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ECONOMICS OF REDUCING METHANE EMISSIONS FROM CATTLE PRODUCTION IN CENTRAL QUEENSLAND

Project number NAP3.226
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ISBN 1 74036 218 7

June 2001

Natural Resources

EXECUTIVE SUMMARY

1. It is relatively simple to estimate annual methane emissions from cattle in northern Australia (including all of Queensland) using average weight and average liveweight gain over the period.

2. The average specialist beef producer in Queensland has 1158 head of cattle (ABARE 2000) which emitted 103 tons of methane per year. This is equivalent to emitting 2,163 tons of carbon dioxide each year.

3. The average specialist beef producer in Queensland would release approximately39.5 tons of carbon dioxide each year from using fossil fuels (petrol, diesel, oil). When both fossil fuels and methane emissions are considered from grazing properties, methane emissions from cattle account for approximately 95.6% of total emissions.

4. More efficient production systems result in more beef being produced per unit of methane emitted. Key efficiencies can be gained by improving the rate of weight gain or the herd reproduction rate. Lower quality pastures and lower turnoff management systems will produce higher levels of methane emissions per kilogram of beef produced.

5. A large proportion of methane emissions is tied up in the breeding herd. In comparison, the fattening herd produces more beef per kilogram of methane emitted. The largest potential gains in reducing the amount of methane produced per kilogram of beef produced appear to be in the breeding herd in northern Australia.

6. Increasing liveweight gains of cattle without reducing cattle numbers will lead to an increase in methane emissions. This is because the average weight of cattle increases, more than compensating for the beneficial effects of better feed utilisation.

7. Improvements in pasture and herd management will increase the efficiency of beef production, but will contribute to an increase in methane emissions. The only ways to reduce total methane emissions are to modify the rumen activity in some way (e.g. a vaccine) or to reduce stock numbers.

8. If beef is produced from younger, lighter cattle, then overall methane emissions may drop. However, if a larger breeding herd has to be maintained, the additional emissions will be larger than any potential gains.

9. Improving feed quality through fodder crops and tree crops such as leuceana are important ways of increasing beef production per unit of methane emitted. However, the increase in total beef production is associated with an increase in methane emissions. There may be other carbon sequestration benefits of tree crops such as leuceana which make them attractive.

10. In many cases, a reduction in stocking rates will reduce methane emissions. In cases where a reduction in stocking rates does not reduce the amount of beef that is produced, then there may be no net reduction in methane emissions. There will be other cases where a reduction in stocking rates (i.e. from high to medium rates) will be financially rewarding because of reduced risk factors, as well as contributing to lower methane outputs. These situations are win-win situations.

11. There will be many situations where a reduction in stocking rates (i.e. from medium to low rates) is not financially rewarding but does contribute to reduced methane emissions.

12. In one grazing trial in Central Queensland, the opportunity costs of reducing stocking rates from medium to low in order to reduce methane emissions by 1 kilogram was one kilogram of liveweight beef production. At $1.50/kg for cattle (liveweight), the opportunity cost of reducing stock numbers to reduce methane emissions can be estimated at approximately $35/ton of carbon dioxide equivalents.

13. Development of a vaccine, or other rumen modifier, appears to be the best option for making any reductions in methane emissions. The vaccine would have offsetting benefits in increasing animal performance, and would be a verifiable way of reducing emissions.

14. To involve beef producers in any efforts to reduce greenhouse gas emissions, it is important to develop strategies that:

    - provide clear targets and sufficient information so producers can modify behaviour,

    - provide adequate technology and options for change,

    - provide an adequate degree of certainty about change.

    It appears that most feeding and management options would not meet these criteria, and would have to be assessed on an individual property basis to determine actual impacts. A vaccine against methanogens might meet the criteria, but may take several years to develop commercially.

15. A tax on methane outputs would not work effectively in Australia to reduce methane emissions. This is because of the variability in animal performance and seasonal conditions, and the lack of clear strategies to make emission reductions. A simple reduction in animal numbers may not reduce methane emissions much if livestock are replaced by heavier animals utilising the same amount of feed. In northern Australia where there are no alternative industries, taxes would have to be very high before producers could be expected to modify behaviour.

16. The beef industry should promote the automatic and ongoing improvements in beef production which are helping to increase the amount of beef produced per unit of methane emitted. Among the key contributors to these trends are improved

feed conditions, improved herd management, finishing cattle on grain, the development of the live export markets, and lower turnoff ages.

17. Further research and development is needed to identify technical options for modifying activity in the rumen, identifying the impacts of supplementary feeding, and assessing the impacts of feeding and management changes at a property level.

CONTENTS

1. INTRODUCTION

The first two reports in this series have provided an overview of the background information relating to methane emissions from cattle production (Zeil and Rolfe 2000), and provided a summary of how to estimate methane emissions at a property level in central Queensland (Rolfe and Zeil 2001). In this report, some economics of strategies to reduce methane emissions from cattle production are outlined.

Because beef cattle produce such a major component of the agricultural sector's contribution to national greenhouse gas emissions, this is the industry to concentrate on in terms of making significant reductions to overall emissions (Rossiter and Lambert 1998). At the property scale, it is very likely that much larger reductions per hectare can be made by dairies and farmers than by beef cattle operators. However, the limited area of farming compared to grazing means that the total potential gains in emission reductions from various farming sectors are much smaller than potential gains from reductions from beef cattle operations.

There are three main options to pursue in reducing emissions from the beef industry. The first is to use rumen modifiers to reduce the activity of specific bacteria (methanogens) in the fermentation process. These modifiers have the potential to reduce methane emissions from the rumen by around 20%, and will create offsetting gains in animal production as more energy becomes available to the animal.

The second option is to improve the efficiency of animal production systems. Methane essentially represents lost carbohydrates to the animal, and animals that have poor feed conversion ratios have high methane emissions. Measures such as supplementary feeding which enable animals to grow faster tend to reduce emissions per head, while improved herd management means that more beef tends to be produced for a given level of methane emissions.

A third option that has also been canvassed (eg Hassall and Associates 1999) is to reduce cattle numbers. The greatest benefit from a reduction in livestock numbers would come from rangelands areas, where productivity of livestock is low relative to other regions of Australia. Reduction in livestock numbers would not only save on methane emissions, but would also allow for a buildup of carbon stocks in areas that were no longer grazed. However, the social and economic costs of this option may not make it a preferred choice.

The mechanisms by which these options might be pursued should also be considered in order to determine if particular outcomes are possible. Mechanisms can be broadly classified into voluntary and regulatory groups. An example of a voluntary mechanism might be an incentive structure that encourages changes in herd management. An example of a regulatory approach might be the imposition of a tax on ruminant animals which was designed to reduce livestock numbers.

In order to consider which, if any, options might be successful in reducing emissions from livestock, it is important to judge potential options and mechanisms against a number of criteria. These might include:

- Clear targets and sufficient information so that beef producers know how they might be expected to modify their behaviour,

- Adequate technology and options for change, so that beef producers have options to reduce greenhouse gas emissions,

- An adequate degree of certainty, so that beef producers know the outcomes of different management strategies, which measures have priority and the timing and extent of emission reduction targets.

In this report it is demonstrated that most of the potential minimisation strategies do not meet these criteria very well, which means it will be difficult to involve beef producers in strategies to reduce methane emissions.

2. THE PRODUCTION OF METHANE FROM GRAZING PROPERTIES IN CENTRAL QUEENSLAND

A summary of the estimation procedures used in the national inventory estimations has been given in Rolfe and Zeil (2001). Feed intake per day (**I** kg dry matter/head/day) is estimated from liveweight and liveweight gain of the beast as follows:

$$I = (1.185 + 0.00454W - 0.0000026W^2 + 0.315LWG)^2 \quad \text{.... (1)}$$

Where: W = liveweight in kg
LWG = liveweight gain in kg/head/day

For animals on tropical pastures total daily production of methane (**M** kg CH_4/head/day) is given by Kurihara et al. (1999) as:

$$M = (41.5 \times I - 36.2) / 1000 \quad \text{...(2)}$$

In the national inventory approach (NGGI 1997), methane emissions from cattle in Queensland are estimated using equations 1 and 2. Note that emissions from dairy cattle, cattle in feedlots, and cattle on temperate grasses in southern Australia are estimated in different ways, as outlined in the national inventory (NGGI 1997).

Table 1: Daily liveweight gain (kg/head/day) for Queensland beef cattle of various classes defined by season and age (NGGI, 1997)

Season	Bulls >1(kg)	Bulls <1(kg)	Steers <1(kg)	Cows 1-2(kg)	Cows >2(kg)	Cows <1(kg)	Steers >1(kg)
Spring	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Summer	0.70	0.70	0.70	0.70	0.00	0.70	0.70
Autumn	0.40	0.40	0.40	0.40	0.30	0.40	0.40
Winter	0.10	0.10	0.10	0.10	0.10	0.10	0.10

For Queensland, average methane yeilds per day in a quarter are estimated by using the average weight and average liveweight gain of a beast over the quarter. The average methane yield is then multiplied by the number of days in a quarter (91.5) to give the methane emissions per quarter. In this way, variations in emissions between the seasons are apparent. Default values for average annual weight gains in the Queensland cattle herd are used as the best available approximation (see Table 1).

