THE BEEF CATTLE GRAZING INDUSTRY IN NORTHERN AUSTRALIA

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Summary

There has been almost a 50 per cent increase in beef cattle numbers in tropical Australia in the last five or more years. This increase has occurred in the traditional beef cattle areas, especially those with higher rainfall incidence; ie in excess of 25 in (635 mm) annually. The rainfall in Northern Australia which is tropical and sub-tropical is largely of summer incidence with the proportion of the total rainfall falling in the summer increasing from 66 per cent in the sub-tropics to nearly 100 per cent in the northern tropics.

The higher rainfall beef cattle zone is readily divided into three zones — the high rainfall (> 1000 mm) tropical and sub-tropical forests, the tropical and sub-tropical woodlands and grasslands (750-1000 mm rainfall) and the brigalow region (600-750 mm rainfall). The need for amount and complexity and response to fertilizers decreases sharply with the decrease in rainfall.

In the three regions, substantial pasture improvement has been undertaken, although the woodlands and grasslands which is the predominant region, has had the least development. Legumes have played a major role in the regions other than the brigalow region.

In general, it has been shown that, despite severe seasonal water stress, both nitrogen and phosphorus (and sulphur?) deficiencies seriously limit pasture production on almost all virgin Australian soils during the periods when water is adequate. The system of using nodulating legumes is extremely sensitive to adverse soil conditions. Deficiencies of some elements required in minute quantities limit plant or animal growth on many Australian soils.

Land clearing methods and the use of fertilizers designed to remedy the known deficiencies in the soils have turned virtually wasteland into highly productive pastures. On the tropical coast annual livemass gains of over 300 kg/ha at stocking rates of 1,5 to 2,5 beasts per ha have been achieved with fertilized improved pastures with a high and evenly distributed rainfall.

The use of the legume (Townsville stylo) with superphosphate and controlled stocking has lifted production to at least four times that on native pastures at the normal stocking rate.

In the brigalow region which has been developed by massive timber treatment and pasture sown in the ash after burning, high production has been achieved up to 20 times but commonly five times that prior to clearing the timber.

All these methods have been shown to be economically sound, although the returns on the higher rainfall zone have not been as attractive as the others because of higher land costs and operational costs.

While these improved pastures are usually evaluated with growing and fattening cattle, they are mostly used in commercial practice by breeding cattle. To obtain maximum productivity from breeding cattle, management practices must be closely related to the seasonal fluctuations of pasture quantity and quality.

Stocking rate is important and must be related to the balance between optimum productivity per animal and optimum productivity per acre. Flexibility of stocking is one of the most important tools of the stock men.

Controlled mating is essential for the best utilisation of pastures and best results have been obtained with calving times to coincide or precede with the flush of pasture growth. Heifers should be mated early in the mating season as there is a tendency for their calving time to slip back in later pregnancies.

Weaning of calves is important so that the dam has the opportunity to regain sufficient condition going into the dry season. It is more important to have regularity of breeding than to have a few good calves.

Age at first mating is important. In areas where it is possible to grow heifers well so that they can calve as two year-olds, this offers many advantages in overall herd productivity. This should be possible in most areas where a reasonable growth rate of heifers can be achieved through the whole year.

Mating management using pregnancy diagnosis, mating of excess females and culling of empty cows can yield a substantial dividend in an increased number of calves. If only pregnant cows are maintained in the herd over the dry season, the resulting calf crop can easily repay any additional costs.

Management of bulls and of the cows at calving is also very important.

Supplementary feeding must play an important role in assisting even out animal performance throughout the year. Improved fertilized pastures increase the quality and quantity of pasture in the growing season and extend its nutritive value into the dry season, particularly when a legume is involved. However, in many situations in Northern Australia, we have found that protein or NPN supplementation is essential to help carry the more vulnerable classes of stock through the dry season.

For successful utilisation of improved fertilized pastures, sound management practices have proved to be essential to assure an adequate return on investment.

The research and extension services available to the beef producer in Northern Australia are briefly reviewed. The contribution of the Commonwealth Extension Services Grant and the Government and industry contribution to research to this area are discussed.

Special projects of assistance to the producer are listed with particular emphasis on the Beef Cattle Roads and the Brigalow Lands Development. As instances of assistance which could be made available to the beef industry, the Marginal Dairy Farm Reconstruction Scheme and the Queensland Dairy Pasture Subsidy Scheme are discussed.

A review is also made of the financial assistance to producers by way of fertilizer assistance and taxation concessions.

Introduction

The beef cattle industry in Northern Australia is based predominantly on production from grazing animals which utilise native grasslands dominated by indigenous species, improved and sown pastures partly or wholly dominated by introduced species, and crops. There has been much interest in feedlot fattening of cattle and a substantial amount of research has been directed towards it, but to date there has not been any significant development of feedlots except occasioanlly in conjunction with grazing. In recent months, there has been an upsurge of interest in feedlots directed particularly at supplying the Japanese market which shows a marked preference for feedlot beef. However, these feedlots will need to be fully competitive with feedlots in the USA for economic viability.

The increase in beef cattle numbers in Australia from 14 million to over 20 million in five years can be attributed to a major extent to increased productivity of pastures. In Queensland the increase in cattle numbers has been from 6,5 million to 9,2 million in that period. While in the last three years this increase has been partly at the expense of sheep, it has been more marked in the traditionally beef cattle areas.

The factors contributing to this expansion have been manifold and date back to the decade following World War II. In the early 1950's the Australian Government recognised the need to stimulate export income. One industry which seemed to have a potential for expansion was the beef cattle industry. Besides steps taken to assist and develop other industries, a number of programmes were undertaken to assist in the development and expansion of the productivity of the beef industry.

Research to assist the beef industry up till that time was virtually non-existent and programmes of research were undertaken both at State and Federal level to provide the basis for expansion of the industry. Extension services to the industry were expanded and supported. A number of direct incentives to graziers to expand as well as a number indirect benefits were introduced.

In this paper I propose to discuss (a) the advances in technical information which have contributed to this expansion of the industry and how they were brought about; (b) the extension and field research programme and (c) the governmental measures, both State and Federal, which assisted the grazier.

