Understanding the economics of grazing management practices and systems for improving water quality run-off from grazing lands in the Burdekin and Fitzroy Catchments

Reef Plan Action 4: Gap Analysis Report

2016

Queensland Government

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Executive Summary

The declining health of the Great Barrier Reef (GBR) is predominantly attributed to run-off from agricultural land use in the catchments adjacent to the reef. The Scientific Consensus Statement 2013 conducted an assessment of the relative risk of current land management practices and identified grazing in the Burdekin and Fitzroy catchments as the highest priority for sediment reduction to be achieved through soil erosion management. The grazing industry in the Burdekin and Fitzroy catchments is the largest agricultural industry located in the catchments of the Great Barrier Reef (GBR) lagoon, however, historical business performance in the industry is poor. Therefore, there is a need for improved practices which improve the profitability as well as provide water quality outcomes.

There are a number of practices which can contribute to better water quality outcomes. As outlined in the P2R Water Quality Risk Framework, these are:

- Managing ground cover with stocking rates and wet season spelling
- Rehabilitation of poor or very poor condition country
- Management of selectively grazed landtypes
- Riparian and wetland area management
- Rehabilitation of gullied areas

This report, which reviewed published economic literature on these practices, with respect to the Burdekin and Fitzroy catchments found, for each of the practices, the following:

1. Managing ground cover with stocking rates and wet season spelling

    - Management of grazing systems at sustainable stocking rates was generally more profitable than grazing systems operating at heavier stocking rates.
    - There is not a consistent economic outcome with respect to the profitability of wet-season spelling.
    - Sediment run-off was lower under moderate, sustainable, stocking rates compared with heavier stocking rates
    - There is not always a “win-win” scenario between reducing sediment and increasing profit.
    - Few studies exist on the economic impact of changing management practices as opposed to operating at different levels of management practice.
    - There is no data on the costs of changing these management practices.
    - No studies have been done at the whole-of-business level.

2. Rehabilitation of poor or very poor condition country

    - Land in poor condition may be rehabilitated through grazing land management practices, such as wet season spelling although this may take years. Land in very poor condition requires mechanical intervention.

    - Modelling of wet season spelling suggests it may be an economically viable method of rehabilitating poor land condition – however, no trials exist to demonstrate this.

    - Cost to rehabilitate land in very poor condition can vary significantly. Reviewed data shows a range of $14.11/ha to $379.00/ha.

    - Economic outcomes for the rehabilitation of very poor condition (D condition) country vary greatly with landtype and cost of the intervention used.

3. Management of selectively grazed landtypes

    - Four practices are suggested to manage selectively grazed landtypes. These are, landtype fencing, wet season spelling, supplementary feed sites and watering points, and the use of fire.

    - There are no published studies which present the economic value of using any of the recommended practices to manage selectively grazed landtypes.

4. Riparian and wetland area management

    - Three practices are suggested to manage riparian and wetland area management. These are, riparian fencing, off-stream supplementary feed sites and off-stream water points.

    - There are no published studies which present the economic value of using any of the recommended practices to manage riparian and wetland areas.

5. Rehabilitation of gullied area

    - Four practices are recommended for rehabilitation of gullies and these are: fencing, revegetation, earth works and stock control. It is likely a combination of these practices are required for successful gully rehabilitation.

    - Landholder returns on gully rehabilitation are assumed to be negative, nil or very small.

    - Sediment reductions from rehabilitation activities range from 10% to 70%.

    - Case studies found that the cost of rehabilitation for individual gullies ranged from $7500 to $150,000 per gully and cost per tonne of sediment reduction ranged from $73/tonne/annum to over $5000/tonne/annum.

    - No economic studies have been published in conjunction with replicated trial work for gully rehabilitation.

This report has identified a number of high priority areas for future economic work, including continued collaboration with project partners, to provide economic expertise in research trials in order to validate the profitability, risk and cost-effectiveness of the adoption of recommended management practices. In particular research is needed that will:

- Demonstrate the rehabilitation of land in poor condition using stocking rates or wet season spelling to provide biophysical data for economic modelling.
- Determine the whole-of-business impact of both best management practice programs and the specific management practices related to the water quality framework, including detailed consideration of the implementation phase on business outcomes.
- Investigate the economic impacts of recommended practices for management of riparian and wetland area management. Note: there is an opportunity to review previous on-ground work such as the Natural Heritage Trust (NHT) and Reef Rescue programs.
- Collaborate with gully rehabilitation trials to collect bio-physical data to inform economic modelling.

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1 Introduction

The declining health of the Great Barrier Reef (GBR) is predominantly attributed to run-off from agricultural land use in the catchments adjacent to the reef (Thorburn, et al., 2013). The Reef Water Quality Protection Plan (Reef Plan) (Queensland Government, 2016) is a joint initiative by the Australian and Queensland governments that focuses on improving the health of the reef. Reef Plan sets a number of targets for sediment, nutrient and pesticide run-off reductions in the grazing, grain, sugarcane, and banana industries. These include a reduction of 20% in sediments, 50% of nutrients and 70% of pesticides through changes in land management practices.

The Scientific Consensus Statement 2013 (Brodie, et al., 2013) conducted an assessment of the relative risk of current land management practices and identified grazing in the Burdekin and Fitzroy catchments as the highest priority for sediment reduction to be achieved through soil erosion management. The baseline sediment loads attributed to Burdekin grazing lands are estimated at 4.1 million tonnes with a further 2.9 million tonnes from the Fitzroy (Queensland Government, 2009). Sediment loads that reach the GBR lagoon reduce the available light for the photosynthesis of coral populations, and thereby smother the reef ecology (McKergo, et al., 2005).

The grazing industry in the Burdekin and Fitzroy catchments is the largest agricultural industry located in the (GBR) lagoon catchments. The total land area occupied by the industry in these catchments is over 20 million hectares (Australian Bureau of Statistics, 2014). In 2012-2013, the industry reported a gross value of production of approximately $1,040 million. Grazing industries operate in a variable climate, across multiple landtypes and face a number of internal and external factors which influence their economic performance. These include external expectations on environmental custodianship, animal welfare and implementation of best management practices.

Action 4 of Reef Plan aims to increase the understanding of farm management practices and systems, economics and water quality benefits.(The State of Queensland 2013b). Under this Reef Plan action, The Queensland Department of Agriculture and Fisheries (DAF) is required to “review existing commodity specific management practices which affect water quality runoff from agricultural lands and identify the most critical, cost effective and profitable management practices and systems” . DAF is also required to identify where gaps in research are with respect to management practices that have water quality benefits.

1.1 Report objectives

The objective of this Synthesis Report is to support the understanding of the first deliverable of Reef Plan Action 4 with respect to the grazing industry. The first deliverable of Action 4 is to “*Review existing commodity specific management practices and identify the most critical, cost effective and profitable management practices and systems”.* In particular, the information compiled in this Synthesis Report aims to:

- Briefly examine the business environment in the grazing industry
- Provide a summary of the latest information available on the cost-effectiveness and profitability on management practices for improving the quality of farm water run-off.
- Identify information gaps in the cost effectiveness and profitability of priority management practices and opportunities for future work to address these.

