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Opportunity costs of pasture rundown in Queensland: Is tree clearing viable over the longer term?

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Abstract.

Resource development issues remain topical in Queensland, with continued high rates of vegetation clearing and arguments that up to 15 million hectares of tropical woodland areas in the state could be profitably developed. In this paper the contribution of pasture development to beef production in the state is assessed. It appears that the gains from pasture development are partially offset by other losses in pasture production. Potential reasons for these losses are considered. The decline in pasture production following a spike in productivity after tree clearing is considered in some detail. Preliminary values for the opportunity costs of this pasture rundown are assessed.

1.0 Introduction.

The pastoral industry makes an important contribution to the Queensland economy. The beef industry is the major contributor, although there are still substantial numbers of sheep on the western plains. Although cattle numbers peaked in the 1970s, the result of a market downturn and corresponding good seasons, beef production has continued to expand since those times. The additional production results from a number of factors, including the use of feedlotting, improved pastures, and faster turnoff rates.

Clearing vegetation to grow improved pastures (mostly exotic grasses) has been one key factor in the expansion of the industry. In the brigalow bioregion, which runs from approximately Moree in New South Wales to Bowen in northern Queensland, widespread clearing of acacia and softwood scrubs and successful establishment of improved pastures has contributed to large increases in productivity. Typically, scrubs on the better soils were cleared first. As development costs fell (with increased mechanisation), capital accumulated, and returns from higher grade (fattened) cattle became relatively higher, it became increasingly profitable to clear more marginal country types (Rolfe 2000).

Over the past decade, the clearing activities have tended to focus further west and north in the state, away from the heavier scrubs (which are now mostly cleared), and into the sparser eucalypt woodlands. In many cases these woodland communities are associated with poorer soils and/or lower rainfall than the brigalow communities on the heavier clay soils. Although the increases in productivity from developing woodlands are much lower than the scrubs on more fertile soils to the east, Burrows (1990) estimated conservatively that at least 15 million hectares could be profitably developed.

Clearing rates in Queensland have been estimated to be as high as 500,000 hectares per annum during the 1980s and 1990s. In 1995-97, approximately 340,000 hectares per annum of both regrowth and virgin timber were cleared in the State. In 1997-99, the total amount was 425,000 hectares per annum (DNR 2000)¹. Because approximately one-third of the clearing involved regrowth, the rates suggest that up to 300,000 hectares of remnant vegetation is being cleared per annum.

Controls over clearing on leasehold land were introduced by the Queensland Government in 1995, and additional controls were introduced over freehold land in 2000. The introduction of controls was protested by landholders, partly because they perceived the introduction of clearing controls to have some impact on their property rights, both real and implied (Rolfe 2000). In some cases, tree clearing controls were justified because of risks of land degradation or salinity, or because the returns from development were perceived to be very low relative to the potential risks. These arguments were often rejected by landholders.

The debate about tree clearing is difficult to resolve because of the differences in perceptions between the groups involved. For many advocates of development, Queensland remains different to the southern states, with few serious environmental problems and many opportunities for development. The latter include opportunities for pastoral and irrigation development in rangeland and northern parts of the state. For example, Burrows (1990) suggested a minimum of 15 million hectares of woodland could be profitably be converted to pasture, and recommended that 20% of original vegetation be conserved for stock and native fauna protection.

¹ By comparison, the approximate area of the Australian Capital Territory is 240,000 hectares.

In contrast, other commentators (eg Williams et al 1997) suggest that problems such as dryland salinity and land degradation do not stop at the New South Wales border, and that continued clearing activities may generate future problems. The returns from clearing are generally seen to be low, and potentially swamped by long term production losses resulting from environmental problems.

The issue of whether pastoral lands in Queensland are better classified as development opportunities or lands in need of rehabilitation and maintenance is difficult to test. One of the key issues is the extent to which there may be productive losses from land degradation, and soil and pasture rundown. If there are major production losses, this would suggest that resource condition is a more critical factor than has been generally recognised. It would also indicate the possibility that further pasture improvements may have limited production gains.

