THE HARRY STOBBS MEMORIAL LECTURE FOR 1985*

THE ROLE OF IMPROVED PASTURES IN COMMERCIAL PRODUCTION IN THE TROPICS AND SUB-TROPICS

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ABSTRACT

A brief review is made of the introduction of tropical and sub-tropical pasture species into northern Australia and the subsequent rise and fall in the area of improved pasture that was planted annually between 1970 and 1984.

Some of the reasons for this rise and fall in plantings are discussed and the relation of input costs to the returns from beef, wool and milk over the period 1967 to 1984 is examined.

Specific roles of improved pasture in primary production are identified and some suggestions are made as to where more research could assist primary producers to get more value from their pastures. Possible changes in the use of phosphatic and nitrogenous fertilizers are discussed in relation to their comparative prices.

The role of improved pastures in developing countries of the world is also discussed for both traditional subsistence farmers and for larger ranches and government projects.

INTRODUCTION

The role of improved pastures is to increase net income in a cash economy or to increase the net amount of animal protein food and draft power that can be produced in a subsistence economy. If they do not fulfill this role consistently, then farmers will not persevere with them.

Most of the tropical and certainly sub-tropical pasture species in use today have only been bred or selected over the last thirty years, and still little is known about how to manage them. Management systems for temperate pastures have evolved over centuries and much more work and observation will be required before we have comparable systems for most of our tropical pastures. However, we do know that overstocking leads to the demise of native tropical perennial species such as kangaroo grass and blue grasses (Qld. pitted and forest) as well as some of the introduced and bred legumes such as Siratro (*Macroptilium atropurpureum*).

HIGHLIGHTS OF EARLY INTRODUCTION AND RESEARCH IN NORTHERN AUSTRALIA

The first recorded introduction of an improved pasture species into Queensland was that of Guinea grass (*Panicum maximum*) in 1867, followed by *Kummerowia (Lespedeza striata)* in 1886 and *Paspalum dilatatum*, Rhodes grass *(Chloris gayana)* and para grass *(Brachiaria mutica)* in the 1890's. Two of the most widely spread introduced species, Townsville stylo *(Stylosanthes humilis)* and buffel grass *(Cenchrus ciliaris)*, were both accidentally introduced in the early 1900's. It is interesting to note that all these early introductions still play a major role today.

In 1930, a plant introduction garden had been established at the Queensland Agricultural College at Lawes and by 1931, under the supervision of W. W. Bryan, this garden contained 140 accessions.

Early pasture workers soon realised that the tropical pastures lacked a good legume and that the native legumes and kangaroo grass *(Themeda australis)* went out

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under heavy grazing and the latter was replaced by black spear grass *(Heteropogon contortus)* and wire grass *(Aristida spp.)*.

One factor to influence pasture work in Northern Australia was the appointment of Griffiths Davies as Assistant Chief of the C.S.I.R.O. Division of Plant Industry and his recruitment of staff to work on pastures in south-east Queensland. In 1952, Davies became Associate Chief of the Division and was transferred to Queensland, where the moulded a diverse and energetic group of pasture scientists into a closely knit team that was to have a profound influence on pasture development in Northern Australia. The number of C.S.I.R.O. pasture workers peaked at 57 in 1974; now there are only 42. Pasture research sites peaked at 21 in 1969; now there are only 6. The QDPI had 47 workers in the Agriculture Branch in 1970, now there are only 39 (Eyles and Cameron 1985).

One of the scientists recruited by Davies to work on dairy pastures was the late T. H. Stobbs. He worked mainly at Samford from 1969 to 1978, when his brilliant career was sadly terminated. This lecture is given in his honour and I feel very proud, as a primary producer, to be giving it. Harry Stobbs' work sparkled with inventive thinking but his goal to help the end user was always very clear. He linked animal behaviour and performance with pasture type and growth habit and looked for an economic end result. We are all indebted to him for his work and its clear documentation (e.g. Stobbs 1975; Stobbs and Hutton 1974).

GETTING THE NEW PLANTS INTO COMMERCIAL PASTURES

PROGRESS AND PROBLEMS

In southern and south-western Australia, a great deal of publicity was given to the success and high stocking rates obtained from clover-based pastures after nutrient deficiencies were corrected using superphosphate, and in many cases, copper and zinc.

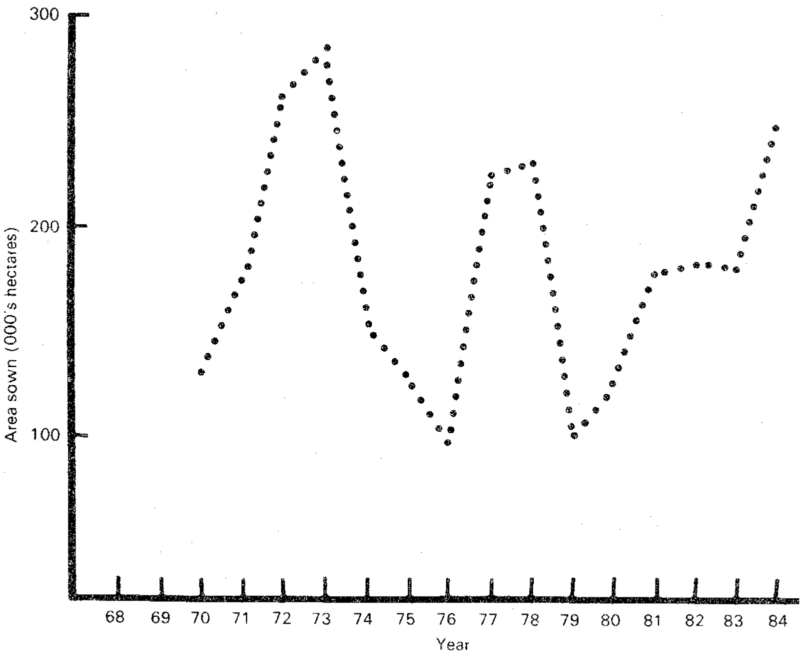

FIGURE 1

Area of new pasture sown in Queensland in the years 1970–84.