The second deliverable of Reef Plan Action 4 is to, “*Use this information* [from deliverable 1] *to prioritise investment of the most critical, cost-effective and profitable practices and systems at a regional/catchment scale”.*

The scope of this report is the provision of information to meet the first deliverable which may assist organisations, such as natural resource management (NRM) groups, interpret this information and prioritise investment.

1.2 Report scope and approach

This report focuses on those issues directly relating to (DAF) obligations as a lead agency for the delivery of Action 4 for the grazing industry.

Through Reef Plan, significant work has been undertaken to identify the most critical commodity specific practices impacting on water quality, and critical areas needing improvements in management practices (i.e. Scientific Consensus Statement Update (SCSU)). This report will review the economics work with respect to: Reef Plan priorities; the Scientific Consensus Update (SCSU) findings on relative risk; and the critical practices identified and prioritized in the Paddock to Reef (P2R) Monitoring and Evaluation Program's management practice water quality risk frameworks.

The areas of focus for this report will be the Burdekin and Fitzroy grazing regions. These regions were identified by the *Reef Water Quality Protection Plan Prioritisation Project Report* (2014) as having very high overall relative risk to water quality entering the reef with respect to sediments (Table 1).

Table 1: Relative risk assessment of pollutants and respective catchments

Region	Overall relative risk	Priority pollutants for management		
		Nitrogen	Pesticides	Sediment
Cape York	LOW			
Wet Tropics	VERY HIGH			
Burdekin	HIGH	*		
Mackay Whitsunday	MODERATE			
Fitzroy	HIGH			
Burnett Mary	UNCERTAIN**			

* Lower Burdekin and Haughton focus
** Most reefs and seagrass meadows in this region were not included formally in the analysis and therefore the validity of the result has high uncertainty.

The Paddock to Reef (P2R) Water Quality Risk Framework sets out grazing management practices and key performance indicators which have the highest potential to influence water quality run-off. (Queensland Government, 2014). The performance indicators (Table 2) are supported by high level practices for each erosion source (which are used to inform more detailed supporting actions (example in Table 3) (Queensland Government, 2016). These supporting actions are ranked in terms of their risk to water quality outcomes. The risk ratings are as follows (Queensland Government, 2014):

- High risk (superseded or outdated practices)
- Moderate risk (a minimum standard)
- Moderate-low risk (best practice)
- Lowest risk (innovative practices expected to result in further water quality benefits, but where commercial feasibility is not well understood)

Table 2: Water quality risk framework performance indicators and practices

	Indicators & Associated Practices
Hillslope	**Performance Indicator 1:** Average stocking rates imposed on paddocks are consistent with district long-term carrying capacity benchmarks for comparable land types, current land condition, and level of property development
	Performance Indicator 2: Retention of adequate pasture and groundcover at the end of the dry season, informed by (1) knowledge of groundcover needs and (2) by deliberate assessment of pasture availability in relation to stocking rates in each paddock during the latter half of the growing season or early dry season.
	Performance Indicator 3: Strategies implemented to recover any land in poor or very poor condition (C or D condition).
	Performance Indicator 4: The condition of selectively-grazed land types is effectively managed
Streambank	**Performance Indicator 5.** Timing and intensity of grazing is managed in frontages of rivers and major streams (including associated riparian areas) and wetland areas.
Gully	**Performance indicators 1-4:** Hillslope erosion assessment.
	Performance Indicator 6: Strategies implemented to remediate gullied areas.
	Performance Indicator 7: Linear features (roads, tracks, fences, firebreaks, pipelines and water points) located and constructed to minimise their risk of initiating erosion.
	Performance Indicator 8: Use of agricultural chemicals

Table 3: Water Quality Risk Framework Grazing

		Very low risk	Low risk	Low to moderate risk	Moderate to high risk
Performance Indicator: 1. Average stocking rates imposed on paddocks are consistent with district long-term carrying capacity benchmarks for comparable land types, current land condition, and level of property development.					
High-level actions	There are realistic expectations of the average stocking rate each paddock will likely carry over a number of years (long-term carrying capacity or LTCC).	Supporting Action: Estimates consistent with district benchmarks, and any that are significantly above have a solid rationale for being so[ii]. Estimates account for key factors (as in GLM[iii]), or an equivalent process. Reviewed anytime there is a change in either land condition, subdivisional fencing, or location of water points.	Supporting Action: Estimates generally consistent with district benchmarks, and any that are significantly above have a solid rationale. Estimates account for key factors or an equivalent process, **or** have reliable estimates based on long-term experience, paddock records, and observed trend in condition of land. Good understanding of key factors affecting LTCC. May be routinely reviewed.	Supporting Action: Estimates tend to be above district benchmarks for some or all land types, and rationale for this is unclear. Estimates typically based on personal experience and/or limited records. Some understanding of key factors affecting LTCC. Not reviewed.	Supporting Action: Estimates are clearly above district benchmarks for some or all land types, with no solid rationale. Estimates typically based on personal experience. Limited understanding of key factors affecting LTCC, and these are not accounted for in any fashion. Not reviewed.

It should be noted that grazing cattle production comprises a range of management aspects, for example; herd management, grazing land management and business management. However, only published economic studies for the practices outlined in the water quality risk framework have been reviewed.

To summarise, the practices which are outlined in the P2R Water Quality Risk Framework and which will be reviewed in this report are:

- Managing ground cover with stocking rates and wet season spelling
- Rehabilitation of poor or very poor condition country
- Management of selectively grazed landtypes
- Riparian and wetland area management
- Rehabilitation of gullied areas

Appendix A contains definitions of these practices, the land condition classifications and some background information on processes connecting them to water quality outcomes.

2 The business environment in the Burdekin and Fitzroy grazing industry

Key Points

- Grazing in the Fitzroy and Burdekin catchments has a gross value of production of more than one billion dollars per annum.
- Businesses operate in a highly variable climate, both spatially and temporally, which impacts on all aspects of the grazing operation.
- There are 23 major landtypes in the Burdekin and 32 in the Fitzroy.
- Beef producers face a highly variable business environment with price, climate, and production, and financial risk impacting economic outcomes.
- The grazing businesses of the Burdekin and Fitzroy have shown significant growth in wealth of the last four to five decades.

Grazing is the predominant agricultural land use type in the Fitzroy and Burdekin catchments (Figure 1). (The total area of grazing land in the Fitzroy catchment is about 12,321,811 ha and approximately 7,887,189 ha are allocated to grazing in the Burdekin catchment (Australian Bureau of Statistics, 2014). There are about 3,090 grazing business in the Fitzroy catchment and approximately 550 in the Burdekin catchment (Australian Bureau of Statistics, 2014).