Pasture and husbandry research

Organisation of research

In the early 1950's, the Australian Meat Board acquired two properties to serve as the bases for research into beef cattle production in Queensland. 'Belmont' near Rockhampton was developed by CSIRO to become the National Cattle Breeding Station where studies on the Brahman and Africander were commenced. 'Brian Pastures' near Gayndah was developed by the Queensland Department of Primary Industries as a pasture research station. Since then other research stations have been developed and CSIRO established a Division of Tropical Pastures in Queensland which has grown to over 70 research personnel and supporting staff. Over the same period, the Queensland Department of Primary Industries has developed a group of approximately 40 agrostologists of whom half service the beef cattle industry as well as nearly 20 beef cattle husbandry officers.

There was also expansion in other sectors of CSIRO servicing the beef industry and also in State Departmental services. But these serve to illustrate the substantial increase in investment in research for the beef cattle industry.

It became apparent at an early stage that the major lift in production would come in the high rainfall zones and most effort was concentrated in the 500 mm and higher rainfall area.

Definition of areas

(a) *Climate*

The districts in which beef cattle are produced in Northern Australia receive monsoonal and tropical cyclonic rains in summer and there is a mid to late summer peak in both quantity and quality of pasture followed by a long winter and spring decline in both attributes. Further south in Queensland and northern New South Wales, at the limites of both northern tropical and southern mid-latitude rains, an occasional winter rain may combine with satisfactory light and thermal conditions to produce pasture outside the summer period. Year to year variability is high in this zone.

The rainfall incidence in the summer rainfall region of northern Australia is characterised by droughts and frequent periods of extreme rainfall deficiency (Foley, 1957). It is estimated that, in Queensland, there is a likelihood of any one area of the State being drought stricken in three years out of ten and that, on the average, the area remains in the 'declared drought stricken' category for nearly seven months (Queensland Department of Primary Industries, 1966). However, 50 per cent of droughts in Queensland last no longer than five months. As one moves southward into the predominantly winter rainfall regions, the incidence of drought becomes less.

(b) *Grazing lands and pastures*

In Northern Australia the main beef cattle regions, listed in order of decreasing annual rainfall, include tropical and sub-tropical forests and heaths, tropical and sub-tropical woodlands and grasslands, brigalow forests, semi-arid woodlands, and a variety of arid formations. Some of these vegetation forms have been extensively modified by land-clearing, fires, pasture seeding and fertilizer application, whilst others have been modified only by grazing.

The tropical and sub-tropical forests include the higher rainfall regions of Northern Australia between the 900 mm and 3 500 mm rainfall isohyets and cover about six million hectares; they support over one million beef cattle. More than half the area is too rugged or too swampy for the development of pastures for beef cattle, and a considerable part of the suitable area is pre-empted by other enterprises including sugar cane, tobacco, dairying and forestry. The native grazing lands of the region are dominated by tropical tall grass *(Heteropogon — Themeda — Sorghum)* of poor food quality, but a wide variety of productive high-quality grasses and legumes is now available (Bryan, 1970). These grasses include cultivars of exotic species in genera such as *Brachiaria, Digitaria, Paspalum, Pennisetum, Setaria,* and legumes include exotic species in genera such as *Centrosema, Glycine, Leucaena, Phaseolus, Pueraria* and *Stylosanthes* in addition to *Trifolium.*

The tropical and sub-tropical woodlands and grasslands extend between the 500 and 750 mm rainfall isohyets and form an important beef producing region, containing approximately 3,5 million beef cattle. A wide range of techniques of pasture improvement has been developed for this region and there is considerable scope for implementing these techniques (Shaw & Norman, 1970).

The brigalow forest is also a significant region for cattle production in Northern Australia particularly after the development of improved pastures (Coaldrake, 1970). Characterized by dense stands of the leguminous tree, *Acacia harpophylla* (brigalow), this region lies in a circumscribed area in Queensland bounded by the 750 and 500 mm annual rainfall isohyets and by the 20°S and 29°S meridians of latitude. The unimproved grazing lands are of low nutritional value, but when the forests are cleared, productive pastures can be sown with species selected from *Chloris gayana* (Rhodes grass), *Chenchrus ciliaris* (buffel grass), *Sorghum album, Panicum* and *Digitaria* spp. (Coaldrake, 1970).

The semi-arid woodlands, a belt of shrub and low woodland, extend from the north east of Western Australia across the Northern Territory through Queensland to the junction of the Murray and Darling Rivers. In the north where most rain falls in summer these woodlands lie between the 750 and 500 mm isohyets, but further south where the incidence of winter rain is higher the woodlands occur where the annual rainfall is only 250 mm. Beef cattle in this region are usually kept on unimproved grazing lands though some southern areas have been sown to improved species (Moore, Condon & Leigh, 1970).

Arid vegetation formations occupy another immense area including the central part of the continent and extending to the western and south central coasts; part of the northern region and a comparatively small area of central Australia are used for beef cattle production.

(c) *Beef husbandry*

(i) Range of enterprise

Management and its aims vary greatly between the different regions. The more intensive methods are used in higher rainfall regions which are more closely settled and nearer to markets than in regions of lower rainfall. The distribution of property size is markedly skewed, most properties being smaller than the average size. In south east Queensland, two-thirds of properties are less than 2,000 ha and about two-thirds of beef properties carry less than 500 cattle. In Central Queensland, two-thirds of beef properties are less than 8 000 ha and carry less than 1 000 cattle. In north western Queensland, two-thirds of beef properties are less than 225 000 ha and carry less than 5 000 cattle (Bureau of Agricultural Economics, 1970a). These figures illustrate the wide range of management possibilities as well as pointing up the scale of operation in the northern region which is largely devoted to an open range system of beef cattle production. To date there has been more pasture development and construction of facilities in the tropical and sub-tropical forests and heaths, the brigalow forest and parts of the tropical and sub-tropical woodlands and grasslands than in the more arid regions which are lightly stocked and present considerable management problems and where at present there appears to be little scope for intensifying pastoral production. Throughout the industry there is a wide gradation from stock being kept in small paddocks and handled every week or two to stock being mustered no more than twice yearly at branding and sale time.

