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Estimating the economic implications for grazing properties in the Mackay Whitsunday catchments of practice changes to more sustainable landscapes

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Abstract

In the Mackay Whitsunday region, the dominant grazing based operations are small intensive systems that heavily utilise soil, nutrient and chemical management practices. To improve water quality entering the Great Barrier Reef, graziers are being encouraged to adopt improved management practices. However, while there is good understanding of the management changes required to reach improved practice classification levels, there is poor understanding of the likely economic implications for a grazier seeking to move from a lower level classification to the higher level classifications. This paper provides analysis of the costs and benefits associated with adoption of intensive grazing best management practices to determine the effect on the profitability and economic sustainability of grazing enterprises, and the economic viability of capital investment to achieve best management. The results indicate that financial incentives are likely to be required to encourage smaller graziers to invest in changing their management practices, while larger graziers may only require incentives to balance the risk involved with the transition to better management practices.

Keywords: grazing, management practices, incentives, Mackay Whitsunday

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Introduction

This paper presents an economic analysis of the costs and benefits involved for typical grazing properties in the Mackay Whitsunday region to improve their management practices.

It has been identified that while grazing extension resources in the region have good understanding of the management process required for each of the respective classification levels, there is poor understanding of the likely economic implications for a grazier seeking to move from D or C level classification to B or A. Note that these classifications refer specifically to classes of management practices used to operate the grazing business, rather than the land condition of a typical property. Further compounding the poor understanding of the economic implications of practice changes for graziers in the Mackay Whitsunday, is the fact that there is little information available about the **economics** of best management practices for **intensive** coastal grazing systems in any region.

Agricultural production in the Mackay Whitsunday region is characterised by small properties that are intensively managed. These intensive grazing systems heavily utilise soil, nutrient and chemical management practices and are the dominant grazing based operations within the Mackay Whitsunday (MW) region as well as much of the Terrain and Mary Burnett NRM regions within coastal environments. Fertiliser application rates on farming land in the MW region are some of the highest in Queensland (Rolfe et al. 2007:4), as soils in northern Australia are typically deficient in phosphorus, which is an important limiting factor of cattle growth rates, cow fertility and breeder survival (Holmes 1990:250). In addition, regular fertilisation of pastures may only be economic with more intensive stocking rates (Holmes 1990:250). In the MW region, stock numbers are high per hectare (intensive grazing) but total cattle numbers per property are low compared to the extensive grazing enterprises throughout the rest of Queensland. In these more intensively managed grazing systems, there is more potential for nutrient and sediment runoff if appropriate management practices are not used (Dougherty et al. 2008).

Over recent years, many studies (McKergow et al. 2005; Mitchell, Brodie & White 2005; Packett et al. 2009; Queensland Department of Premier and Cabinet 2003) have highlighted nutrient and sediment runoff from agricultural enterprises into waterways that empty onto the Great Barrier Reef (GBR). The Mackay Whitsunday river catchments are small compared to the Burdekin and Fitzroy river basins that also flow onto the GBR. However, modelling by McKergow et al. (2005:206) indicates that rivers within the MW region deliver significant sediment to the reef due to greater areas of steep slopes in closer proximity to the coast. They also indicate that relatively steep sloping cropping and grazing land within 100km of the coast coupled with high rainfall events increase the erosion hazard (McKergow et al. 2005:203), particularly when cattle selectively graze more desirable grass species which can lead to areas with low vegetative cover (Bartley et al. 2006:3318).

In recent years there has been an increasing community focus on trying to minimise nutrient and sediment loads reaching the reef, and significant Government money has been committed to various programmes to assist this process. Some past and current funding programmes include the National Heritage Trust, Reef Resuce and Caring for our Country. However the regional natural resource management groups charged with distributing the funds to landholders often lacked the economic capacity to adequately allocate funds between competing agricultural industries and between competing landholders. Rolfe et al. (2007) investigated the process used by Reef Catchments (formerly the Mackay Whitsunday Natural Resource Management group) to distribute funds to graziers and cane growers in the Sustainable Landscapes program. They found that while the program was highly successful in terms of landholder participation, the allocation of funds between landholders could have been improved to increase the cost-effectiveness of the investment (2007:15).

This paper was commissioned by the Mackay Whitsunday regional natural resource management group, Reef Catchments, to assist in decision making on money spent to improve water quality within the grazing industry. Analysis of the costs and benefits associated with adoption of intensive grazing best management practices is required to determine the effect on the profitability and economic sustainability of grazing enterprises, and the economic viability of capital investment to achieve best management. This study adds to the limited economic information available about best management practices in an intensive grazing system, rather than the more common extensive grazing systems.

ABCD classification framework

The ABCD framework for grazing soil management is contained in the Mackay Whitsunday Water Quality Improvement Plan (Drewry, Higham & Mitchell 2008). The framework sets out the differing management practices that a grazier could employ into four categories, D, C, B and A classes. The management practices in D class can be interpreted as a general lack of management practices, while the management practices in A class can be interpreted as cutting edge practices, with C and B classes falling between these two extremes. The management practices carried out on individual grazing properties lies somewhere within these descriptive parameters. While for simplicity this paper has assumed that a landholder operates solely in one of these management practice classes, in reality, the landholder is likely to operate across a few of the classes with some practices from each class. For example, a landholder may have some watercourses fenced off from stock (Class B practice) but may run cattle at a continuous set stocking rate (Class C practice).

Note that in addition to the ABCD classification for management practices, there is also a well known ABCD classification of land condition developed by Meat and Livestock Australia (MLA) in partnership with the Queensland Department of Primary Industries and Fisheries. These two classification systems are separate, although for simplicity this paper has assumed that a landholder practicing D class management would have D land condition (poor), while a landholder consistently practicing B class management would have B land condition (good). This simplification was necessary to avoid confusion between the two classification systems and also to isolate the economic costs and benefits of changes between management practices, rather than the complication of changing land conditions as well.