A simpler way of calculating emissions is to adopt an annual approach, where average liveweight and daily liveweight gain over the year are used in equation (1), and the resulting daily methane yield multiplied by 365 days. A simple example of the equivalence of the two approaches is given below for a steer that has a bodyweight of 400 kilograms at the beginning of spring. In table 2, the calculations used in the national inventory approach are replicated, using the assumed daily liveweight gains per quarter for beef cattle in Queensland. As can be seen, the total emissions over the four quarters for the one steer is approximately 102 kgs.

Table 2: Methane emissions for steer over one year starting at 400kg in Spring.

Season	Assumed LWG (kg/day)	Average LW in quarter	Dry matter intake (kg/day)	Methane emssions (kg/day)	Total methane over quarter (kg)
Spring	0.2	409.15	7.13	0.26	23.76
Summer	0.7	415.98	8.09	0.30	27.40
Autumn	0.4	434.28	7.80	0.29	26.29
Winter	0.1	438.85	7.33	0.26	24.54

If the methane emissions were calculated on the basis of annual averages, then the same steer would have an average liveweight of 424.6 kgs, and an average liveweight gain of 0.35 kgs/day over the year. Total methane emissions thus can be estimated at 101.7 kgs. This shows that using average weights and liveweight gains over a year produces accurate estimates in relation to the quarterly approach of the NGGI (1997).

Accurate ways to model methane emissions

A more accurate way of estimating methane emissions over period would be to calculate the weight, weight gain, dry matter intake and methane yield for each day. Weight would change between days by the amount of weight gain (which might be assumed to be constant over a period). Because the weight will change for each day (for a growing beast at least), the amount of feed intake and methane emitted will also vary each day. A simulated model will allow the balances for each day to be calculated, and the total amounts at the end of certain period. For the example reported in Table 1, a simulated model for a steer starting at 400 kgs and growing at 0.35 kgs/day generates total methane yield over one year at 108.87 kgs/day.

Simulated models show that for lower weight gains (below 0.4 kgs/day), the NGGI approach or an annual approach tend to underestimate methane yields. For high rates of daily weight gain (> 0.6 kgs/day), the NGGI approach tends to overestimate yields slightly, while it remains quite accurate when liveweight gain ranges between 0.4 and 0.6 kgs/day. In the work that follows in this report, methane yeilds are simply estimated on the basis of average weight and weight gain over a one year period.

2.1 The scale of methane emissions from specialist beef properties

The scale of methane emissions from the average beef property in Queensland can be estimated using some assumptions about cattle weights and weight gains. In ABARE

(2000), specialist beef producers in Queensland are estimated to have 1,157 head (average from 1993/94 to 1997/98), as shown below in Table 3. Assumptions have been made about animal weights, and an average weight gain of 0.35 kgs/day have been used for liveweight gain, apart from cows where a default of 0.15 kgs/day has been chosen.

Table 3: Methane emissions from the average Qld beef specialist property

	Number	Average weight	LWG	Annual methane emitted (kg/head)	Total annual methane (kg)
Bulls	27	600	0.35	130.7857	3531.213
Cows	470	500	0.15	110.0169	51707.95
Heifers	119	350	0.35	86.5041	10293.99
Calves	269	350	0.35	86.5041	23269.6
Other cattle	273	200	0.35	53.53977	14616.36
Total					103419.1

This example shows that the average beef specialist property in the state is emitting 103 tonnes of methane per year. This amount can be converted into carbon dioxide equivalents by multiplying the amount of methane by 21. This means that the average beef specialist property is emitting 2,163 tonnes of carbon dioxide equivalents each year from their cattle.

In comparison, the emissions from fuel use on beef properties is very small. The average specialist beef property spent an average of $10,294 on fuel, oil and grease between 1993/94 and 1997/98 (ABARE 2000). If fuel prices are assumed at $0.70 per litre, total fuel use is approximately 14,700 litres. At a conversion rate of 2.69 for diesel, this would generate approximately 39,543 kgs of carbon dioxide equivalents. This means that the average beef specialist property in Queensland produces 2,163 tonnes of carbon dioxide equivalents from methane and 39.5 tonnes of carbon dioxide equivalents from fuel use. Methane emissions count for 95.6% of the property emissions (excluding any for vegetation and land use change). The example confirms that for specialist beef producers wishing to reduce their contribution to greenhouse gas emissions, reductions in fossil fuel use will have very limited impact compared to potential reductions in methane emissions.

2.2 Examples of emission levels from different beef operations

Some examples can be drawn up to demonstrate the scale of methane emissions from different beef cattle operations in Queensland. These are done by identifying the average weight and liveweight gain of cattle in a herd over a year, and using this information to estimate methane emissions. Only simple examples have been used below, and other herd dynamics such as deaths and herd replacements have not been considered at this stage.

Case studies have been presented below to represent comparisons between breeding herds on native and improved pasture, and fattening operations on native and improved pasture. The rates of liveweight gain used are 0.4 and 0.6 kgs/day for native and improved pasture respectively. While these rates are at the higher end of the scale for both pasture types, they provide some indication of the differences that do exist. To account for additional feed needs of lactating cows, a weighting for breeders raising a calf has been set at being equivalent to 0.15 kgs/day.

Case Study A - a breeding operation on native pasture with 1,000 breeders

It is assumed that there is a calving rate of 75%, and that cows have a calf maintenance requirement that is equivalent to a liveweight gain of 0.15 kgs/day. Calves are assumed to gain 127 kgs in the year following birth (0.35 kgs/day), and have an average weight of 104 kgs.

	Cows	Calves < 1	Total
Number	1,000	750	1,750
Average liveweight over year (kg)	500	104	
Average liveweight gain (kg/day)	0.15	0.35	
Average feed intake (kg/day)	8.135	3.025	
Total feed intake for year (tonne)	2,969	828	3,797
Additional liveweight produced (kg)	0	127,500	127,500
Daily methane emission (kg/day)	0.3014	0.0893	
Total methane/beast/year (kg)	110.0	32.6	
Total methane for year (kg)	110,017	24,457	134,475

In this case, a total of 750 calves weighing approximately 170 kgs each have been turned over after one year for a methane yeild of 134,475 kgs. This equates to 1.055 kgs of methane produced for every kilogram of liveweight beef produced.

Case Study B - a breeding operation on improved pasture with 1,000 breeders

It is assumed that there is a calving rate of 85%, and that cows have a calf maintenance requirement that is equivalent to a liveweight gain of 0.15 kgs/day. Calves are assumed to gain 220 kgs in the year following birth (0.6 kgs/day), and have an average weight of 150 kgs.

	Cows	Calves < 1	Total
Number	1000	850	1850
Average liveweight over year (kg)	550	150	
Average liveweight gain (kg/day)	0.15	0.6	
Average feed intake (kg/day)	8.660	3.986	
Total feed intake for year (tonne)	3,161	1,237	4,398
Additional liveweight produced (kg)	0	221,000	221,000
Daily methane emission (kg/day)	0.3232	0.1292	
Total methane/beast/year (kg)	118.0	47.2	
Total methane for year (kg)	117,961	39,147	157,108

In this case, a total of 850 calves weighing approximately 260 kgs each have been turned over after one year for a methane yeild of 157,108 kgs. This equates to 0.711 kgs of methane produced for every kilogram of liveweight beef produced. Even though much more methane has been produced by the herd in Case Study B than Case Study A, this has been more than offset by increased beef production, so that methane emissions per kilogram of beef produced are much lower.

Case Study C - a steer fatting operation on native pasture with 1,000 steers

It is assumed that 500 steers are purchased in each year as weaners at 230 kilograms. Average weight gain is 0.4 kgs per day, which means that steers gain 150 kgs per annum.

Steers are sold out after two years at 530 kilograms. Average weights are 305 kgs in the first year and 455 kgs in the second.

	Steers 1-2	Steers 2-3	Total
Number	500	500	1000
Average liveweight over year (kg)	305	455	
Average liveweight gain (kg/day)	0.4	0.4	
Average feed intake (kg/day)	6.021	8.057	
Total feed intake for year (tonne)	1,099	1,470	2,569
Additional liveweight produced (kg)	75,000	75,000	150,000
Daily methane emission (kg/day)	0.2137	0.2982	
Total methane/beast/year (kg)	77.99	108.83	
Total methane for year (kg)	38,997	54,413	93,410

Over one year, the 1,000 steers could be expected to gain a total of 150,000 kilograms liveweight. This means that the beef is grown on the native pasture for approximately 0.623 kgs of methane output for every kilogram of beef (liveweight) that is produced. It is notable that if this situation is compared to Case Study A, methane emissions per kilogram of beef produced are higher for breeders than for fattening cattle.

If the productions efficiencies increased by 10% in the operation, this would imply that liveweight gains increase to 0.44 kgs/day, with resulting increases in average weights over the year. Total methane emissions would increase by 3.2% to 96,364 kgs, while the amount of beef produced would increase by 10%. The rate of methane emissions per kilogram of beef produced would fall from 0.623 kgs to 0.602 kgs, a drop of 3.2%.

Case Study D - a steer fatting operation on improved pasture with 1,000 steers

It is assumed that 500 steers are purchased in each year as weaners at 230 kilograms. Average weight gain is 0.6 kgs per day, which means that steers gain 220 kgs per annum. Steers are sold out after two years at 670 kilograms. Average weights are 340 kgs in the first year and 460 kgs in the second.