These issues are explored in this paper. In the next section, the expected productivity of pastoral lands in Queensland after tree clearing is analysed. In section three, the actual production of livestock and beef from pastoral lands is calculated, and the actual increase compared to the expected increase. The three key explanations for a difference are explored in section four, and section five completes the paper.

2.0 The expected gains from clearing and pasture development

There has been approximately 37 Million hectares of land cleared in Queensland (see Table 1). This includes 5000 hectares of area cleared in the Wet Tropics, Central Queensland Coast, and South East Queensland, where clearing has been largely for farming, urban and aesthetic purposes. The rate of clearing was 340,000 hectares per annum in 1995-97, rising to 425,000 hectares per annum in 1997-1999 (DNR 2000).

Table 1. Summary of remnant areas ('000s of hectares) across bioregions.

	Total Area (‘000 ha)	Total Remnant Area in 2000	% of region	Area Cleared
North West Highlands	7 314	7 281	100	33
Gulf Plains	22 001	21 948	100	53
Cape York Peninsula	12 167	12 096	99	71
Mitchell Grass Downs	24 183	20 201	84	3 982
Channel Country	23 815	23 770	100	45
Mulga Lands	18 500	15 310	83	3 190
Einsleigh Uplands	11 861	11 082	93	779
Desert Uplands	7 031	5 647	80	1 384
Brigalow Belt	36 416	14 395	40	22 021
New England Tablelands	775	266	34	509
Wet Tropics	1 983	1 153	58	830
Central Queensland Coast	1 444	1 039	72	405
South East Queensland	6 212	2 445	39	3 767
Total	173 702	136 633		37 069

Source: Summarised from Table 1.6 in Boulter et al (2000).

To estimate the amount of clearing for agricultural land, perhaps half of the clearing in the Wet Tropics, Central Queensland Coast, and South East Queensland regions can be attributed to urban, infrastructure and aesthetic purposes. To estimate the area of land cleared for agriculture

purposes in 1997-98, the area of clearing in the three previous years should be also discounted. This allows an estimate of 34.4 Million hectares of agricultural land at that time period to be made. There had been large areas of vegetation cleared before 1957-58, mostly for farming purposes. To allow for this activity, a cleared area of 4 Million hectares is assumed to have existed at 1957-58. This effectively allows for all the cleared land in the coastal zones to have been developed by that time period, and allows for a further 1.5 Million hectares of land to have been developed further inland for farming and grazing.

The balance is an area of 30.4 Million hectares which has been cleared for agricultural purposes between 1957-58 and 1997-98. The area of land farmed in Queensland has approximately doubled over the forty year period, from 1.052 Million hectares in 1955 to 2.685 Million hectares in 1995². There has also been approximately 35,000 hectares of grazing land converted to growing leuceana in the same time period. This indicates that 28.5 Million hectares of vegetation have been cleared for grazing purposes in the forty years from 1957-58 to 1997-98.

Table 2. Estimates of areas cleared for grazing in Qld, 1957-8 to 1997-8.

	Million hectares
Cleared vegetation in Qld in 2000	37
Less area cleared 1997-2000	1.16
Less allowance for urban and infrastructure	2.5
Less estimated clearing in 1957-58	4
Less increase in farming 1957-8 to 1997-8	1.8
Net estimated cleared for grazing 1957-8 to 1997-8	28.5

Gains in cattle stocking rates after tree clearing and pasture development are typically 2 – 7 times the original stocking rates (Burrows 1993, quoted in ABARE 1995). Burrows (1990) suggests that in the woodlands areas of Queensland, a typical increase in carrying capacity is one beast to 15 hectares. In much of the more fertile soils to the east, especially where brigalow and softwood scrubs were developed, the increase in carrying capacity is approximately 1 beast to 5 hectares and higher³.

Assuming that an average increase in carrying capacity of 1 beast to 7.5 hectares has been achieved, the total expected increase in cattle numbers over the past forty years in Queensland is 3.8 Million. Identifying the extent of these productivity gains is the focus of the next section.

