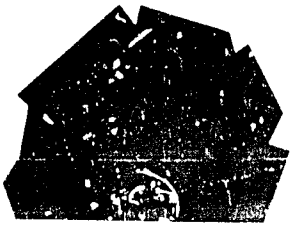

WINROCK INTERNATIONAL

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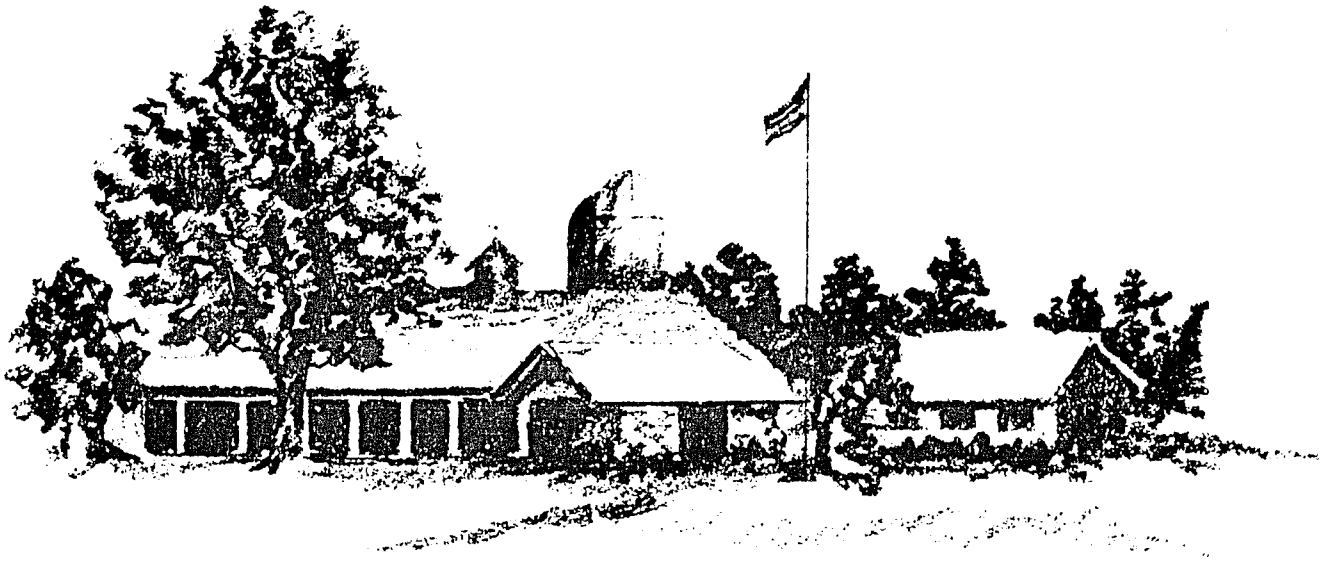
Executive Summary

The Role Of Ruminants In Support Of Man



Winrock International
Livestock Research & Training Center

Winrock International's basic mission is to support programs for the advancement of animal agriculture for the benefit of humans.

Winrock has its headquarters on Petit Jean Mountain in Arkansas (about seventy miles west of Little Rock). Extensive livestock facilities surrounding its offices were built by the late Winthrop Rockefeller, Governor of Arkansas from 1967 until 1971. It was Mr. Rockefeller's wish that the experimental operations he had begun would continue. Support was received from the Winthrop Rockefeller charitable trust to enable Winrock International to begin its operations in 1975.

Winrock is an independent, non-profit institution, not connected with any governmental, commercial or professional agency. All of its operations and financial transactions are publicly reported.

All Winrock International training and research programs are supported by its endowment and by funds from foundations, individuals, corporations, government contracts, and grants. As a publicly supported organization, Winrock International accepts and actively seeks tax deductible gifts from individuals, foundations, governments and corporate donors.

Winrock International Livestock Research and Training Center is classified as a non-profit, publicly supported organization described in Section 170 (b) (1) (A) (vi) and 509 (a) (1); exempt from federal income tax under section 501 (c) (3) of the United States Internal Revenue Code.