	Steers 1-2	Steers 2-3	Total
Number	500	500	1000
Average liveweight over year (kg)	340	560	
Average liveweight gain (kg/day)	0.6	0.6	
Average feed intake (kg/day)	6.849	9.616	
Total feed intake for year (tonne)	1,250	1,755	3,005
Additional liveweight produced (kg)	110,000	110,000	220,000
Daily methane emission (kg/day)	0.2480	0.3629	
Total methane/beast/year (kg)	90.53	132.45	
Total methane for year (kg)	45,265	66,226	111,491

Over one year, the 1,000 steers could be expected to gain a total of 220,000 kilograms liveweight. This means that the beef is grown on the improved pasture (eg high quality buffel country) for approximately 0.5067 kgs of methane output for every kilogram of beef (liveweight) that is produced. Again, it is notable that if this situation is compared to Case Study B, methane emissions per kilogram of beef produced on improved pasture are higher for breeders than for fattening cattle.

When this case study is compared to steers on native grass pasture in Case Study C, it is notable that total methane emissions are higher for steers on improved pasture (because the average weight of the cattle is higher), but that the methane emissions per unit of beef produced is much lower.

If the production efficiencies increased by 10% in Case Study D, this would imply that liveweight gains increase to 0.66 kgs/day, with resulting increases in average weights over the year. Total methane emissions would increase by 4.4%, while the amount of beef produced would increase by 10%. The rate of methane emissions per kilogram of beef produced would fall from 0.5067 kgs to 0.4852 kgs, a drop of 4.2%.

The information provided in these case studies can be summarised in a couple of ways.

Figure 1: Projected methane emissions per year from different herds

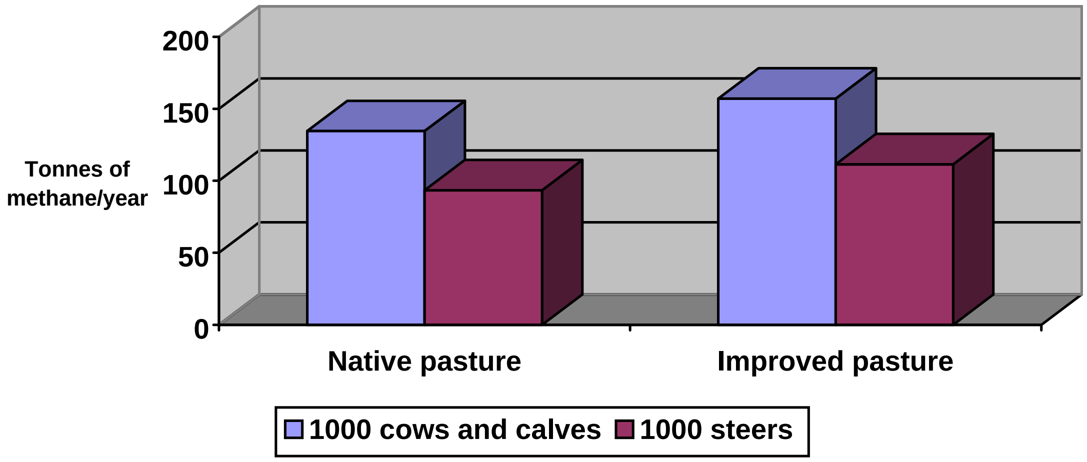


Figure 2: Projected beef production per annum from different herds.

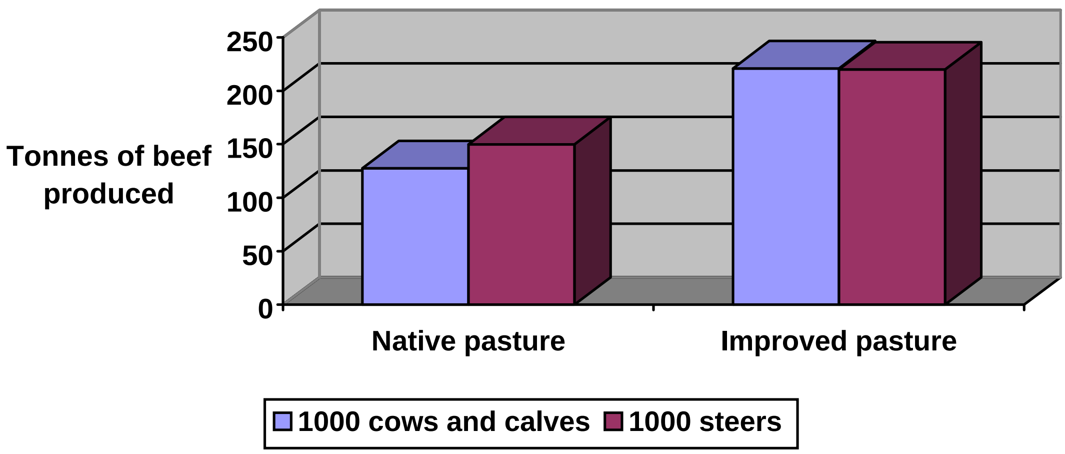
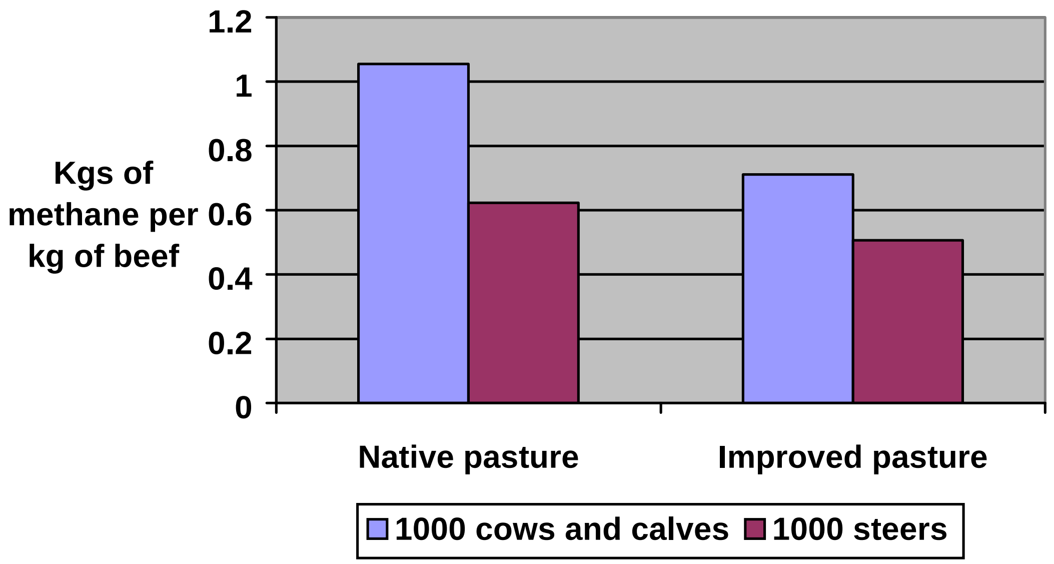


Figure 3: Projected methane emissions per kg of beef produced for different herds



2.3 Conclusions

These case study examples allow three important conclusions to be drawn. The first is that more efficient production systems result in lower methane emissions per kilogram of beef produced. Key efficiencies can be gained by improving the rate of weight gain, or the herd reproduction weight. Lower quality pastures and lower turnoff management systems will produce higher levels of methane emissions per kilogram of beef produced.

Second, a large proportion of methane emissions are tied up in the breeding herd. By comparison, the fattening herd is more efficient at producing beef per unit of methane production.

Third, increasing the liveweight gains of cattle without adjusting livestock numbers will lead to higher overall levels of methane emissions. This is because the average weight of the livestock increases, and the beneficial effects of better feed utilisation rates are countered by the increased dry matter intake. However, an increase in liveweight gains will lead to a reduction in methane emissions per kilogram of beef produced.

3. SEARCHING FOR OPTIONS TO REDUCE METHANE EMISSIONS

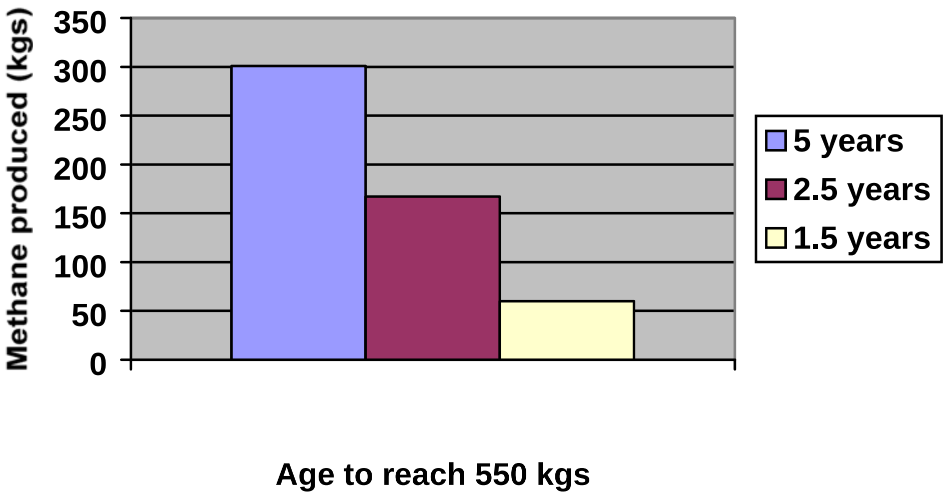
A number of options to reduce methane emissions have been outlined (Hassall and Associates 1999, Rossiter and Lambert 1998, Rolfe and Zeil 2001). Some modelling of emissions from beef properties in Queensland are used to explore the effects of these different options.

3.1 Improving feed utilisation

One of the main options is to improve the utilisation of feed in the rumen in some manner so that less dry matter is converted into methane and more is utilised by the animal. The key argument is summarised by Hunter and McCrabb (1998), who note that the difference in methane emissions is most noticeable over the lifetime of an animal.