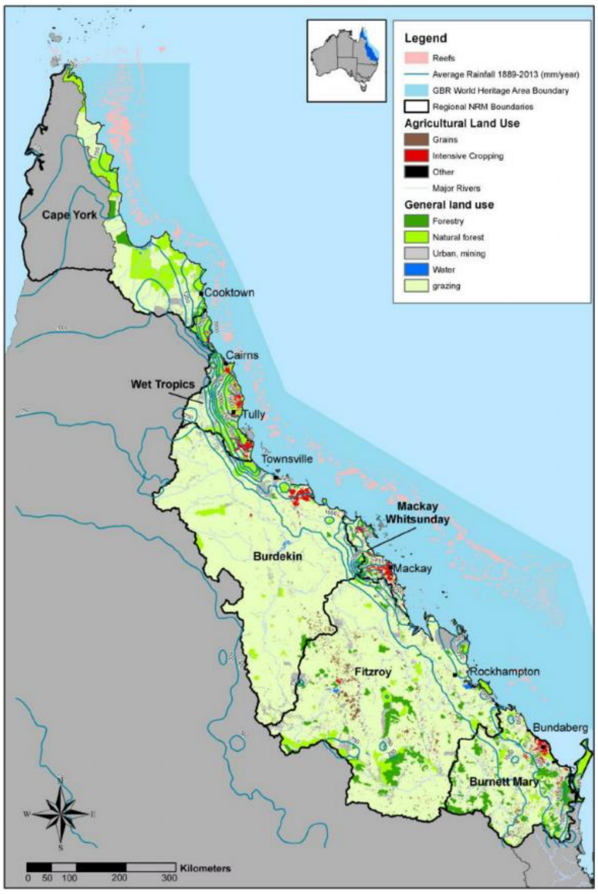

Figure 1: Land use in the Great Barrier Reef lagoon catchments (Thorburn, et al., 2013)

The Fitzroy and Burdekin catchments are located in a semi-arid to sub-tropical climate and contain a variety of diverse ecosystems and land types. There are 23 major grazing land types in the Burdekin

Catchment and 32 in the Fitzroy catchment (Whish, 2011). Any individual grazing enterprise may have several of these land types to manage. Additionally, climate variability is significant (O'Reagain & Bushell, 2011) with average annual rainfall varying from about 530 mm in the west to about 850 mm in the central regions and approximately 2000 mm in the northeast ranges near the coast (Bowker, et al., 2008). Rainfall is also extremely variable at any specific location throughout time. Intense rainfall events in the catchments are typically generated by monsoonal depressions and tropical cyclones during summer (Bowker, et al., 2008).

Figure 2 shows the number of meat cattle in Queensland. The Fitzroy and Burdekin catchments together usually run between 20% and 25% of Queensland's cattle herd. The number of cattle in Queensland has grown at an average annual rate of 0.21% since 2000 and at more than 1.5% per annum since the 1960's.

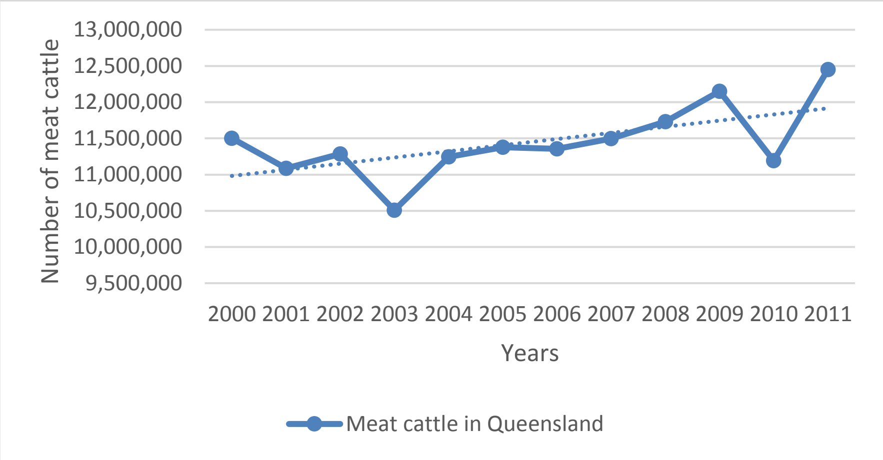

Figure 2: Number of meat cattle in Queensland

Figure 3 shows meat production from beef cattle in Queensland since 2000. Although cattle numbers have grown slowly, meat production has expanded at about 1% per annum over the same period. The value of livestock slaughtered and other disposals in the Fitzroy, Burdekin and Mackay Whitsunday NRM regions for the 2014 -15 financial year is recorded as $1,862,442,655 (ABARES, 2016).

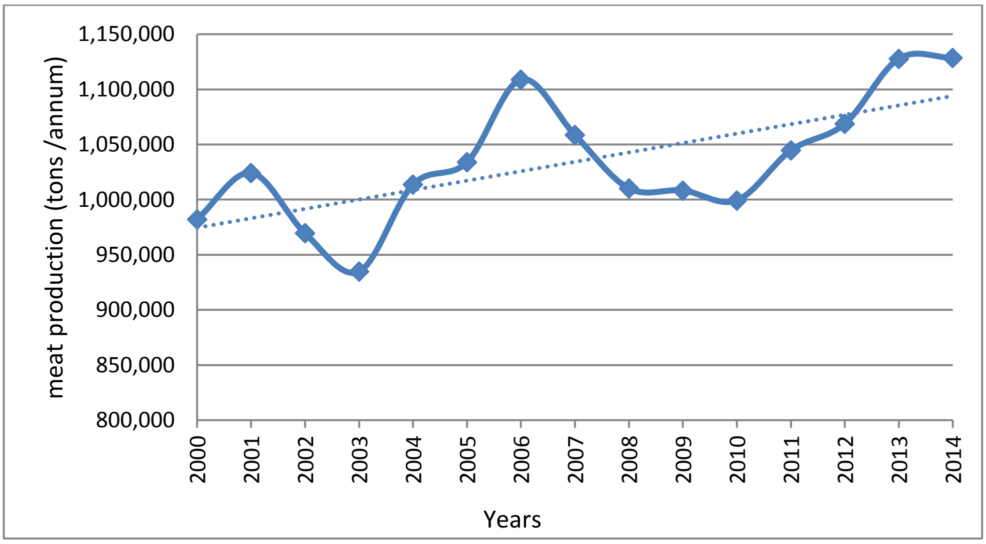

Figure 3: Meat production in Queensland

The current key drivers of business profitability in the grazing industry are price received, seasonal conditions, the value of the Australian Dollar, increasing government regulation, high finance costs, management skills, increasing overhead costs and poor herd performance (McCosker, et al., 2010). Beef businesses are likely to face a continuing decline in the terms of trade, increasing competition for the products in both domestic and export markets and greater societal pressures of the production and animal welfare practices.

Table 4 shows the northern Australian beef industry has significantly outperformed the southern beef industry in terms of controlling input growth and improving output growth. The rate of growth in Total Factor Productivity (TFP) has averaged 1.5% per annum since 1977-78, a standout performance amongst Australian extensive livestock industries (ABARES, 2016)

Table 4: Average annual beef industry TFP growth, by region, 1977–78 to 2013–14

Beef farms	Input growth	Output growth	TFP growth
	%	%	%
All beef farms	–0.2	1.1	1.3
Southern region	0.5	1.2	0.6
Northern region	–0.4	1.1	1.5

A beef producers' capacity to generate farm income and productivity growth is influenced by their past investments in land, farm infrastructure, and plant and machinery. From 2000–01 to 2014–15, an average of 50 per cent of beef cattle farms made an annual average net capital investment of around $40 000 (ABARES, 2016). Net capital investment is the difference between total value of plant, vehicles, machinery and farm infrastructure purchased and total value of those items sold. This level of investment is likely to continue the growth in productivity shown across northern beef enterprises.