The Role of Ruminants In Support of Man

H.A. FITZHUGH, H.J. HODGSON, O.J. SCOVILLE
T.D. NGUYEN AND T.C. BYERLY

The Role Of Ruminants In Support Of Man, published in April 1978, reports results from a major research project by Winrock International. Objectives of this project include: assessment of the world population of ruminants, their productivity and feed requirements — with projections to the year 2000; identification of opportunities and constraints to improving ruminant efficiency and productivity; development of priorities for research, training and development programs; and establishment of a data base useful in developing private and public policies affecting ruminant livestock.

This Executive Summary — extracted from the 136-page document — provides a broad overview of the research results. It is our hope that this study will stimulate interest and action to the end that ruminants will more fully contribute to the support of man.

WINROCK INTERNATIONAL LIVESTOCK RESEARCH AND TRAINING CENTER
Petit Jean Mountain, Morrilton, Arkansas U.S.A. 72110

April, 1978

The Role of Ruminants in Support of Man — Executive Summary —

Mankind has experienced a long and favorable relationship with ruminant animals . . . That relationship is neither generally understood nor fully appreciated.

FOR nearly 100 centuries, mankind has depended substantially on ruminant livestock not only for food but also for a wide variety of byproducts and services. Ruminants supply almost all the milk and nearly half the meat consumed by people of the world. The estimated value of ruminant products throughout the world amounts to well over $100 billion annually, which really is a conservative estimate because it does not include values for work done by cattle and buffalo, the manures they produce as fertilizers, and other byproducts and services. Actually 12 percent of the world population derive their support almost entirely from ruminants because they live in areas where food crops cannot be grown.

The basis of the importance of ruminants to mankind lies in the fact that these animals can obtain their nourishment from grasses and other fibrous forage which people cannot directly utilize. In turn, they provide humans with an adequate supply and proper balance of energy, minerals, vitamins and essential amino acids which human metabolism cannot do without. The nonfood contributions of ruminants — many of which cannot be precisely estimated — are also substantial.