3. The productivity of pastoral lands over time.

In 1957-58, there were 6 Million head of beef cattle in Queensland. This had risen to 10.35 Million in 1997-8. However, the rise in numbers is the result of several factors, including the conversion of sheep and dairy grazing to beef, and the provision of additional feeds through feedlotting, fodder crops, and other sources. To analyse the increase in numbers carefully, it is more useful to focus on actual amounts of beef produced.

² ABS, Queensland 1999 Year Book.

³ For example, Clark (1999) indicates that a rate of 1 beast per 1.5 hectares is achievable on buffel grass pastures during the nine non-winter months of the year.

In the five years from 1955-56 to 1959-60, there was an average of 1.279 Million cattle and calves slaughtered in Queensland each year. These produced an average weight of beef of 417.9 million pounds of beef, or 187, 600 metric tons of beef per annum. Forty years on in 1997/98, 3.114 million head of cattle were slaughtered in Queensland meatworks, up more than 500,000 head on the previous year. A total of 807,000 tons of beef and veal were produced, 330% more than the average production between 1955 and 1960⁴.

Adjusting for stock movements

These 1997-98 estimates are overstated to some extent by the movement of cattle interstate. Improved transport links now allow Queensland meatworks to source cattle as far south as Victoria. In 1997-98, there was a net movement of cattle into Queensland from the other states of 505,000 head (Table 1). If the production of beef is reduced proportionally to the net supply of cattle from interstate, production of beef and veal from the Queensland herd can be assumed to be 676,120 metric tons, still 260% higher than production forty years before.

There was also 140,437 head of cattle that left Queensland ports as live exports⁵ in 1997-98 (Table 3). Assuming a liveweight of 350 kilograms per beast and a dressing percentage of 54% (Rutherford 1995), and then a yield percentage of 60%, the average amount of meat per beast is approximately 97.2 kilograms. Across the number of live exports directly from Queensland, the additional production of meat is approximately 13,650 metric tons. This brings the total production of beef and veal from the Queensland herd in 1997-98 to 689,770 metric tons.

There are many reasons apart from actual productivity increases why the increase in production has been so dramatic. These include substitution of beef cattle for sheep and dairy cattle as wool and milk prices have declined, the increase in feedlotting, and the use of fodder crops and supplementary feeding. The decrease in sheep and dairy cattle numbers at the same time that beef cattle numbers have risen are depicted in Figure 1.

Table 3. Movements of stock from Queensland.

