been observed around Port-au-Prince and on the shores of the Artibonite delta. Where soil composition is known in the Artibonite Valley, calcium is definitely in excess, and potassium and phosphorus deficient. In the Camp Parrin and Les Cayes region, where soil minerals have also been studied, phosphorus, potassium and calcium are deficient.

Reports from *Honduras* indicate that animal nutrition surveys are quite incomplete. In general, the soils of the country are low in phosphorus but sufficient in potash. Indications of mineral imbalance are reports of cases of grass tetany and non-pathological abortions in cattle. On the north coast, animals drink water high in calcium obtained from deep wells. Evidences of osteomalacia have been reported, indicating a Ca/P imbalance. There is also some reason to believe that certain other animal losses may be due to minor element deficiencies, or to maladies associated with lack of minerals. A new laboratory for the analysis of soils, plants and animals has recently been established, which should be invaluable to the work of animal improvement.

Mexico, like most large countries, has a wide variety of conditions. No general account of the soils seems available, although rather complete analyses are at hand for at least two areas — the Comarca Legunera in the western part of Jalisco State, and a region in the north comprising parts of Durango and Coahuila states. In an extensive area around Salinas, lambs have died with symptoms indicative of a cobalt deficiency. This malady only appeared as the local sheep type was being changed to the more robust Rambouillet, through a grading-up program. Here, a very significant point exists. A most important aspect of adaptability is concerned with local breeds and types which, through the centuries, have accustomed themselves to a certain dietary and management regime. Any sudden change, such as increased size due to grading up, will result in a higher maintenance requirement and, possibly, increased production. This gives rise to a need for more nutrients which, if not supplied, will cause a general upset in the organism as it attempts to meet these demands. If the environmental level (nutrition and proper management) changes concurrently, uninterrupted progress can be expected. Thus, there is a very real need for the animal breeder and the animal nutritionist to work together most closely.

Northern South America may well offer most excellent opportunities for livestock development because of year-round grazing. However, a real deterrent under present conditions is the lack of knowledge of the mineral needs of forages and animals. The

Guianas represent an area about which little is known from the standpoint of animal nutrition.

In *Surinam*, which is part of this area, it is suspected that mineral deficiencies exist. As an insurance, it is becoming a common practice to feed all cattle a rather complete mineral supplement. On the plant side, on heavy clay soils no deficiencies have appeared. However, sandy soils are reported generally lacking in zinc. Studies on citrus soils have revealed a shortage of manganese, copper and magnesium. A serious problem in cattle has not yet been resolved; it does not seem related to a lack of copper or Vitamin A. During long periods, cows fail to come into heat. While authorities are satisfied the problem is related to mineral or vitamin metabolism, no specific study, other than one involving unsuccessful gross therapy, has been reported.

Serious hypocalcemia is reported to occur in many parts of *Paraguay*, where soils are often very acid.

In *Peru*, feeding trials with sheep have been under way for a year in which animals fed $^1/_2$ lb. of cottonseed cake per day have showed increases in body weight, have given birth to larger lambs and have produced more milk for their lambs than the ordinary range-fed control animals.

A recent report of the Government of *British Guiana* indicates that the vast areas inland from the coast of northern South America are probably lacking in certain mineral elements. Inland savannah pastures responded tremendously to basic slag (P plus many minor elements) and Potash (K) applications. However, costs remain a problem in improvement. Locuntu grass (*Ischaemum timorense*) growing on Wallaba sand is reported to support continuous grazing of hybrid Freisian cattle. In spite of the non-use of fertilizers, *Desmodium* sp. and *Alysicarpus vaginalis* are strongly established in the swards. The region reported upon is at the junction of the Essequito and Mazaruni rivers.

In variety trials of forage crops at Ebini, sorghums millets, and *Coix lachryma-jobi* appear markedly chlorotic. However, Pangola grass makes tremendous growth in a leafy sward. Analyses made on different samples of native range, ungrazed and unburned, during the previous 18 months show P_2O_5 to range from 0.18 to 0.31 percent; CaO to range from 0.15 to 0.55 percent; and K_2O with a range of 0.08 to 0.28 percent. Presumably this is on the basis of the total ash, which varied from 6.0 to 7.0 percent. Applications of 1.2 cwt. of 36 percent superphosphate per acre raised the yield of native range grass from 8.4 to 13.0 cwts. acre on the basis of 6 months growth.