Herd productivity in the various regions is reflected by the branding, mortality and turn-off percentages. Branding percentage is the number of calves mustered for fire branding and castration through the year, and is based on the number of cows in the breeding herd. The mortality percentage represents the annual losses of all classes of stock after branding, and covers wastage due to deaths in drought, calving, accidents and disease. Turn-off is usually considered as the number of cattle sold annually expressed as a percentage of the number on the property. Productivity measured in these terms is closely associated with the size of property and size of herd. The pattern of productivity is largely due to the marked seasonal incidence of pasture availability through the year and to the great variation in annual rainfall in the more extensive areas where mass losses and deaths are regular features which may reach catastrophic levels during drought.

(ii) Animal performance

There are direct measurements of animal performance in many regions and growth rates of beef cattle have been documented in the more developed regions (Chester, 1952; Alexander & Chester, 1956; Franklin, 1956; Sutherland, 1959; Norman & Arndt, 1959; Norman, 1965) and in the semi-arid woodlands regions (Dowling, 1960). These have demonstrated an animal growth curve which closely follows the pasture growth curve. Studies on reproductive performance have shown that branding percentage of northern beef cattle herds is low and variable (Donaldson, 1962; Donaldson, Ritson & Copeman, 1967; Lamond, 1969; Barr, 1971) and considerable mortality in the long dry season, during non-seasonal drought and at calving has been documented (Howard, 1966; Smith & Alexander, 1966; Jenkins & Hirst, 1966). Disease, both infectious and parasitic, has also played a major role in limiting beef cattle production in Northern Australia.

These production problems of the northern regions have been met by a variety of methods including improvement in nutrition through the use of sown pastures, crops, conserved fodder or other supplements in seasons of feed shortage or reduced feed quality. Reproductive performance is also being improved by controlled mating, planned weaning and pregnancy diagnosis.

Investigations with sown pastures

There has been a major effort in pasture development for Northern Australia. This became a search for legumes to take the place held in the south by subterranean clover, medics, white clover and lucerne. This preoccupation with legumes has been based on trends in pastures in Australia over the last 50 years, particularly in Southern Australia. Legumes have been used to increase nitrogen availability in deficient soils, nitrogenous fertilizers having been in the past prohibitively expensive. The solution of problems of mineral nutrition and nodulation have made highly productive pastures possible. A second reason for the use of legumes is their intrinsic value as feed for ruminants. An accidental introduction, Townsville stylo *(Stylosanthes humilis)* has been one of the first legumes to achieve prominence. Methods of harvesting seed in commercial quantities have also assisted materially in pasture development in the tropics.

Fertilizers have played an important role in the development of improved pastures in Northern Australia. Research on the effects of fertilizer on pasture production has yielded the following important concepts. Despite severe seasonal water stress, both nitrogen and phosphorus deficiencies seriously limit pasture production on almost all virgin Australian soils during periods when water is adequate. The symbiotic system of utilising atmospheric nitrogen is especially sensitive to adverse soil conditions. Deficiencies of some elements required in minute quantity of the order of 100 g/ha limit plant or animal growth on many Australian soils. There are multiple deficiencies on many soils and these could be understood by studying interactions between soil additives and the responses to them. In the tropical and sub-tropical areas, legumes were used almost exclusively to supply the nitrogen required by pasture, but in the 1960's use of nitrogenous fertilizer on pasture commenced since it became apparent that the rate of supply of nitrogen from legumes was inadequate for the associated grasses under intensive conditions. This was stimulated by new fertilizer plants, government subsidies and a reduction in price (in 1974, these stimuli to the use of fertilizers are being withdrawn). Usually the application of nitrogen is at such a level as to stimulate both the grass and the legume and so maintain a legume-based pasture as much as possible.

Phosphorus is an important element in Australian pasture production. Superphosphate is applied primarily for the benefit of the legumes but, where the level of phosphorus in the surface soils is low, it can prove beneficial to the grasses also. This is particularly the case in pasture establishment.

(a) *Sown pastures in the tropical and sub-tropical forest region*

The soils underlying these forests are very variable but, in general, they are deficient in at least one nutrient; often more. The common deficiencies are in N, P, K, Ca, S, Mo and sometimes Cu and Zn. Because of the high rainfall, the potential for animal production is high but the high-yielding pastures are expensive to establish because of land clearing costs, seed costs, and the relatively high levels of fertilizer required.

A considerable amount of animal production research has been carried out in the Wallum which is the southern area of this region. These have demonstrated that the pattern of livemass change of steers on grass-legume mixtures is fairly constant over the years, with the most rapid gains being made in spring, a slightly slower rate of gain in mid to late summer, slower still in autumn and either no gain or a loss in winter. In general the rate of gain is associated with the legume content, the higher the content the better the animal performance. Livemass gains of up to 348 kg per hectare at 2,47 beasts/ha and 328 kg per hectare at 1,65 beasts/ha at the higher P level of 250 kg/ha annually are recorded (Bryan, 1970).

Performance on grass pastures with N + P + K fertilizer has been high. Pangola pastures given between 336 and 476 kg N/ha produced in good years gains of 558 kg/ha at 7,4 beasts/ha with 336 kg N and 610 kg/ha at 4,3 beasts/ha (Bryan & Evans, 1971). The number of applications of N was important, with proportionately more N in autumn and winter having a markedly favourable effect on animal production. Although the use of fertilizer N on grass has given considerable increases in livemass gain over grass-legume mixtures, the use of such grass pastures as the sole source of feed is doubtful as an economic proposition (Michell, Bryan & Evans, 1972). Possibly the role of nitrogen fertilized pastures will be to supplement a main use of grass-legume pastures at times when these are low in quality or amount. Limited use of N on mixed pastures may fill this need.

A number of economic appraisals have been made for returns from cattle fattening in the area. Moore (1967) found that, with a turn-off of 2,5 beasts/ha/year, a net return of about 12,5 per cent on the total cost of development would be achieved assuming income tax concessions for development but not interest on capital invested. In another study, McGuire (1968) found that the internal rate of return (IRR) for fattening stock ranged from three per cent to ten per cent depending on beef price assumptions. For breeding and fattening the IRR was lower. In a further study examining pangola grass-legume pastures and N fertilized pangola pastures, the IRR's were approximately 3-5 per cent for grass legume and 4,5 to 6 per cent for pangola, with 168 kg N/ha. By applying taxation concessions to an investment of non-farm taxable income, it was possible to produce returns in excess of nine per cent. At the time of these studies, it should be remembered that the average return to capital for Australian farms was about four per cent so that these enterprises compared reasonably well with other farming enterprises.