Average total cash receipts for Australian beef farms increased by around 14 per cent in 2014–15 and by a similar percentage in the following year (ABARES, 2016). The increases in total cash receipts largely reflected higher receipts from cattle sales, which were largely a result of higher cattle prices. The average farm cash income for beef farms increased by more than 50 per cent in 2014–15 and by an estimated one-third in 2015-16. In real terms, estimated average farm cash incomes for 2014–15 and 2015–16 are among the highest recorded since 2000–01.

Northern region beef farms recorded higher average farm incomes than farms in the Southern region in both 2014–15 and 2015–16 (ABARES, 2016). Receipts from beef cattle sales in the Northern region account for a much higher proportion of total enterprise receipts than in the Southern region.

Reflecting higher incomes, the average rate of return (excluding capital appreciation) for beef farms increased from –0.1 per cent in 2013–14 to 0.6 per cent in 2014–15. Average rate of return is estimated to have increased further in 2015–16 to around 1.9 per cent.

Table 5: Rate of return, beef farms, 2013–14 to 2015–16

average per farm

Farm cash income	Unit	2013-14	2014-15	2015-16
Australia	%	–0.1	0.6	1.9
Northern region	%	–0.5	0.1	1.6
Southern region	%	0.2	0.9	2.2

Notes: 2015–16 data are preliminary estimates. Rate of return excludes capital appreciation.
Source: ABARES Australian Agricultural and Grazing Industries Survey

3 The cost-effectiveness and profitability of grazing management practices for improving water quality off-farm

This section will review the current economic research and information related to the grazing practices identified by the P2R water quality framework outlined in section 1.2 above. An economic analysis can take a number of forms and the three main types that were included in the publications reviewed in this section are defined below.

A partial net return (PNR) or partial net benefit only considers the gross revenue received, plus or minus inventory change, less the variable costs that are impacted by a particular practice change (e.g. levies, animal husbandry treatments, transport to market). This is then compared to the partial net benefit of the current approach in isolation of the rest of the grazing system. This is a very limited approach that gives an approximate estimate of the relative benefit of alternative practice to the current application. Fixed costs are assumed to be constant when using this method and it does not consider other aspects of the farming system or capital requirements. This method is only occasionally useful when comparing the relative difference of a simple management practice change that only involves revenue or variable cost attributes. Limitations are that this method assumes that the variable costs, capital requirements, receipt of income and timing of costs associated with all other management practices not being trialled remain constant which may not be true at all. For example, if a producer is implementing rotational spelling and thus limiting access to better quality country, supplementation programs may need to be adjusted elsewhere on the property.

A gross margin approach (GM) (gross revenue, plus or minus inventory change, less all variable costs) is similar to a partial net benefit approach but it also subtracts the variable costs of other practices involved in grazing businesses, not just the practice that is being considered. For example, if a producer is implementing rotational spelling, supplementation costs on other areas of the property are adjusted. This approach also has many of the limitations identified for the PNR approach.

A whole-of-farm (WOF) approach to economic analysis looks at the impact of a change in grazing practice across the whole business, rather than focusing on one particular component. Instead of looking at a single practice change it is possible to look at a suite of changes at the same time. Breedcow and Dynama is an integrated software package for the extensive beef industry that allows a full economic and financial analysis to be undertaken for a comparison of the economics of various components of a new grazing system. Breedcow and Dynama can identify herd gross margin, business cash flow and profit together with business and partial net returns.

The level of economic analysis undertaken depends on the data collected in a study and the question that needs to be answered. This is determined by the objective of the research and the subsequent design of the study.

Source: Adapted from (Harvey, et al., 2016)

Each study also used a biophysical methodology to determine the biological component. Three types of biophysical methods were used in the studies. Some studies used a combination of approaches. These were:

Trial approach: This approach used physical, real world, replicated data to produce outcomes. This method gives the highest levels of confidences.

Bio-economic modelling: This approach uses grass and animal production modelling, usually GRASP (Day, et al., 1997). It is a calibrated modelling approach which uses site specific inputs.

Desktop modelling: This approach uses broad information based generally on regional information sources.

3.1 Managing ground cover with stocking rates and wet season spelling

Key Points

- Four studies were reviewed which included stocking rate management and wet season spelling impact on profitability.
- All four studies found that, generally, operating grazing systems at sustainable stocking rates was more profitable than using heavier stocking rates.
- Three of the studies measured or modelled soil loss, with all studies showing that soil loss was lower under moderate, sustainable, stocking rates compared with heavier stocking rates.
- There is not a consistent outcome with respect to the profitability of wet-season spelling. One trial showed it was more risky and less profitable than a moderately stocked, continuously grazed system. Other studies using modelled data suggested that it can be more profitable.
- The cost to reduce tonnes of sediment does not always result in a win-win situation between business profitability and environmental outcomes.

Four studies were reviewed which looked at the economics of different stocking rate and/or wet season spelling strategies. A summary of the key points for each study can be found in Table 6. Three of these used a gross margin analysis and one used a partial net return.

Table 6: Summary of studies reviewed for stocking rate, wet season spelling and ground cover management

Year Author	Region & Landtype	Publication type	Practice	Economic method	Biophysical method
(Ash, et al., 2002)	Burdekin – red & yellow earths	Report (Several Journal Articles also exist)	Stocking Rates and Wet Season Spelling	PNR	Biophysical modelling
(O'Reagain & Bushell, 2011)	Burdekin – Yellow-brown earths, Box, Silver-leaf Ironbark, Brigalow	Report (Several Journal Articles also exist)	Stocking Rates and Rotational Spelling	GM	Trial - 2 replications.
(Star, et al., 2013)	Burdekin – Narrow-leaved Ironbark (NLIB), Silver-leaved Ironbark (SLIB) Fitzroy – Brigalow, Coolibah floodplains, NLIB, Open downs.	Report & Journal Article	Stocking Rate	GM	Bio-physical modelling
(MacLeod, et al., 2009)	Burdekin - Goldfields	Journal Article	Wet Season Spelling	GM	Bio-physical modelling

The Wambiana Grazing Trial (O'Reagain & Bushell, 2011) (O'Reagain, 2016) has found that 19 years of accumulated gross margin from either moderate stocking rates (~$24000/100ha), rotational spelling (~$23000/100ha), variable stocking (~$24000/100ha) or seasonally adjusted stocking (~$23000/100ha) was significantly more profitable than heavy stocking ($8000/100ha). Pasture yield, composition and ground cover were also far highest in the rotational spelling and moderate stocking rate treatments, followed by the two variable treatments but was by far the poorest in the heavy stocking rate treatment he (O'reagain, 2011). The key finding was that its heavy stocking treatment was neither sustainable nor profitable and was far more risky than the other treatments. The study also found that the variable stocking rate treatments were no more profitable than moderate set stocking but were far riskier and more difficult to manage. Lastly, it found that wet season spelling appears important for maintaining pasture condition.