Studies made at the Rothamsted Station in England on brown sand soils from the Ebini station gave the following analyses in parts per million: Cr 45; Ni 40; V 50; Mn 90; Mo 4; Yt 5; Sn 10;

CO 5; Pb 50; Cn 8. Workers in the country believe cattle exhibit a phosphorus and cobalt deficiency. Without doubt, these areas in British Guiana are indicative of much of the terrain of northern South America, and while soil types need to be studied, findings would have some value for adjacent regions of Brazil and Venezuela.

The *Islands of the Caribbean* represent an interesting geologic phenomenon. Their isolation and the ancient geologic origin, except for a few which have new volcanic soils, create, at the same time, problems and opportunities in animal husbandry.

From *Jamaica*, it is reported that some work on mineral deficiencies has been done. Phosphorus deficiency is widespread except in the so-called "Blue Mountain" area of granitc rock. In the remainder of the island, excesses of calcium, aluminum and, probably, iron, set up a mineral imbalance involving phosphorus. Analyses of blood, and of soil and herbage, confirm this lack of phosphorus. Suggestions of cobalt, copper and manganese deficiency are not convincing, nor are they confirmed through feeding trials. However, there is a peculiar syndrome of cattle, characterized by wasting, stiffness of the joints, symptoms associated with impared circulation and calcification of the elastic tissue of the body, particularly of the great blood vessels and lungs, which occurs in the limited area within the *terra rossa* group of calcareous soils of the central upland, that are high in alumina and which are mined to obtain aluminum ores. The local name for the trouble is "Manchester Wasting Disease." A definite aetiology is not yet possible, but it seems to be related to a mineral imbalance. Jamaican authorities believe it identical with "Enteque seco" of Argentina (Lignières, 1912) and the Matto Grosso area of Brazil (Pardi and dos Santos, 1947). A similar condition has been described in Hawaii (Hendershot, 1942) which has long been recognized as associated with grazing in certain parts of the island. Arnold and Fincham (1950) have given a description of the conditions under which the syndrome occurs and some of the gross pathological changes. Arnold and Bras (1955) have made available further information and have described in greater detail the histological changes associated with this disease. In view of the fact that this condition has been encountered in various places in the tropics, several illustrations from the paper by Arnold and Bras are reproduced in *Figures 3* to *9* so that the details may be generally available to workers who encounter the disease.

Other diseases related to mineral metabolism appear in Jamaica. Among these are hypomagnesemia, milk fever and urolithiasis. None are common, however.

In the *United States of America*, total losses through nutritional

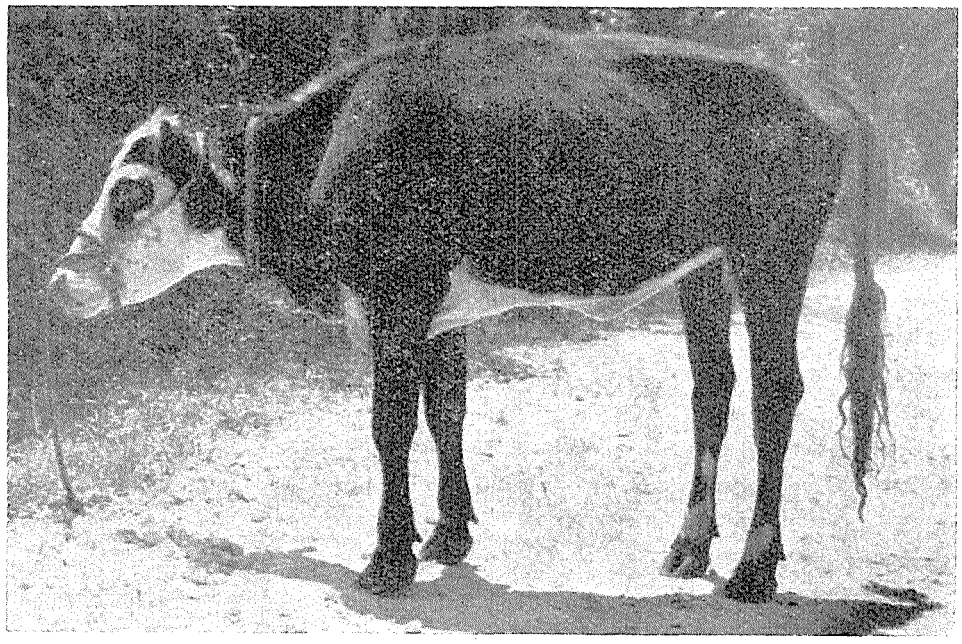

Figure 3. Heifer affected with Manchester Wasting Disease (After Arnold and Bras)