(b) *Sown pastures on the tropical and sub-tropical woodlands and grasslands*

The native grasses of this region in the 500-700 mm rainfall zone are *Heteropogon contortus* (bunch spear grass), *Themeda australis, Bothriochloa, Dichanthum* and *Aristida spp.* There is a general pattern of rapid grass growth in summer, a period of maturation in autumn with an associated decline in quality and a further decline in quality in winter.

In southern Queensland beef steers gain mass over eight months and lose over about four months. The net gain varies considerably from year to year, ranging from about 120 to 300 lb (54-136 kg) and as a result steers are usually three to four years old at slaughter. In north Queensland, the adverse seasonal effects are stronger so that net yearly gain is usually not greater than 90 kg (200 lb).

(i) Townsville stylo

Sown pastures have been developed for the region around the premise that higher pasture production can be achieved using a change of species together with the use of appropriate fertilizers to raise soil fertility. Legumes have been used almost entirely as the source of nitrogen and the most important of these has been Stylosanthes humilis (Townsville stylo). It is a herbaceous legume either erect in habit up to 2 ft (0,6 m) high or semi-prostrate, with thin stems and elongated, pointed trifoliate leaves. It is free-seeding and usually behaves as an annual, although in southern Queensland a proportion of plants may persist for more than one year.

In most instances, Townsville stylo is sown alone to produce a mixture with the existing native grasses. Good establishment is possible on roughly prepared seedbeds and even on uncultivated ground. While Townsville stylo will grow on poor soils without fertilizer, it responds well to improved nutrition, both in dry matter and nitrogen content.

In Central Queensland, fertilized Townsville stylo stocked at 1 beast to 2-3 acres (0,8 to 1,2 ha) fattened steers to market mass at three years compared with 4½ years on native grasses at about 9 acres (3,6 ha) per beast (Shaw, 1961). Native pastures fertilized with superphosphate have given increased yields and phosphorus content in the drier areas. However, in one experiment over three years to assess the value of superphosphate on native spear grass pastures, there was no significant effect of the fertilizer on animal gains.

In experiments in the Burdekin basin, a level of 125 kg/ha annually increased legume yield and increased the phosphorus content of the pasture (Winks, 1973). Three years of superphosphate application at this rate should provide sufficient reserves in the soil to last for 4-5 years. Animal performance on both Townsville stylo and native pastures is seasonal. Even on fertilized areas, animals suffer mass losses during the dry season in all years. The major differences associated with the legume and fertilizer are in the rate of gain and the period of gain. Usually animals will gain mass until May-June on native pastures, June-July on unfertilized Townsville stylo and August-October on fertilized Townsville stylo all stocked at 1 beast/2,4 ha. Once mass losses commence, they occur at a similar rate on all areas. Economic appraisal of the results of these experiments in the Burdekin area showed that returns to additional invested capital in a steer-fattening operation were of the order of 15-20 per cent, indicating that investment in both Townsville stylo and fertilizer was economically sound.

Two major experiments have been carried out to evaluate fertilized Townsville stylo with breeding cows.

At 'Swan's Lagoon' reproduction rates have been superior on the fertilized Townsville stylo based pasture (Winks, personal communication). This advantage in favour of the Townsville stylo pasture is even more marked when one considers that it is stocked at twice the rate of the native pasture (1 beast/2,4 ha *vs* 1 beast/4,9 ha). See Tables 1 and 2.

In the other trial with breeding cows, a similar pattern of results emerged (Edye, Ritson & Haydock 1971; Edye *et al* 1972). However, there was no treatment with native pasture. Cows on the pastures receiving superphosphate were heavier throughout the four years of the experiment than cows on unfertilized (Fo) pasture as were their calves (Table 3). In most years there was little difference between pastures receiving superphosphate at 377 kg/ha (F_3) and 126 kg/ha per year (F_1). While stocking rate was of importance, superphosphate was the only treatment that significantly affected conception and calving rate. Superphosphate increased the phosphorus and sulphur contents of all pasture species, the nitrogen content of Townsville stylo and the sodium content of the grasses. Cow conception rate was significantly and positively correlated with the phosphorus contents of the pasture components. However the phosphorus content of all pasture components was less than 0,15 per cent for much of the year at all but the highest rate of superphosphate. Only at this rate did the pastures approach an adequate phosphorus content for pregnant and lactating cows.

These experiments show quite clearly that Townsville stylo-based pastures provide an adequate margin over native pastures in this area with climate suitable to the plant. The establishment of these pastures is proceeding steadily on properties in the area and many properties have now substantially increased their carrying capacities and productivity as a result.

TABLE 1 Pregnancy rates by pastures by years

Pasture	1970-71	1971-72	1972-73	Mean
Native Pasture	84	88	38	70
Fertilized Townsville stylo	88	91	68	82

Weaner productivity on the two pastures followed a similar pattern.

TABLE 2 Weaner productivity

Pasture	Weaner Rate	Weaner mass	Weaner Prodn/ Cow mated
	%	(kg)	(kg)
Native Pasture	65	160	104
Fertilized Townsville stylo	76	179	136

In terms of production per hectare, the weaner yields were 21 and 60 kg/ha for native pasture and *Townsville stylo* respectively.

(ii) Other pastures and legumes

Other legumes which are suitable for sown pastures in the region are siratro *(Phaseolus atropurpureus)*, *Glycine wightii* and *Desmodium intortum* in the higher rainfall areas. These have been generally limited to the southern half of Queensland. Rhodes grass *(Chloris gayana)*, green panic *(Panicum maximum* var. *trichoglume)* buffel grass *(Cenchrus ciliaris)*, and other introduced grasses have been used in the region. The choice of grass depends largely on rainfall, but the major factor determining persistence is a continuing supply of nitrogen from a legume or as fertilizer.

(c) *Sown pastures on the brigalow forest region*

There is a fairly wide range of introduced grasses that are suited to the brigalow region, but the range of legumes is quite limited. The grasses commonly in use come from the following genera: Chloris, Panicum, Sorghum and Cenchrus. The first sown grass to be used extensively in the brigalow was *Chloris gayana* (Rhodes grass) and it is still used extensively as it establishes well on newly cleared land. It is not as drought resistant as the other grasses such as Petrie panic *(Panicum maximum* var. *trichoglume)* or buffel grass *(Cenchrus ciliaris)* (Coaldrake, 1970).