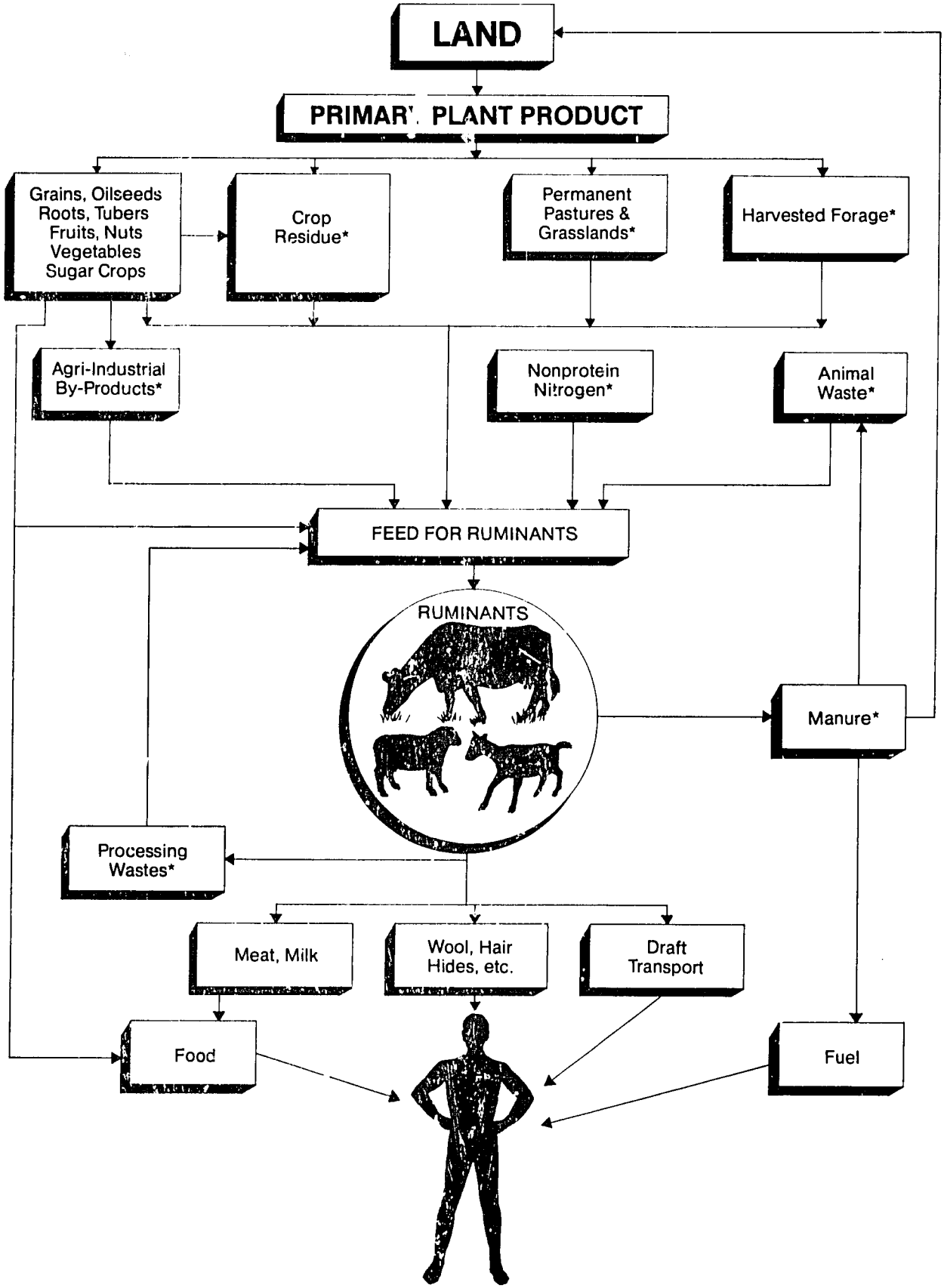
Characteristics of Ruminants

A ruminant animal is a cloven-footed, cud-chewing mammal which has a multicompartment stomach — a feature that distinguishes it from simple stomached herbivores such as pigs, horses, poultry. It is the largest of these stomach compartments — the rumen — that sets ruminants apart from other animals and makes them the most efficient in converting otherwise unusable plant materials into nutritious food for humans. The rumen is really a large fermentation vat, the contents of which may amount to about seven percent of the weight of the animal itself. Within the rumen are literally billions of microorganisms that break down plant materials into relatively simple compounds that ruminants can utilize. The interior temperature of the rumen is warm and nearly constant; saliva and digestive juices keep the fluids neutral or slightly alkaline and well buffered; conditions are anaerobic or nearly so, and the microbial byproducts are constantly removed by secondary fermentations as the plant material passes through the gut. The microbes, consisting mostly of bacteria, protozoa and yeasts, flourish under these conditions. It is a superbly designed feed processing system.

Feed materials entering the rumen are first attacked by enzymes produced by the rumen microflora. Plant cell walls and fibers are degraded into sugars. Sugars containing six carbon atoms (like glucose) are the most common. These in turn are attacked by more enzymes that convert them into volatile fatty acids, which are the ruminant's principal source of energy.

The rumen flora is remarkably abundant and diverse. The number of microorganisms is on the order of 10 billion bacteria and 1 million protozoa per gram of rumen contents. At least 30 species of protozoa have been identified and the kinds of bacteria can probably be numbered in the thousands. With proper adjustment of flora and adequate mineral and nitrogen balance, the rumen fermentation tank can be marvelously efficient. All kinds of cellulosic wastes can be utilized. In fact, it has been calculated that the protein requirements of the world population could be met by ruminants fed five percent of the world's cellulosic wastes.

Only one-third of the world's ruminant population lives in the developed regions; yet they produce two-thirds of the world's meat and four-fifths of the world's milk.



A graphic representation of land-ruminant-man relationships. Products that are starred (*) are not normally consumed by man.

Protein — or actually a balanced supply of the essential amino acids which make up protein — must be available in the diet of non-ruminants, such as man. Ruminants, however, can utilize non-protein nitrogen sources, such as urea, which the rumen microflora then use to synthesize the protein for their own body building. Subsequently, these microbes pass through the ruminant's stomach where the digestive juices break down the microbial cells to yield amino acids. These amino acids are absorbed through the gut wall to form the amino acids pool for protein metabolism by the ruminant itself.

Within an hour or so after a mature ruminant animal has eaten its fill of forage, the rumen microorganisms will have partially broken down the plant fibers. At this point in the digestive process, the esophagus of the animal contracts and a bolus, or cud, is propelled up to the mouth cavity at great speed. The animal then begins chewing its cud to further break down the fibers. After it swallows the cud, the whole process may be repeated several times until all the rumen contents are ready to pass along to the next stomach compartment, the reticulum, for further digestion.