A steer in southern Australia that fattens on grain and reaches 550 kg at 18 months will only produce 60kg of methane in its lifetime. By contrast a steer in northern Australia that fattens slowly on grass and reaches 550kg at 5 years of age will produce 301 kg of methane over its lifetime. The estimates provided by Hunter and McCrabb (1998) are summarised in Figure 4.

Figure 4: Estimated CH_4 emissions by steers reaching 550kg slaughter weight at different ages



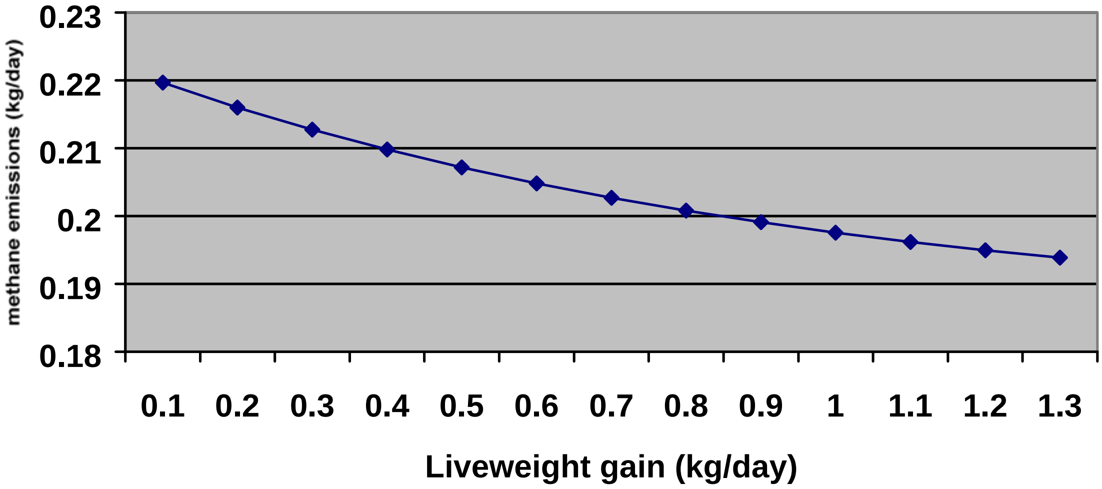
On average, cattle in northern Australia produce more methane than cattle in southern Australia. This is because grasses in the north are less digestible than temperate pastures, and because cattle in northern Australia do not fatten as quickly. Finishing cattle on grain for 2-5 months can reduce methane emissions by 34-54% (McCrabb and Hunter 1999) but there will be off-setting carbon losses involved in growing and transporting grain.

However, simply improving the available feedstocks for cattle is unlikely to reduce overall emissions. Instead, it will increase the amount of beef produced per unit of methane emitted. If pasture utilisation is improved in Queensland, the overall impact is likely to be that both methane emissions and beef production will increase. This conclusion can be explained in several ways.

If a beast has its feed ration improved, it has a better feed conversion rate, and a lower level of methane emissions. This information is shown in Figure 5, where the projected daily emissions for a 340 kilogram steer have been plotted at different potential daily liveweight gains. The graph shows that for higher liveweight gains, there are lower levels of methane emissions.

Figure 5 also demonstrates that as liveweight gain increases, the corresponding fall in methane outputs is quite slight. In fact, for every 0.1 kg improvement in liveweight gain, the corresponding reduction in daily methane emissions varies between 2.5% and 3%. This means that for cattle of the same weight but differing liveweight gains, the rate of daily methane emissions does not vary largely between animals.

Figure 5: Predicted CH_4 emissions in kg /day for cattle of various LWG(kg/day).



If the efficiency of methane production (methane output per kilogram of liveweight gain) is plotted against liveweight gain, a much more concave relationship can be generated. McCrabb and Hunter (1999) demonstrate this concave relationship, where there are slight falls in methane efficiency for increasing liveweight gains above 0.5 kgs/day, but much larger falls for increasing liveweight gains up to 0.5 kgs/day. This indicates that the biggest gains in methane efficiency are to be found in northern Australia, where liveweight gains tend to be lower.

If beef producers can improve the feed utilisation of cattle, they will reduce the amount of methane emitted at each particular liveweight. But improved feed utilisation means that cattle will grow faster and heavier. Beef producers are likely to have heavier stock and to turn off more beef, or to run more stock on the same feed with the same end result. The outcome of better feed utilisation is that more beef will be produced, methane emissions per kg of beef produced will fall, and overall methane emissions may or may not rise.

This outcome can be demonstrated in another way. Case Study C demonstrated the level of methane emissions that might be expected from 1,000 steers starting at a base weight of 230 kilograms if the growth rate was 0.4 kgs/day. If the growth rate was boosted by 10% to 0.44 kgs/day, feed intake, weight gains, and overall methane emissions per beast would increase. Of course, beef producers might have a limited amount of feed, and need to reduce livestock numbers to compensate for higher intake levels by each beast. If the total amount of feed intake is held constant in that example, then 974 steers growing at 0.44 kgs/day will have the same feed intake requirements as 1000 steers growing at 0.4 kgs/day.

At this level of liveweight gain, 974 steers will produce 93.859 tonnes of methane in a year. The 1,000 steers growing at a slower rate of 0.4 kgs/day will produce slightly less methane of 93.41 tonnes over the year, because their average weight over the year is lower. Therefore reducing cattle numbers but maintaining the same grazing pressure (by having larger animals) actually increases methane emissions.

Improving feed utilisation is clearly advantageous to cattle producers because it increases the amount of beef that is produced. Normal market incentives will thus operate to encourage producers to search for such efficiencies. It is also clear, from the above analysis, that improved feed utilisation does not automatically lead to reduced methane output. In fact, because faster growth rates often lead to producers holding heavier stock, overall methane outputs may increase. It is only when improved feed utilisation is coupled with younger, lighter animals that faster growth rates can be definitely associated with reduced methane emissions. The issue of running younger cattle is looked at more closely below.

3.2 Reducing turnoff weight

Improving feed utilisation only contributes to overall methane reductions when it is coupled with reduced animal weights; i.e. by running younger, lighter cattle. For example, if the amount of total feed utilised in Case Study C is held constant, liveweight gains are increased to 0.44 kgs/day, and only younger steers (1-2 years) are run, an additional 143 steers can be run on the same amount of feed. This represents an increase in beef production of 25.7%, while methane output actually falls by 2%. This scenario is listed below as Case Study E.

Case Study E - a steer fatting operation on native pasture with 1,143 steers

It is assumed that 1,143 steers are purchased in each year as weaners at 230 kilograms. Average weight gain is 0.44 kgs per day, which means that steers gain 160 kgs per annum. Steers are sold out after each year at 390 kilograms. Average weight over the year is 310 kg. Total feed intake for the year is equivalent to 1,000 steers in Case Study C.

	Steers 1-2	**Case study C**
Number	1,143	1,000
Average liveweight over year (kg)	310	
Average liveweight gain (kg/day)	0.44	
Average feed intake (kg/day)	6.156	
Total feed intake for year (tonne)	2,568	2,569
Additional liveweight produced (kg)	182,880	150,000
Daily methane emission (kg/day)	0.2193	
Total methane/beast/year (kg)	80.03	
Total methane for year (kg)	91,481	93,410

In this case, fattening animals up to two years instead of three years allowed a 2% reduction in methane output for the same amount of feed intake. However, when the contribution of the breeding herd is factored in, there may be no reduction. This is because there should be an increase in the breeding herd to supply more fattening cattle. For example, in Case Study C, 500 steers were introduced per year, and held for two years. At an 85% calving rate, this would have involved 588 cows to produce those steers. In case study E, 1,143 steers are introduced per year and held for only one year. At an 85% calving rate, this would have involved 1,344 cows. On native pasture (i.e. Case Study A), the additional 756 cows needed would produce 83,160 kgs of methane per year, far in excess of the 2% saving outlined in Case Study E.

When the contributions of the breeding herd are considered alongside the fattening animals, it is clear that total emissions are lowest when a smaller number of breeding cows are needed to produce the fattening herd. There is no advantage in reducing the average age of turnoff if an increase in the breeding herd is necessary to provide throughput numbers.

3.3 Improving feed quality – leuceana.

One of the major options that is pursued by landholders in the Central Queensland region is to establish a fodder tree, leuceana, for cattle grazing. Cattle grazing on leuceana in association with grass have much higher weight gains than do cattle on grass pastures. While steers on native pastures might gain 100 – 130 kgs per year, and steers on improved pasture gain 150 – 180 kgs per year, steers on leuceana can gain 250 – 300 kgs per year. At such high weight gains, it is worthwhile considering the methane emissions that might be involved.

Case Study F – a comparison of three different pasture types

It is assumed that 1,000 steers are purchased in each year as weaners at 230 kilograms. There are three options for feeding them, being native pasture, high quality improved pasture, and leuceana. The respective growth rates associated with each pasture type are 0.4, 0.6 and 0.8 kgs/day.