Figure 4. Gross aspects of the left ventricle and aorta in Manchester Wasting Disease, showing rugosity of aorta due to calcific deposits. The semilunar valves are thickened and rigid (After Arnold and Bras, 1955)

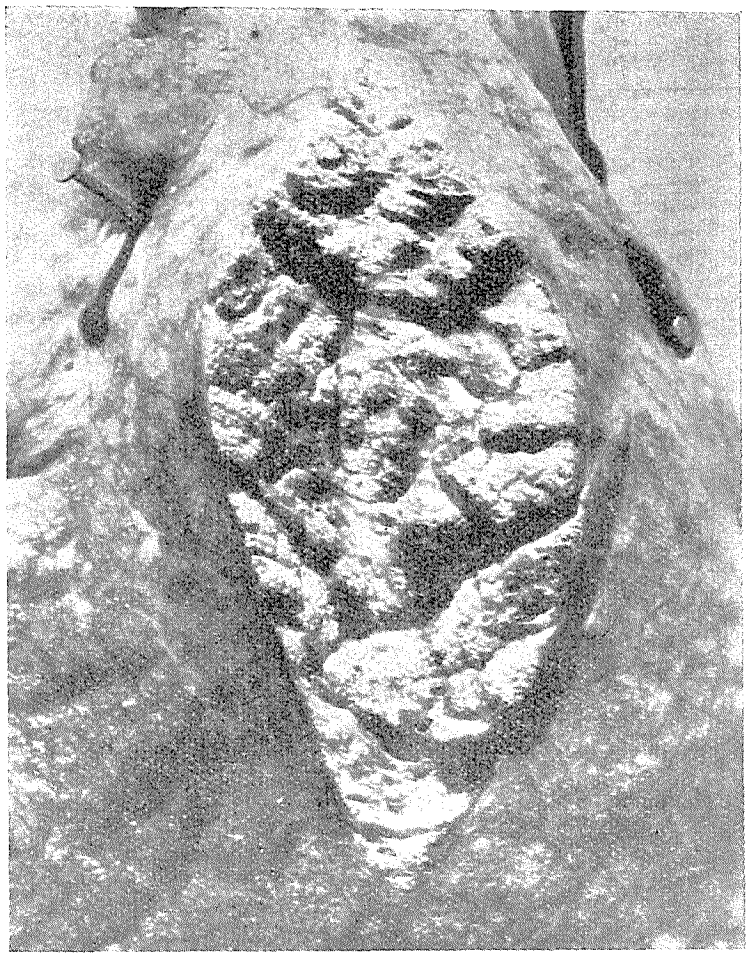

Figure 5. Gross aspect of the lung, showing calcification in Manchester Wasting Disease (After Arnold and Bras, 1955)