A ruminant is well named. The Latin root of the word, *ruminare*, carries a number of connotations that fit ruminant characteristics. Thus, *rumination* is a process for extracting maximum value out of a crude resource, whether it is a high cellulose leaf or stem or an embryonic idea. Likewise, *to ruminate* is to rechew or rethink basic materials before products of final digestion or thinking are possible.

Crop residues, otherwise unused by humans, are an important source of feed for ruminant animals. Here, sheep are seen eating corn stover. *Winrock International Photo.*

Ruminants have a remarkable ability to survive on high fiber, low quality diets that would have little value for other animals.

"So, Bos . . . So-o-o, Bos"

Those generations of dairy people who knew not the convenience and pleasures of an automated milking system sometimes had to quiet a nervous cow when drawing up a stool at milking time.

"So, bos . . . so-o-o, bos," spoken to the animal in a soothing tone, generally had the proper effect of putting her at ease and inducing the flow of milk. Some cows could be trained — and may still be trained — to respond to the command, "Come, bos; here, bos; here, bossy."

One farmer, when asked why he had used the expression, "So, bos," said he thought he remembered his father and perhaps his grandfather using it years earlier. He had no further reason.

Actually, the Latin term, *Bos taurus primigenus*, gives a logical clue. One can reasonably suppose, therefore, that the origin dates back nearly 1300 years to an era when Old Latin was spoken by European herders. Somehow, the expression continued from generation to generation.

Ruminant Resources

TOTAL population of ruminants making some contribution of food and nonfood uses to man approaches 2800 million head. Cattle and sheep are the most numerous; each includes more than 1000 million head. Other domesticated ruminants include 400 million goats, 125 million buffalo and a combined total of 30 million camel, yak, llama and reindeer. World population of wild ruminants is several hundred million.

About 30 percent of the world human population and 32 percent of the ruminant population live in the developed regions. But ruminants of these same regions produce two-thirds of the world's meat and 80 percent of the world's milk. Chief reason for the difference is the better nutrition provided in developed regions.

Projected ruminant numbers and productivity in 2000 with percent change from 1972

	Developed regions		Developing regions				World	
			India		Others			
	Amount	% Change	Amount	% Change	Amount	% Change	Amount	% Change
Cattle								
Number, million	496	20	179	0	760	41	1435	27
Carcass meat, kg[1]	78	15	1	0	38	90	47	38
Milk, kg[1]	885	14	178	295	229	183	449	36
Buffalo								
Number, million	1	0	75	29	88	29	164	29
Carcass meat, kg[1]	28	12	6	0	15	18	11	37
Milk, kg[1]	54	15	259	0	100	0	173	0
Sheep and Goats								
Number, million	743	30	130	20	1132	50	2005	40
Carcass meat, kg[1]	8	12	8	118	6	48	7	30
Milk, kg[1]	9	2	13	117	16	53	13	38

[1] Average yield per head in regional herds.

Products — Of all the ruminant products utilized by humans, milk and meat rank first, not only in quantity but in value. In 1972, world ruminants produced 47 million metric tons of meat and 408 million metric tons of milk.

A liter of milk a day provides the average person with daily requirements of fat, calcium, phosphorus, riboflavin, one-half the needed protein, one-fourth the energy (calories), one-third the vitamin A and considerable amounts of other vitamins and minerals. The biological value of meat protein is about 80 percent of that of milk.

The relative importance of meat and milk in the human diet varies considerably from region to region. About 10 percent of the protein in the Indian diet comes from milk; in other parts of Asia and much of Africa, few adults consume milk — often because of milk protein allergies or lactose intolerance.

Other products from ruminants include wool, hair, hides and pelts. Although synthetic materials have made some inroads into markets for these products, world wool production has remained relatively stable over the past 15 years. It is important to note that in more than 100 countries, ruminant fibers are used in domestic production and cottage industries for clothing, bedding, housing and carpets.

Ruminants have been companions of man; they have been revered, worshipped, ritually sacrificed and considered holy.

The annual production of animal wastes from ruminants contains millions of tons of nitrogen, phosphorus and potassium. Of that which is effectively utilized, the value is estimated at $1 billion.