I feel that farmers in Northern Australia were anticipating a similar "Pasture Revolution" when a suite of new tropical legumes and grasses were released onto the market in the period between 1960 and 1975, e.g. siratro, glycine, desmodiums, lotononis, leucaena, setaria, and new accessions of buffel, Rhodes, panic and paspalum. During this time (the late 1960's and early 1970's), beef prices were good, the Dairy Pasture Subsidy Scheme and the Brigalow Development Scheme were in operation, and fertiliser prices were low in comparison to the price of beef.

As well as this, extra funds for pasture research were supplied by the meat, wool and dairy industry boards. These factors encouraged a spate of plantings (see Fig. 1).

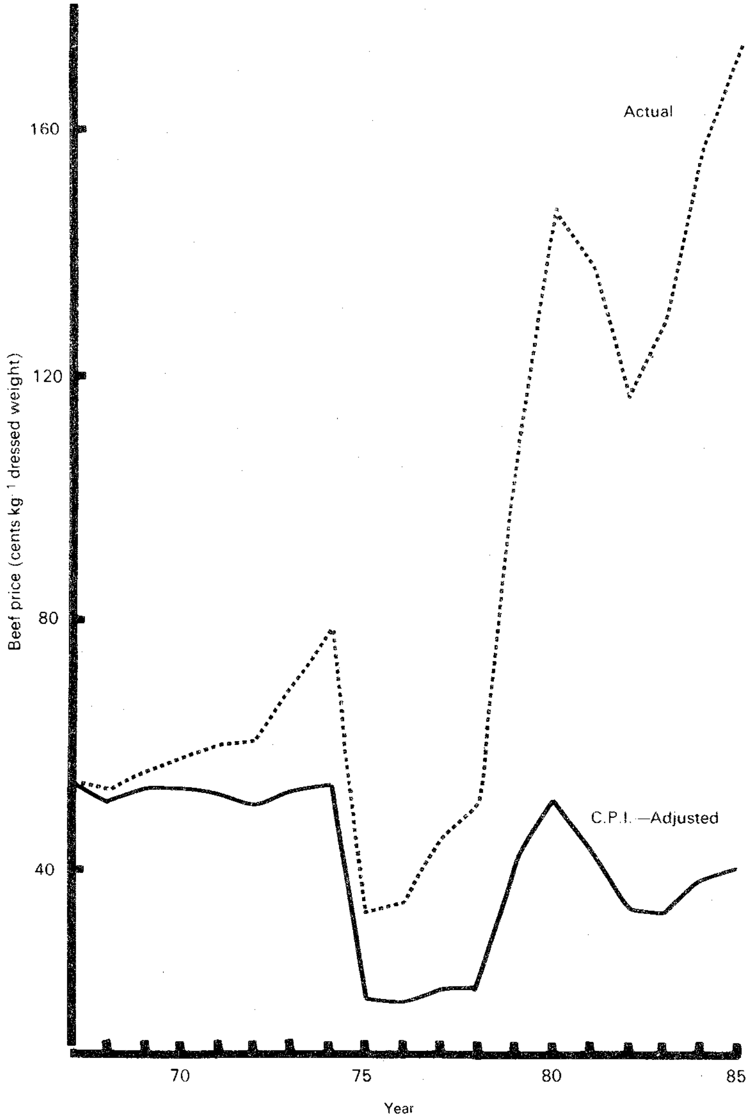

FIGURE 2

Change in the actual and C.P.I.—adjusted price of beef between 1967 and 1985.

Then the crash came in the mid 70's, beef prices plummeted, anthracnose attacked Townsville stylo pastures in Northern Australia, the Dairy Pasture Subsidy Scheme was wound up, and costs and inflation skyrocketed. Butchers' steers dropped from $1.00 per kg dressed weight at the beginning of 1974 to 25 cents per kg by the middle of 1975.

Many farmers held stock hoping for a rise in prices, but could not afford fertiliser. On beef properties, this led to the continued overgrazing of improved pastures coupled with underfertilisation. In the dairying industry, many farmers had developed a small proportion of their total area to improved pastures, mainly under the subsidy scheme, and with adequate initial fertiliser, these established and grew well. However, these small highly palatable areas were frequently overgrazed and many were not adequately top-dressed with fertiliser. The end result was the failure of many improved pastures and particularly of the legume components. Impetus in the improved pasture industry was lost and has not yet been totally regained. However, there seems to be some resurgence of interest as the area planted in 1984 was the highest since 1973 (Fig. 1).

