THE ROLE OF IMPROVED PASTURES FOR BEEF PRODUCTION IN THE TROPICS†

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ABSTRACT

Tropical regions of the world with more than 4½ months of wet season and sub-tropical regions with year-round rainfall or hot wet summers are considered suitable for pasture improvement. These regions comprise 4.5 $\times$ 10[9] *hectares, of which* 23% *is grazing land. The total number of cattle is* 566 $\times$ 10[6] *and beef production* 7.7 $\times$ 10[6] *tonnes. However, mean beef production is only* 7 *tonnes per* 1000 *ha of grazing lands and* 13.6 *tonnes per* 1000 *head of cattle. Tropical pasture research has resulted in the availability of adapted grasses and legumes. With the solution of legume-rhizobium and soil-nutrient deficiency problems, the concept of tropical grass-legume pastures is now widely accepted, but development of such pastures has been slow. If pasture improvement on* 25% *of existing grazing lands of Africa, Central and South America were improved beef production in these regions could be increased from* 6.1 *to* 13.6 $\times$ 10[6] *tonnes. However, this would require* 800 $\times$ 10[6] *kg of grass and legume seed,* 40 $\times$ 10[6] *tonnes of superphosphate and the establishment cost is estimated at more than A*\$10[9]. *In addition nearly twice the number of cattle now available in these regions would be required.*

However, it is agreed that beef production from improved pastures offers the best prospect for meeting the increasing demands for animal protein. Increases in pork and poultry production and the use of cattle feedlots require the use of feed grains for which arable land is required, whereas improved pastures utilise non-arable land at present not fully exploited.

The role of improved pastures in tropical and sub-tropical Australia is not to increase total beef production, but to improve efficiency of production. Unless beef export prices increase markedly, the use of improved pastures and adapted cattle may well be conditions for the financial survival of beef producers.

INTRODUCTION

Throughout the ages grasslands have been used by humans for the production of animal protein, either as the sole component of the diet or as a supplement to foods of vegetable origin.

As a natural vegetation type, grasslands are restricted to regions where trees do not grow, either because it is too dry, too wet or too cold. In dry areas they are often associated with fertile soils and many such grasslands have since been converted to croplands, mainly for the production of cereals. This has happened particularly with the prairies of North America, the pampas of South America, the steppes of the USSR and the open downs in Australia. Conversely, forested areas not suitable for cropping have been converted to grasslands by clearing, burning, sowing and subsequent grazing. There is an increasing trend for grasslands to be restricted to non-arable land because of population pressures combined with the fact that the conversion of solar energy to human food is less efficient through ruminants than through crops grown for direct human consumption.

In recent times the raising of livestock on grasslands has been improved by such methods as the selection and breeding of better grasses and legumes, the use of

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fertilizers, disease control and the selection and breeding of better cattle as well as the introduction of specialized animal husbandry practices. Pasture and animal improvement have been practised in temperate areas of Europe and North America since last century, but in tropical areas of the world these developments are only very recent.

The objective of this paper is to emphasize the present lack of pasture improvement, and the low animal production in the tropics, the improvements that could be obtained and the problems associated with large scale development. Because research is more advanced in northern Australia and the role of improved pastures is different from that in other tropical regions, these are dealt with separately.

AREAS SUITABLE FOR PASTURE IMPROVEMENT

The tropics are geographically defined as the area between the Tropics of Cancer and Capricorn, but when the sub-tropics are included this is generally extended to 30° latitude. However, from the point of view of vegetation type and agriculture, it is more appropriate to delimit the tropics, including the sub-tropics, on climatic criteria. The classification of climates of Troll (1966) is used in this paper, because it is based on length of the wet season and this classification agrees well with natural vegetation types.