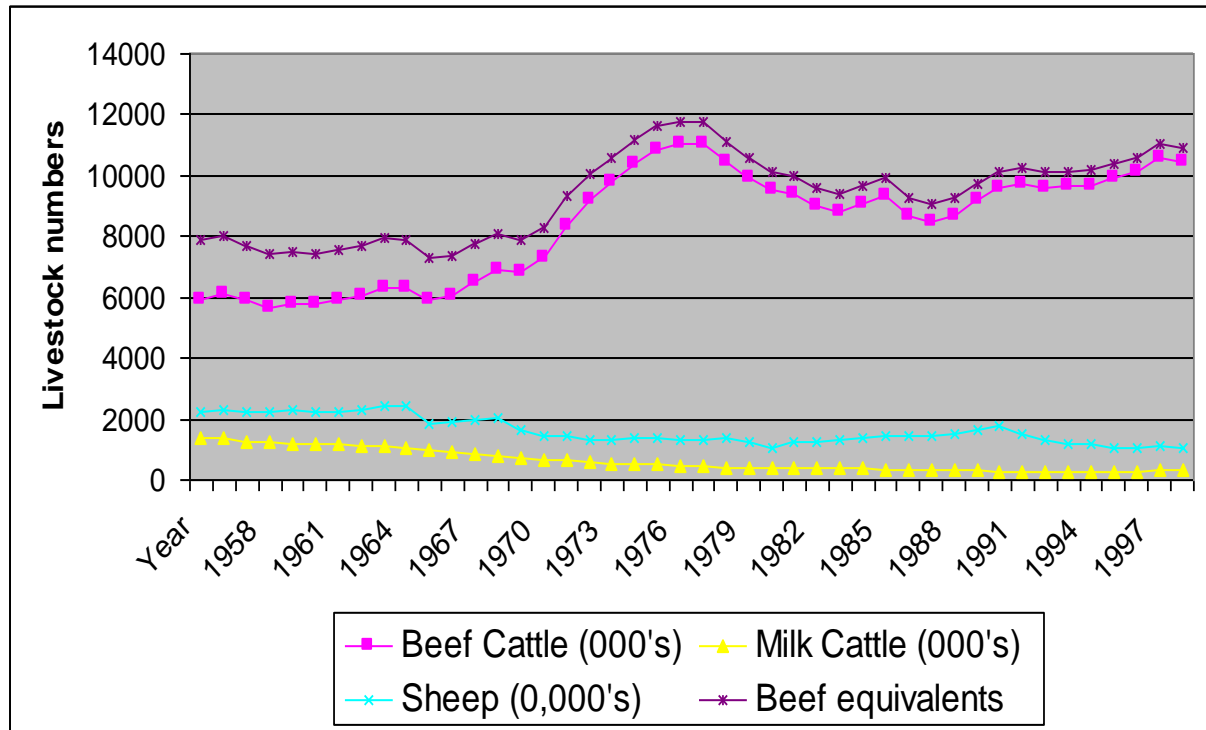
Movement	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
Northern Territory to Qld	103,799	57,721	161,205	100,506	108,780	108,677	125,148
NSW and Vic to Qld	470,639	373,574	694,344	634,665	366,083	515,446	704,649
Qld to Northern Territory	5,893	41,543	57,461	107,411	194,801	196,76	89,229
Qld to New Wales	449,400	803,387	485,515	322,088	426,247	356,363	234,953
Net interstate movement	119,145	-413,635	312,573	305,672	-146,185	71,044	505,615
Live exports from Qld	48,530	34,494	18,367	31,147	84,126	136,154	140,437
Total net movement	70,615	-448,129	294,206	274,525	-230,311	-65,110	365,178

Source: Rolfe and Reynolds 1999.

⁴ Statistics compiled from various ABS sources, including Queensland Year Books.

⁵ These are younger animals that are subsequently fattened for slaughter in countries like the Philippines and Indonesia. Some live exports from Queensland were trucked to the Northern Territory and then shipped from Darwin.

Figure 1. Livestock numbers in Queensland over time.



Source: ABS data (Qld yearbooks 1960 – 1999).

Using a conversion factor of one dairy beast per 1.2 beef beasts, and 8 sheep per beef beast, the numbers of stock in Queensland can be converted to beef cattle equivalents. This is also reported in Figure 1, (in thousands of head of beef cattle equivalents). In terms of beef cattle equivalents, stock numbers in Queensland rose from 7,882,000 in 1957-58 to 10,941,000 in 1997-98, a rise of 38.8%. Using this rate to adjust upwards the production of beef figures in the 1956-60 period gives an amount of 260,388 tons.

This means that after adjusting for livestock movements and conversion of sheep and dairy farms to beef cattle, there has been an increase in both livestock numbers and the amount of beef produced during the forty year period. The number of beef cattle equivalents has risen by 38.8% from 7,882,000 head in 1957-8. It is noticeable that the number of beef cattle equivalents peaked in 1977 (see Figure 1). The growth in beef production has been more dramatic, rising from an adjusted amount of 260,388 tons in 1957-58 to 689,770 tons in 1997-98. This represents an increase of 165% over the base period, and an annual increase in productivity of 2.66% (compounded) over the same time period.

Adjusting for other feed inputs

The reason why the growth in beef production has been so much faster than the increase in cattle numbers over the same period relates to two key factors, being improved turnoff rates and better feeding. To identify the contribution of improved pasture to improved feeding of animals, it is important to take out the contribution of other feed sources. These include the contributions of

feedlots, crops planted for hay and fodder, and land planted to leucaena⁶. These are discussed in turn in relation to their contribution to the production of beef over the 40 year period.