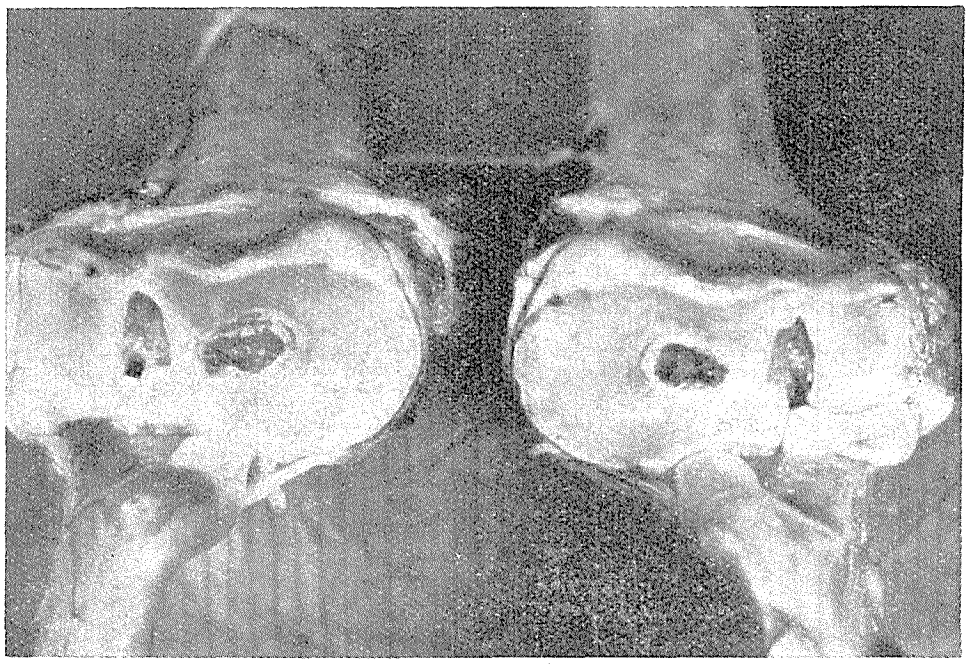

Figure 6. Ulceration and degeneration of articular surface of a joint in Manchester Wasting Disease (After Arnold and Bras, 1955)

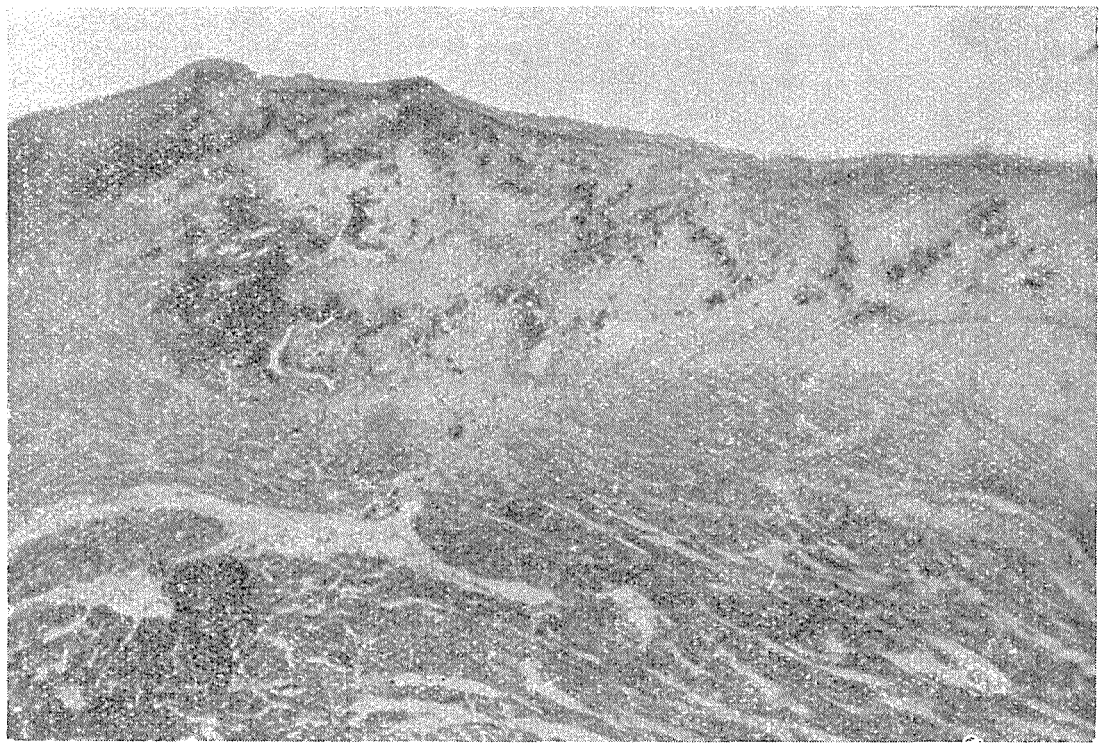

Figure 7. Cross-section of endocardium (x 43) showing sub-endocardial calcification in Manchester Wasting Disease (After Arnold and Bras, 1955)