	Leuceana	Improved pasture	Native pasture
Number of steers	1,000	1,000	1,000
Starting weight (kg)	230	230	230
Finishing weight (kg)	520	450	380
Average liveweight over year (kg)	375	340	305
Average liveweight gain (kg/day)	0.8	0.6	0.4
Average dry matter intake (kg/day)	7.694	6.849	6.021
Total feed intake for year (tonne)	2,808	2,569	2,098
Additional liveweight produced (kg)	292,000	219,000	146,000
Daily methane emission (kg/day)	0.2831	0.2480	0.2137
Total methane/beast/year (kg)	103.33	90.53	77.99
Total methane for year (kg)	103,338	90,530	77,994
Kgs of beef/tonne of dry matter intake	103.98	85.25	69.59
Kgs of methane/kg of beef	0.354	0.413	0.534

The example demonstrates that cattle on leuceana do relatively better than cattle on grass pastures. More beef is produced for each tonne of dry matter intake, and the amount of methane that is emitted to produce each kilogram of beef is lower on leuceana pastures. However, the overall production of methane is higher on leuceana, because the average weight of animals is higher.

The example above understates the advantages of leuceana to some extent because the average weight of steers on leuceana are assumed to be higher. If the amounts of methane are calculated for steers to achieve a finishing weight of 550kgs on each pasture type, the advantages of leuceana become clearer. It would take 400 days for a steer on leuceana to reach a target weight of 500 kgs from a starting weight of 230 kgs. In that time, the steer would be expected to 116.8 kgs of methane.

On improved pasture, it would take 533 days to achieve the same weight gain, and a steer would release 147.9 kgs of methane over the same time period. One native pasture, it would take 800 days to achieve the same weight gain, and a steer would release 210.6 kgs of methane.

However, the example demonstrated in Case Study F also demonstrates that while leuceana may be a more efficient way of producing beef, it is unlikely to contribute to an overall reduction in methane emissions[1]. This is because 1,000 steers on leuceana for a year will produce more methane than steers on grass pastures, due to the higher amount of dry matter consumed, and the higher average weight of the steers. If the aim of the pastoral industry is produce more beef for small increases in methane emissions, then establishing better quality pastures is one alternative to pursue. If the aim is to reduce methane emissions overall, then this objective cannot be gained by simply improving pastures and feed quality.

3.4 Improving breeding herd management

One of the important ways in which beef producers can improve the amount of beef produced for every unit of methane emitted is to improve the performance of breeding herds. Each breeding cow emits a lot of methane in comparison to younger animals because of its large size and transportation and lactation requirements. Potential improvements in reproduction rates, turnoff rates, and reductions in mortality all contribute to improvements in the amount of beef produced for a certain level of methane emissions.

The gains from improving breeding herd management can be demonstrated in relation to Case Studies A and B. In Case Study A, methane emissions were modelled from 1,000 breeders on native pastures with a calving rate of 75%. Over a one year period, 127,500 kgs of beef (liveweight) were produced for a total methane emission of 134,475 kgs.

If a higher calving rate was recorded, then the methane emissions per kilogram of beef produced falls. For example, if the calving rate in Case study A was higher at 85%, then the methane yield per kilogram of beef produced is 0.949 kg. In this case, a 10% increase in calving rate would increase overall methane emissions by approximately 3,500 kgs or 2.6%, but reduce methane emissions per kilogram of beef produced by 10%.

In case study B, methane emissions were modelled from 1,000 breeders on high quality improved pastures with a calving rate of 85%. Over a one year period, 221,000 kgs of beef (liveweight) were produced for a total methane emission of 157,108 kgs.

If the calving rates in Case Study B were to increase to 95%, then total methane emissions would increase a further 3.6% to 162,767 kgs. However, total beef production would rise by 11.8%, so that the average methane emissions per kilogram of beef produced would actually fall to around 0.659, a drop of 7.3%.

Similar results would be achieved by other measures which reduced herd mortality and improved turnoff rates. Beef producers already face large incentives to achieve these improvements because of the potential gains in production. This means that these types of improvements are already occurring over time due to market forces. However, there may be opportunities for further gains to be made with appropriate research, development and extension inputs.

[1] Leuceana may however contribute to carbon sequestration.

It is notable that a 10% increase in the output of a breeding herd (Case Studies A and B) has a greater impact than a 10% improvement in the operations of a fattening operation (Case Studies C and D). While the reductions in methane per kilogram of beef were 10% and 7.3% in the breeding examples, they were only 3.2% and 4.2% in the steer fattening operations. These outcomes are demonstrated in Figure 6.

Figure 6: Effects of a 10% improvement in production on methane emissions per kilogram of beef produced.

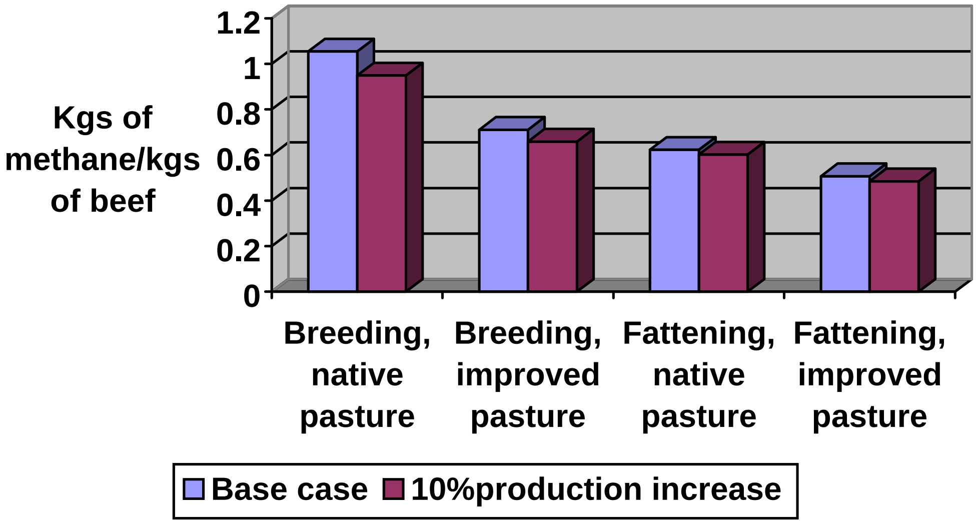


Figure 6 demonstrates that breeding operations on native pasture have the higher level of methane emissions per kilogram of beef produced, and also the highest potential to reduce methane emissions per unit of beef produced. In contrast, fattening operations on improved pasture have lower methane emissions per unit of beef produced, and lower reductions in this rate if production is improved.

It is important to note that all of these modelled production increases led to overall increases in methane emissions because of additional stock numbers or higher average weights. The benefit of production increases is not in reduced emission levels, but in an improved rate of beef production per unit of methane emissions.

3.5 Reducing stocking rates.

The case studies that have been examined to date in this report have explored options for altering management or feeding strategies that have maintained the overall grazing pressure. Another option to consider is to reduce grazing pressure in some regions. Reductions in grazing pressure are likely to have beneficial impacts on carbon stocks in many areas because of likely increases in stocks of pasture and scrubs, and potential increases in soil carbon stocks. However, the impacts on total methane emissions should also be included.

Case study results are available from a Meat and Livestock Australia funded grazing trial site in Central Queensland[2]. The trials have been run by the Department of Primary Industries

[2] The provision of data from the MLA project (NAP3.208) by Mr Paul Jones (DPI) is gratefully acknowledged. Data summaries and estimation of methane yields are the responsibility of the author.

and Tropical Beef Centre at "Keilambete", which is near Rubyvale, west of Emerald. The trials have run since 1994, and involve comparisons between paddocks grazed at low, medium and high grazing pressures[3]. The trials are also replicated across sites that have been cleared of the timber (broadleaf ironbark forest on granite country). Each year steers have been run in the trial paddocks and liveweight gains recorded.

The information from the trial data can also be utilised to predict methane emissions, using the same NGGI (1997) approach. The average liveweight and liveweight gain of the steers in the trial can be used to predict dry matter intake and methane emissions. The results are summarised in Table 4, and are also shown in graphical form in Figures 7, 8, 9 and 10.

The trials took place in the 1990s when there were substantial climatic variations, with subsequent impacts on animal performance. This can be seen from Figure 7, where there are large variations in the amount of beef produced in the different trials. Over the trial period, there has been no recorded difference in pasture production between cleared and uncleared sites. However, there has been a higher rate of beef production from cleared sites compared to uncleared (Table 4), suggesting that the quality of pasture in the cleared areas has been higher.

Figure 7 indicates the variation in animal production that occurs over time, according to different seasonal conditions. It also shows that low grazing pressures (in both cleared and timber sites) can generate higher liveweight gains than higher grazing pressures, but that this relationship does not hold across all seasons.

Figure 8 indicates that beef production per hectare is usually higher with the higher grazing pressure, but that this strategy is more risky. In some years a negative production was recorded. (Cattle had to be removed from the high grazing pressure sites in some years, and these have been entered as zero production). When other resource factors are taken into account, such as reducing ground cover and higher soil losses, the higher grazing pressures are likely to be associated with other indirect costs, and may not be viable in the longer term. This is also indicated by the narrowing difference in production between low and high grazing pressure treatments.

Figure 9 indicates that the kilograms of methane produced per beast can vary over time, according to seasonal conditions. It also shows that none of the treatments produced consistently higher or lower methane outputs per beast. Figure 10 indicates that methane emissions per hectare tend to be higher for high stocking rates compared to low stocking rates.

Table 4: Production of beef (kgs) and methane (kgs) from grazing trials

	Treatment	**Cleared – Low grazing pressure**	**Cleared - Medium Grazing Pressure**	**Cleared - High Grazing Pressure**	**Timber - Low Grazing Pressure**	**Timber - Medium Grazing Pressure**	**Timber - High Grazing Pressure**
94/95	Beef produced per beast	162	162	109	180	174	128
	Total methane/beast	71.6	66.0	54.7	68.0	63.9	58.8
	Beef produced per hectare	46.6	87.9	90.4	26.5	52.6	55.7

[3] The grazing pressures were calculated using feed budgets at the end of the summer growing season (about March/April). High grazing pressures were aimed at using 75% of available feed, while medium and low grazing pressures were aimed at using 50% and 25% respectively.