The Wambiana trial findings were confirmed in modelling conducted at the scale of a typical beef enterprise in the Charters Towers district (Scanlan, et al., 2013). These findings showed that long term profitability and sustainability were maximized at moderate stocking rates.

The findings of the Wambiana trial were similar to the Ecograze modelling results (Ash, et al., 2002). Ecograze modelled a representative 28,000 hectare property and found that those properties in better condition (State I) was able to sustainably carry more cattle and had a better cash return than properties in either average (State II) or degraded (State III) condition (Table 7). The modelling also showed that wet season spelling was not as profitable as continuous grazing at the recommended stocking rate (1 cow / 7 Ha). However, the trial suggested that wet season spelling is sustainable with higher stocking rates which suggests that wet season spelling could also improve profitability. This finding was in contrast to the Wambiana grazing trial which found that rotational grazing was not able to buffer the effects of higher stocking rates on pasture condition (O'Reagain & Bushell, 2011). Lastly, the Ecograze modelling showed that soil loss was lower under wet season spelled systems at both average stocking rates and higher stocking rates.

Table 7: Results of the Ecograze bio-economic modelling

	State I (continuous grazing – 1 cow/7 Ha)	State II (continuous grazing – 1 cow/7 Ha)	State III (continuous grazing – 1 cow/7 Ha)	Continuous Grazing – (1 cow/7 Ha)	Continuous Grazing – (1 cow/5 Ha)	Wet Season Spelling (1 cow/7 Ha)	Wet Season Spelling (1 cow /5 Ha
Herd Number	3,600	3,410	938	3600	4200	3600	5000
Soil Loss (kg/ha/year)	590	1060	2310	590	2,291	548	861
Cash Return ($/annum)	38,000	35,000	-95,000	38,000	-114,000	37,000	57,000

Other studies using bio-economic modelling has shown that the optimal level of stocking rates (shown as pasture utilisation rates), as measured by profitability, varies significantly between landtypes and land condition (Table 8) (Star, et al., 2013). In all cases, sediment export was highest under the maximum utilisation scenarios and lower land condition. There can be considered a “win-win” situation where very high utilisations are presently used in the majority of landtypes, with 29 out of the 36 scenarios showing that the lowest profitability for enterprises were likely to be at maximum utilisation rates. However, there also appears to be cases where economic benefit is highest under heavier utilisation rates. For example, the results for Brigalow Blackbutt in “A” condition suggests that the economic optimum is the highest utilisation rate. Similar results are suggested for Coolibah Floodplains. This is further highlighted through 14 of the 36 scenarios where the lowest utilisation rate is not the economic optimum, suggesting that for a majority of cases, some tradeoff between enterprise returns and sediment run off is likely. Lastly, there appears to be scenarios in which heavier utilisation rates are less risky. For example, Narrowleaved Ironbark (NLIB) and Coolibah Floodplains in “A” condition have their lowest profitability at lowest utilisation rates.The limitations of the results shown in Table 8 should also be noted as they are important for interpretation. The major limitation is that it shows the profitability of operating at a given utilisation. It is not the profitability of changing from one utilisation to another. Therefore, the interpretive power for any given landholder is limited, however, it does guide strategic thinking of where a change might be feasible. Further work is required to determine if changing to another pasture utilisation rate is economically viable.

Table 8: Bio-economic modelling results for all landtypes – treed

Landtype /Condition	Pasture Utilisation							
	15	20	25	30	35	40	45	50
Black Basalt								
C		$H						$L
B			$H					$L
A	$L		$H					
Brigalow Blackbutt								
C			$H					$L
B	$L					$H		
A	$L							$H
Coolibah Floodplains								
C		$H						$L
B					$H			$L
A	$L					$H		
Goldfields								
C	$H							$L
B		$H						$L
A		$H						$L
Loamy Alluvial								
C	$H							$L
B	$H							$L
A	$H							$L
NLIB – Deeper Soils								
C		$H						$L
B			$H					$L
A	$L			$H				
NLIB – Shallow Soils								
C	$H							$L
B	$H							$L
A	$H							$L

Table continued on next page

Landtype /Condition	Pasture Utilisation							
	15	20	25	30	35	40	45	50
NLIB Woodland								
C	$H							$L
B	$H							$L
A	$H							$L
Open Downs								
C	$H							$L
B			$H					$L
A	$L			$H				
Red Basalt								
C		$H						$L
B			$H					$L
A	$L		$H					
Silverleaf Ironbark								
C		$H						$L
B		$H						$L
A			$H					$L
Silverleaf Ironbark on duplex								
C	$H					$L		
B	$H							$L
A	$H							$L

$H – Denotes the highest net present value for the relevant scenario.

$L – Denotes the lowest net present value for the relevant scenario.

The final study reviewed used bio-economic modelling to compare six rehabilitation scenarios using wet season spelling against continuous grazing on goldfields country in "C" condition (MacLeod, et al., 2009). A description of scenarios and economic outcomes can be seen in Table 9. The results show that, regardless of length of recovery (up to 14 years), animal productivity assumptions and whether excess cattle had to be agisted, all wet season spelling rehabilitation scenarios tested were more profitable than continuing to operate on "C" condition country. While this was a rehabilitation scenario, given it assumed no costs were required to implement wet season spelling, it is fundamentally a comparison of economic outcomes between using wet season spelling and continuous grazing.

(MacLeod, et al., 2009) clearly identify the limitations of the study – "the economic simulation discussed in this paper is based on only a single case study example and, in the absence of quantitative data drawn directly from wet season resting field experiments or station records, the projected carrying capacity and animal productivity data were necessarily heuristic" and "in the absence of detailed empirical data, the collection of which should be a high research priority, the present modelling exercise seeks to throw some exploratory light on the economic merit of wet season resting and the results are interpreted accordingly.

Table 9: Scenario descriptions and economic outcomes of wet season spelling bio-economic modelling.

Scenario	Description	GM / Ha relative to Continuous Grazing ($)
1	Assumes that recovery (measured as breeder carrying capacity) is slow during the early years of resting. Stock numbers are not immediately increased for the initial 2 years of the resting strategy to promote recovery, are then increased by 33% of the full recovery level by 8 years and then accelerated so that full recovery is achieved after 10 years. Cattle are agisted where required.	+19.29
2	Assumes the recovery trajectory is more rapid, and after an initial lag of nil change for 2 years follows a linear trajectory to year 10.	+25.93
3	Assumes a slower rate of recovery of the targeted paddocks than used for Scenario 1, so that after nil change for 2 years the first 33% of recovery occurs over 13 years and the remainder in years 14 and 15.	+8.22
4	Is identical to Scenario 1 in breeder carrying capacity and recovery rates, but assumes that the increasing stock numbers carried over the recovery period will, through higher utilisation of the available herbage resources, restrict per animal productivity gains	+3.78
5	Is identical to Scenario 1 in all respects except that the market price for all stock categories is reduced by 20% in this scenario and the baseline, continuous grazing scenario.	+13.15
6	Identical to Scenario 1, except it assumes that stock displaced from the rested paddocks can be accommodated on other parts of the property during the resting period without placing excessive grazing pressure on those pastures. Cattle are not agisted.	+25.42

Source: Adapted from (MacLeod, et al., 2009).