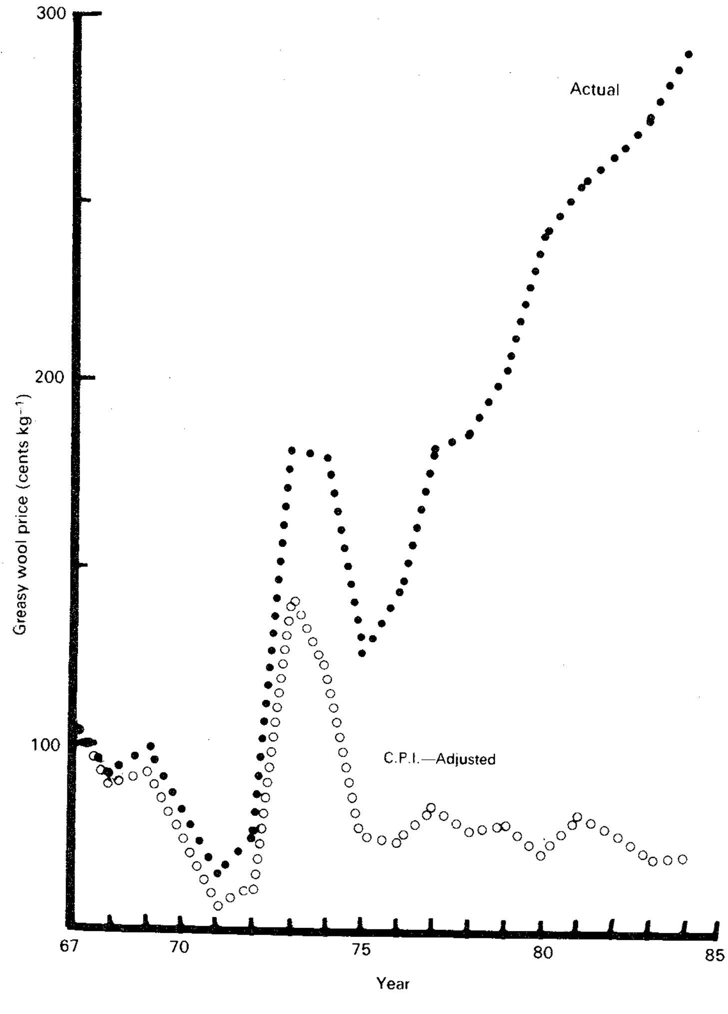

FIGURE 3

Change in the actual and C.P.I.—adjusted (1967 = 100) price of greasy wool between 1967 and 1985.

Beef prices rose significantly in 1979–80, but in real terms they have again slipped back and, using the national C.P.I. figure as an indicator, the real prices in 1985 of beef (Fig. 2), wool (Fig. 3) and milk (Fig. 4) are down by 25%, 32% and 15% respectively on those being paid in 1967.

The number of dairy farmers has continued to decline (Fig. 5) and, for those remaining in the industry, greater emphasis has been placed on irrigated temperate pastures and the use of nitrogen fertiliser on ryegrass.

In amongst all this gloom, some farmers continued to maintain and expand their areas of improved pasture. Why was this? The answer usually received in reply to this question is that the farmer has learned to manage them to suit his particular circumstances. He does not claim to be getting the optimum benefits, but at least he feels that he is financially better off than he would be if he relied entirely on native pastures and fodder crops. He is almost invariably worried about the price of seed and fertiliser in relation to the price of his end product. Gone are the days when he could just apply 100–200 kg per ha of superphosphate every year, whether it was wanted or not. He wants to know how much of each element is required and how often it must be applied, not only for good pasture growth but also for good animal production.

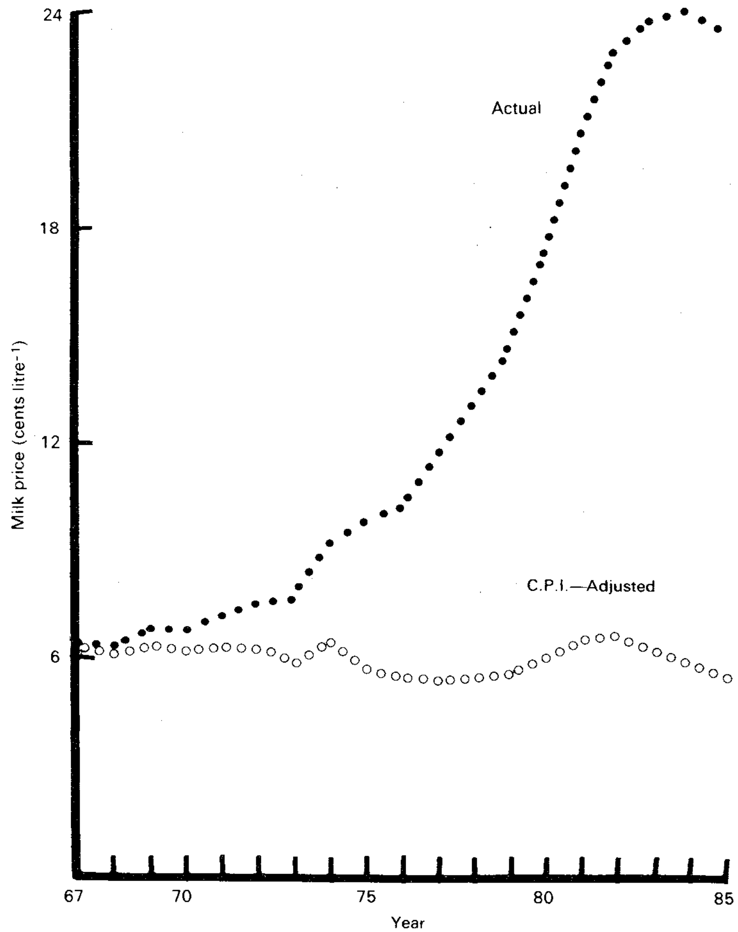

FIGURE 4

Change in the actual and C.P.I.—adjusted (1967 = 100) price of milk between 1967 and 1985. [Milk price based on 40% market and 60% manufacturing].