The A, B, C, D classification framework for management practices as detailed in the Mackay Whitsunday Water Quality Improvement Plan (Drewry, Higham & Mitchell 2008:52) is shown in Table 1 on the following page.

Methodology and scenarios

Herd gross margins were calculated using BreedcowPlus in the Breedcow and Dynama Herd Budgeting Software (Holmes 2009). BreedcowPlus is a steady state model that generates steady state herd profiles using branding and death rates, prices and costs (Holmes 1990:251). A steady state herd was constructed in BreedcowPlus for each of the scenarios listed below.

A benefit cost analysis (or discounted cash flow analysis) was used to evaluate the investment potential where capital investment is required to implement the proposed grazing management changes. The benefit cost analysis estimates the net present value (NPV) of the incremental net cash flow stream over 20 years following a capital investment. The net present value is the estimation of the difference in annual cash flow for the farm, with and without the proposed investment. This analysis is presented to determine the viability of investments in land regeneration, fencing and watering points for the grazing enterprise to operate in a higher class of management actions. The increase in land value (if any) of the capital investment has not been included in the analysis. If it is expected that the capital investment in improved grazing management practices will increase the land value, then the reader can consider the increase in value together with the net present value of the investment.

Table 1: Soil management practices for grazing classified in the ABCD framework.

D Class Grazing Soil Management	C Class Grazing Soil Management
Description: No pasture management 1. High stocking rates 2. Minimal infrastructure 3. Pasture utilisation exceeds sustainable thresholds 4. Emergency feeding or de-stocking required every year 5. No weed management	Description: Basic pasture management 1. Continuous set stocking rate 2. Minimal infrastructure 3. Pasture utilisation regularly exceeds sustainable thresholds in dry season 4. Emergency feeding or de-stocking required one in three years 5. Records kept in daily diary
Resource condition indicators (one or more indicators): 1. General lack of any perennial grasses 2. Increasing areas of bare ground. Erosion problems in fragile soils 3. Thickets of woody plant growth 4. Riparian areas very degraded	Resource condition indicators (one or more indicators): 1. General decline in perennial, palatable and productive (3P) grasses 2. Increase in less desirable pastures 3. Susceptible to erosion 4. Some increase in areas of bare ground 5. Increase of weeds 6. Riparian areas degraded
Planning and record keeping: 1. None	Planning and record keeping: 1. Basic pasture management 2. Keep daily diary
Capital: 1. Basic boundary fence 2. Basic internal fencing and watering	Capital: 1. Same as Class D
B Class Grazing Soil Management	**A Class Grazing Soil Management**
Description: 1. Six monthly pasture monitoring used to adjust stocking rates annually 2. Some soil testing & nutrient deficiency remediated 3. Some grazing to land types 4. Some drainage lines and watercourses separated by internal fences 5. Pasture utilisation exceeds sustainable thresholds 3 in 10 years 6. Pasture spelling incorporated into management 7. Emergency feed core breeders 8. Records kept in Paddock Journal	Description: 1. Monthly pasture monitoring used to adjust stocking rates as required 2. Soil testing & soil nutrient deficiencies remediated 3. All grazing to land types 4. All major drainage lines and watercourses separated by internal fences 5. Pasture utilisation exceeds sustainable thresholds rarely. Pasture utilisation never exceeds sustainable thresholds for drainage lines and watercourses 6 – 8. Same as Class B
Resource condition indicators (one or more indicators): 1. Some decline in 3P grasses 2. Some minor weeds 3. Some decline in soil condition 4. Some thickening of woody plants 5. Some decline in riparian condition	Resource condition indicators (all indicators at this level): 1. Good cover of 3P grasses 2. No significant weeds 3. No erosion and good soil surface condition 4. No sign of woodland thickening 5. Riparian areas in good condition
Planning and record keeping: 1. Identify grazing land types and pasture types for each paddock using existing farm maps 2. Develop and implement Grazing Land Management Plan, including plan for water infrastructure 3. Keep records in Paddock Journal 4. Record pasture condition and cattle production 5. Adjust Grazing Land Management Plan the following year if required	Planning and record keeping: 1 – 5. Same as Class B – but with more formal documentation and accurate record keeping
Capital: 1. Some fencing to separate grazing land types drainage lines and watercourses 2. Some off-stream watering points	Capital: 1. Stock fences to separate grazing land types & all major drainage lines and watercourses 2. All off-stream watering points

The benefit cost analysis over 20 years has been calculated for four scenarios:

- Scenario 1: 200 hectare north MW property - grazier transition from D class to A class management practices.
- Scenario 2: 200 hectare north MW property - grazier transition from C class to A class management practices.
- Scenario 3: 1000 hectare south MW property - grazier transition from D class to A class management practices.
- Scenario 4: 1000 hectare south MW property - grazier transition from C class to A class management practices.

Representative or "typical" farms have been used for the analysis based on the majority of properties within the Mackay Whitsunday region. This allows graziers to compare their own property with the results that most closely match their own situation.

The smaller representative modelled farm is 200 hectares of grazing land located in the northern section of the Mackay Whitsunday region. It is assumed that the property is comprised of 42% eucalypt hills and ranges (85ha), 34% poplar gum woodlands (67 ha), 14% coastal tea tree plains (28 ha) and 10% alluvial flats and plains (19 ha). See Appendix 1 for details of each land type.