The legumes are dominated by lucerne *(Medicago sativa)* as well as some medics. Siratro *(Phaseolus atropurpureus)* show drought resistance and is of some value in the region.

In brigalow soils there are no initial deficiencies of mineral nutrients that seriously limit growth of pastures. Production is high because of the soil nitrogen available after the removal of the nodulating legume, brigalow and the soil moisture stored in the fallow between clearing and burning. It appears that soil nitrogen declines rapidly under pastures for two to three years and then at a slower but steady rate. The phosphorus status is marginal on some of the brigalow soils. Some of the solodic soils of the brigalow region have multiple nutrient deficiencies notably nitrogen and phosphorus but also calcium, potassium, molybdenum and other trace minerals.

There are two main stages in the conversion from brigalow forest to pasture. The forest is first flattened by a heavy chain or cable pulled between two crawler tractors; this uproots or breaks at ground level, all except the smaller trees. One clearing team of two tractors covers about 100 acres (40 ha) per day at a cost of \$2,00–\$4,00 per acre (\$4,90 to \$9,80 per ha) depending on density of the forest and location. The fallen scrub is allowed to lie for up to one year and then burned to produce an ash-bed. Burning during hot dry weather leads to the almost total destruction of timber. Grass seed is sown from aircraft on the loose ash as soon as it has cooled so that the ash provides both seed cover and nutrients. A typical seeds mixture is 2 lb/acre (2,2 kg/ha) each of Rhodes grass and *Sorghum album* and 1 lb per acre (1 kg/ha of green panic, costing \$2,50 per acre for seed and \$0,50 per acre for the sowing.

TABLE 3 (a) Effect of superphosphate on calf birthmass

Main effects		Calf birthmass 1964-65	1965-66	1966-67	1967-68	Mean#
Superphosphate						
Nil	(F_0)	29,2 NS	27,7 NS	29,5 NS	31,5 NS	28,6
126 kg/ha/yr	(F_1)	29,2	27,7	29,5	31,5	30,0
377 kg/ha/yr	(F_3)	29,2	27,7	29,5	31,5	30,0
Overall mean		29,2	27,7	29,5	31,5	29,5

(b) Effect of superphosphate on calf weaning mass at 180 days

Main effects		Calf weaning mass 1964-65	1965-66	1966-67	1967-68	Mean#
Superphosphate						
Nil	(F_0)	170,4***	189,5 NS	190,0*	191,7**	180,2
126 kg/ha/yr	(F_1)	191,4	189,5	206,9	210,4	197,9
377 kg/ha/yr	(F_3)	196,1	189,5	214,8	217,8	202,5
Overall mean		186,0	189,5	203,9	206,6	193,4

#Weighted mean of all calves over all years (nonorthogonal).

*$P<0,05$, **$P<0,01$, ***$P<0,001$, NS — not significant for difference between compared treatments in the given year

Given suitable rains for germination, pastures established by this method are ready for stocking at one steer to two acres or higher, 6-8 weeks after sowing. On the solodic soils, the timber is heaped in windrows with ploughing to prepare a seed-bed.

The high pasture production possible on brigalow land is rarely maintained for very long because of lack of soil moisture. The pattern of production in the brigalow region follows that in the other regions. In the southern brigalow region where there is a reasonable winter rainfall, quite satisfactory growth rate of steers can be maintained. Coaldrake *et al* (1969) found that steers on introduced pastures (green panic, Rhodes grass, buffel grass) averaged mass gains of 300 lb per head (135 kg), while the pastures carried less than 1 000 lb/acre (1 120 kg/ha) of standing dry matter at any time. This indicates that, in the brigalow region, it is more or less normal for pastures to be growing at much less than their maximum rate due to a shortage of water, animal production can be sustained at satisfactory levels for long periods. Similar mass gains have been reported from other observations — 392 lb per head (178 kg) in 12 months on *Sorghum almum* and green panic at 1 beast to 2,3 acres (1 to 0,9 ha) in the southern brigalow; gains of 0,7 to 1,24 lb per day (0,32 to 0,56 kg) over periods of 500 to 600 days on Rhodes grass and green panic at 1 beast to 7,5 acres (1/3,0 ha) in the northern brigalow.

The erratic rainfall of the brigalow region makes it difficult to reproduce these production figures annually. It would seem logical for fodder conservation to be practised in this region but the majority of landholders prefer to use stocking rate as their major tool to meet feed deficiencies.

Beef cattle management research

With a predominantly summer rainfall, there is a seasonal variation of quantity and quality of pasture whether sown or native. Cattle require management in order to meet these fluctuations and utilise them to best advantage. This is particularly the case with breeding cattle. There are, of course requirements on the cattleman for pasture management but these need to be considered in unison with those of cattle management. The former have largely been considered in the previous sections.

The factors of importance in cattle management context are:

(a) Stocking rate
(b) Time of calving
(c) Time of weaning
(d) Age at first mating
(e) Pregnancy diagnosis
(f) Management at calving
(g) Management of bulls
(f) Supplementary feeding

(a) *Stocking rate*

Stocking rate is probably one of the most powerful tools which a grazier can use. If the stocking rate is low, much forage will be wasted and will either accumulate, be burnt or broken down. Light stocking rates allow a greater range of plant species than do heavy stocking rates.

There is more bare ground at heavy than at low stocking rates with greater risk of erosion and poorer moisture penetration of the soil. Over-grazing may reduce the proportion of desirable species in the pastures and herbage production may be reduced.

The intake of grazing animals is reduced with increasing stocking rate and the animal finds it increasingly difficult to satisfy its appetite.

These are features of very high stocking rates. Annual livemass rates gain per head is decreased as stocking rates increase but gain per unit area increases except at very high rates when it may be reduced. It is unlikely that a heavy stocking rate which produces the maximum mass gain per unit will be the most profitable rate because it may not produce carcasses with sufficient fat cover to meet market requirements. Also the difference between costs and returns is not necessarily greatest at the stocking rate that produces maximum mass gains. (Wheeler & Hutchinson, 1973).