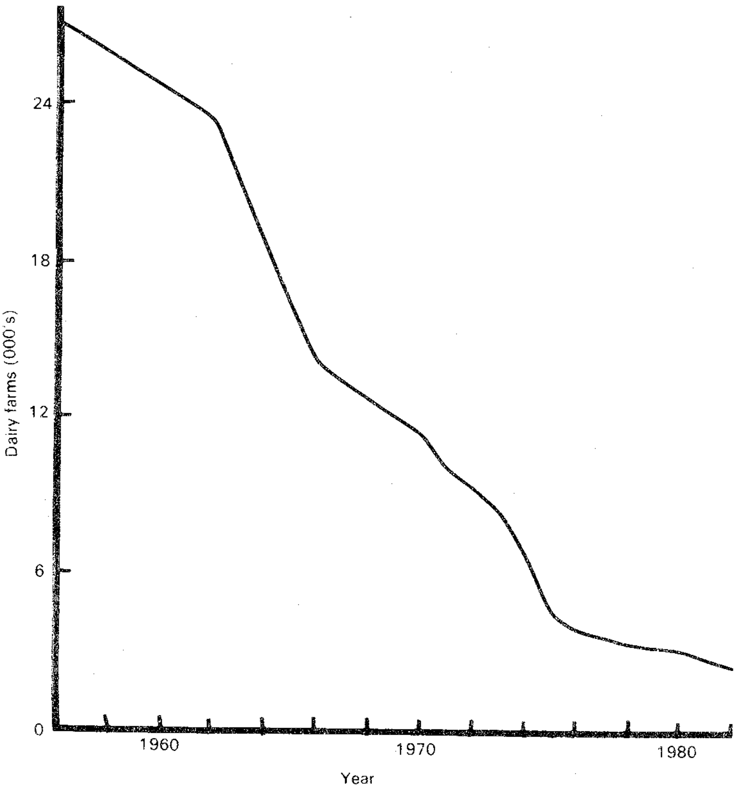

FIGURE 5
Decrease in the number of dairy farms in Queensland between 1956 and 1982.

THE LESSONS LEARNED

Much has been said and written about "Grazier-Proof Pastures". There will always be periods of drought in tropical and sub-tropical Australia and during these periods, pasture will inevitably be overgrazed. In most areas, pastures will have to withstand fire either frequently or infrequently, whether it be started by man or nature. Despite these factors and the possibility of infrequent defoliation by insect plagues, I am confident that farmers will, with the help of science, be able to evolve grazing systems that will enable them to maintain productive and profitable improved pastures, *if they so desire*. Here we come to the personal preference of individuals. Some take great pride and interest in developing and maintaining stands of productive improved pasture. Another farmer's first preference may be to spend the available time and money in other ways to increase net profitability. These other ways include buying more land, timber control, fencing, improving stock water facilities or investing on the stock exchange!

At this stage, very few properties have all their available land under improved pasture, and indeed this may not be a desirable goal. Native pastures usually have a few months of high productivity before their quality rapidly decreases. This period gives a manager the opportunity to spell some of the improved pasture area where it is desirable to allow seeding or the build-up of higher quality standover feed for later in the season. The area of buffel grass is still being expanded in the gidyea and semi-desert sheep country, where it grows without fertiliser and gives a longer period of green pick than the native pastures but carries only a few more cattle than the native Mitchell grass.

On most properties, the area of improved pasture is seen to have a specific role where it can give a good return on the money outlaid on development and maintenance. These roles include:-

—the finishing of cattle for slaughter that might otherwise have had to be carried over for another year if only native pasture was available.

—mating paddocks where cows and heifers can be put on a high plane of nutrition just before mating in order to increase conception. An increase in calving, and subsequently weaning percentages, is probably the most significant way that the profitability of a breeding property can be increased.

—calving paddocks which have to withstand heavy stocking rates for a short period of the year for management purposes.

—weaning paddocks to prevent rapid weight loss in the first few months after weaning. These pastures also have to withstand heavy stocking over a short period. Adequate nutrition at this time can mean that steers are fattened or sold as stores at an earlier age or that heifers can be mated at an earlier age. All these factors increase the net profitability of the enterprise.

—paddocks for vealer rearing where the cow needs a high level of nutrition for milk production and the growing calf needs a readily digestible pasture to supplement its milk diet.

—night paddocks for milking herds, particularly in hot weather when night grazing hours increase.

—lengthening the period when a green pick is available for sheep, and to build up a body of feed for drought periods. Unfertilised buffel grass fulfils this role.

—reclaiming eroded land that has become unproductive, usually as a result of overstocking and overclearing.

—ley pastures to spell and improve marginal cropping land.

Different pasture species or mixtures will be required for each different role and in each different climatic zone. Much is yet to be learned about the selection and management of species to fulfil these roles. However, in areas where there is more than one adapted species, the risk can be minimised by planting a mixture of these species. A single species pasture could be very seriously affected by disease, whereas only one component is likely to be affected in a mixed pasture.

In the wet tropics, quick-growing pioneer legumes, e.g. puero *(Pueraria phaseoloides)* can be used to give extra feed in the first one or two years in a pasture that will later be dominated by legumes that establish more slowly, e.g. centro *(Centrosema pubescens)*. In areas where rain can fall at any time of the year, a careful selection of pasture species can ensure that one or more of these species will be able to grow and utilise soil moisture whenever it becomes available. In parts of south-east Queensland, mixtures of tropical and temperate legumes, e.g. siratro, glycine, clover and medics can give this desired result when planted in association with compatible grasses.

LIMITING FACTORS AND RESEARCH NEEDS

1. *Costs and returns*

The first factor limiting pasture improvement is cost in relation to the expected returns and to the reliability of establishment and persistence. These costs can be broken up into: clearing, seedbed preparation and planting, seed cost, and fertilizer cost.

In suggesting areas where I believe that more research is needed, I am fully aware of the paucity of funds for pasture research in northern Australia and urge our Governments to rectify this need.

Clearing

In more heavily timbered areas, clearing may represent a major part of the establishment costs, and efficient clearing methods have been developed for most areas. What is less clear is the degree to which the timber should be cleared to get the best long term result from pastures. Some pasture species, e.g. green panic, grow better under trees. Overclearing can cause erosion and salinity problems on many soils.

Seedbed preparation and planting

A great deal of experimentation has gone into this area and advice on how to establish most species is readily available from extension officers. Special establishment practices may be needed where erosion is a major threat. The more recent emphasis on leucaena (*Leucaena leucocephala*) and shrubby stylo (*Stylosanthes scabra* cv. Seca) has led to complaints about slow establishment. More work is needed in this field to ensure a greater use of these valuable plants. Poor initial vigor could be related to the ineffectiveness of the presently available rhizobium strains. Apart from the direct costs of land preparation, there is the hidden cost arising from the fact that the area planted will, for all species except some of the Stylos, be out of production for several months, or even a year, to allow establishment and self-seeding.