The larger representative modelled farm is 1000 hectares of grazing land located in the southern section of the Mackay Whitsunday region. It is assumed that the property is comprised of 26% eucalypt hills and ranges (258ha), 24% poplar gum woodlands (241 ha), 33% coastal tea tree plains (330 ha), 8% alluvial flats and plains (76 ha) and 10% coastal wetlands (95 ha). See Appendix 1 for details of each land type.

Farm Model Assumptions

Most assumptions are consistent for both representative property sizes, however, the larger property is expected to have more purchasing power which results in some lower costs. The assumptions consistent for both property sizes are:

- The properties are assumed to run a breeding cattle herd turning off store weaners which are sold at the Sarina saleyards. All older heifer, cow and bull sales are direct to Borthwicks meat processors.
- An owner operator wage and other fixed costs have not been included in the analysis as the analysis focuses on the grazing enterprise rather than whole farm profit. In addition, it is expected that for most smaller grazing properties in the Mackay Whitsunday region the owner operator wage is supplied by either a cane enterprise or off-farm income.
- It is assumed that land on which D class management actions are practiced will be in D land condition, land with C class management will be in C condition, and so on. In reality this may not always be the case, however, if land is in good condition but D class management actions are consistently practiced, the land will revert to D condition over time.
- When operating with C and D class management practices, it is assumed that over-stocking is occurring as the landholder has insufficient knowledge and record keeping to accurately stock the property in line with available pasture. Therefore, the analysis assumes that when practicing C and D class management, the land is stocked to the B condition stocking rate (emergency feeding keeps the stocking rate above what the pasture can carry). When operating with B or A class management, it is assumed that sufficient skill has been acquired in pasture monitoring so that the stocking rate is correct for the B or A condition land, respectively.
- Emergency feeding is assumed to be required in all classes of grazing soil management. However, the frequency decreases as a landholder moves towards A class management. In

D class, feeding is required for six months, 8 in 10 years. In C class, feeding is required for six months, 3 in 10 years. In B class, feeding is required for six months, 2 in 10 years. In A class, feeding is required for three months, 2 in 10 years.

- Pasture re-establishment is required to move from D condition land to C condition land or better. Pastures in D condition are assumed to be fully weed infested and require spraying and cultivation in preparation for re-seeding with improved pasture species (Bishop n.d.:70). It has been noted that in semi-arid regions that it is less desirable species that grow on degraded land (Campbell et al. 2006:79). Coastal pastures respond in similar ways (Bishop n.d.:74), thus requiring re-seeding of productive, perennial and palatable (3P) grasses to move to C condition land. Cultivation should only be undertaken on slopes with lower gradient. In this analysis, the relatively flat land received two cultivations in preparation for sowing, land with a slight slope received one cultivation and land with higher slopes unsuitable for cultivation were burned then aerial seeded. Pastures are assumed to be re-sown with improved grass species suitable for each land type and the specific enterprise feed requirements. For this analysis, the representative properties have been re-sown with a mixture of Callide Rhodes grass with a legume component, Signal grass, Pangola grass, and Creeping Bluegrass with a legume component.
- To allow for pasture re-establishment, half of all livestock were sold in the first year of pasture re-establishment, and the re-seeded area left for 12 months before restocking.
- Fertiliser is assumed to be required to bring all soil types from D condition to C condition, and then fertiliser is required to maintain pasture productivity (Bishop, n.d.:73) and reduce weed competition (R. Dodt 2009, pers. comm.). Fertiliser applications should be tailored to meet the specific mineral requirements of the land type, pasture species and cattle enterprise through regular soil tests. The fertiliser is best applied towards the end of the wet season (April/May) to minimise leaching and to allow the grass to "bulk up" prior to the onset of cooler temperatures in autumn/winter that slow grass growth (Bishop, n.d.). For this analysis, it is assumed that 100kg/ha fertiliser (Di-Ammonium Phospate - DAP) is required at re-sowing of all grasses (Bishop, n.d.:74) and periodically through the 20 years to maintain the soil phosphorus level at around 15 parts per million.
- Fencing is assumed to be required to assist the land regeneration from D and C condition to B and A condition. It is assumed that 1km per 100ha would need to be constructed to move from D class management to C class management, reflecting some fencing of riparian areas and land types. A further 1km per 100ha would need to be constructed to move from C class management to B class management, reflecting the fencing of all riparian areas and land types. Cost of fencing is assumed to be $7,000 per kilometre, which is a contractor cost for fence construction and includes the cost of fence materials and labour. Annual fence maintenance costs have also been included at 5% of the value of the fences constructed.
- It has been assumed that pasture monitoring will be undertaken by graziers who have been using D class practices in preparation for pasture re-establishment. This is in association with education through attending a Grazing Land Management course and a Stocktake course. The pasture monitoring in advance of the pasture re-establishment is a learning phase so that the pasture re-establishment will be successful and the correct stock pressure applied at all times of the year. So in D class it is assumed that 1 site per land type will be monitored twice per year, and the same for C class management. For B class and A class management it is assumed that 2 sites per land type will be monitored twice per year. Although there are no direct costs of pasture monitoring, a cost of $40 per site per monitor is included to cover the labour cost of completing the pasture monitoring.

Due to the large difference in property size of the two representative grazing properties, there are economies of scale involved that enable large properties to purchase some inputs at a lower per unit cost than small properties, such as fence materials, fertiliser and cattle drench. These input costs are assumed to be 3% lower for the large representative property in the analysis. In addition, some of the capital costs required to transition a property from D class management to A class management do not increase at the same rate as an increase in hectares grazed. The following assumptions have been used with the small property assumptions in the left column and the large property assumptions in the right column.