(b) *Time of calving*

In the extensive cattle raising areas of the arid and semi-arid zones and the tropical and sub-tropical woodlands and grasslands, no control is practised over mating. However, in the more developed areas, bull control is practised and, in these situations the choice of calving time is a critical management decision.

The choice of a calving period depends on animal factors such as growth rate and reproductive performance and upon pasture factors such as expected availability and quality of feed. It also depends on the market to be supplied and the modifying influence of management practices such as stocking rate and supplementary feeding. Consequently it is unlikely that there could be a single best time to calve but rather an optimum when the above factors are fully considered.

In south-eastern Queensland controlled mating is also widely practised with calving in the early summer to coincide with the flush of pasture growth and conception rates of cows mated in spring, summer or autumn are similar. However, calves from spring matings grow more rapidly and are ready for market earlier than those from matings at other times. (Alexander & Carraill, 1973).

Under the more extensive conditions in northern Australia, observations on cows in continuously mated herds demonstrated that invertals between consecutive births were longer than 12 months (Table 4). This poorer fertility is associated

TABLE 4 *Percentage of cows with different conception intervals and different times of previous mating on properties in different parts of the State*

Conception Interval* (Month)	(i) South Queensland			(ii) North Queensland						(iii) Central Queensland					(iv) Central Queensland						
	Month of ception			Month of previous conception						Month of previous conception					Month of previous conception						
	Jan	Feb	Mar	Nov	Dec	Jan	Feb	Mar	Apr	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
20											2										
19					1																
18					1	1					2	4									
17						1		1				2		2							
16				1		3	1			1			2				1				
15	0,2	0,3		5		2	2			6											
14	8	4	0,2		4	3	4	1			2	14			1		3	4	1		
13	26	23,2	0,5	7	7	6		2				16	6			1	2	5			
12	2,3	26	2,3	5	4	6	11	2	1			14	12			2	5	14	1	2	1
11		0,7	6,3		4	5	3	1				2	12	1		1	5	20	2	2	1
10							4	1									1	15	1	5	2
9																					1

*Conception interval is the time between successive conceptions calculated from the calving intervals with wide fluctuations and poor condition of the breeding cows, while the cows are gaining mass and in good condition and cows that are not lactating have a high change of conceiving at mating (Alexander, 1965). Over much of northern Australia controlled mating in the absence of early weaning and improved nutrition would result in many cows failing to produce a calf each year.

(c) *Time of weaning*

Industry practice in Northern Australia had, until recent years, been to permit calves to run with their dams until weaned at 8 to 10 months of age. If the calves were smaller than acceptable at that time, they would be allowed to remain on the cow until later. This aggravated the adverse effect of the dry season on the cow, particularly the cow which had gone into calf while nursing the existing calf.

Weaning of calves at the commencement of the dry season allows the cows to maintain mass and even to improve in condition during the dry season (Table 5). These cows had a better chance of survival when calving in the next calving season. However, it was found desirable to supplement the weaners for a period, particularly those less than six months old to prevent severe retardation in growth rate.

In the southern areas of Queensland where there is some winter rainfall, it has been found that supplementation may not be as necessary as in the more tropical areas, although the advantages of weaning at the commencement of the dry season have been readily apparent. Trials on properties in Central Queensland showed that, on improved pastures, weaning at the onset of the dry season resulted in a 77 lb (35 kg) advantage in the early weaned cow at the peak of the dry season mass loss.

(d) *Age of first mating*

There are clear economic advantages in having heifers calve for the first time at two years of age, but this is not general industry practice in Northern Australia probably because the heifers are small, and subsequent growth and reproductive performance may not be satisfactory. Small heifers usually have poor fertility, and to achieve high conceptions at 13 to 15 months it may be necessary to supplement or feed the heifers on crops after weaning.

Management during pregnancy should aim to promote continued growth of the heifer until the last third of pregnancy when nutrition may be somewhat restricted so as to reduce the size of the calf and the fatness of the heifer. This measure

TABLE 5 Mass change in cows following weaning at early and normal weaning times

	Average mass change (lb)		
	Early weaning Normal weaning time	Normal weaning time-end of wet season	Whole period
Townsville District:			
Trial 1			
Early weaning (Jul)	+5,6	–	+5,6
Normal weaning (Oct)	–25,4	–	–25,4
Trial 2			
Early weaning (Jul)	–1,3	–20,4*	–21,7
Normal weaning (Oct)	–10,7	–25,4*	–36,1
Rockhampton District:			
Early weaning (Jun)	–5,6	+18,8	+13,2
Normal weaning (Sep)	–26,1	+10,5	–15,6
Monto District:			
Early weaning (Jun)	–38	+155,1	+117,1
Normal weaning (Aug)	–58,6	+132,5	+73,9

* This mass change was taken to November whereas the mass changes in the other districts were taken to the end of March.

reduces the incidence of dystocia which is particularly common in Herefords. However, the restricted nutrition also reduces the subsequent growth of the calf and increases the post partum period of anoestrus (Hodge & Rowan, 1970).

The reproductive performance may be reduced at the second calving in commercial herds in which heifers are mated to calve at about 2 years of age or even later; there may be an extension of the period between calvings, or by a reduction in calving percentages where the mating period is restricted. This reduction in reproductive performance reflects inadequate nutrition after calving and represents another situation where supplementary feeding may be of value (Barr, 1971).

(e) *Pregnancy diagnosis*

Pregnancy diagnosis of the breeding herd at strategic times can prove a useful tool in the management of beef breeding herds. Pregnancy diagnosis allied with adequate herd records can give information on the conception rate and even the rate of conception for each mating group and the conception rate for each age group. These follow certain decisions to be made for the next year's mating programme. Pregnancy diagnosis is of greatest benefit when it is used as an aid in culling and in breeder management. Pregnant cows may be managed according to their estimated calving date while the nutrition of non-pregnant cows can be restricted, or they may be culled from the herd. If all empty cows are culled immediately after pregnancy diagnosis in autumn, then the breeding paddocks are automatically lightened off over the critical winter/spring months. (Alexander, 1964).

Adherence to a plan of culling for non-pregnancy in a herd with an 80 per cent conception rate can reduce the stocking rate from 1 cow to 7 acres (2,9 ha) to 1 cow to 9 acres (3,6 ha).