Early history of the developed world abounds with examples of the importance of ruminants as a source of work energy. Today, in the developing world, animals provide as much as 99

Camels used for draft on a land reclamation project near Lake Chad, Africa. *FAO Photo.*

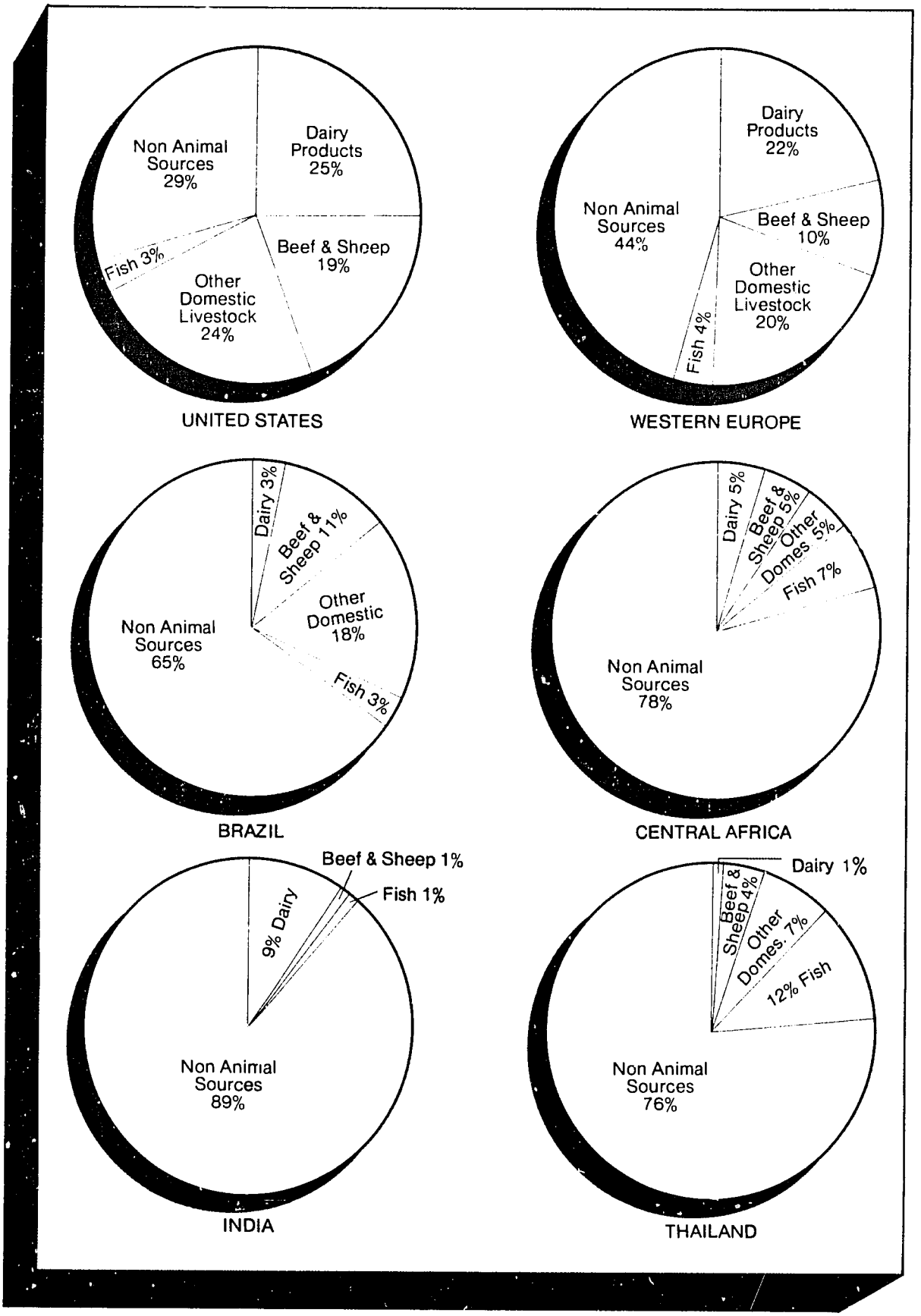
percent of the power for agriculture. It is estimated that India alone would have to spend $1 billion annually for gasoline to replace the animal energy used in agriculture.

Species Distribution — The species distribution of domestic ruminant livestock varies widely among the regions of the world. About 40 percent of the cattle and 50 percent of the sheep are in the developed countries, but more than 90 percent of the goats and 99 percent of the buffalo are in the developing countries. These figures reflect differences in climate, food preferences, native customs and animal utility. Goats, for example, are especially important as providers of milk and meat to the millions of subsistence farmers in these countries. Among Asian farmers, buffalo plow their fields as well as feed their families.