The direct planting costs have been adversely affected by the disproportionate rise in the prices of farm machinery, fuel, fertiliser and labour when compared to the price of the end products, beef, milk and wool (Table 1).

TABLE 1

Percentage increase in value of inputs and outputs between 1967 and 1985

a. Increase in cost of inputs		b. Increase in value of outputs	
	%		%
Diesel	972	Milk	368
Tractors	714	Beef	324
S.E. Qld Station Hands Award	607	Wool (1984)	283
Single superphosphate	613		
Urea	354		
Pasture seed mix	214		
COST PRICE INDEX	432		

Seed cost

Rightly or wrongly, farmers generally quote the high cost of tropical pasture seed as one of the reasons why they do not plant more pasture. There are only two scientists, both from the Queensland Department of Primary Industries, working full time on pasture seed production in Queensland. The production of adequate quantities of clean seed of high germination from existing and new pasture species may involve research on plant breeding, mechanical methods of harvesting, the breaking of dormancy and the safe level to which hard seed should be treated. Luckily, seed producers are inventive people who constantly adapt machinery to harvest various

TABLE 2

Change in buying power of 100 kg weight of beef carcase +

Input	1967	1976	1985
Diesel fuel ex Brisbane (litres)	1216	390	405
50 KW tractor	0.015	0.004	0.007
Hours of work*	56	12	30
Single superphosphate (kg)	254	71	134
Urea (kg)	63	28	56
Pasture seed mix (in ha sown)	1.0	0.8	1.6

+ For steer at dressed weight of 250–300 kg.
* Based on S.E. Qld Station Hands award.

seed crops, and experiment with the timing and quantity of fertilisers used to give the best results. We must also realise that seed prices are affected by overseas demand, as many developing countries rely on Australia to supply pasture seed, particularly grass seeds.

However, the rise in price of the pasture seed mix that I use has been less than that of any of the other major input costs (Table 1 and 2).

Fertiliser cost

Without subsidies, we can do little to influence the price of fertilisers as these are closely linked to the world market price. However, there has been a great change in the relative price of nitrogen to phosphorus over the last twenty-eight years (Fig. 6). In Figure 6, phosphorus is expressed as P in single superphosphate and nitrogen is expressed as N in urea, both prices are ex works Brisbane and are adjusted for bounties and subsidies.

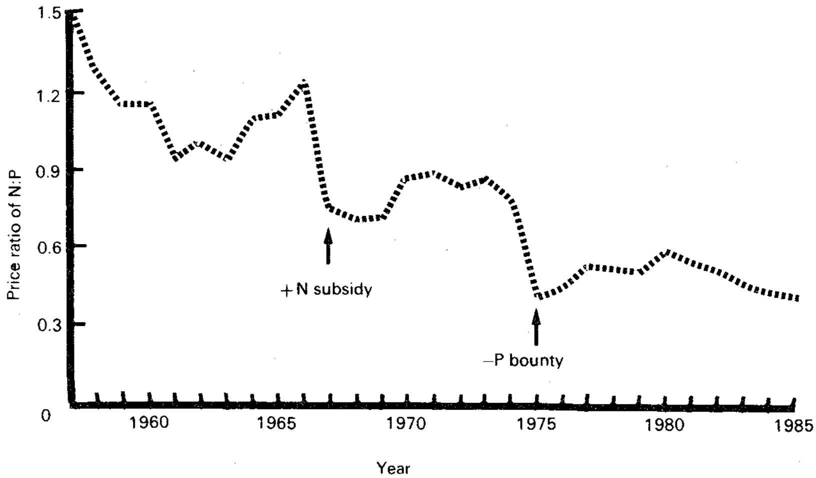

FIGURE 6

Change in the ratio of the price of nitrogen (as urea) to the price of phosphorus (as single superphosphate) between 1957 and 1985, prices are ex works in Brisbane and adjusted for bounties and subsidies.

If the trend shown in Figure 6 continues, there will probably be an increase in the use of nitrogen on grass in more heavily stocked areas at the expense of the use of phosphate on legume-based pastures. Initially, this will probably show up in the dairying areas, but may then spread to the more intensive beef fattening areas.

Sales of superphosphate in the years since 1980 have lost their relativity to the area of pasture planted and now are responding negatively to price rises (Fig. 7). According to the agricultural statistics, 75% of new pasture plantings for 1984 were of grass only, while in 1971 only 54% of new plantings were of grass only (Cameron 1978). The vast majority of these pure grass plantings would be of buffel, green panic and Rhodes grass that would not receive any fertiliser.

Insufficient is known about the nutrient status or location of the various soil types throughout northern Australia. A combination of soil analysis and plant tissue analysis can give us a guide to the fertiliser requirements but we are still a long way away from having a system where a farmer can be told exactly what fertiliser he should be using, and in what quantities and when, to give the best economic return. We need more research into the uptake of nutrients by various pasture plants growing on different soil types and the effect of competition between plants for these nutrients. When designing fertilizer experiments, one should keep in mind the effect they have on