	Treatment	Cleared – Low grazing pressure	Cleared - Medium Grazing Pressure	Cleared - High Grazing Pressure	Timber - Low Grazing Pressure	Timber - Medium Grazing Pressure	Timber - High Grazing Pressure
	Methane emissions/hectare	20.6	35.7	45.6	10.0	19.3	25.6
95/96	Beef produced per beast	175	-12	0	209	156	0
	Total methane/beast	75.9	48.3	50.4	80.5	72.4	47.9
	Beef produced per hectare	50.3	-6.5	0	30.9	47.1	-0.1
	Methane emissions/hectare	21.8	26.1	40.9	11.9	21.8	20.8
96/97	Beef produced per beast	186	165	161	184	163	166
	Total methane/beast	63.5	60.6	60.1	63.9	60.9	61.4
	Beef produced per hectare	52.7	59.1	89.4	27.1	49.3	47.9
	Methane emissions/hectare	18.2	21.8	33.4	9.4	18.4	17.8
97/98	Beef produced per beast	129	116	115	93	76	72
	Total methane/beast	89.8	80.1	74.1	80.8	80.6	75.2
	Beef produced per hectare	61.5	84.0	110.8	41.3	55.2	46.2
	Methane emissions/hectare	43.0	57.8	71.6	35.8	60.1	49.0
98/99	Beef produced per beast	219	279	242	209	226	223
	Total methane/beast	101.9	91.6	108.7	98.0	104.3	105.0
	Beef produced per hectare	72.8	118.2	67.3	77.0	68.4	32.4
	Methane emissions/hectare	33.9	41.7	30.2	36.1	31.4	15.3
99/00	Beef produced per beast	16	6	-16	4	-9	-27
	Total methane/beast	87.4	87.0	80.6	82.0	82.9	75.1
	Beef produced per hectare	6.2	3.3	-17.3	1.1	-4.4	-21.5
	Methane emissions/hectare	33.4	47.0	89.7	24.2	41.7	59.7
Average	Beef produced per beast	147.83	119.33	118.17	146.50	131.00	114.83
	Total methane/beast	81.68	72.24	73.96	78.87	77.53	73.83
	Beef produced per hectare	48.36	57.66	70.42	34.00	44.68	35.98
	Methane emissions/hectare	28.48	38.34	54.17	21.23	32.11	32.79
	Methane per kg of beef	0.59	0.66	0.77	0.62	0.72	0.91
	Stocking rate ha/beast	3	1.9	1.8	4.1	2.8	3

Figure 7: Kgs of beef produced per beast at Keilambete trials

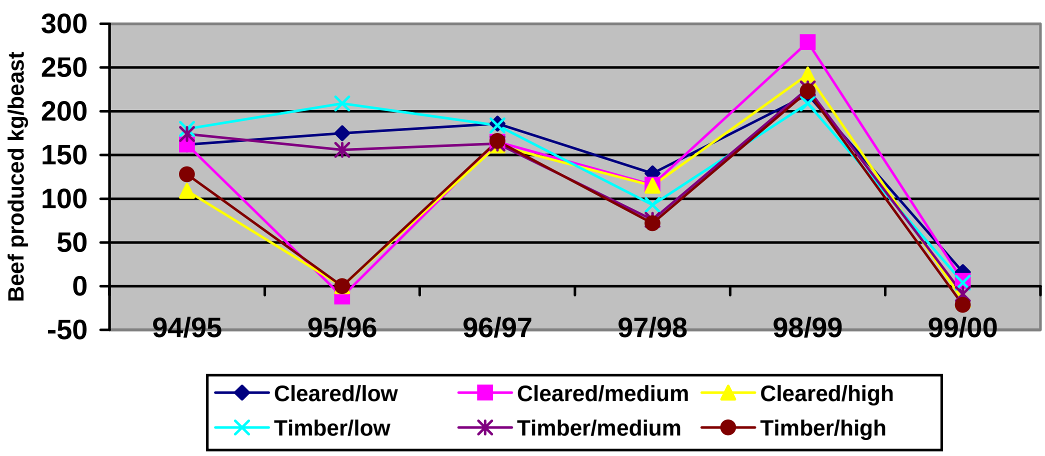


Figure 8: Kgs of beef produced per hectare at Keilambete trials

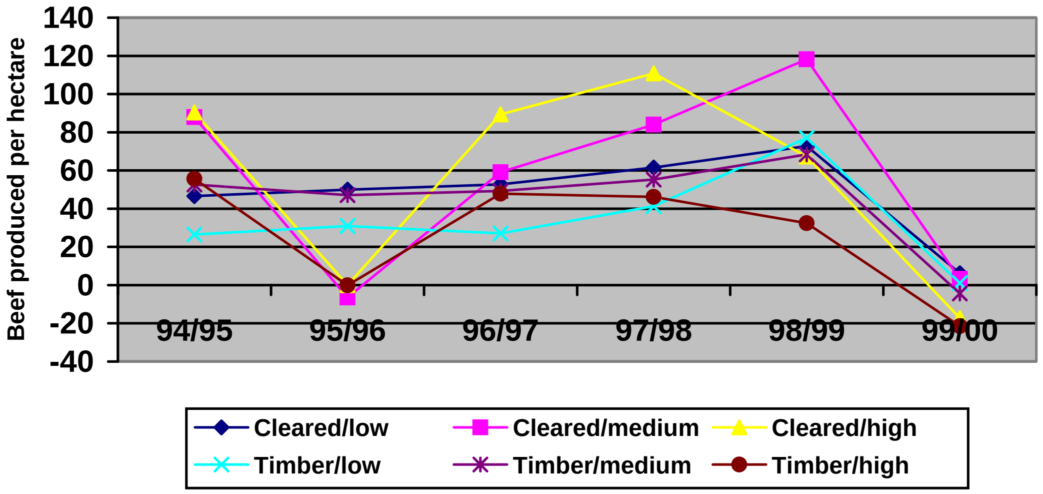


Figure 9: Kgs of methane produced per beast at Keilambete trials

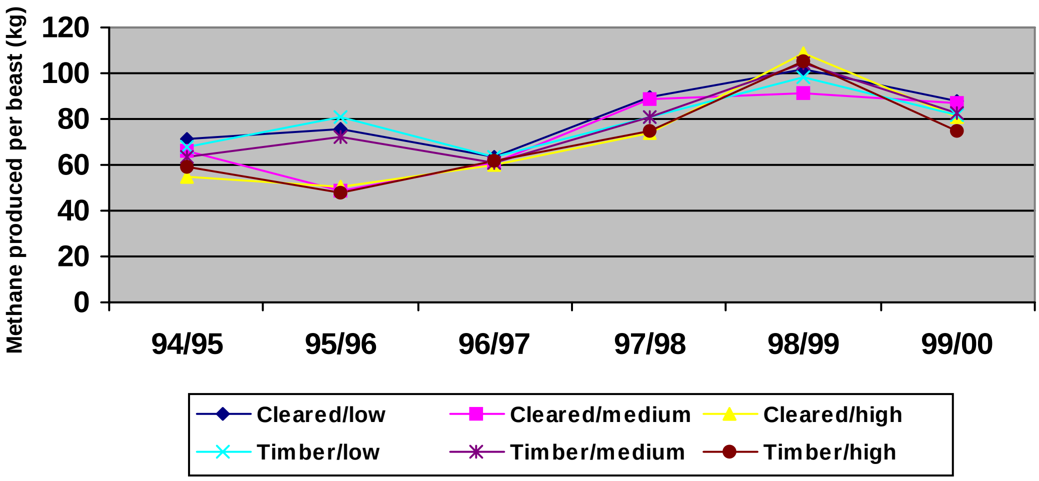
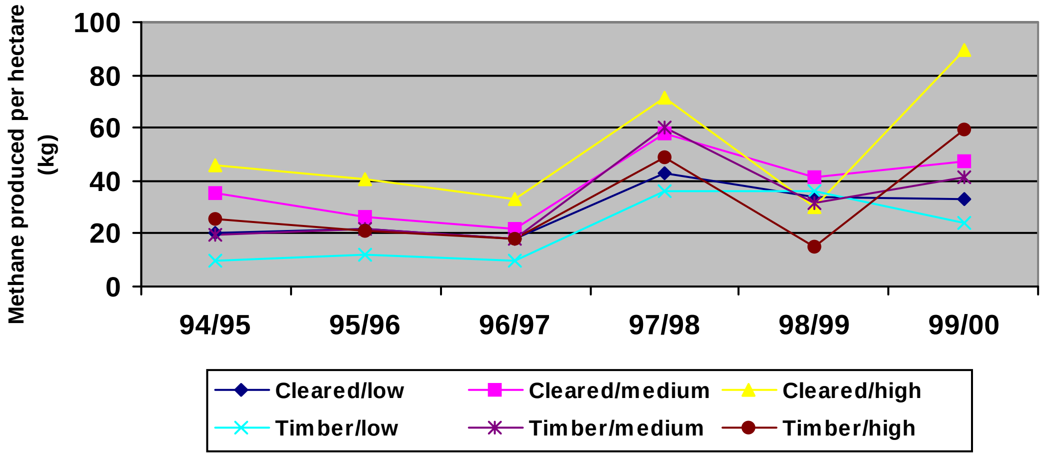
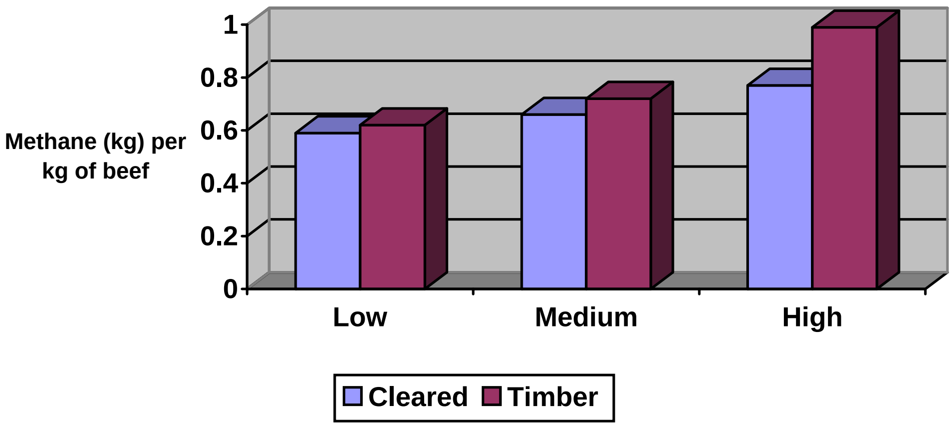