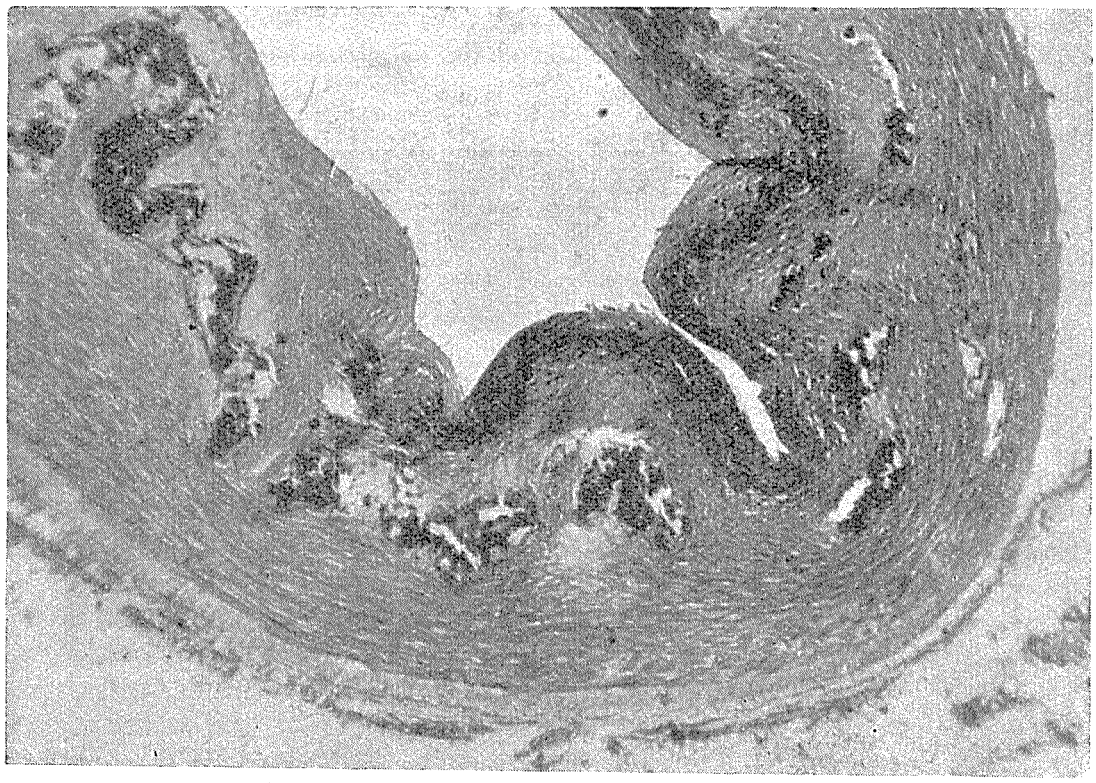

Figure 8. Cross-section of a small artery (x 43) showing calcification of the sub-endothelium and media in Manchester Wasting Disease (After Arnold and Bras, 1955)