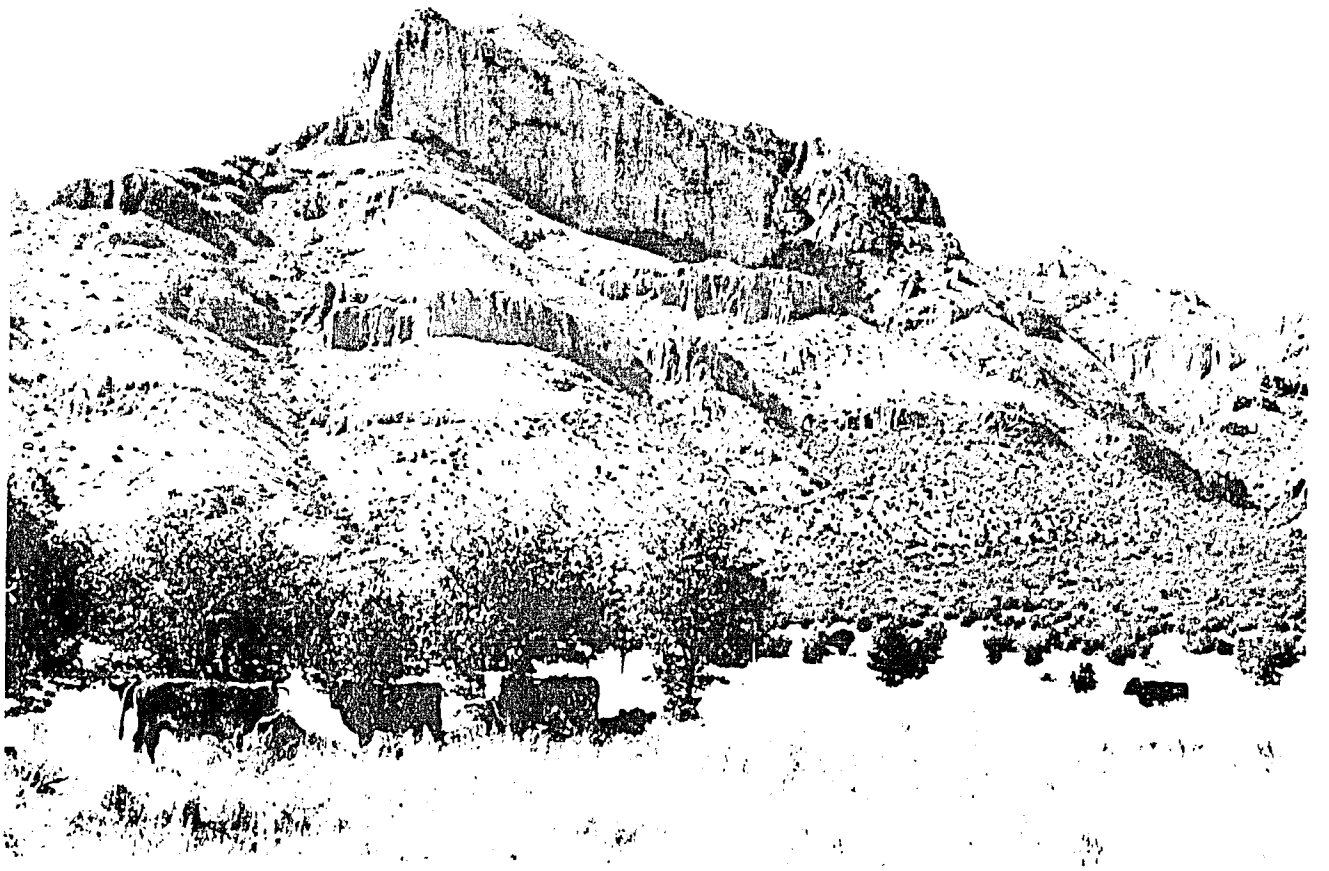
Genetic Variation — The tremendous genetic variation among ruminant species is obvious. Compare the stolid bodies of cattle and buffalo to the svelte frames of fleet-footed gazelle. Llamas in the Andes, reindeer in the Arctic, buffalo in Asian rice paddies, goats on the desert, cattle on the grasslands and in the big feedlots . . . all this adaptive variation greatly increases the environmental range over which ruminants can be productive.