Troll's tropical zones with more than 4½ months of wet season (V_{1-3}), his humid sub-tropical zones ($IV_{6 and 7}$) and that with wet summers and dry winters (IV_4) are considered by the present author as being able to sustain productive pastures because their rainfall and temperature regimes favour the growth of tropical pasture species. Zones with less than 4½ months of wet season were excluded because they are semi-arid or arid. Sub-tropical zones with dry summers were also excluded. Troll included parts of Japan and northern New Zealand in sub-tropical zone IV_7, but they are considered unsuitable in this paper, because sub-tropical pasture species are only marginally adapted there due to temperature limitations. Similarly the montane tropics, as found in Kenya and South America, were excluded. Generally, in areas considered suitable temperate pasture species are either not persistent or unproductive, except for clovers (*Trifolium* spp.), lucerne and medics (*Medicago* spp.) in sub-tropical zones with adequate winter rainfall.

The zones are shown in Figure 1. They are generally well endowed with radiant energy, except for some areas during times of prolonged heavy rainfall; temperature and moisture regimes range from hot wet summers and cool dry winters with frequent frosts to year-round high temperatures with either high rainfall throughout the year or one or two periods of low or no rainfall. Soil fertility varies from extremely low to high and soil type from pure sands to heavy clays. These factors combined determine the pasture species that occur or may be grown, the level of herbage production and the quality of feed on offer.

AREAS OF GRAZING LANDS AND VOLUME OF BEEF PRODUCTION

The areas within the relevant climatic zones with cattle numbers and beef production are listed in Table 1. These data were mainly compiled from FAO statistics with adjustments for countries which lie partly outside the zones considered in this paper. In Australia only a small coastal strip around the north and north-east falls within zones V_2, V_3 and IV_4. This area coincides well with that covered by 't Mannetje *et al.* (1976) and their data on land and cattle were used. The area of grazing lands in northern Australia was arrived at by subtracting Reserves, National Parks and areas under crops. Data for southern China were not available.

Of the total area of $4\frac{1}{2} \times 10^9$ hectares under consideration 23% is grazing lands or pastures, but this ranges from 0.2% for New Guinea to 80% for Australia. The total area of course would be much larger if ungrazed forests, which could be cleared for pasture development, were included. Forested areas are not considered in this