In 1997-98, there was an average of 503,410 cattle on feed in Queensland at the start of each quarter⁷. However, cattle are in feedlots for differing amounts of time, depending on the markets that they have been fed for. Using the methodology employed in the National Greenhouse Gas Inventory, these cattle on feed each quarter can be converted to equivalent annual numbers on feed. The conversion comes to 243,564 annual equivalents. At an average daily liveweight gain, the total production from feedlotting in Queensland in that period is approximately 115,571 tons of beef. This converts to 37,445 tons of meat.

By 2001, there was approximately 60,000 to 70,000 hectares of leucaena planted in Queensland⁸. In 1997/98, the area of leucaena planted may have been approximately 35,000 hectares. The production from leucaena is approximately 250 – 300 kilograms/steer/year at stocking rates of between 0.5 and 1.0 steers per hectare (TBC 2000). Taking the lower end of these estimates generates total beef production in one year of 4,250 ton. Multiplying this by a dressing percentage (54%) and a yield percentage (60%) generates net meat production in one year of 1,377 ton from leucaena.

In 1957-58, the average area of cropping land in Queensland to grow hay and green forage for livestock was approximately 260,000 hectares (ABS 1978). The total cropping area in the state at that time was approximately 1,020,000 hectares. Clarke (1999) suggests that at stocking rates of 2 beasts/hectare on forage sorghum and oats, the corresponding daily weight gains are 0.7 and 1.0 kilograms/day respectively. Over 70 days, a beast on forage sorghum could be expected to gain 49 kilograms, and a beast on oats could be expected to gain 70 kilograms.

In 1986-87⁹, the area of fodder crops, including forage sorghum, oats and hay, was 580,000 hectares. Assuming that there has been no further increase in the area of production of fodder crops, and that the average weight gain per hectare per year from fodder crops is 119 kilograms, the total extra beef production that is expected is 38,080 metric tons. This converts to approximately 12,338 metric tons of additional meat production.

Increases in beef production have also occurred through improving pastures without clearing trees. This has particularly occurred in open woodland country, where the introduction of exotic stylos and legumes into native pastures has improved stock production. Noble et al (2000) suggest that the annual advantage per beast of running stores on this mixture of native grasses and exotic species ranges from 30 to 60 kilograms. There has been approximately 1 Million hectares of woodland across Queensland where stylos and legumes have been introduced¹⁰. Assuming a stocking rate of 1 beast per 15 hectares, and an annual liveweight gain of 45 kilograms, the total additional meat production is 992 tons.

These factors are summarised in Table 4, and show that the net increase in meat production from pastures in Queensland over the forty year period is approximately 377,230 metric tons. Not all of this increase can be attributed solely to pasture growth from tree clearing and pasture improvement, as management and other development factors also play a part.

⁶ Leucaena is an exotic scrub that planted for grazing by beef cattle.

⁷ Data supplied by Meat and Livestock Australia.

⁸ Col Middleton, DPI, personal comment.

⁹ This was the last year that data on the area of fodder crops in Queensland has been published by the ABS.

¹⁰ Col Middleton, DPI, personal comment.

Table 4. Net increases in meat production from pasture 1957-8 to 1997-8.

	Meat production in metric tons
Queensland herd in 1957-8 (adjusted)	260,388
Queensland herd in 1997-8 (adjusted)	689,770
Contribution from feedlotting	37,445
Contribution from fodder crops	12,338
Contribution from leuceana	1,377
Contribution from stylos and legumes	992
Net contribution from improved pasture 1957-8 to 1997-8	377,230

Apportioning gains between pasture improvements and other factors

There is no clear way of apportioning the reasons for improvements in beef production between the increased pasture production and other production improvements. Some of the most important ways in which the industry has improved production are:

- Improved breeds of cattle (eg introduction of brahmans to northern Queensland)
- Improved disease control
- Reduced mortality (especially reduced mortality of cows in rangelands areas)
- Increased branding and weaning rates
- Increased turnoff rates (through reduced age of turnoff and reduced mortality rates)
- Supplementary feeding (especially in drought years)
- Improved water, fencing, yards and other capital improvements
- Improved pest control (eg over ticks and buffalo fly)
- Improved management (eg stock control, rotational grazing).