3.2 Rehabilitation of poor (C) or very poor (D) condition country

Key Points

- Five studies were reviewed which included economic outcomes on rehabilitation of poor or very condition country. Three studies investigated D condition rehabilitation, two investigated C condition rehabilitation.
- Land in poor condition may be rehabilitated through grazing land management practices, such as wet season spelling. Land in very poor condition requires mechanical intervention.
- Cost to rehabilitate land in very poor condition can vary significantly. Reviewed data shows a range of between $14.11/ha and $379.00/ha.
- There are significant time lags between the rehabilitation activity and land condition improvement. Studies suggest up to 14 years is not unreasonable.
- Economic outcomes for rehabilitation of land in very poor (D) condition country vary greatly between landtypes and intervention.
- Modelling shows that using wet season spelling might be an economically viable means of rehabilitating poor condition country if rehabilitation was rapid (<2 years). However, no trials have been undertaken to test the effects on profitability and modelling has been necessarily heuristic.
- No data was presented on the costs of implementing wet season spelling as all studies looked at potential benefits only.

Five studies were reviewed which looked at the economics of rehabilitating land in poor or very condition. All used a gross margin approach. A summary of the studies can be found in Table 10. For the purpose of this review, land in poor condition is classified as land in "C" condition and land in very poor condition is in "D" condition as described under the ABCD land condition framework. Generally, land in "D" condition requires some mechanical intervention while land in "C" condition is thought to conducive to rehabilitation through management practices (Moravek & Hall, 2014).

Table 10: Summary of studies reviewed for rehabilitation of poor or very poor condition country.

Year & Author	Region & Landtype	Publication type	Practice	Economic method	Biophysical method
(Moravek & Hall, 2014)	Burdekin – Loamy Alluvial	Report	Mechanical Intervention	GM	Trial - 2 Replications. Desktop modelling for animal performance.
(Gowen, et al., 2012)	Burdekin & Fitzroy – unspecified landtypes	Report	Mechanical intervention	GM	Case Studies using desktop modelling
(Star, et al., 2011)	Fitzroy – Brigalow Blackbutt, NLIB	Journal Article	Mechanical intervention	GM	Desktop modelling
(MacLeod, et al., 2009)*	Burdekin - Goldfields	Journal Article	Wet Season Spelling	GM	Bio-physical modelling
(Edwards & Star, 2013)	Burdekin – Black Basalt, Goldfields, NLIB, Red Basalt	Report	Wet Season Spelling	GM	Desktop modelling

The first study trialled and compared three mechanical interventions on the Loamy Alluvial landtype in the Burdekin Catchment at the Spyglass Research Facility (Moravek & Hall, 2014). The interventions were deep ripping, chisel ploughing and crocodile seeding. Each treatment incurred different costs to implement and resulted in different success rates of rehabilitation, as measured by pasture yield (Table 11). While the trial continued for 3 years, the economic modelling used a 20 year investment horizon. The results show that with increased costs came improved pasture yield responses and economically, each intervention returned an equivalent internal rate of return of around 4.3% to 4.5%. This meant that at a discount rate of 5%, no intervention was profitable. The study also concluded that an incentive between 50 and 51% of upfront intervention capital costs would allow the project to break even. The study did not model sediment saving/loss or report on water quality outcomes.

Table 11: Summary of input costs, pasture yield and economic results from (Moravek & Hall, 2014).

Treatment	Total cost ($/ha)	Average pasture yield (kg dry matter / ha)	Internal Rate of Return
Deep Ripping	260.85	3091	4.36%
Chisel Ploughing	210.85	2499	4.55%
Crocodile Seeding	150.85	1633	4.37%

Another study which used a case study approach showed that the economic outcomes of mechanical intervention can be variable, depending on seasons, intervention used and time for rehabilitation (Gowen, et al., 2012). The study looked at six case study properties and used site specific costs along with general desktop economic analysis to determine the economic outcomes of mechanical interventions. The study used a discount rate of 6% and a 20 year investment horizon. All case studies involved the rehabilitation of land in “D” condition. Landtype was not specified. The results show positive economic returns for three of the six case studies (Table 12). The study did not model sediment saving/loss or report on water quality outcomes.

Table 12: Summary of key parameters and economic outcomes from (Gowen, et al., 2012).

Case Study	Location	Total Cost ($/ha)	Treatment	Ending Condition	Time to Rehabilitate	Net Present Value ($/ha)
1	Fitzroy	14.11	Aerial seeding	C	<1 year	75.44
2	Fitzroy	155.86	Deep ripping	B	6 years	152.86
3	Fitzroy	379.01	Deep ripping	B	4 years	-164.04
4	Burdekin	138.54	Blade plough	B	3 years	-23.16
5	Burdekin	144.00	Stick rake	B	8 years	-59.33
6	Burdekin	152.00	Divoting	B	4 years	32.06

Mechanical intervention has also proven to have variable economic outcomes when analysed through modelling (Star, et al., 2011). In the study, cost-benefit analysis of the rehabilitation of two landtypes in the Fitzroy basin was performed. The key parameters and outcomes can be seen in Table 13. The results here show a scenario of 200 hectares degraded in a 1000 hectare paddock and included deep ripping and stock exclusion of the degraded area. The investment analysis assumed a regeneration from “D” condition to “B” condition over an unclear timeframe, a discount rate of 6% and an investment horizon of 20 years. The results show that the more fertile Brigalow Blackbutt had a benefit-cost ratio (BCR) of 2.71, while the less fertile NLIB landtype did not have a positive outcome, with a BCR of 0.81. The study did not model sediment saving/loss or report on water quality outcomes.

Table 13: Summary of key parameters and economic outcomes from (Star, et al., 2011).

Landtype	Method	Total Costs ($/ha)	NPV ($/ha)	Benefit-Cost Ratio
Brigalow Blackbutt	Deep ripping	236*	45.05*	2.71*
Narrowleaved Ironbark	Deep ripping	236*	0.74	0.81*

While mechanical intervention is required to for rehabilitation land in very poor (D) condition, it is thought that land in poor (C) condition is conducive to rehabilitation through variation in stocking rate or through implementation of wet season spelling. One study performed bio-economic modelling using heuristic data to investigate the potential economic outcomes of rehabilitation using wet season spelling (MacLeod, et al., 2009). The study was reviewed in section 3.3 above, where a description of the scenarios and the economic results can be found in Table 9.

Other modelling has also established that wet season spelling could be an economically desirable method of rehabilitating land in C condition. A desktop study for four land types of the Burdekin catchment has shown that if rehabilitation can occur within two years, it is an economically viable option when analysed over 10 years with a discount rate of 6% (Edwards & Star, 2013). The study also suggested if the rehabilitation takes more than four years, it is unlikely to be viable, however, data was not presented. Key parameters and economic outcomes of the study can be seen in Table 14.