Native stock are generally better adapted to climatic and disease constraints of the local environment than imported breeds.

Much variation within species, especially in their productive capacities under different environments, is available for molding by animal breeders. For example, genetic capacity for milk production in cattle varies from a few hundred kg to record productions of 20,000 kg. Genetic variation provides the material which has been used in the past to increase genetic capacity for quality and quantity of production, environmental adaptation, resistance to disease. Full genetic potentials for ruminants are yet to be realized.



Proportions of protein supplied from specific sources in selected areas



Cattle play an important role in the conversion of grass from arid rangelands to high quality protein for human consumption. This photo was taken in northern Mexico. *Winrock International Photo.*

Nutrient Resources for Ruminant Production

FEED is the first limiting variable in ruminant production. More than 90 percent of the feed available to ruminants of the world consists of roughage — grass, browse, legumes, hay, straw. The remainder of their diet consists of grains, oilseed meals, millings and industrial byproducts; the amount fed varies from one country to another and from year to year, according to availability and price. In the USA where grain surpluses are frequent, grain and concentrates provide about 30 percent of the energy used by cattle, sheep and goats.

During the balance of this century, significant increases in productivity from arid rangelands are not anticipated . . . The potential for increasing productivity on humid and subhumid and tropical and subtropical permanent pasture is very great.

Considerable effort was expended in this Winrock study to determine (a) the extent of the nutrient resources presently available to ruminants throughout the world and (b) the potential available for year 2000. Forages and crop residues will remain high on the list of available nutrient sources. And of these two sources, permanent pasture and meadow will continue to rank first — at least on a world basis. Despite the fact that total area of permanent pasture and meadow will be only slightly higher in 2000 than it is at present, production of metabolizable energy from that source will be about 16 percent greater than at present. Most of the increase will be due to wider use of applied technology. Since advanced technology has been applied to less than 8 percent of total permanent pasture and meadow, it is clear that a tremendous reservoir of untapped ruminant feed production potential exists.

Overseeding grasslands with legumes, establishment of grass-legume mixtures and use of

improved grasses with nitrogen fertilizers on only modest areas of permanent pasture could increase offtake of ruminant products immensely. The amount of grain fed to ruminants will be determined on economic grounds. It is interesting to note that in 1972 less than one percent of the feed energy requirements for India and other developing regions came from grain concentrates. Little change in these feeding patterns is expected by 2000.

The obvious conclusion is that, except for India, there are abundant supplies of noncompetitive feed resources available to support expansion of ruminant populations and production.

There is a desperate need in the developing world for more and better trained research, extension and management personnel.

Constraints on Production

THE degree of progress that ruminant livestock producers of the world will make in the next two decades will depend to some extent on how ably they meet the constraints that inevitably face animal agriculturists — diseases, parasites and certain nonbiological or socio-economic factors that can impede progress unless they receive serious attention.

Diseases and Parasites — Each year, more than 50 million head of cattle and buffalo and 100 million sheep and goats are killed by diseases and parasites. Production losses in both quality and quantity of meat and milk from ailing and unthrifty animals represent an even greater loss.

The main disease problems of ruminants are in the developing countries, and, although some progress is being made, improvement is slow. Reasons are lack of sufficient financial resources, inadequate administrative backing, insufficient numbers of veterinarians and the fact that some disease pathogens have a way of developing resistance to new control measures. The costs of fighting tick-borne diseases in Africa and South America are staggering. Millions of cattle have to be dipped up to 50 times a year. Such measures merely hold down the incidence; the real problem remains latent. More breakthroughs are needed, such as the successful rinderpest vaccination program in Africa and biological control of screw worms.

The animal health picture in the developed countries is somewhat brighter. In Western Europe, the brucellosis eradication program is moving ahead; in Australia, a vaccination program and good management procedures largely eliminated bovine contagious pleuro-pneumonia. Progress in other areas will require more research, more funds, more knowledge on the location and incidence of disease and public understanding of the measures that need to be taken.

The production potential of small ruminants has yet to be realized. Goats noted for survival on arid rangelands do well on lush tropical pasture. *Winrock International Photo.*

Nonbiological Constraints — Some of the nonbiological constraints that inhibit expansion of ruminant production are associated with land tenure, markets and transportation, credit, human resources and government policies.