- Watering points are assumed to be required for stock watering as riparian fencing is constructed to limit watering at natural water sources. Cost of watering point materials (poly pipe, tank & pump) and installation is estimated at $8,000 per water point (average full cost of watering points applied for by landholders under the Sustainable Landscapes program run by Reef Catchments). See Table 2 for number of water points. A labour cost for checking the new watering points has been included at 2 hours per water point per month at $25 per hour.
- Soil tests are assumed to be required to provide analysis of soil mineral and nutrient deficiencies. The soil tests advise the fertiliser applications to improved pastures (Bishop n.d.:73; Dougherty et al. 2008). See Table 2 for number of soil tests. Cost of soil test is assumed to be $140 each.

Table 2: Assumptions that vary for small vs. large properties

200 hectare property	1000 hectare property
Watering points	
It is assumed that 1 new watering point per 100ha will be required in the transition from D to C class management. A further 1 new watering point per 100ha will be required in the transition from C class management to B class management.	It is assumed that 1 new watering point per 200ha will be required in the transition from D to C class management. A further 1 new watering point per 200ha will be required in the transition from C class management to B class management.
Soil testing	
It is assumed that 1 soil test be conducted to inform the pasture re-establishment required in the transition from D to C class management. Once in C class management, it is assumed there is 1 annual soil test. In B class management 2 soil tests are assumed annually. In A class management, 4 soil tests are assumed annually (one per land type) which inform fertiliser applications.	It is assumed that 2 soil tests be conducted to inform the pasture re-establishment required in the transition from D to C class management. Once in C class, 2 soil tests are assumed annually. In B class management 4 soil tests are assumed annually (one per land type, excluding the coastal wetland). In A class management, 8 soil tests are assumed annually (two per land type, excluding the coastal wetland) which inform fertiliser applications.

- Animal husbandry costs, gross cattle prices, freight costs and selling costs per head are detailed in Appendices 2 - 4.

The modelled examples were tested and refined with a Reef Catchments Cattle Working Group to verify the assumptions and farming systems modelled. This working group included a variety of technical experts and local graziers.

Results

The base case **D class** management describes a lack of grazing management where overgrazing pressure has caused a significant decrease in productive, perennial and palatable (3P) grasses with a corresponding increase in weeds. In this base case most stock watering points are natural watercourses. Changes to grazing management to move from **D class to C class** are relatively large and require significant capital investment. It is expected that graziers would take part in both the Stocktake and the Grazing Land Management workshops. These workshops result in a much greater understanding of pasture growth, stock feed requirements and safe pasture utilisation levels for each land type. In addition, through the workshops graziers develop a Grazing Land Management Plan which includes installation of new fencing and watering points to protect fragile riparian areas. After new fences are completed, land is expected to require a complete destock for a minimum of 12 months. During this time, remedial works such as construction of contour banks and trash cropping may be required, as well as resowing of 3P pasture grass species and weed control (Bishop n.d.:70). To maintain newly re-established pastures in C, B or A land condition, appropriate care must be taken by practicing management actions contained in B and A class.

To move from **C class to B class** management requires further capital investment as well as education. Soil tests and additional pasture monitoring per land type every six months allow for nutrient deficiencies to be corrected and stocking rates to be adjusted annually. Pasture spelling every few years assists in maintaining pastures in good condition. Further fencing and water points are installed to separate all land types, drainage lines and watercourses, with all watering points now off-stream.

As a grazier undertakes a move from **B class to A class** management, the changes in grazing management are smaller and build upon changes made to reach B class. Additional soil testing to remediate soil nutrient deficiencies is carried out so that each land type is tested individually. This allows fertiliser application to be very accurate, thus only applying the correct volume of fertiliser and minimising loss of nutrients through poor timing or unnecessary application. Pasture monitoring becomes more frequent as required, with stocking rates adjusted when necessary, and a regular planned pasture spell during the wet season (Ash, Corfield & Ksiksi 2002) is incorporated into pasture planning.

The three main benefits of these cumulative grazing management changes are:

1. Higher conception rates for 2 year old heifers (first mating) and cows (subsequent matings). This results in higher weaning percentages as the grazier moves towards A class management.
2. The quality (weight and general appearance) of weaners, and culled heifers/cows is better when they are turned off, resulting in a higher price.
3. The greater volume of pasture available per head results in a reduction in the frequency of emergency feeding to sustain livestock – thus lower costs.

The steady state gross margins for both properties operating with each set of management practices are shown below in Table 3. The gross margin for an operation within a stable herd structure is equivalent to the gross income received less the variable costs incurred. Variable costs are those directly attributable to an animal which vary in proportion to the size of the operation, such as animal husbandry and marketing expenses. A gross margin is not a measure of farm profit as it does not take into account the fixed costs of the enterprise. These fixed costs include: rates, operators labour, insurance, depreciation, administration, and so forth.

The modelled gross margins when operating with B, C and D management practices assume that the 200ha property is carrying 85 adult equivalents (AE's), which is over-stocked when the land is in C and D condition but the correct stocking rate when the land is in B condition. Likewise, the stocking rate of 562 AE's for the 1000ha property is over-stocked in C and D condition but correct for the B condition land. For both properties, the A condition stocking rate is the correct stocking rate for the pasture. Therefore, as a grazier moves from D class management practices through to B class management practices, the stocking rate for the property does not increase, rather the stock already running on the property are assumed to have better liveweight, condition and weaning rates, and the amount of emergency feeding reduces (R. Dodt, pers. comm.). As a grazier moves from B class management to A class management, the stocking rate increases for the property in accordance with improved pasture condition. The gross margin per AE is calculated based on the husbandry costs, gross cattle prices, freight and selling costs, weaning rates and stock weights as detailed in Appendices 2 – 4. The gross margin figures do not include emergency feeding costs or any capital costs involved with changing from D and C class management to B and A class management. These costs are included in the net present value analysis.