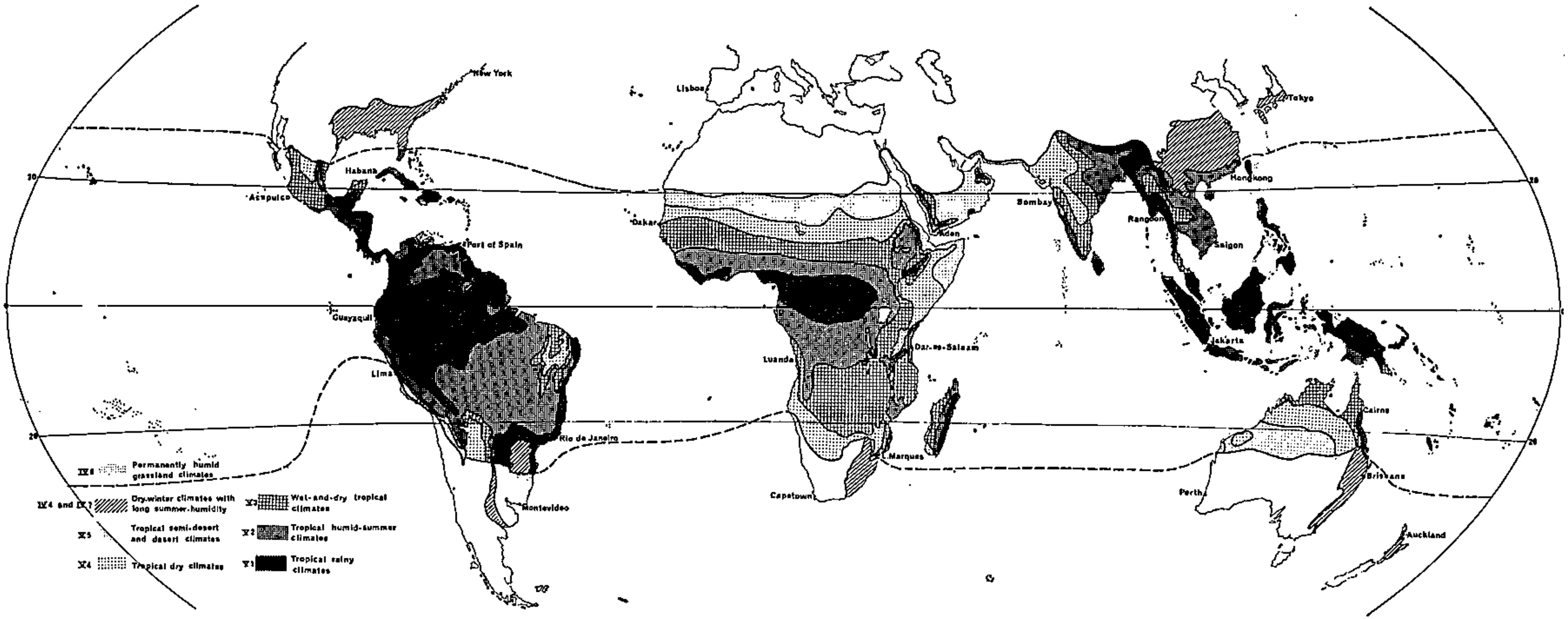

FIGURE 1
Climatic zones of the tropics and subtropics as defined by Troll (1966).

TABLE 1

Total areas of land and grazing lands, numbers of cattle and beef and veal produced in 1975

Areas	Total Area ha × 10^6	Grazing lands		Cattle		Beef and veal production		
		ha × 10^6	%	× 10^6	Number per 1000 ha of grazing land	× 1000 t	Tonnes per 1000 ha grazing land	Tonnes per 1000 head of cattle
Africa[1]	1750	493	28	113	230	1400	3	12.4
America—								
Southern U.S.A.[2]	62	11	18	11	980	615	57	58.0
Central America[1]	272	81	30	48	590	1100	14	23.1
South America[1]	1430	290	20	151	520	3600	12	23.9
Asia[1]	762	31	4	236	7600	700	23	3.0
Oceania—								
Northern Australia[3]	175	142	80	8	54	250	2	32.9
Papua New Guinea[1]	46	0.1	0.2	0.1	1300	2	20	15.4
Pacific Islands[1]	9	0.5	6	0.6	1180	10	20	17.0
Total or Mean	4506	1048	23	567	540	7677	7	13.6

[1] Source: F.A.O. 1975 Production Yearbook.
[2] Source: U.S.D.A. Agricultural Statistics Handbook, 1976.
[3] Source: See text.

paper, because existing grazing lands offer enough scope for future development. However, there may be a need for forest clearing in areas which lack grazing lands and have an abundance of forest. Cattle numbers also vary greatly, but these are not a good measure of beef and veal production. Asia has the largest number of cattle but the lowest volume of beef production per 1000 head of stock. This reflects the fact that cattle are not kept solely for beef production, but also for milk and as draught animals with meat only as a by-product. In addition, there is a religious ban on slaughtering in some parts of Asia. The high cattle density per 1000 ha of grazing lands in Asia is completely unrealistic because most cattle are raised on wastelands and on fallowed cropland. Vast areas of Australia are thinly populated and have low carrying capacities which is indicated by the low cattle density and the low beef production per 1000 ha of land. On the other hand, beef production per 1000 head of cattle in tropical Australia is second only to that of the southern U.S.A. The African figures indicate low production on an area as well as a per head basis.