The success of ruminant production systems can be visibly affected by attitudes and policies of both local and national governments on land tenure, income transfer, research and extension. Poorly functioning transportation, marketing, processing and preservation of ruminant products can lower productivity, increase costs to consumers and lower returns to producers.

Mores and prejudices against some ruminant products occur in both developed and developing regions. Their basis may be mystical, whimsical or trivial; yet to the people concerned the reasons for certain actions may have well-grounded rationale.

The problem with many of these nonbiological or socio-economic constraints is partly one of benign neglect. Broadened and enlightened viewpoints accepted by all agencies and persons involved would do much to bring about understanding in attitudes and favorable changes in socio-economic environments.

Agriculture's Unfair Burden:
Disproving Malthus

How can we best solve the food/population problem? As a biologist, I cannot bring myself to believe that it is in the best interests of humankind to lead with increased food production rather than decreased fertility. I view with misgivings the proposition that more food must be produced to accommodate an ever expanding population. The question is not whether the world *can* feed 40 billion people but whether it *should*. I hold that population growth must be halted as harmlessly as possible and soon — within the next two decades. Attention could then be given to the elimination of hunger, malnutrition and disease among the impoverished who remain untouched by the capacity for dignity and the productive and creative potential of mankind. The population problem is manmade and will either have to be solved by man or it will be solved by the harsher methods of nature. — *R. O. Greep, Harvard University*

Increased world population and increased consumer buying power will create a demand for 74 percent more milk, 82 percent more beef and 90 percent more sheep and goat meat in the year 2000 from what was consumed in 1970.

Future Economic Demand

ON a percentage basis, the projected rates of increase in ruminant livestock products are modest. For the world as a whole, compound annual growth rate to the year 2000 for dairy products is 1.9 percent; for beef and veal, 2.2 percent. These increases, however, conceal some rather large increases that will be required in less developed countries. World averages are strongly influenced by the high proportion of livestock numbers in the developed regions where population is growing slowly and demand elasticities are moderate to low. Rates of increase in consumption for developing regions, except China, are considerably above the world averages.

One factor that should be kept in mind because it may alter projected increases is the swift growth of the middle class, whose individual members consume five times as much as members of the poor class. This vast middle class is beginning to exert far more pressure against scarce resources than the growth of the poor population.

Strong consumer demand for livestock products means that production can be pushed vigorously without fear of saturating the domestic market, provided suitable steps are taken to develop an effective market structure.

Increasing per head productivity is the most efficient way to meet increased future demand for ruminant products.

Meeting the Demand

INCREASED world population and increased consumer buying power will create a demand for 74 percent more milk, 82 percent more beef and 90 percent more sheep and goat-meat in the year 2000 than was consumed in 1970. This increased demand can be met by (a) increasing the numbers of ruminant animals without appreciably increasing per-animal productivity, and (b) increasing the per-animal productivity by improving fertility, health, nutrition and genetic potential. It seems likely that a mix of these strategies will be followed.

Most authorities agree that in order to meet the demands of the future much more emphasis will have to be placed on research, technology application and training of both professionals and producers. This effort should be directed toward minimizing nonrenewable resources (land, water, energy, etc.) and maximizing output of ruminant products.

Along with the recognized need for more research is the realization that governments must do something to maintain the viability of the world's 100 million small farmers, because it is in this group where the majority of the world's domesticated ruminants are found. Although smallholders are generally slow to accept better resource management and technology, it has been proved that unfavorable policies, ignorance and prejudice will change or dissipate when the people concerned are exposed to accurate information as to the true effects of constraints and are given a chance to become involved in working out solutions.

More than 85 percent of ruminant animal production in the developing world comes from the traditional small producers.

* * * * * * * *

This study by Winrock International has led to some succinct conclusions as to the questions and concerns about the current value and future importance of ruminants in the support of man.

Humans do not want to give up ruminants.

• The majority of the world population has consistently shown a marked preference for ruminant products — both food and fiber.

• The emotional relationship between man and his most important domesticates have deep social, cultural and religious meanings and values.

Humans need not give up ruminants.

• Noncompetitive feed resources are available and the potential for increases is sufficient to nourish the required ruminant population and allow a high rate of productivity.

Humans should not give up ruminants.

• The many millenia of evolution have made ruminants an integral and critical part of the natural ecosystem which must be preserved if man is to survive.

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