Once the likely conception rate is known together with the safe winter stocking rate for breeding cows with calf at foot, it is possible to mate sufficient heifers in excess of requirements to provide for as nearly as practicable a 100 per cent calving (Table 6). The non-pregnant and any surplus pregnant cows can be sold off before the dry winter.

Where the cost of pregnancy diagnosis precludes its use on all cows in the breeding herd, it may be used to advantage on heifers pregnant for the first time.

(f) *Management at calving*

In certain specialised situations, intensive supervision by daily or twice daily inspections in small paddocks can be given where the calving period is restricted. The most common reason for this is to reduce calving losses from dystocia, particularly in heifers, but certainly under Queensland conditions, this would be an uneconomical use of labour for most situations (Hodge & Rowan, 1970).

Yarding of the breeding herd at the end of calving also provides the opportunity to identify cows that failed to calve and to allocate cows to subsequent mating groups.

(g) *Management of bulls*

It is usual to use three to five bulls for every 100 breeding cows; the smaller proportions tend to be used in large herds, on flat open topography and where there is ample supervision. Mating procedures vary considerably; one or several bulls may be put with a mob of cows and bulls may be spelled and replaced by others or exchanged between mobs of cows. Usually young bulls are first used at 15-24 months of age depending on breed with care taken to prevent young bulls from being overworked.

TABLE 6 *Age composition of the herd of different conception rates, all empty cows being culled to give a constant number after culling*

Herd composition at end of mating	Without culling of empty cows	Culling at conception rate of				
		60	70	80	90	95
Heifer replacements–						
2 year old	91	361	253	178	127	106
Cows–						
3 year old	87	213	173	138	110	97
4 year old	85	126	19	108	97	90
5 year old	83	74	81	84	85	84
6 year old	79	40	53	63	73	76
7 year old	74	19	32	45	61	67
Total before culling	499	833	711	616	553	520
Total after culling	499	500	497	491	498	495

Many cattlemen on intensively managed properties select bulls on the basis of semen testing and care is taken to see that bulls are in good condition at the commencement of mating. Some cattlemen follow the practice of introducing fresh bulls midway through the mating season to improve the calving percentage.

(h) *Supplementary feeding*

Supplementary feeding has been the subject of much research in Australia as well as South Africa and in many areas Australia has followed the South African lead. Even in situations with improved pastures with legumes or fertilizers, seasonal inadequacies in fodder quality and availability remain, although the severity and duration may be much reduced.

Interest in supplementary feeding in Northern Australia has centred on the use of nitrogen-rich rather than energy-rich supplements such as grain or non-legume hay, since except under drought conditions, live mass response to supplementation seems to be more closely related to the intake of supplementary protein than to the energy intake. (Alexander, Daley & Burns, 1970). The supplements used take the form of legume hay, protein-rich meals or non-protein-nitrogen such as urea or biuret.

The severity of the dry season increases the response to supplementation and reduces the likelihood of subsequent compensatory mass changes (Alexander, 1971). Supplementation assumes even greater importance if the dry season is likely to produce mortalities.

Supplementation of breeding stock is of increasing interest because many calving, lactating and young animals die in dry seasons, and because livemass is an important determinant of fertility. Supplementary feeding with urea in Central Queensland eliminated losses of 47 per cent in breeding cows and increased calf turn-off from 18 to 58 per cent (Alexander *et al*, 1790).

Research and extension services

With the development of the research programmes to assist the beef industry over the whole of Australia, there has been an expansion of the extension services to the beef industry. In Queensland, the extension services for pastures and for cattle husbandry were provided by the Queensland Department of Primary Industries and were within the same branch as that conducting the research, namely Agriculture Branch or Cattle Husbandry Branch. This had the effect of promoting close liaison between the extension officer and the research officer. In fact the extension officer participated in the research programme and vice versa. Also much field experimentation and demonstration was carried out with grazier cooperation and participation. This promoted the flow of information not only from the research officer to the extension officer but also on to the producer. Therreverse flow was also evident and important.

Commonwealth Extension Services Grant

The Commonwealth Government's interest in the efficiency of agricultural production and the welfare of the rural sector is the basis for its special grants since 1948 to the States to assist them in the further development of extension services for Australian primary producers.

The Commonwealth Extension Services Grant was established in 1948 and with assistance from this Grant, the States have been able to finance the expansion of their extension service to the beef industry amongst others. While in earlier years, the funds were supporting general extension services, emphasis is now being increasingly placed upon the training of extension staff. Regional research is also supported by this Grant.

Government and industry contribution to research

The Commonwealth Government has developed a policy of promoting with the relevant industry research schemes jointly financed by public funds and a levy from the particular industry. This has resulted in an appreciable lift in the volume of research being undertaken to assist farmers in overcoming problems of production and marketing.

Funds provided under approved research programmes are allotted to CSIRO (the Commonwealth Scientific and Industiral Research Organisation, a Commonwealth organisation financed mainly by the Commonwealth), State Departments of Agriculture, Universities and other institutions for the conduct of specific projects, which are additional to those undertaken within the normal budgets of these organisations.

For the beef industry, the Cattle and Beef Research Scheme commenced in 1962-63 and has been modified since then to include mutton and lamb. It is now administered by the Meat Research Committee. The current levy is 20 cents per head, plus one cent for meat processing research, on slaughter cattle over 200 lb (90,7 kg) dressed mass and 1,75 cents per head, plus 0,1 cent for meat processing research, on slaughter sheep and lambs. This levy is paid into the Meat Research Trust Account and expenditure therefrom is matched on a dollar for dollar basis by the Commonwealth.

The general meat research programme covers a wide field of activities embracing development of new pastures, disease and parasite control, carcass appraisal, nutrition, herd and flock improvement and economic research into production and marketing.

Special projects of assistance to producers

The Commonwealth Government up till 1972 had greatly increased its financial contributions to development projects likely to encourage production in industries which contribute substantially to export income or savings of imports. There has been great importance attached to development in Northern Australia in this regard. Many of these have been for irrigation and development of water resources of indirect benefit to beef producers in associated areas. However, there have been a number of schemes of more benefit to the beef producers.

(a) *Beef Cattle Roads*

Since 1961-62, the Commonwealth Government has made grants and loans available to the States for the construction and improvement of specific roads in developing areas. These are known as Beef Roads. The Northern Territory, Queensland and Western Australia, and more recently South Australia participate in this programme.