Table 3: Gross Margins

	A	B	C	D
200ha north MW representative property				
Herd gross margin	$16,823	$8,901	$5,394	$3,119
Gross margin per AE	$148.88	$104.72	$63.46	$36.69
AE's run	113	85	85	85
1000ha south MW representative property				
Herd gross margin	$112,182	$59,627	$35,764	$20,525
Gross margin per AE	$150.58	$106.10	$63.64	$36.52
AE's run	745	562	562	562

The gross margins shown above in Table 3 are the gross margins for the whole cattle herd under each scenario and land condition. Note that the gross margin does not include any fixed costs or the owner operator's labour to manage the herd. The herd gross margins for the 200ha property are low, indicating that the majority of graziers with a herd around 100 AE's would only continue to operate with additional income external to the cattle enterprise, potentially external to the farm.

The net present values calculated are the sum of the discounted annual cash flows from the capital investments over a 20 year time period using a 5% real discount rate. Benefit cost ratios are also provided to assist in determining the viability of the capital investment. The benefit cost ratio is the ratio of the sum of the discounted costs of the investment to the sum of the discounted benefits over the 20 year investment period. The benefit cost ratio tells the return over a 20 year period for every dollar spent in present dollar value. For an investment to be viable, the benefit cost ratio needs to be equal or greater than 1. Discounting is used to bring all costs and benefits over the 20 years to present values so that comparisons can be made between investment options.

Table 4: Discounted cash flow analysis

	D-A	C-A
200ha north MW representative property		
Net present value	**-$94,970**	**-$71,177**
Benefit cost ratio	0.60	0.63
1000ha south MW representative property		
Net present value	**$87,299**	**$103,754**
Benefit cost ratio	1.07	1.12

The net present value of undertaking the capital investment required to move a typical 200 hectare property located in the north Mackay Whitsunday region and using D class management practices to a position where all A class practices are used is -$94,970. If the property is initially using C class management practices and moves to A class practices, the net present value is -$71,177, i.e. small graziers would be worse off under both scenarios..

The net present value of undertaking the capital investment required to move a typical 1000 hectare property located in the south Mackay Whitsunday region and using D class management practices to a position where all A class practices are used is $87,299. If the property is initially using C class management practices and moves to A class practices, the net present value is $103,754, or over 20 years the grazier would be better off by around $103,754.

The negative NPVs for the 200ha property indicate that the increases in cattle production and the gross margin are insufficient to cover the large capital investment required, while the larger operation of the 1000ha property makes a positive return. Despite the smaller capital costs when moving from C class to A class as pasture re-establishment is not required, the NPV is larger but still negative for the 200ha property, as the change in gross margin is also smaller. The benefit cost ratios less than 1 indicate that a grazier from a 200ha size property is better off to not invest in moving from D or C class management practices to A class practices under the scenarios analysed because there are insufficient cattle numbers on small properties to pay for the large capital investment required. So, for most typical smaller properties currently using D class or C class management practices, it is likely that financial incentives will be required to help offset some of the capital costs and assist the grazier move towards A class practices.

On the other hand, the positive net present value and benefit cost ratio greater than 1 indicate that investment into management practice improvement is marginally profitable for larger properties. Therefore, education alone may encourage some larger graziers to improve their management practices, however, due to the riskiness of the transition activities and the relatively low return on investment, financial incentives may still be required to encourage change for larger graziers.

The costs of management practice improvement are likely to vary greatly between individual properties. Characteristics such as the number and extent of land types on the property, the extent of riparian areas, the existing fences, etc. will all influence the costs of undertaking management practice improvement. Therefore, individual property assessment is required to determine the costs relevant to specific properties before embarking on a transition process, and also when determining any incentive payments applicable.

The net present values shown in Table 4 are based upon the various assumptions detailed earlier. As noted above, many of the costs used in the analysis are variable depending on the individual farm circumstances and also on factors external to the farm. Also, there are many risks in the process of improving the grazing management practices of a grazier, such as partial or full failure of re-establishing pasture species, which may result in costs higher than those used in this analysis, thus further increasing the unattractiveness of the project. To account for some of the variability in costs, sensitivity analysis has been carried out below.

Sensitivity Analysis

Sensitivity analysis has been undertaken to show the volatility of the modelled results to changes in cattle prices and changes to fertiliser application rates. Cattle prices are highly variable both between and within seasons. The prices used in the analysis are considered reasonable for the Mackay region, however, cattle prices fluctuate widely based on rainfall, feed availability, the Australian dollar, and local and export demand. The fertiliser application rates are constant in this analysis, however, as a grazier improves management practices towards A class, the fertiliser application rate is closely tied to the soil tests and land types. As fertiliser is such a large expenditure to maintain pasture condition, sensitivity analysis has been undertaken to show the volatility of the modelled results to changes in the quantity of fertiliser applied.

Table 5: Sensitivity analysis on cattle prices

	D-A	% change	C-A	% change
200ha north MW representative property				
NPV with 25% higher cattle prices	-$65,901	31%	-$37,382	47%
NPV with 10% higher cattle prices	-$83,337	12%	-$57,660	19%
Base NPV	**-$94,970**	**0%**	**-$71,177**	**0%**
NPV with 10% lower cattle prices	-$106,593	-12%	-$84,694	-19%
NPV with 25% lower cattle prices	-$124,039	-31%	-$104,972	-47%
1000ha south MW representative property				
NPV with 25% higher cattle prices	$264,964	204%	$325,365	214%
NPV with 10% higher cattle prices	$158,364	81%	$192,392	85%
Base NPV	**$87,299**	**0%**	**$103,754**	**0%**
NPV with 10% lower cattle prices	$16,236	-81%	$15,106	-85%
NPV with 25% lower cattle prices	-$90,363	-204%	-$117,865	-214%

Table 5 shows the volatility of the modelled results to changes in cattle prices. For the 200ha property, changes in cattle prices bring a reasonably proportionate increase (decrease) in the NPV when changing from D class or C class to A class. For example, a 25% increase (decrease) in cattle prices results in a 31% increase (decrease) in the NPV for a change from D class to A class, while it results in a 47% increase (decrease) in the NPV when changing from C class to A class.