TROPICAL PASTURE RESEARCH AND DEVELOPMENT IN AUSTRALIA

Serious tropical pasture research was commenced in the 1930's with plant introduction and evaluation in several countries, including Australia. In Australia most emphasis was given to grasses as is reflected by the history of tropical pasture plant introduction, which was reviewed by Cameron (1977). He showed that 19 of the 59 grasses now commercially available were already in use in 1945.

The pasture legumes introduced before 1945 were calopo (*Calopogonium mucunoides*), centro (*Centrosema pubescens*), puero (*Pueraria phaseoloides*) and stylo (*Stylosanthes guianensis*) for the wet tropics (V_1), of which there is only a small area between Ingham and Cooktown. These legumes had already been used for many years as cover crops in tree plantations in South-East Asia. For the dry tropics there was only Townsville stylo (*S. humilis*) and for the sub-tropics Townsville stylo and phasey bean (*Macroptilium lathyroides*). However, success of these early efforts was hampered by a lack of knowledge of plant nutrition and legume—*Rhizobium* symbiosis. This often resulted in failures, particularly in regard to the productivity and persistence of legumes. This led to a bad reputation for tropical legumes, a view which is occasionally still expressed (c.f. Appadurai 1975). Fortunately, where indigenous legumes are present, many tropical legumes are able to nodulate from infection by naturally occurring rhizobia. However, major advances were not made and tropical legumes were not universally recognized as efficient nitrogen fixers until Norris (1970) commenced research on tropical legume bacteriology in Queensland in the 1950's. An equally important contribution to legume productivity and persistence has been made by the recognition and correction of nutrient deficiencies in soils (Andrew 1962).

Once these basic principles had been developed, the philosophy of tropical legume-based pastures received wide acceptance. Plant introduction and breeding were stepped up and the systematic evaluation of new accessions at many sites gradually provided adapted grasses and legumes for the better watered areas of northern Australia (Cameron 1977). At the same time, research and development in tropical pastures was accelerated in other countries, particularly in Africa and Central and South America. However, it is indicative of Australia's role in tropical pasture research that many species collected in Africa and America were later returned to their origins as named cultivars. This has led to a stimulation of the pasture seed industry in Australia and a constant demand on expertise to assist in pasture research and development in other countries.

Much of the present research effort is put towards expanding the range of legumes and grasses. Notable successes have been *S. hamata* cv. Verano, *S. scabra* cv. Seca and *Setaria anceps* cv. Narok. There is increased emphasis in ecological studies, both on a pasture community basis, in species relations, and on population dynamics of individual species. Seed production research also receives more attention. Pasture agronomy investigations encompass studies in pasture-animal relations, maintenance fertilizer requirements and grazing management. Animal nutrition research is particularly concerned with the effects of minerals and of sward structure on feed intake. Plant physiologists are studying the effects of water stress on growth, adaptability and feed quality.

THE IMPACT OF PASTURE IMPROVEMENT ON WORLD BEEF PRODUCTION AND RESOURCES REQUIRED

Present animal production on unimproved pastures in northern Australia is low because animal weight gains occur for only about six months of the year, followed by a period of no change and weight losses during late winter and spring. This is caused by limitations of pasture growth and low feed quality during most of the year. As a result carrying capacities are also low. In other parts of the tropics the same limitations apply, but added to that are constant overstocking, e.g. in Africa and lack of grazing lands, e.g. in Asia.

Pasture improvement ranges from the simple inclusion of a legume into existing pastures with or without fertilizer to the complete replacement of existing vegetation by productive grasses and legumes, which, in order to persist and remain productive, require regular fertilization, on most soils. The level of input chosen depends on available finance and on economics but at each level an improvement in beef production will occur, which will be enhanced by the use of productive animals, control of their parasites and diseases, and the application of proven animal husbandry practices. 't Mannetje *et al.* (1976) estimated that improved pastures covering 3.6 million hectares in non-arid Queensland constitute about 5% of available grazing lands, whilst in the Northern Territory and in northern Western Australia the areas of improved pasture are negligible. On a world scale, pasture improvement would certainly cover less than 5% of the grazing lands of the tropics. Stobbs (1976) reviewed beef production in the tropics and concluded that pasture improvement could increase beef production per unit area of land six-fold.