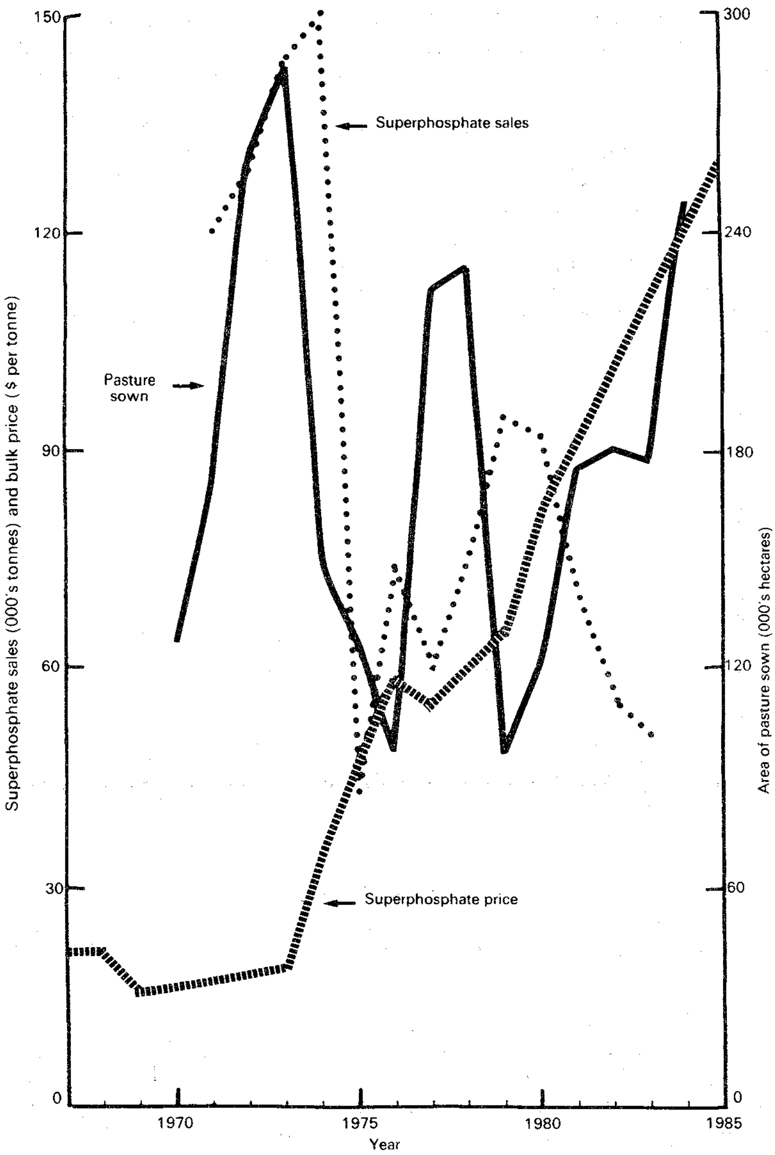

FIGURE 7
Comparison of the area of new pasture sowings, sales of superphosphate and price of superphosphate (bulk ex Brisbane and adjusted for bounty and subsidy) for the years 1967 to 1985.

animal performance, grazing selection and appetite as well as their direct effect on the growth of pasture plants.

2. *Inadequate legume*

The second factor limiting pasture improvement is the need for a persistent legume that spreads naturally and tolerates heavy grazing, particularly in south-east Queensland and in the brigalow areas with cracking clay soils.

Annual medics *(Medicago polymorpha, M. minima* and *M. truncata)*, white clover

(Trifolium repens), Kenya white clover *(T. semipilosum)*, lotononis *(Lotononis bainesii)*, *Vigna parkerii* and fine stem stylo *(Stylosanthes guianensis)* all meet the above criteria for some districts within the above zone but are not adapted to the whole region. Siratro *(Macroptilium atropurpureum)*, and to a lesser extent glycine *(Neonotonia wightii)*, grow well over much of the area but few farmers have been able to adapt their grazing management to allow the long term persistence of these species. However, they have shown their ability to spread well beyond the areas where they have been planted and the role they can still play should not be underestimated.

Only small areas of leucaena have been planted commercially but increased plantings can be anticipated following recent introduction of particular rumen bacteria that overcome any of the toxicity problems previously associated with this species, and also lead to better weight gains even where no toxicity symptoms are visible (R. J. Jones, personal communication).

We need anthracnose resistant *Stylosanthes* accessions to replace Townsville stylo and to safeguard Caribbean and Seca stylos. We also need a companion grass to grow with them in north Queensland, where the better native grasses go out under increased grazing pressure. Recently, *Centrosema pascuorum* has shown considerable promise as another legume for northern Australia.

3. *Uncertainties in pasture and animal management*

More work is needed to establish if an optimum pasture management system exists for the various pasture mixtures that will give both a reasonable return to the primary producer for his outlay on establishment and maintenance, and maintain a stable pasture. This can only be done through co-operation between primary producers and pasture research workers. The latter may be able to identify the critical factors that determine why pastures continue to flourish under one management system but rapidly degrade under another. As many new releases of pasture legumes are likely to come from previously unused genera, e.g. *Cassia* and *Arachis*, promising lines should be released to selected primary producers as early as possible so that they can be observed under a range of practical management systems.

We need to know if the animals grazing the pasture require any additional mineral supplements to be able to efficiently utilise the pasture. Recently I was involved in a mineral supplement trial in Sabah, where the trial steers were grazing on quite a well balanced grass/legume pasture. Cobalt and, to a lesser extent copper, were both giving significant weight increases in the early part of the trial and then all trial groups started to lose weight, while cattle in adjoining paddocks still appeared to be healthy and to be gaining weight. On investigation, it was found that the trial steers had not only had their shotgun mineral lick removed, so that it would not mask the trial results, but their salt and rock phosphate lick had also been removed. Soil and plant tissue sodium levels are extremely low in this area, as they are in parts of the top end of the Northern Territory, and no advantages are obtained from improved pastures unless the animals are fed a sodium supplement, i.e. a salt lick.