On the other hand, the results of the 1000 ha property are very highly sensitive to the cattle price used for the analysis. Table 5 shows that for the large property changing from D class to A class, a 10% increase (decrease) in cattle prices leads to a 81% increase (decrease) in the NPV, or a 204% increase (decrease) with a 25% increase (decrease) in cattle prices. Likewise, a change from C class to A class is also very sensitive to the cattle prices used, with a 25% increase (decrease) in cattle prices increasing the NPV by greater than 3 times or 214%. The greater sensitivity of the results for the 1000 ha property are explained by the significantly greater number of cattle sold each year and the lower capital costs relative to the number of cattle.

Table 6 shows the volatility of the modelled results to changes in the amount of fertiliser applied. In recent years fertiliser prices have continued to increase and therefore, the rate of fertiliser application has become more of an issue. This analysis has sought to apply the amount of fertiliser required to maintain healthy pastures for cattle production with around 15 parts per million (ppm) phosphorus. However, the actual fertiliser required on individual properties may be higher or lower than the base rate of 100kg/ha used in this analysis for planting and ongoing maintenance. Table 6 shows for the 200 ha property moving from D class management to A class management, if only 75kg/ha fertiliser is applied, the NPV increases by 19% to -$77,021 for the 20 year investment, while if 150kg/ha fertiliser is applied, the NPV decreases by 38% to -$130,868.

Table 6: Sensitivity analysis on fertiliser application rates

	D-A	% change	C-A	% change
200ha north MW representative property				
NPV with 75kg/ha fertiliser	-$77,021	19%	-$50,447	29%
Base NPV (100kg/ha fertiliser)	**-$94,970**	**0%**	**-$71,177**	**0%**
NPV with 125kg/ha fertiliser	-$112,919	-19%	-$91,907	-29%
NPV with 150kg/ha fertiliser	-$130,868	-38%	-$112,636	-58%
1000ha south MW representative property				
NPV with 75kg/ha fertiliser	$182,188	109%	$213,292	106%
Base NPV (100kg/ha fertiliser)	**$87,299**	**0%**	**$103,754**	**0%**
NPV with 125kg/ha fertiliser	-$7,590	-109%	-$5,785	-106%
NPV with 150kg/ha fertiliser	-$102,479	-217%	-$115,323	-211%

The NPV for the 1000 ha property is quite sensitive to the fertiliser application rate. Table 6 shows that when moving from D class management to A class management, if only 75kg/ha fertiliser is applied, the NPV increases by 109% to $182,188, while if 150kg/ha fertiliser is applied, the NPV decreases by 217% to -$102,479. The high sensitivity to the fertiliser application rate is due to the larger area of pastures to be fertilised and the lower capital costs relative to the size of the property.

Conclusion & Discussion

The analysis has shown that based on the assumptions used, it is likely that few **small** graziers will voluntarily move from D class and C class management practices to A class management practices due to the negative economic returns from the capital investment required to make the transition. **Larger** graziers may just require education to be willing to voluntarily move towards A class management as the economic return from the capital investment is positive over 20 years. However, the costs of change will vary significantly between properties due to property specific characteristics, and so individual property assessment is essential to inform the change process for the graziers involved.

As a result of the low or negative economic returns to improving management practices for graziers in the Mackay Whitsunday region, it is likely that financial incentives will be required to encourage graziers to invest in changing their management practices towards A class. Even although for larger properties the results indicate that they will be better off when moving to more improved management practices, financial incentives may still be required due to the riskiness of the capital investment and the low economic return.

Sensitivity analysis does indicate that higher cattle prices than the ones used in the analysis are likely to improve the economic potential of investments into management practice improvement, although even with higher cattle prices, incentives are still likely to be required to offset the large capital costs and cattle prices are volatile. Sensitivity analysis also indicated that the results are sensitive to the volume of fertiliser applied and the price at which the fertiliser is purchased. If individual grazing properties require less (more) fertiliser than used in this analysis to maintain their high animal productivity when using B class and A class management, then the economic return from the capital investment will be higher (lower).

This paper highlights some of the challenges facing graziers in the MW region. The economic costs of improving management practices is high for the majority of grazing enterprises in the region due to their small size. For the few larger grazing businesses in the region, there are economic benefits to improving management practices, but the overall benefit is low due to high capital costs. Therefore, even if graziers are aware of the better management practices and desire to improve for the benefit of the region and the Great Barrier Reef, the economics are likely to prevent them adopting the improved practices. This finding is consistent with other research that notes that economic considerations are the most important determinant of adoption (Pannell 1999) and the costs of management changes to more conservation orientated practices are beyond the financial resources of many landholders (MacLeod & McIvor 2006:395). In addition, these same authors note the long time scales for the environmental benefits of improved land management practices to be realised (MacLeod & McIvor 2006:395; Pannell 1999:1007) which may discourage some landholders from undertaking the change process. This latter point is similar to other work by Richards, Lawrence and Kelly (2005:192) who argue that while financial viability of the changed practices is important, there are a range of other factors such as strongly held beliefs, attitudes, values, peer pressure and social sanctioning also influence land management practices. Another problem that may be experienced by extension staff when trying to encourage landholders to move toward improved management practices depends on the how different the improved practices are from the practices used by the neighbours/community of the landholders involved. Richards, Lawrence and Kelly (2005:205-206) also found that many 'early adopters' of new grazing management practices faced negative comments and isolation from the farming community, despite potentially improving both their productivity and income. Therefore, landholders who implement improved management practices face not only the economic risk involved with the capital costs of change, but also have to be strong enough to withstand criticism from their community and neighbours (Richards, Lawrence & Kelly 2005:206).