Landsberg et al (1998) notes how the introduction of Brahman cattle and supplementary feeding, along with other changes, allowed cattle numbers to increase by 60% on one station in north Queensland during the 1980s. For modelling purposes, it may be appropriate to apportion the increase in beef production equally between improved pastures and other production improvements. Using this approach, the increase in production from pastures is expected to be half of the net improvement in beef production. This is 188,615 metric tons. The annual increase in production attributable to pasture improvement is 1.35% (compounded), with an equivalent percentage being attributable to the other factors.

In 1997-8, there were 10.35 Million beef cattle in Queensland producing 689,770 tons of beef at slaughter. This equates to a net production per beast of 66.64 kilograms. The additional 188,615 metric tons in production that have been identified can be associated with 2.83 Million head of cattle. The extra increase in production that was expected from the vegetation clearing exercise is 3.8 Million. On these estimates, there has been a loss in carrying capacity in Queensland of 1 Million head over the forty years from 1957-8 to 1997-8.

In 1997-8, the value of beef production in Queensland was \$1,507M. If there had been an additional 1M head of cattle in Queensland, then the increase in the value of production would have been \$124.45M. This is the opportunity loss that can be identified with the reasons why pasture production has been lower than expected. Because beef prices have increased substantially since that time period, this opportunity loss would have become larger.

4. Reasons for production declines.

There are three main reasons why declines in pasture productivity may have occurred in Queensland. These are discussed in turn.

Vegetation thickening/proliferation and pasture production

Vegetation thickening is the increase in number and size of trees/shrubs. The historical records shows that vegetation has increased in some areas since the arrival of Europeans. Fensham (1998) reported that a comparison of landscape photos from as early as the 1950s in Central Queensland identified that substantial thickening had occurred. Burrows et al. (1998) studied the carbon signatures on soil organic carbon to differentiate organic carbon derived from C₃ and C₄ plants. The results revealed that woodlands have thickened up in the recent times. The data collected from permanent transect recording sites from different locations in Queensland exhibited 0.24m²/ha/year increase in basal area for grazed woodlands. Burrows et al. (1998) explained that increased grazing pressure from sheep and cattle as well as reduced fire incidents are possible reasons for vegetation thickening.

Vegetation thickening may be responsible for declines in pasture production. Vegetation is usually measured in terms of basal area increment and number of trees per unit area. A negative relationship between basal area of trees and pasture production has been established for *Eucalyptus melanophloia*, *E. populnea* and *E. crebra* (Scanlan and Burrows 1990), and *A. harpophylla* (Scanlan 1991). The main reason is competition for soil moisture between trees/shrubs and grasses (Burrows et al. 1988). Jackson and Ash (1998) concluded that the effects of trees on pasture growth are less important when soil nutrients are limited. A similar story exists in northern Queensland where the monsoon climate effectively means that there is no lack of moisture during the summer growing months (McIvor and Gardner 1995). In these areas, vegetation thickening would not be expected to impact much on pasture production.

The impact of vegetation thickening on pasture production will vary with the type of tree community, soil conditions and climate conditions. ABARE (1999) reported that almost two-thirds of beef specialist producers indicated that pasture productivity was decreasing as a result of changes in woody vegetation. This applied particularly to regrowth, but also included uncleared vegetation. The area affected was approximately 20% of the total grazing area of beef specialist properties.

Land degradation

There are land degradation impacts on pasture production in Queensland (Boulter et al 2000). Tothill and Gilles (1992) outline the deteriorating condition of pastures in Northern Australia, and how these are being affected in some areas by land degradation. There are problems with soil acidification in some areas (Boulter et al 2000), and there is about 10 000 hectares of land estimated to be affected by dry land salinity (Gordon 1991). Low levels of ground cover in some areas influence runoff and soil movement (McIvor et al 1995, Landsberg et al 1998).