The majority of improved pastures throughout the world are short to medium term ley pastures and so it is not surprising that we are having some difficulty in establishing and maintaining permanent grass/legume pastures in northern Australia. Perhaps we should consider ourselves fortunate that we have even a few species that persist reasonably well. With the exception of a few grasses (e.g. pangola) and some of the tree or shrub legumes (e.g. leucaena) most of our perennial pasture plants have a relatively short life and are then replaced by new seedlings. Thus it is not surprising that our most successful pasture plants all seed freely and the seedlings can establish and survive under grazing conditions. If we are to rely on new seedlings to perpetuate our pastures, then we must learn to manage these pastures in a way that ensures that a large number of viable seeds are in the soil at all times.

The same pastures will still be subjected to overstocking in bad seasons or even over a period of drought years. However, when better seasons return, the pasture must be allowed to re-establish from seed and these plants must be allowed to flower and replenish the soil seed reserve. At this stage, my guess is that we must adjust our stocking rates so that even on the more intensively grazed pastures, we do not utilise more than 50% of the grazable material during the growing season. Once the cooler or dryer months herald the end of the growing season and seed has been set, then the more complete utilisation of the dry matter produced can do little harm.

Tussock grasses protect some of the actively growing material of twining legumes and although these tussocks may look untidy, they are serving a useful purpose and should not be mowed or slashed. In fact, even the widely believed theory that better production can be obtained from regularly slashed tropical grass pastures has recently been disproved (Buchanan *et al.* 1985). In addition to this, it has already been shown that the cost of fuel and farm machinery is rising at a much more rapid rate than is the price of the rural end product and this must continue to make slashing less attractive.

LOOKING AHEAD

Now let us look at the grazing resources of Queensland. Currently 89% of the livestock carrying capacity of Queensland is supplied by native pastures (Weston *et al.* 1981). Wire grasses (*Aristida* spp.), blue grasses (*Bothriochloa* spp.), Mitchell grass (*Astrebla* spp.) and black spear grass (*Heteropogon contortus*) presently cover half of Queensland.

We have 154.8×10^6 ha of native pastures and only 3.9×10^6 ha of improved pastures. It has been estimated by Weston *et al.* (1981) that 30×10^6 ha of Queensland could be planted with existing well-adapted 'improved' pasture species.

Of the grasses, buffel grass has the greatest potential (15.9×10^6 ha); and for the legumes, Stylo (9.7×10^6 ha) and siratro (4.4×10^6 ha) (Weston *et al.* 1981).

However, establishment costs and maintenance fertiliser requirements make it unlikely that much of this area will be sown to improved pastures in the present economic climate. Even though we have a number of adapted species and abundant experimental evidence that improved pastures can markedly increase animal production per hectare, the fact that primary producers are not rushing in to develop the large areas of suitable land means that they are not convinced that to do so would be to their economic advantage. If they do rush in, the increase in supply of beef may well reduce the price and leave producers no better off financially.

DEVELOPING COUNTRIES

The bulk of Australian pasture technology has been developed using sophisticated machinery on large areas of land. This technology is not directly applicable to most developing countries where farmers frequently have only very small areas of privately owned land. Their animals either graze on common land or pasture is cut and carried to the animals. The existing Australian technology does not adequately cover the behaviour of pastures under a cut and carry system of use or when they are heavily grazed by herds of mixed animals, all with different grazing habits. Initially, good practical farmers or extension workers are the people best suited to help to develop ways for small farmers to efficiently utilise improved pastures in these countries (Harrison 1972). Sophisticated research projects should be limited to solving problems that have been identified as major retarding factors.

Let us look at three different roles that improved pastures can play in developing countries: e.g. smallholders on a subsistence economy; common land; medium to large scale commercial or government projects.

Smallholders on a subsistence economy

In the wet tropics, smallholders may have from less than 0.25 ha to 2 ha of land and most of this will be used for food crops, mainly rice. Draught animals, buffalo or cattle, are frequently used to prepare the crop land. These animals need to be well fed to withstand the peak work periods when land is being prepared for planting. Much of their food ration is gleaned from grazing bunds and banks, and along roadsides, and is supplemented by crop residues, human food scraps, and pasture (mainly grass) that is cut and often carried long distances for them. These small farmers frequently plant a hedge or windbreak around their small house and fruit garden area, but usually the species used is not edible for livestock. These hedge or tree lines can be replaced with leucaena or gliricidia or other edible trees and can greatly improve the quality of the diet for the draught or other domestic animals if a small amount of leaf is picked daily and added to the ration. In addition to this, legumes can be sown on the bunds and banks between and around the crop areas. Because of the very heavy grazing pressures, stylo appears to be the most suitable legume for this purpose. In Timor, tethered bulls fatten at an excellent rate of over 1 kg per day on an *ad lib* diet of leucaena leaves plus a metre of banana stem for moisture, each day. There was no sign of any toxicity problem when I observed these bulls in 1974. It is very encouraging to see a number of countries in South East Asia with large nurseries rearing seedlings of leucaena and other tree crops for distribution to smallholders.

Common land

In the wet tropics, a very high proportion of domestic animals, sheep, goats, cattle and buffaloes, graze together on common land. In the monsoon tropics of N.E. Thailand, the dry tropics of Asia Minor, the Middle East and Africa both small and large groups of mixed animals are almost totally dependent on common land for their grazing. Under these systems, where there is no land tenure and often only loose tribal or village boundaries, there can be little, if any, planned grazing management. Consequently, any pasture species introduced into these areas must be very hardy and able to withstand constant overgrazing. Townsville and Verano stylos and the native *S. fruticosa* in Africa, have proved useful in the areas with a seasonal rainfall. Buffel (*Cenchrus ciliaris*) and birdwood grass (*C. setigeris*) have also made some contribution in semi-desert sandy areas.

Revegetation projects are being undertaken by the Government in Indonesia where species of leucaena and *Acacia* are being planted on hilly areas that have been denuded of tree vegetation by shifting agriculture and have been badly damaged by erosion. These are worthwhile projects but it is still very hard to prevent hungry stock from entering the area and damaging the young seedlings. The cost of conventional fencing for large areas would be prohibitive and they can easily be cut or broken. However, 'live fencing' using leucaena or other similar species can be very effective if protection can be given in the early stages.