Figure 10: Kgs of methane produced per hectare at Keilambete trials



The amount of methane that is emitted per kilogram of beef that is produced trends upwards as stocking rates move from low to high (Table 4). The relationship is mirrored across both timber and cleared sites, as shown in Figure 11.

Figure 11: Methane emissions per kilogram of beef produced at different stocking rates



The explanation for such a result is that under low grazing pressures, cattle have more choice about available feed, and tend to have higher weight gains. Production is more efficient, and methane emissions per unit of beef produced are relatively low. As stocking rate increases, overall production increases because of the higher cattle numbers, but weight gains per beast tend to fall. Methane emissions per beast tend to rise, because of the lower feed conversion efficiency, and methane emissions per kilogram of beef produced trends upwards. In this case study, weight gains on cleared sites were higher than on timber sites, meaning that more beef was produced per unit of methane in cleared areas.

The results of this trial site indicate that reductions in stocking rates will not only reduce overall methane emissions but will improve the amount of beef produced per unit of methane production.

3.6 Estimating the opportunity costs of reducing methane emissions

Estimating the cost of reducing stock numbers to methane emissions is of interest, because this is the basic concept behind a livestock tax that has been suggested in countries like New Zealand. Reductions in stocking rates will sometimes lead to reduced output and profitability. The data from the Keilambete trials indicates that medium grazing rates are likely to be preferred over high stocking rates. Under high grazing pressure, there appeared to be more soil movement and annual reductions in the amount of pasture produced. In the timber sites, more beef was produced per hectare under medium grazing pressure than under high grazing pressure, while in the cleared sites, negative weight gains were recorded under high grazing pressure in two out of six seasons. When risk factors are taken into account, medium stocking pressures are likely to be more profitable that high stocking rates in that country type. More beef may be produced at medium grazing pressure compared to high grazing pressures.

This example shows that there are three broad outcomes that may be expected from reducing grazing pressure (or stocking rates). The first is that reducing stocking pressure may allow beef production to increase, because the remaining animals have more feed available, and thus higher weight gains. In this case, lower cattle numbers are offset by increased financial returns from the amount of beef sold.

The second possible outcome is that reduced grazing pressure leads to a small fall in total beef production, but this is compensated for by the reductions in risks to the producer and the reduced variation in animal condition. In this case, lower cattle numbers may be offset by increased financial benefits over time, particularly when risk factors are taken into account.

The third possible outcome is that reduced stocking pressure may lead to lower beef production and reduced financial outcomes to the producer. In this case, the lower cattle numbers and lower beef production would mean that methane outputs are lower, but this would occur at a cost to producers.

Under the two scenarios where there may be financial incentives for producers to reduce stocking pressure, different implications exist for methane emissions. If reduced stocking numbers actually increase the amount of beef production, then overall methane production may rise (even though the amount of beef produced per unit of methane may fall). In the other case where reduced stocking numbers is attractive financially because of reduced risk, even though beef production will probably fall, then methane production is also likely to fall.

This means that reductions in stocking rates will only sometimes provide win-win situations. In some cases reducing stock numbers may be attractive financially but may not generate reductions in methane emissions. The identification of win-win situations from reductions in stock numbers will have to be assessed on a case by case basis.

Reductions in stocking pressure that reduce methane emissions at a cost to producers are of particular interest in terms of the opportunity cost involved. In the Keilambete example, reductions from medium to low stocking rates would mean a drop in 10.68 kgs/hectare of beef production in the timbered country, and 9.3 kgs/hectare in the cleared country. These reductions would allow methane emissions to fall by 10.88 kgs and 9.86 kgs per hectare in the timbered and cleared country respectively. If beef producers were to reduce stocking rates in order to reduce methane emissions, approximately 1 kilogram of beef production would have to be lost to reduce every 1 kilogram of methane emissions. The next question to consider is the costs that producers might incur to potentially meet emission reduction targets through lower stocking numbers.

It would not be accurate to equate the market price of beef cattle with the potential opportunity costs of reducing stocking rates. First, the variable costs associated with operating a beef herd should be counted out of the net return. Second, some allowance should be made for the capital costs involved in owning additional stock, and the potential savings from reducing cattle numbers. Third, some allowance should be made for the additional flexibility that low stocking rates afford producers, both in terms of the improved weight gains and marketability of the remaining cattle, and the lower risks that producers run in the event of dry years.

Liveweight prices for store cattle for fattening purposes have often been above $1.50/kg in Queensland in 2001. From this total sale price needs to be deducted the various allowances to gain some idea of the opportunity costs involved in reducing stocking numbers. QBII (2000) estimates that variable costs on beef properties are about 15% of revenue on Central Queensland brigalow blocks, and about 28% of revenue on northern speargrass country. ABARE (2000) indicate that on medium size beef properties (1000 – 2800 cattle) in Queensland, variable costs are approximately 24.4% of cattle sale income.

For this exercise, 25% of sale price is adopted to represent potential variable costs, 10% selected to represent interest on capital, and 15% selected to represent an allowance for reduced risk and increased per head returns associated with running reduced numbers. This means the available sale price can be reduced by 50% to gain some indication of the opportunity costs involved with reducing stock numbers in order to reduce methane emissions. On the basis of cattle prices in 2001, sale prices of $1.50/kg can be discounted to $0.75/kg. This represents the potential loss per kilogram of beef that beef producers who are already stocking at conservative rates might suffer if they reduced stocking rates to reduce methane outputs.

Methane has 21 times the impact of carbon dioxide, and 47.6 kilograms of methane have the same impact as one ton of carbon dioxide. To estimate the cost of preserving one ton of carbon dioxide equivalents in methane, the opportunity cost of $0.75 should be multiplied by 47.6. In this way, the opportunity cost of reducing cattle numbers to reduce greenhouse gas emissions can be estimated to be $35 per tonne of carbon dioxide equivalent. Clearly, the option of reducing cattle numbers below efficient operating levels is an expensive way of meeting greenhouse gas reduction targets.

3.7 Using a vaccine

Over the past ten years, researchers from CSIRO have been developing vaccines for sheep and cattle against methanogenic organisms. Field trials of vaccines on cattle are continuing, and early indications are that a vaccine will increase animal performance by approximately 3%, and reduce methane emissions by approximately 20% (Baker, pers comm). It is unclear how much variation there might be in these results in the field.

There are two main advantages of a vaccine. The first is that the application is verifiable, which will give rise to a greater degree of confidence about outcomes than is the case with many other strategies. The second advantage is that there are offsetting production gains, giving a potenial win-win situation. For example, if a steer gaining 0.5 kgs/day is vaccinated and production increases by 3%, the steer should put on an additional 5.5 kilograms over a 12 month period.

3.8 Feed supplements

McCrabb and Hunter (1999) note that finishing cattle on grain in northern Australia has the potential to significantly reduce the amount of methane that a beast would emit over its lifetime. This is because the beast would reach slaughter weight much more quickly.

Similar advantages may be achieved by supplementary feeding where grain, cottonseed or other feed additives are offered to cattle in a grazing situation. Part of the advantages of such supplements (apart from increased protein levels) are that they give animals a more constant feed intake at times when protein levels in grasses may vary.

However, there has been little work done to identify the impact of supplements on methane emissions and whether some supplements enable feed conversion rates to increase. There has also been little work done on estimating methane emissions from supplementary feeding programs. It is likely that this will involve the combination of estimation procedures from grazing and feedlot situations.

4. EVALUATING STRATEGIES TO MEET EMISSION REDUCTION TARGETS

Beef cattle in Australia contribute about 7% of national greenhouse gas emissions as itemised in the national inventory (Zeil and Rolfe 1990). The size of the contribution means there will continue to be interest in determining where there might be cost effective ways of reducing methane emissions from livestock. In order to consider which options might be successful in reducing emissions from livestock, it is important to judge them against a number of criteria.

These might include:

- Clear targets and sufficient information so that beef producers know how they might be expected to modify their behaviour,
- Adequate technology and options for change, so that beef producers have options to reduce greenhouse gas emissions,
- An adequate degree of certainty, so that beef producers know the outcomes of different management strategies, which measures have priority and the timing and extent of emission reduction targets.