Waters (1997) studied the impact of grazing on soil run off at “Glentulloch” and “Keilembete” in central Queensland and revealed greater soil runoff at higher grazing pressure. At “Glentulloch”, soil movement (deposited bed load at the end point of slope) was 3,900 kg/ha/year at heavily grazed sites compared to 1,700 kg/ha/year for enclosed plot (no grazing). Similarly, at “Keilembete”, 18,700 kg/ha/year of soil was lost at heavily grazed sites compared to 2,200 kg/ha/year at enclosed site (no grazing).

In some circumstances, vegetation clearing for pasture development can lead to degradation of soil structure, soil erosion, acidification, salinity and change in nutrient status over time (Boulter et al 2000). Soil functional processes may be altered with clearing due to change in soil microclimatic conditions. Structure degradation commonly occurs in cropping and grazed soils and can have greater impact in fragile soils (Bruce et al. 2000).

Soil acidification also intensifies with tree clearing. In Queensland, more than 2 000 000 hectares of agricultural soil area is acidic (pH <6.5) due to leaching processes and from previously climatic conditions (Moody 2000). Tree clearing is an acidifying process. Acidification is accelerated due to increase in loss of products of acid reactions in biological carbon and nitrogen cycles.

Pasture run down

In many areas the decline in pasture productivity is better referred to as rundown rather than degradation. This identifies that while the pasture may still appear productive, its productivity is declining. Tothill and Gillies (1992) identified this pattern in Queensland. Yates et al. (2000) reported that livestock grazing in eucalypt woodlands of South Australia was associated with loss of soil surface micro-topography, loss of soil cryptogam cover, increase in exotic annual cover, degradation of soil structure, reduced soil water infiltration and changes in soil microclimate. The same impacts may be reducing pasture production in Queensland.

Pasture run down is often associated with cleared and improved pastures, where there is often a spike in production in the years following development, and then a decline as nutrients become limited. Partridge et al. (1988) reported a decline in pasture productivity 5-10 years after clearing. The degraded soil conditions (in terms of increase in soil pH, greater compaction, soil erosion, runoff and decline in soil fertility) resulting in pasture run down as a consequence of clearing in brigalow (*A. harpophylla*) country are reported by Lawrence et al. (1988). A flush of nutrients occurs in the top 10 centimeters of soil after pulling and burning brigalow scrubs, as available nitrogen increases by seven fold, and phosphorus and potassium levels double. Graham et al. (1981) identified lower levels of soil organic carbon and higher bulk density at cleared sites compared to uncleared sites for similar reasons.

The introduction of exotics and tree clearing could be factors influencing plant diversity and subsequent lower production. Fairfax and Fensham (2000) studied the impact of exotic buffel (*Cenchrus ciliaris*) pastures on plant diversity in *A. harpophylla*, *E. populnea*, *E. melanophloia* and *Acacia cambagei* vegetation types and found higher plant species diversity in uncleared vegetation types than in those cleared and sown to exotic pastures. McIntyre and Matin (2001) also showed that soil disturbance significantly reduces the richness of native species. Ash and McIvor (1998) identified that higher green leaf, grass nitrogen, and in vitro dry matter digestibility were evident in pastures (native and sown) containing trees compared to the pastures without trees.

Indirect production values and ecosystem services

Indirect production values refer to the services that native vegetation provides in a landscape, and to the potential loss of services if trees are removed (Cork and Shelton 2000). Trees are not just competitors with pasture for water and nutrients. They may also provide ecological services such as shade, windbreaks, nutrient recycling and as a refuge for wildlife (Chillcott 1999). For example, bird habitat may be important in keeping insect populations low. In some cases trees may provide limited

food sources for stock, and can help to protect against erosion and salinity. Trees may also protect grasses from weather extremes such as frosts and heatwaves, and provide a fodder reserve for stock at these times.