With little pasture improvement having taken place, one can safely state that present beef production in the tropics is only a small fraction of that physically possible. However, it is not realistic to suppose that a very large proportion of undeveloped grazing lands could be improved in the short or medium term. The biggest restraints for development are lack of capital, knowledge and motivation. With sufficient financial and technological aid from international bodies such as FAO and World Bank and from bilateral programs between wealthy and developing countries one might hope that over a period of 25 years or so a significant proportion of the grazing lands could be improved. However, local research on species adaptation, nutrient requirements and grazing management needs to be carried out first within the prevailing socio-economic climate (Shaw and Bryan 1976).

With pasture improvement on X% of existing grazing lands, increased beef production per unit area of land of A times the present production, total beef production from both improved and unimproved grazing lands will be Y% of total present production according to the formula:

$$Y = 100 + (A - 1)X$$

With improvement of 25% of grazing lands and a six-fold increase in beef production per unit area of land, total production after development would be 225 percent of that before development.

Applying these calculations to Africa, Central and South America with a total of 864×10^6 ha of grazing lands, if 25 percent (216×10^6 ha) were improved, beef production after development would be 13.6×10^6 tonnes compared to the present production of 6.1×10^6 tonnes (Table 1). Similarly, beef production in northern

Australia, at present estimated at 250,000 tonnes, would be increased to 560,000 tonnes after improvement of 25 percent of the 142 $\times$ 10^6 ha of grazing lands.

However, such calculations do not take into account the practical feasibility and the resources required. The improvement of 200 $\times$ 10^6 ha of grazing lands would require 400 $\times$ 10^6 kg of grass and an equal amount of legume seed. If we assume that 200 kg ha^{-1} of superphosphate is required for establishment and a further 100 kg ha^{-1} $year^{-1}$ in subsequent years, this would involve 40 $\times$ 10^6 tonnes of superphosphate or equivalent fertilizer for establishment and half that amount annually thereafter. Also the investment in machinery and the cost of fuel and labour would be high.

The magnitude of the seed and fertilizer requirements alone can be put in perspective by comparing these with present production and consumption, respectively. Queensland is the major producer of tropical pasture seed in the world and yet in 1974 it produced less than 2 $\times$ 10^6 kg of grass and legume seed combined (Anon. 1974). The superphosphate requirement for establishing 200 $\times$ 10^6 ha of pasture is approaching half the world's consumption of phosphatic fertilizers in 1974 (FAO 1975). If we assume that it would cost A$50 per ha to establish pasture the total cost would be A$$10^9$ and this does not include interest on borrowed capital and the extra cattle required. Assuming that improved pasture can carry one animal per ha, which is an underestimate for humid areas, the newly developed pastures would require 200 $\times$ 10^6 head of stock. This would mean that after development of only 25% of the grazing lands in Africa, Central and South America nearly twice the number of cattle presently available in these regions would be required.

THE ROLE OF BEEF PRODUCTION FOR HUMAN FOOD SUPPLY

Despite these vast resource requirements, beef production from improved pastures offers the best prospect for increasing the world's animal protein production, although milk, sheep, goats and fish could also play a major role. Not denying the importance of pork and poultry, further increases in production from these sources will depend on the use of more feed grains, which are in short supply in developing countries. For the same reasons cattle feedlot systems are not likely to play an important role in increasing beef production in these countries. Until the recent slump in world trading beef prices, these labour, capital and energy intensive systems were fashionable proposals for the improvement of beef production in the tropics (Jasiorowski 1975, Creek *et al.* 1975).