The resulting conclusions from this analysis is that the capital costs of regenerating poor condition land are large, so if land is in good condition… prevent it declining. While there are additional annual costs to a grazing business operating with B or A class management, in most years the gross margin associated with the higher productivity cattle herd would cover the additional operating costs. The landholders who are already operating with these improved management practices are likely to play an important role in assisting any other landholders in their community who wish to improve their practices by supporting them in the process, thus slowly changing community ideas and attitudes. For those landholders who have been practicing with D or C class management practices, the economic rewards may be small from changing to more sustainable practices, however, with the assistance of financial incentives to partially or fully cover some of the capital costs, and community encouragement, they should be able to achieve a positive outcome for the Great Barrier Reef and their annual business cash flow.

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Appendix 1: Land type descriptions

Alluvial flats and plains

Description	Small to large creek flats that are frequently flooded.
Woody vegetation	Most of these areas may have been originally rainforest with some blue gum and Moreton Bay ash. Disturbed areas tend to have regrowth of eucalypts, especially where fire is used.
Soil	Deep soil with a sandy to loam to light clay topsoil over a grey to brown sand to sandy loam to clay subsoil. The soil types include rudosols and dermosols. Soil fertility: Moderate to high total nitrogen, moderate to high phosphorous.
Utilisation	50%.
Land use and management recommendations	Suitable for pasture improvement (much used for cane growing). Retain trees on bed and bank of streams; potential for Agro-forestry. Best to fence separately to less fertile land types to avoid over grazing. Maintain good pasture cover to avoid erosion during flooding. Use off stream watering points for cattle grazing.
Land use limitations	Flooding and water logging on clay soils. Restricted access in wet conditions.

Coastal tea tree plains

Description	Very low fertility, flat to undulating land with a sandy surface that supports mostly tea-tree and patches of bull oak.
Woody vegetation	Broad-leaved tea-tree, pink bloodwood, narrow-leaved ironbark, cabbage palm and small areas of bull oak and grevillea. Occasionally a grass tree understorey.
Soil	Shallow to deep soil with a sandy loam topsoil over a grey to yellow clay. The dominant soil types are sodosols. Soil fertility: Very low total nitrogen, very low phosphorous, low potash.
Utilisation	15% for native (30% for improved pastures).
Land use and management recommendations	Tea tree sucker regrowth can be a serious problem. When developing new country, or clearing regrowth country, it is recommended to leave clumps or strips of original vegetation, and blade plough or use Grasslan (chemical) pellet, to prevent tea tree regrowth on areas to be pastured. In some areas deep ploughing may bring sodic clay to the surface which could hinder grass growth. If ripping is chosen, only rip to 30-40cm depth, bumper and immediately spread pasture seed to stabilise the area.
Land use limitations	High input costs for sown pastures. Tea tree regrowth problems. In some areas the soils overlie sandstone. Poorly drained soils with summer flooding often resulting in these areas turning ‘mushy’ with water logging affecting pasture & causing problems for animal & vehicle movement. Risk of soil compaction & ‘debil debil’ formation necessitates frequent renovation (tillage). This country is very erodible despite the lack of elevation and slope.

Coastal wetlands

Description	Frequently flooded and often waterlogged floodplains which include swamps.
Woody vegetation	Mixed melaleuca/tea-tree woodlands with occasional blue gum, Leichhardt tree, pandanus and cabbage palms.
Soil	Deep, gradational clay soil. The main soil types include vertosols, dermosols and hydrosols. Soil fertility: Moderate to high.
Utilisation	50%
Land use and management recommendations	Fence where possible to protect sensitive areas.
Land use limitations	Flooding. Acid sulphate soils can be present and, because of this soil hazard, professional advice should be sought before excavating in these wetland areas.

Eucalypt hills and ranges

Description	Moderate to steep slopes with eucalypt woodlands and forests on moderately fertile soils. Occur at an altitude higher than 700m.
Woody vegetation	Pink bloodwood, grey ironbark, Moreton Bay ash, and scattered poplar gum.
Soil	Shallow to moderately deep soil. The soil types are mostly brown chromosols. Soil fertility: Low.

Utilisation	30% (35% for sown pastures).
Land use and management recommendations	Limited sown pasture development possible. Woody regrowth control could be required in cleared areas. Clearing not recommended on slopes > 20%.
Land use limitations	Shallow soils, moderately well drained but erodible. Low soil phosphorous, steep topography.

Poplar gum woodlands

Description	Flat to slightly undulating country which experiences occasional (one in every 10-50 years) flooding and supports eucalypt woodlands dominated by poplar gums.
Woody vegetation	Poplar gum woodlands associated with swamp mahogany, pink bloodwood, Moreton Bay ash.
Soil	Deep soil. The soil types are mostly Sodosols and Chromosols. Fertility: Low to moderate.
Utilisation	30% (35% for sown pastures).
Land use and management recommendations	Moderate to high fertiliser inputs to maintain high productive sown pastures. Woody regrowth control could be required in areas cleared for pasture.
Land use limitations	Low soil phosphorous. Soils are moderate to poor drainage.