To revegetate arid areas in the middle East and Africa requires agreement between the Governments and the tribal leaders that areas will be left unstocked while new seedlings establish. In very low rainfall areas, i.e. less than 150 mm in Oman, revegetation may only mean increasing the number of browse trees (*Acacia* spp., *Prosopis* spp. and *Ziziphus* sp.) by 20 to 30 per hectare. In this type of country, the carrying capacity is only 1–5 goats or sheep per km^2. In these countries, even armed guards cannot prevent nomadic herdsmen from entering forbidden areas if they are the only source of feed and water to prevent their stock from dying.

Medium to large scale commercial or government projects

The Governments of developing countries frequently request aid or advice for the establishment of large scale ranching projects based on pasture development. These often appear to be little more than status symbols and ranches run by the public sector seldom reach high levels of efficiency. The cost of mechanical breakdowns are enormous and the developing world is littered with broken machinery.

The other common problem with Government run ranches is that the livestock are often introduced before the pasture is established and it is then very difficult to establish good pastures when starving animals are waiting to nip off each green shoot as it emerges.

Overclearing of jungle or forest land is another common problem and this when followed by overstocking, even after a good pasture has been established, leads to erosion. Of course, the problem of combined overclearing and overstocking is found in Australia as well as in the developing countries.

In the arid Middle East countries large irrigation projects are favoured, growing lucerne (*Medicago sativa*) which is indigenous to this area or more recently, Rhodes grass (*Chloris gayana*).

Some Government and some private ranches are well run and these are producing increased amounts of animal products and can benefit directly from Australian technology. In some areas good pastures have been developed under plantation crops such as coconuts and oil palm. However, in the heavily populated countries of South East Asia, the main increase in animal production will come from smallholders improving the nutrition for their small numbers of animal and not from the large ranching projects.

In the more sparsely populated hilly areas of grassland, the low cost introduction of legumes into the native grass pastures can give increases in animal production. Quite large areas of cogon pastures (*Imperata cylindrica*, *Themeda triandra* and *Saccharum* spp.) in the Philippines have been improved by the hand introduction of stylo, centro and siratro onto burnt or heavily grazed grass areas, together with small quantities of phosphatic fertiliser. This type of low cost development should be encouraged and if each farmer grows a small area for seed collection, then he can progressively expand his improved area without having to outlay money for seed. Where labour costs are cheap in relation to animal products, very high quality samples of pasture seed can be economically hand harvested (Harrison and Snook 1972).

CONCLUSIONS

I believe that improved pastures do have a very important on-going role to play in the tropics and sub-tropics. However, we are still in the infancy of knowing how to manage these pastures to the best economic advantage, either in northern Australia or in the developing countries.

Establishment and management techniques developed in Australia for Australian conditions, will only have a limited direct application in developing countries, and different management techniques will have to be developed to suit areas where fodder is cut and carried to animals or where mixed species graze on communal land.

Because of the unreliability of the rainfall in northern Australia, its basically seasonal nature, and the low fertility of most of the soils, large areas of improved pasture will be required to significantly increase animal production from our tropical areas. Because of this, it is not practical to base our grazing industries on pastures that have to be replanted regularly. For the vast majority of the area, permanent or at least long term pastures are the only practical answer.

It is encouraging to see closer co-operation between pasture research scientists in the Queensland Department of Primary Industries, New South Wales Department of Agriculture, C.S.I.R.O. Division of Tropical Crops and Pastures and the University of Queensland. This is essential if we are to get the best value out of the limited research funds available. Greater use could probably be made of primary producers by making early releases of the seed of some promising new pasture species so that they could be observed under a variety of practical management conditions.

With the limited research funds available, I believe that a high priority should be given to research programs aimed at areas that should give a short to medium term benefit to the end user whereas only a low priority should be given to areas of pure research such as those aimed at improving the inherent feed quality of tropical grasses.

I regard the following as high priority areas:-

—To establish grazing management systems in conjunction with producers, that encourage good pasture growth and persistence from both native and improved pastures as well as giving economic increases in animal production.

—To determine the fertilizer requirements in type, quantity and time of application to give both good pasture growth and profitable animal production on each of the major soil types in each of the major climatic regions.

—To develop methods to produce and harvest adequate quantities of high quality seed of new pasture plants.

—To design compatible pasture mixtures to obtain the maximum benefit from available soil moisture at any time of the year and to reduce the risk of totally losing an improved pasture through an outbreak of disease on one species.

—To find ways to encourage the more rapid establishment of leucaena and shrubby stylo.

—To identify and test new species of legumes that will persist under grazing for both south-east Queensland and the brigalow soil areas.

—To test and release new anthracnose resistant *Stylosanthes* accessions for northern Australia and to look for a productive grass that will persist in these pastures.

—To establish the degree to which various types of tree vegetation should be cleared to give the best long term result from pasture improvement without exposing the land to erosion or a build-up of salinity.

Of the three main pasture based primary industries, the beef industry appears to have the most to gain from these areas of research. The dairy industry is contracting and those remaining in it are making more use of temperate irrigated pastures. The western wool growers will still continue to expand pure grass pastures as funds become available and they already have some suitable species for this purpose.

If the area of improved pasture is to be significantly expanded on beef properties it will have to be capable of increasing the net return to the producer.

It is not necessarily the lowest cost system of establishment and maintenance that will achieve this aim, but the longer the productive life of the pasture can be extended, the better will be the chance of success. An increase in weaning percentages and a younger turn off age will be the main factors in improving the throughput of a property. However, we must first develop markets, and producers must be protected from governments wanting to reduce the size of their holdings, as it is only through the efficiency of scale that farmers can possibly survive on declining or even stable real prices for their commodities.

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