Even if beef prices returned to those prevailing in 1973, cattle feedlots in the tropics would only be profitable for export oriented production. They could play an important role if they depended mostly on by-products of other crops, but when they rely on feeds grown on arable land they detract rather than add to the net food supply. Ruminants are poor converters of grain into human food.

The great value of cattle lies in their ability to convert into human food plant material indigestible to humans and grown on land which cannot otherwise be used for food production. With the present demand for animal protein and its potential production on non-arable land we must make the best use of this vast resource.

The increase in requirement for animal protein can be divided into two kinds. One is for the improvement of human diet in developing countries and the other to meet increasing demand in developed countries. The first will have to come from local production because of the lack of foreign exchange to import meat, and the second from the export of meat from countries such as Argentina, Australia and New Zealand, where local production exceeds consumption. The need in developing countries is indicated by the fact that animal protein consumption in the poorest countries is only 5 g per head per day compared with 75 g in wealthy countries (Jasiorowski 1975). The problem is particularly acute in Africa, the only continent where total food supply has not kept pace with population increase.

However, in regions where the people consume a negligible amount of animal protein, a doubling of a very low beef production will have little impact, even if they can afford to buy more meat. Assuming that general buying power could be improved, it would be necessary to develop more than the projected 25% of grazing lands. As a greater proportion is improved the impact on total beef production is increased linearly to a six-fold increase according to the formula in the previous section. In some areas with very low beef production, however, it is likely that improvement would be greater than six times the production before development. The strong and growing demand for meat in richer countries was shown by Tracey (1975). In France, for example, 53% of the population and 72% of skilled workers would consume more meat if they could afford it. Taiwan has increased livestock production between 1965 and 1970 by 45% against crop production by only 4%. In Japan the total protein intake in 1968 compared to that in 1949 increased by 13%, whilst that for animal protein doubled.

In exporting countries, like Australia, the rate of pasture improvement will depend on the demand and price on world markets. However, developing countries with a population suffering from malnutrition will need help to develop their grazing lands to improve beef production. Wealthy countries should provide such assistance. In the case of Australia, which is the world's largest exporter of beef, with 26% of the market, this can be done without detrimental effects on export markets. Brazil, despite its own shortage for domestic consumption, is the only other tropical country with a major beef export, and it accounts for only 7% of the world beef market (Reeves and Hayman 1975).

THE ROLE OF IMPROVED PASTURES IN TROPICAL AUSTRALIA

With the present low price for beef to Australian producers the role of improved pastures is not to increase total beef production, but to improve efficiency of production by individual producers. Cattle on improved pastures not only have better growth rates allowing turn-off at about 2½ years of age, but also higher calving percentages (Edye *et al.* 1971) and higher pre weaning growth rates, resulting in increased turn-off weight of calves per cow mated ('t Mannetje and Coates 1976). Carrying capacity is also increased by a factor ranging from two to six.

Efficiency of production is defined as the ratio of cost of production over returns. Returns to individual producers can be increased by increasing turn-off, both in volume and turn over. The role of improved pastures in this context is obvious. Cost of production consists mainly of labour input for mustering and property maintenance, transport costs, disease and pest control of animals. and interest. The implementation of pasture improvement leads to cost savings because more cattle can be carried on a given area or the same number as before on a smaller area, thus reducing labour cost per animal. The use of better adapted cattle for tropical and tick-infested areas (*Bos indicus* and *B. indicus* × *B. taurus* crosses) increases animal production and saves on pest control. Transport costs are related to distance to slaughtering points. In this respect coastal and sub-coastal areas are favoured compared to inland areas.

In addition, a better rainfall allows for pasture improvement in coastal and sub-coastal areas, which is difficult to achieve in the drier inland. Unless beef prices increase markedly it is probable that many marginal producers will be forced to leave the cattle industry. Producers most affected will be those in inland regions and others who fail to take measures to improve efficiency. Thus, the use of improved pastures and adapted cattle may well be major requirements for beef producers to survive financially.

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