Table 14: Summary of key parameters and economic outcomes from (Edwards & Star, 2013).

Landtype	NLIB	Red Basalt	Goldfields	Black Basalt
NPV ($/ha)	16.80	16.03	20.16	21.84

3.3 Management of Selectively Grazed landtypes

Key Points

- Four practices are suggested to manage selectively grazed landtypes. These are, fencing to landtype, wet season spelling, supplementary feed sites and waters, and using fire.

- There are no published studies which include an economic analysis of using any of the four practices to manage selectively grazed landtypes.

The Department of Agriculture and Fisheries (DAF) suggests there are four ways to distribute grazing pressure evenly across landtypes to avoid selective grazing (Department of Agriculture and Fisheries, 2016). They are:

- Fencing to landtype
- Wet season spelling
- Supplementary feed sites and water points
- Using fire.

For a discussion of wet season spelling, refer to sections 3.3 and 3.4 above. It should be noted that the papers discussed in those sections do not specifically address management of selectively grazed areas. Furthermore, they assume average utilisation across the property (Ash, et al., 2002) (Star, et al., 2013) and are therefore not relevant for inclusion in this section, however, the same learnings apply to the rehabilitation of degraded lands, due to selective grazing, as apply in sections 3.3 and 3.4 above.

There are no published studies which include an economic and/or water quality outcome of using any of the four practices to manage selectively grazed landtypes in the Fitzroy and Burdekin catchments. Furthermore, there appears to be no literature from Australia of the practices, with respect to managing selectively grazed landtypes, which include an economic and water quality outcome.

A small discussion about this section and the practices can be found in Appendix A. However, for an in-depth discussion of these management practices, rationale for their use and effect on other business areas (such as property development) it is recommended that the report "*Enhancing adoption of improved grazing and fire management practices in northern Australia: Synthesis of research and identification of best bet management guidelines* (McIvor, 2010) be referred to. The report contains a synthesis of evidence from on these practices, largely unrelated to management of selective grazing and the economic outcome of use, from areas around Australia. The report, however, contains no quantified economic or water quality benefit analysis regarding these practices.

3.4 Riparian and wetland area management

Key Points

- Three practices are suggested to manage riparian and wetland area management. These are, riparian fencing, off-stream supplementary feed sites and off-stream water points.
- There are no published studies which include an economic analysis of using any of the three practices to manage riparian and wetland areas.

There are three main practices which are suggested to manage riparian and wetland areas (Department of Agriculture and Fisheries , 2016). These are:

- Fencing,
- strategically placing off-stream water points; and
- Supplementary feed sites.

No published literature which include an economic analysis of implementing riparian fencing, off-stream water points and/or supplementary feeding sites was available for review.

3.5 Rehabilitation of Gullied Areas

Key Points

- Three studies were reviewed which had economic outcomes of rehabilitation of gullies.
- Four practices are recommended for rehabilitation of gullies. Broadly these are, fencing, revegetation, earth works and stock control. It is likely a combination of these practices are required for successful gully rehabilitation.
- Landholder returns on gully rehabilitation are assumed to be negative, nil or very small.
- Sediment reductions from rehabilitation activities range from 10% to 70%.
- Case studies found that the cost of rehabilitation for individual gullies ranged from $7500 to $150,000 per gully and cost per tonne of sediment reduction ranged from $73/tonne/annum to over $5000/tonne/annum.

There are a combination of techniques available for the rehabilitation of gullied areas as described by recent research (Wilkinson, et al., 2015). These are:

- Fence around gullies to restrict the magnitude of livestock grazing pressure and control the timing of any occasional grazing
- Revegetate the gully channel by trapping fine sediment and see with small porous check dams or larger engineered structures.
- Revegetate gully features with native perennial tussock grasses, where they will not return naturally
- Manage grazing pressure and timing in surrounding catchment areas to maintain or restore biomass. Avoid vegetation clearing except weeds.

Three studies which include an economic component on rehabilitation of gullied areas have been reviewed. It should be noted that in the case of gullies, landholder returns are assumed to negative, nil (NQ Dry Tropics, 2016) or very small (Wilkinson, et al., 2015). Therefore, most studies have focused on the cost only.

Table 15: Summary of studies reviewed for rehabilitation of gullied areas.

Year & Author	Region & Landtype	Publication type	Practice	Economic method
(Wilkinson, et al., 2015)	All catchments – all landtypes	Report	Several (see Table 16)	Costs only
(Rust & Star, 2016)	Fitzroy – unspecified landtypes	Conference proceedings	Several (see	Costs only – Case Study
(NQ Dry Tropics, 2016)	Burdekin – Blackwood on structured clay	Case Study	Diversion bank construction	Costs only – Case Study

A desktop analysis estimated the cost of implementing a combination of all gully rehabilitation practices at between $4500 and $9000 per kilometer of gully and/or up to $50,000 per gully, depending on rehabilitation technique (Wilkinson, et al., 2015). A description of techniques, costs and sediment saving estimates can be seen in Table 16. The analysis estimated that, if only priority areas in the GBR catchments were rehabilitated, the cost per tonne of sediment reduction ranges between $81 and $217. The study did not investigate private landholder returns of rehabilitation but noted that the returns are likely to be small.

Table 16: Description of gully rehabilitation practices, costs and sediment reductions, adapted from (Wilkinson, et al., 2015).

Practice	Cost ($)	Sediment reduction
1. Destock gullied paddock	0*	10 – 20%
2. Fence Gullied Area	5000/km	30%
3. Practice 2 plus stabilisation using stick trapping or other vegetation	9000/km	50%
4. Practice 3 plus hydroseeding	9000/km + up to 30,000/ha for seeding	70%
5. Practice 2 plus gully reshaping earthworks or rock drop structures	40,000 - 60,000 per gully head	70%

*assumed a net private benefit of sustainable management practices being used in the paddock.

The cost effectiveness of rehabilitating gullied areas has also been demonstrated through a number of case studies. Case studies in the Fitzroy and Burdekin catchments show that both total costs and costs per tonne of annual sediment reduction varies greatly depending on treatment and estimated annual gully growth (Table 17) (Rust & Star, 2016) (NQ Dry Tropics, 2016).

Table 17: Costs effectiveness estimates for gully remediation in the Burdekin and Fitzroy catchments

Case Study	Practice	Cost ($)	Sediment Savings (tonnes / annum)	Cost / tonne of sediment / annum ($)
Burdekin*	Diversion bank, leaky dam	7500	80*	94
Burdekin*	Diversion bank, gully head reshaping, fencing,	22,620	4.5*	5026
Burdekin*	Whoa boys	23,560	130	181
Fitzroy	Gully head reshaping, diversion bank, fencing, pervious weir	49, 433	259**	191
Fitzroy	Whoa boys, diversion banks, silt trap, chutes, fencing	57,676	794**	73
Fitzroy	Silt trap, stick rake, diversion banks, gully head reshaping, whoa boys, rock chute, fencing	81,727	1069**	76
Fitzroy	Gully head reshaping, rock chute, diversion banks, alternative watering point, stick rake, fencing	109,311	164**	666
Fitzroy	Diversion bank, Swales, fencing	58,818	495**	119
Fitzroy	Diversion bank, gully head reshaping, stick rake, whoa boys, fencing	151,402	410**	369

*figures adjusted from 20 year amounts to annual amounts.
**figures adjusted from m^3 to tonnes.