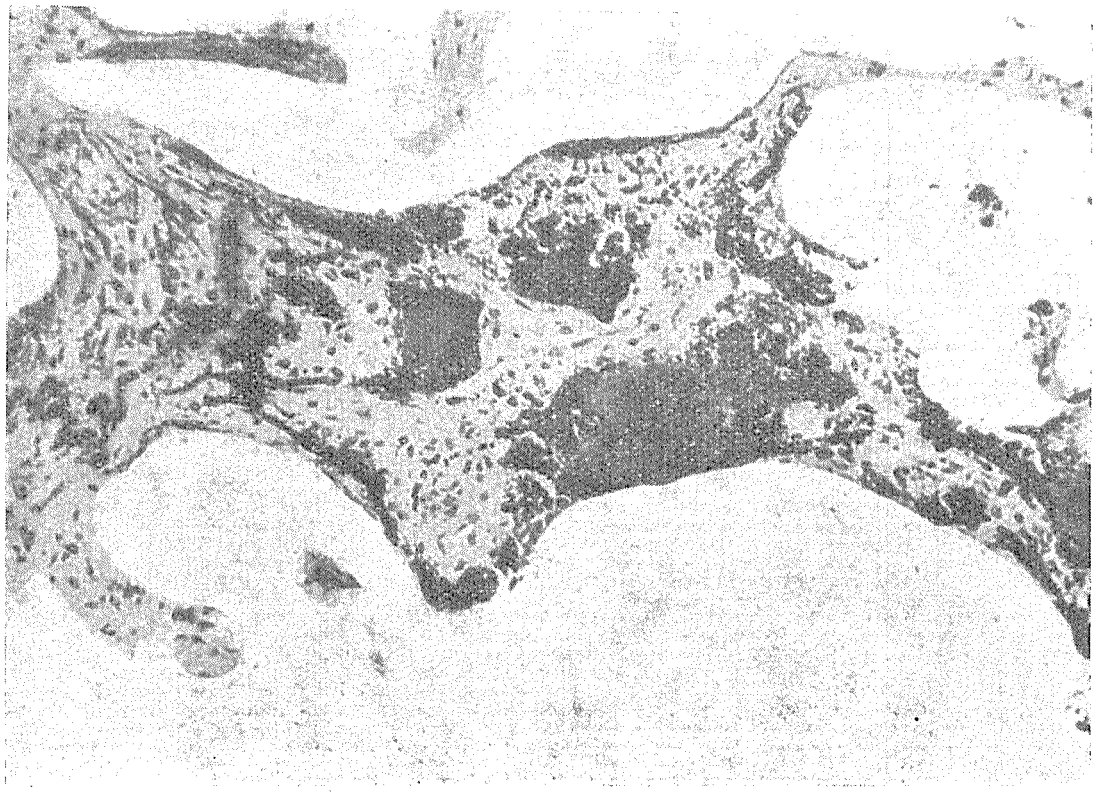

Figure 9. Cross-section of lung tissue (x 260) showing thickened alveolar septa with calcification and collagenization in Manchester Wasting Disease. (After Arnold and Bras, 1955)

deficiencies still represent large figures in financial terms, hence there is a constant attack on old and new problems of nutrition. Work in animal nutrition is carried out in all the states and territories, roughly in proportion to the size of the livestock industry in each. Numerous private organizations also contribute greatly. The results of all this research are conveyed to the people by means of federal and state agricultural extension activities, the farm press, and through private organizations, including radio and television.

Progress in the identification and mapping of nutritional deficiencies (and toxicities) has centered around the mineral nutrients. In the coastal plain of North and South Carolina, extensive surveys of soil and geological conditions, and study of the micronutrient element content of native forages, have revealed certain areas deficient in cobalt. Similar studies in New York and New Hampshire have also shown a lack of cobalt, and may reveal other trace element deficiencies.

The problem of toxicities resulting from excessive absorption of mineral elements from soils is assuming greater importance in certain portions of the United States of America. There are indications that the high manganese content of grasses in certain areas

in North Carolina may be responsible for certain ailments. Molybdenum and selenium are problems in California, Wyoming and South Dakota.

Studies in protein, energy, phosphorus and vitamins are not being neglected. The pastures and ranges in the western and southern states are often low in energy, protein, phosphorus and carotene during certain times of the year and during droughts. Farmers and ranchers are beginning to recognize these situations, and are taking action to overcome them.

The U.S. National Research Council has done much to establish and publish nutrient requirements for the several classes of farm animals, and is constantly attempting, by sponsored research, to increase the knowledge in this field. As a result, a common standard practice to correct certain mineral deficiencies, known or suspected, has been achieved by the use of mixed mineral supplements, including the trace elements. Improved reproduction and increased gains in weight have resulted. Studies on toxic minerals, such as selenium, fluorine and molybdenum, are revealing relationships which are clarifying problems. Occurrences of vitamin A deficiency have served to focus attention on the fact that green leafy roughage, or, in its lack, a vitamin A supplement, will solve this problem. Lack of vitamin D in the northern states is corrected by therapy, during the winter months, or in cases of Ca/P imbalance. A problem in lambs (stiff lamb disease), and in calves (white muscle disease) is related to vitamin E deficiency. Benefits have generally followed the use of concentrated sources of the vitamin or of vitamin E-rich feeds.

In the growing shortage (due to increased demand) of protein-rich by-product feed supplements in the United States of America the use of non-protein-nitrogen (urea) to increase or extend the supply of protein for feeding ruminants has been a subject of considerable interest.

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