In Queensland, this Scheme has been responsible for the construction to the sealed stage of approximately 1 000 miles of road to a final authorised cost of over $60 000 000.

This is additional to the normal expenditure on main roads of which 40 per cent must be spent on rural roads.

(b) *Brigalow Lands Development*

In 1961, the Queensland Government initiated a programme for the systematic development of approximately 11,2 million acres (4,5 million hectares) of brigalow scrub lands in the Fitzroy river basin (Anon 1968). The programme is aimed at increasing the beef producing capacity of the area to permit closer farm settlement. The overall scheme will provide for 238 blocks for new settlers as well as 340 blocks returned to existing lessees as retention areas. The Commonwealth has agreed to lend the Queensland Government up to $ 23 million for development of the overall scheme. This loan covers expenditure on specified works, including scrub pulling and pasture establishment, regrowth control, provision of watering facilities, fences and the purchase of livestock and equipment.

Settlers under the scheme have been the recipients of specialised extension and advisory service from the Queensland Department of Primary Industries and Department of Lands in relation to their development of the property. Maps of the property showing the major land-use types and topographic features are provided together with a volume containing all relevant technical data applicable to the enterprises to be undertaken in that area.

(c) *Marginal Dairy Farm Reconstruction Scheme*

While this scheme has not been applied to beef producers, it has had the effect of assisting a number of beef producers acquire additional land formerly under dairy production. The scheme was designed to provide an opportuniry for the marginal dairy farmer who desires to do so, to sell his property and its improvements at a fair and reasonable price. It also assisted the nearby farmer who, with some additional land, could develop a more profitable unit and possibly diversify his production.

This scheme has nearly reached its completion and an expenditure of approximately $25 million in loans has resulted in approximately 400 marginal dairy farms to be taken out of dairying, of which nearly half have been amalgamated and used for beef. Over this period possibly another 3 000 dairy farmers have gone out of dairying through normal commercial channels. The scheme has had the beneficial effect of removing from dairying, those farms which would have been difficult to handle by normal methods.

(d) *Queensland Dairy Pasture Subsidy Scheme*

For those dairy farmers wishing to remain in dairying and desirous of increasing the productivity of their farm, the Queensland Government introduced the Dairy Pasture Subsidy Scheme. This involved a dollar for dollar subsidy on the establishment costs of pastures up to a certain maximum each year. There has been a substantial use of the scheme with the result that over 1 000 000 acres (0,4 million hectares) have been sown to improved pastures in ten years.

The Queensland Department of Primary Industries which has been responsible for the administration of the scheme provided a detailed advisory service and supervised many of the plantings. Also only approved pasture mixtures, fertilizers and land preparation would be subsidised. This has resulted in a much higher success rate than is normally associated with pasture establishment.

This provides a model for official pasture improvement schemes. It has also provided an excellent demonstration exercise to other producers in the districts with the result that many beef and other producers in the area have established improved pastures with similar methods and success.

Financial assistance to producers

(a) *Fertilizer assistance*

(i) Superphosphate bounty

The superphosphate bounty was first introduced in 1963 and has been modified somewhat over the subsequent period. The purpose of the bounty was twofold, namely, to encourage greater use of superphosphate as a means of increasing production for export and to reduce costs. Application to pastures accounts for approximately two thirds of superphosphate usage.

Superphosphate is of vital importance to primary production over most of Australia. The assistance provided by the bounty has been an incentive to investment on farms particularly through pasture improvement. Since 1962-63, the area of sown pastures has increased by over one third from 41 million acres.

The basic rate of the bounty is $12 per ton. Since the change in the Federal Government in 1972, policies have been reviewed and the superphosphate bounty is scheduled to terminate in December 1974 if the present Government is returned at the Election.

(ii) Nitrogenous fertilizer subsidy

In 1966 the Government introduced a subsidy of $80 per ton of nitrogen contained in naturally occurring sodium nitrate and in products manufactured from inorganic chemical nitrogen sold for use as fertilizer by primary producers in Australia. The subsidy operated until 1972. The subsidy had two main purposes, firstly to reduce costs in industries using significant quantities of nitrogenous fertilizers and secondly, to encourage greater use of these fertilizers, particularly in crop and pasture production where evidence indicated that profitable responses could be obtained by the application of nitrogen.

In addition to reducing the cost of nitrogenous fertilizers in Australia to a level comparable with prices paid by farmers in other countries, the subsidy had the effect of encouraging the development of the Australian nitrogen fertilizer-manufacturing industry by expanding the market for nitrogen products. The range of products was increased.

Bounties on production were introduced in 1962 to support domestic manufacture of sulphate of ammonia and urea. The bounty was increased in 1964 to $8 per ton for sulphate of ammonia and $16 per ton on urea in 1966.

Again, the future of this subsidy and bounty is under consideration, having been referred to the Industries Assistance Commission established by the present Government.

(b) *Taxation concessions*

In recognition of the particular difficulties under which they operate, primary producers have been granted a number of special concessions in relation to income taxation:

*Averaging of incomes. This provision is restricted to taxpayers whose average and current income does not exceed $16 000.

*Depreciation allowances spread over five years.

*Investment allowance of 20 per cent of cost of new plant and equipment in addition to depreciation.

*Capital expenditure on a wide range of improvements may be treated as operating expenses in the year of expenditure.

*Losses of previous years may be carried forward for an unlimited period.

*Forced sales of livestock — the proceeds of sale may be spread over five income years or other options exercised.

*The Drought Bonds Scheme is designed to enable graziers in arid areas to make financial provision for drought years and qualify for certain taxation concessions.

Other concessions in the revenue field include—

*Sales tax — most items essential for primary production are exempt or subject to reduced rates.

*Import duty — items essential for primary production but not produced in sufficient quantity in Australia are admitted free or at reduced rates.

*Estate duty — a number of concessions, including the raising by 20 per cent of exemption levels were introduced in 1969.

The present Federal Government pursuing its policy of re-evaluating the policies of the previous Government has rescinded some of the above concessions, namely:

*Termination of the investment allowance.

*Modification of the special 20 per cent depreciation allowance so that the depreciation allowance is now related to the life of the asset concerned reverting to similar rates applying before 1952.

*Reduction in the number of items drawing 100 per cent deduction in the year of expenditure.

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