Appendix 2: Cattle parameters – both properties

	A	B	C	D
Conception rate				
- 2yr heifer	90%	80%	50%	30%
- 3yr cow	75%	60%	50%	70%
- 4yr cow	85%	75%	50%	40%
- 5+ yr cow	85%	75%	65%	60%
Weaning rate				
- 2yr heifer	81%	72%	45%	27%
- 3yr cow	68%	54%	45%	63%
- 4yr cow	77%	68%	45%	36%
- 5+ yr cow	77%	68%	59%	54%
Liveweight (kg)				
- Steer weaner	198kg	185kg	171kg	158kg
- Heifer weaner	198kg	185kg	171kg	158kg
- 2yr heifer	358kg	334kg	324kg	304kg
- Cow	400kg	392kg	370kg	350kg
- Bull	650kg	630kg	605kg	580kg
Sale weight (weaners kg liveweight, heifers, cows & bulls kg carcase weight)				
- Steer	198kg	185kg	171kg	158kg
- Heifer	198kg	185kg	171kg	158kg
- 2 yr heifer (52%)	186kg	334kg (Lwt)	324kg (Lwt)	304kg (Lwt)
- Cow (50%)	200kg	196kg	185kg	350kg (Lwt)
- Bull (54%)	351kg	340kg	327kg	313kg
Prices (weaners liveweight $/kg, heifers, cows & bulls cwt $/kg dressed)				
- Steer weaner	$2.30	$2.05	$1.78	$1.46
- Heifer weaner	$1.52	$1.36	$1.19	$0.98
- 2yr heifer	$1.57	$1.21 (Lwt)	$1.09 (Lwt)	$0.99 (Lwt)
- Cow	$2.17	$1.57	$1.57	$0.80 (Lwt)
- Bull	$2.18	$2.18	$2.18	$2.18
Prices (Gross $/head)				
- Steer weaner	$455	$380	$305	$230
- Heifer weaner	$300	$252	$203	$155
- 2yr heifer	$292	$403	$352	$300
- Cow	$434	$308	$290	$280
- Bull	$765	$742	$712	$683

- Cull cows sold to meatworks, dressed weight heifer 52%; cows 50%; bull 54%
- Saleyard selling costs: $10/hd plus 6% commission
- Meatworks selling costs: $5 levy = $5/hd

Appendix 3: 200ha representative property in the north MW region

- Breeder death rate: 2%
- CFA: 10 years
- Bull cow ratio: 3%
- Expected calf loss from pregnancy diagnosis to weaning: 10%
- Vaccination/other treatments:
  - 7-in-1 to weaners at branding: $1.66/hd
  - drench to replacement heifers 3-6 months after weaning: $3.52/hd
  - leptospirosis booster to all breeders and bulls annually: $1.06/hd
- Bull purchase price: $4,000
- Preg test: $5.00/female

	A	B	C	D
Carrying capacity (AE's) north MW region				
- Eucalypt hills & ranges	35.86	26.90	16.30	7.34
- Poplar gum	24.47	18.67	10.95	5.15
- Coastal tea tree	14.49	10.99	6.55	2.81
- Alluvial flats	38.18	28.57	17.14	7.53
- TOTAL	113	85	51	23
Freight/hd (120km northern MW region)				
- Weaners	49/deck = $9.55	51/deck = $9.18	52/deck = $9.00	53/deck = $8.83
- 2yr heifer	35/deck =$13.37	37/deck =$12.65	38/deck =$12.32	40/deck =$11.70
- Cow	33/deck =$14.18	33/deck =$14.18	34/deck =$13.76	35/deck =$13.37
- Bull	21/deck =$22.29	22/deck =$21.27	24/deck =$19.50	25/deck =$18.72
Feed supplement ($/hd) (Proserpine costs) – these costs are only some years				
- Weaners	$7.99	$15.98	$15.98	$23.97
- 2yr heifer	$15.98	$31.96	$31.96	$47.94
- Cow	$15.98	$31.96	$31.96	$47.94
- Bull	$15.98	$31.96	$31.96	$47.94

Appendix 4: 1000ha representative property in the south MW region

- Breeder death rate: 2%
- CFA: 10 years
- Bull cow ratio: 3%
- Expected calf loss from pregnancy diagnosis to weaning: 10%
- Vaccination/other treatments:
  - 7-in-1 to weaners at branding: $1.66/hd
  - drench to replacement heifers 3-6 months after weaning: $2.36/hd
  - leptospirosis booster to all breeders and bulls annually: $1.06/hd
- Bull purchase price: $4,000
- Preg test: $2.75/female

	A	B	C	D
Carrying capacity (AE's) south MW region				
- Eucalypt hills & ranges	159.2	120.3	70.8	31.8
- Poplar gum	85.5	64.7	39.3	16.2
- Coastal tea tree	168.1	127.4	75.9	32.5
- Alluvial flats	152.7	114.3	68.6	30.1
- Coastal wetland	179.2	135.1	80.5	36.4
- TOTAL	745	562	335	147
Freight/hd (25km southern MW region)				
- Weaners	42/deck = $1.25	44/deck = $1.19	44/deck = $1.19	45/deck = $1.17
- 2yr heifer	30/deck = $1.75	32/deck = $1.64	32/deck = $1.64	34/deck = $1.54
- Cow	28/deck = $1.88	28/deck = $1.88	29/deck = $1.81	30/deck = $1.75
- Bull	18/deck = $2.92	19/deck = $2.76	20/deck = $2.63	21/deck = $2.50
Feed supplement ($/hd) (Mackay costs) – these costs are only some years				
- Weaners	$22.23	$44.66	$44.66	$66.99
- 2yr heifer	$44.66	$89.31	$89.31	$133.97
- Cow	$44.66	$89.31	$89.31	$133.97
- Bull	$44.66	$89.31	$89.31	$133.97