Most of the options that have been canvassed in the previous section do not meet these criteria very well. The principal problem is variability across seasons, locations and animals. Figures 7 and 8 reflect some of that variability across seasons and management options for one property in Central Queensland. There is also major variation in animal performance between individual animals and in different circumstances. This level of variation means that it would be very difficult to set clear targets for most management options of interest, and that there would continue to be a great deal of uncertainty about levels of emissions and potential reductions in any one year.

The second major problem is that there are few strategies that effectively reduce overall methane emissions from beef cattle. The only two clear alternatives that appear to achieve this are a reduction in cattle numbers and the vaccination option. However, a reduction in cattle numbers on an individual property will not always reduce methane emissions much. In some circumstances, where the remaining cattle achieve higher weight gains and higher average weights, total methane emissions from a property might rise.

Most of the management options that increase the efficiency of beef production are important ways of achieving increased beef production for only limited increases in methane output. However, these options (improved feed efficiency, improved feed quality, improved herd management) all tend to increase both overall beef production and methane output. In some cases, such as with leuceana production, there may be other carbon sequestration outcomes that make the overall option an attractive one.

There appears to be potential for reduced stocking rates to contribute to methane reduction strategies. However, there are a number of difficulties with this strategy in relation to prediction of the net outcomes and the certainty of those outcomes. The main difficulty is that reductions in stocking rates have a wide range of possible production and emission outcomes, and the actual impact in terms of production, financial and emission outcomes will probably have to be evaluated on a case by case basis.

For example, in some cases there are financial benefits in reducing stocking rates because overall, beef production does not necessarily fall. In these cases though, there is not necessarily a reduction in methane emissions resulting from the change in cattle numbers. In other cases there may be financial benefits in reducing stocking numbers when risk factors (seasonal variations) are taken into account. It is possible in this situation that there may also be associated reductions in methane emissions. There are also many cases where there are financial losses associated with reductions in cattle numbers, even though these may reduce methane emissions.

4.1 Using Taxes to Reduce Emissions

The issue of using a tax-based instrument on livestock to reduce methane emissions can also be addressed here[4]. It would be difficult to apply such a tax in practice to achieve the desired results. First, the variation in methane emissions between cattle would make it difficult to apply the tax effectively.

There is little benefit in applying a tax on a per head basis because there is so much variation in emissions between cattle. This variation occurs between cattle, between regions, and across changed seasonal conditions. In some cases, where stocking rates are high, a reduction in cattle numbers in response to a tax may not change overall methane outputs very much.

There is little rationale in applying a tax on a weight or output basis, because the rate of methane emissions per kilogram of meat produced varies so widely (see Figure 4). The additional problem with applying a tax on the amount of meat production is that it would

[4] While the Australian Government has not seriously flagged the use of taxes to reduce methane (or carbon) emissions, tax instruments have been considered more seriously in other countries such as New Zealand.

provide no incentives to find more efficient ways of producing meat per unit of methane emission.

It would be very difficult to apply a tax on the basis of management options because of the uncertainties associated with impacts on emission levels. Most management options would have to be assessed on a case by case basis to determine their effectiveness. It is only with an option such as the vaccine, where there may be some certainty about the impacts on emission levels, where it may be possible to use some incentive/penalty mechanism to encourage compliance.

The second main problem with a tax instrument is that it may have to be imposed at very high levels to generate large reductions in stock numbers. Because variable costs are a low proportion of the cost structure in many grazing enterprises, any form of a tax on livestock is unlikely to influence many cattle operations. This is particularly the case in northern Australia, where there is little or no alternative to grazing.

In the case study example reported above, a reduction in stocking rate to reduce methane emissions by one kilogram would mean a sacrifice of one kilogram of beef production. At the 2001 market levels, after allowing for variable costs and other factors, the opportunity cost of reducing methane emissions by one kilogram is approximate $0.75. This potential reduction equates to $35/tonne of carbon dioxide equivalents. If tax rates had to be applied at this level, it is unlikely to be an economic way to search for emission reductions.

5. OTHER CHANGES WITHIN THE BEEF INDUSTRY.

Many of the options to improve emission standards that have been described in this report also enhance production. It would be expected that beef producers had already found most of the ways to increase their production further. There may not be many avenues left to find win-win situations, because most production opportunities have already been exploited. However, there may be some value in documenting where productivity changes in the beef industry are automatically reducing the relative impact of methane emissions. There are three key areas to describe.

The first is to document the significant production gains that have occurred in the industry over the past two decades. In 1999, the size of the beef herd in Australia was slightly below the level of twenty years earlier, but production had increased by 15% (ABARE 2000). The amount of methane emitted per kilogram of beef produced will have fallen significantly over that twenty year time frame because of productivity gains, improvements in herd management, and improvements in the quantity and quality of feed. These productivity trends are likely to continue, so that while total methane emissions from beef cattle may not fall, the rate of emissions per kilogram of beef produced is likely to continue to do so.

The second key area is the live export sector. Over the past fifteen years live exports have grown to be a significant sector in the industry. Most are younger cattle sourced out of northern Australia. This has stimulated changes to the beef herd in the north, as producers are selling cattle younger and not holding steers to fatten slowly over a number of years. Herd management is likely to have improved, as it is now more profitable to sell cull females at a young age. The outcomes are that turnoff has increased, and the average age and weight of the herd in northern Queensland may have fallen slightly. This means that methane emissions from that sector of the Australian herd may have fallen slightly, and that the amount of beef produced per unit of methane will have risen.

The third key area is in reductions in average age and weight of turnoff nationally. If beef is produced from younger, lighter animals, even if there are more of them consuming the same amount of feed, then methane emissions will fall slightly. This relationship was demonstrated in Case Study E. The development of new markets taking lighter animals, and improved herd management and production techniques (especially supplementary feeding and feedlotting) have allowed animals to be fattened and sold at a younger age. Encouraging the industry to further reduce the weight of turnoff may be another way of reducing emission levels. To the extent that turnoff weight and age has fallen, gains in emission efficiency have already taken place. However, this option only leads to reductions in emissions if there are compensating improvements in the breeding herd so that there is no net increase in the number of breeders needed.

6. CONCLUSIONS

The evidence presented in this report demonstrate many of the difficulties that the beef industry faces in grappling with the issue of greenhouse gas emissions. The difficulties stem from the fact that methane emissions are the dominant contribution to greenhouse gases from most grazing properties. The ability of beef producers to reduce overall emissions will be centered around efforts to reduce methane emissions, as the proportional contribution by fossil fuel use from beef cattle operations is very low.

There are two ways of examining the issue of reducing methane emissions. The first approach is to focus on the efficiency of production, and to maximise the output of beef for every unit of methane that is emitted. Under this approach, many improvements in productivity will automatically reduce the amount of methane emitted per unit of beef that is produced. Improvements in feed quality and herd management are the key areas to pursue. It appears likely that the biggest per head gains in efficiency are to be made by improving herd management in northern Australia, and to improve the liveweight gains of fattening cattle that currently achieve less than 0.5 kgs/day over their lifetime.

However, all these increases in production will probably lead to increased total outputs of methane. Depending on the improvement, more and/or heavier cattle will be run, making more efficient use of the available feed stocks. Improved productivity is an important avenue for the industry to pursue in grappling with issues of methane production, but it will not lead to a reduction in overall emissions. However, it may allow increases in beef production to occur for only slight increases in methane output.

To reduce methane emissions, the two areas to pursue are direct manipulation of the rumen (eg with a vaccine) or reduced cattle numbers. The vaccine being developed by CSIRO looks promising, and if successful, would be the most cost effective way of reducing methane emissions. Reducing livestock numbers is a much more expensive option.

It is possible that in some situations, reduction in grazing numbers and grazing pressure will contribute to both a reduction in methane emissions and improvement in financial outcomes. These are the situations where the reduction in beef output (and methane output) are compensated by the reduced risk of herd management in dry seasons. When a reduction in cattle numbers does not change overall productivity much (because the remaining cattle have higher weight gains), methane emissions remain fairly stable. When cattle numbers are reduced from low or moderate rates, the resulting fall in methane emissions has to be weighed up against the lost income that beef producers will face. For one case study in Central Queensland, the opportunity cost of reducing methane emissions by one kilogram through lower stocking pressure was one kilogram of beef produced.

It is also possible that reducing the age and weight of turnoff so that more beef is produced from younger, lighter animals will automatically reduce the levels of methane production. Fortunately, there are major trends towards reducing the age of turnoff in Australia, with the growth in the live export market providing one example. However, more work needs to be done to estimate the extent of both past improvements and potential future savings.

While these types of examples demonstrate that while there may be some opportunities for improved management to ameliorate methane emissions, the option of reducing cattle numbers to make major reductions in emissions will be a very expensive one. The diversity of the industry means that blunt instruments such as taxes on outputs are impractical. However, the limited knowledge about predicting emissions at a property level and the restricted number of reduction options available also make it hard for any voluntary reduction mechanisms to be feasible either.

There are three important recommendations to be drawn from this analysis. First, the development of technical options to reduce methane emissions should be strongly supported by the industry. Consideration should be given to both improving the level of support for the vaccine being developed by CSIRO and to pursuing other research initiatives in this area.

Second, further work needs to be done to allow the estimation of potential reductions at a property level on a case by case basis.

Third, the industry should highlight the automatic improvements that are occurring in terms of improved productivity which are automatically leading to more beef being produced per unit of methane output.

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