These ecosystem services are difficult to value in practice. Some evidence for the importance of ecosystem services comes from the results of clearing trials reported in Burrows (2001). The clearing trials took place in popular box (*Eucalyptus populnea*) woodland in Central Queensland, and involved a number of treatment strategies. Some trials involved 100% clearing, while others involved 80% clearing. All trials were stocked and animal performance recorded to determine the best strategies for production purposes.

Because trees compete with grasses for water and nutrients, there is normally an inverse relationship between the amount of trees (defined by tree cover or basal area measurements) and the production of grass in an area (Boulter et al 2000). In eucalypt woodlands in central Queensland, the presence of trees tends to reduce grass production, and decreases in grass production are largest when the basal area of trees increases from small initial levels (Scanlon and Burrows 1990). This suggests that grass production should normally be maximised when there is a minimum or zero number of trees, and that 100% tree clearing should maximise grass production and hence cattle production.

In the trials, equivalent maximum returns were generated from both 80% and 100% clearing options under specific treatments (Burrows et al 1999, Burrows 2001). In the 80% cleared trials, the expected loss of production of grass in the timbered areas must have been compensated by other factors, such as improved grass quality (through nutrient recycling or protection factors), greater diversity in diet for cattle, or reduced stress for cattle (from shade and protection factors).

The Net Present Value of the most profitable clearing options over the uncleared base case was assessed at \$28/ha (Burrows 2001). This equates to \$5.60 for each 20% of the hectare cleared. For the 80% clearing trial where the same production returns were generated, the indirect services provided by the 20% of uncleared vegetation should be approximately equivalent to this amount. This means that in the 80% clearing trial, each hectare of remnant vegetation contributed a Net Present Value of \$28 in indirect services towards beef production.

The ecological services provided by trees have important impacts on production, although more work is needed to identify the linkages. In clearing vegetation, landholders would be expected to balance the production benefits of removing trees (competition for water and nutrients) against the indirect benefits provided by trees (ecosystem services). It is unclear what percentage of vegetation should be retained to maximise production, and this may vary according to vegetation types, climate and region.

Excessive clearing of vegetation to maximise grass production may not optimise cattle production because of the associated loss of ecosystem services. This may occur when landholders are not aware of the role or value of ecosystem services, particularly when there are time lags involved.

Conclusions.

The results presented in this paper show that there has been a loss in the productivity of pastures in Queensland by around 1 Million beef cattle equivalents over the forty year time period between 1957-8 and 1997-8. Such conclusions are often contentious because of the number of assumptions and linkages that have to be made. In the analysis, conservative estimates have normally been adopted to minimise this problem. For example, the amount of fodder crops

grown in 1997-8 was taken to be the 1986-7 level, the last year of available data. It is likely that the actual amount of fodder crops grown and importance for fattening cattle is much higher.

Other factors that would identify even higher losses in pasture production have not been considered. These include the gains in cattle production from feeding on the stubble of grain crops after harvest, and the likelihood that the livestock numbers recorded in 1957-8 were largely underestimated. Other factors such as these suggest that the estimated losses in pasture production are a minimum.

The assumption for which no clear evidence is available is the apportionment of production gains between pasture improvements and all other factors. The 50% apportionment for pasture improvements could be higher or lower. However, there is a limit to how much higher it could be, because it would suggest that all the other substantial improvements in the beef industry, including the many improvements from research and extension facilities, have had little contribution to productivity.

The three key explanations for why productivity from pastures have declined are land degradation, vegetation thickening, and reductions in ecosystem services from declines in soil status and other factors. More work is needed to identify the relative contribution from each of these factors. However, it appears likely that it is subtle losses in production from soil and pasture rundown over large areas that is a bigger contributor than land degradation.

Analysis is also needed about whether these losses are likely to continue through time. In relation to tree clearing, the analysis indicates that more care may have to be taken to identify longer term consequences on productivity and resource condition. While tree clearing will remain profitable for landholders in some regions, care has to be taken that the development action does not tradeoff short term gains in productivity against longer term losses.

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