Sources: Burdekin (NQ Dry Tropics, 2016) Fitzroy (Rust & Star, 2016).

4 Information gaps, and potential future work, in the cost effectiveness and profitability of priority management practices

The following sub-sections identify the information gaps in economic data and outcomes of the priority management practices. From these gaps, the highest priority work for economic validations, under Action 4 is the following:

- Demonstrate the rehabilitation of land in poor condition using stocking rates or wet season spelling to provide biophysical data for use in bio-economic modelling.
- Determine the whole-of-business impact of the adoption of both best management practice programs and the specific management practices related to the water quality framework, including detailed consideration of the implementation phase on business outcomes.
- Investigate the economic impacts of the four practices recommended for management of riparian and wetland area management. There is an opportunity to review previous on-ground work such as the Natural Heritage Trust (NHT) and Reef Rescue programs.
- Collaborate with gully rehabilitation trials to collect bio-physical data to inform bio-economic modelling of gully rehabilitation.

It should be noted that this work will require collaboration with project partners and other professional technical expertise to achieve economic analysis with high levels of confidence in the outcome.

4.1 Stocking rates, wet season spelling and ground cover management.

The major economic information gap/s, identified by the review, regarding these management practices, were:

- Only one of the studies reviewed (Ash, et al., 2002) provided economic analysis for *changing* management practice. The other reviewed studies calculated economic outcomes of operating grazing systems *at* different stocking rates. Due to this, no inference can be made as to whether changing from one grazing system to another is profitable.
- No studies identified the capital costs of change. Furthermore, no studies gave guidelines on how to implement these practices which might assist in identification of the capital costs of change.
- Only one physical trial exists (O'Reagain & Bushell, 2011) which is able to provide data on animal production differences of alternative grazing management systems to inform economic analysis of wet season spelling or different stocking rate regimes. However, this data is limited to steers and only covers a few landtypes.
- No study analysed these practices, or the implementation of practices, in a whole-of-business context.
- No studies explicitly linked ground cover to profitability. There may be opportunity to use ground cover data from the Wambiana Grazing Trial (O'Reagain, 2011) to investigate this relationship.

4.2 Rehabilitation of poor (C) or very poor (D) condition country

The major economic information gap/s, identified by the review, regarding practices which rehabilitate poor or very poor condition country, were:

- No trials exists demonstrating the effectiveness of wet season spelling for improving poor condition country. Furthermore, no bio-physical data is available regarding time-lengths required for wet season spelling to rehabilitate land in poor condition.
- Economic evidence which does exist for wet season spelling uses heuristic data (MacLeod, et al., 2009).
- No studies reviewed presented capital costs for implementing wet season spelling.
- No studies analysed rehabilitation practices, or the implementation of those practices, in a whole-of-business context.

4.3 Management of Selectively Grazed landtypes

The major economic information gap/s, identified by this review, regarding management of selectively grazed landtypes, were:

- For gaps on wet season spelling, see sections 4.1and 4.2). Those gaps also apply here, but with respect to management of selectively grazed landtypes.
- No other published studies were available for the other management practices, therefore, all other economic outcomes of those practices remain a gap.
- There is an opportunity to review, through a case study process, landtype fencing and water point distribution of previous Reef Rescue on ground funding.

4.4 Riparian and wetland area management.

The major economic information gap/s, identified by this review, regarding management practices of riparian and wetland areas, were:

- No published studies were available for the management practices as they relate to riparian and wetland area management, therefore, all economic outcomes of these practices remain a gap.
- There is an opportunity to review previous on ground work, such as the Natural Heritage Trust (NHT) and Reef Rescue programs, which have funded practices such as riparian fencing and off-stream watering points.

4.5 Rehabilitation of Gullied Areas

The major economic information gap/s, identified by this review, regarding management practices which rehabilitate gullied areas, were:

- No economic analysis exists of trials which rehabilitate gullies. Therefore, most analysis reviewed in this report used very broad estimate, likely subject to large variations, to estimate sediment loss.

- There is a distinct lack of trials which rehabilitate gullies and have measured sediment reductions to inform biophysical data to bio-economic modelling.

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6 Appendix A

6.1 Description of cattle enterprises and herd performance in the Burdekin and Fitzroy Catchments

The following table is taken from a recent survey done in the Burdekin and Fitzroy catchments (Barbi, et al., 2016). It describes the key attributes, herd performance and adoption levels of management practices currently in use on grazing enterprises in the Burdekin and Fitzroy catchments.

Table 18: A description of cattle enterprises, herd performance and current level of management practice adoption in the Burdekin and Fitzroy catchments.

Factor	Burdekin	Fitzroy
Median property area (ha)	22,300	7,100
Median herd size (head of cattle)	3,650	1,800
Percentage of enterprises with breeding herd	90%	85%
Enterprises where cattle are largely sold direct to abattoir	59%	56%
Enterprises where cattle are largely sold as stores	29%	29%
Target Jap Ox production with steers	55%	55%
Target domestic market with surplus heifers	62%	62%
Target American market with surplus cows	81%	81%
Carcase weight of steers sent to abattoirs	340 kg	346 kg
Carcase weight of heifers sent to abattoirs	268 kg	278 kg
Carcase weight of cull cows sent to abattoirs	275 kg	315 kg
Age in months slaughter steers	35	31
Percentage female sales	44%	44%
Percentage male sales	56%	56%
Average annual sales of males (number)	636	503
Average annual sales of females (number)	522	292
Weaning weight range (poor season to good season)	128 to 176 kg	166 to 221 kg
Weaning percentage – replacement heifers	60%(2011) 66% (2012)	77%(2011) 80% (2012)
Weaning percentage – first calf heifers	69%(2011) 55% (2012)	70%(2011) 70% (2012)
Weaning percentage – breeders	70%(2011) 71% (2012)	84%(2011) 85% (2012)
Weaning percentage – breeders not segregated by age	50% (2011) 66% (2012)	80%(2011) 85% (2012)
Percentage enterprises who segregate heifers	95%	80%
Percentage heifers first joined > 18 months	80%	50%

Factor	Burdekin	Fitzroy
Continuous mating - mature breeders	47%	32%
Continuous mating - maiden heifers	30%	25%
Continuous mating - first lactation heifers	46%	32%
Pregnancy testing not used	14%	17%
Bull soundness examination used	57%	61%
Bull joining percentage	3.4%	3.2%
Use of EBV's when selecting bulls	53%	42%
Health treatment weaners – botulism	44%	16%
Health treatment weaners – 5 in 1	31%	53%
Health treatment weaners – 7 in 1	26%	26%
Health treatment weaners – Leptospirosis	2%	5%
Health treatment weaners – Pestivirus	0%	3%
Health treatment weaners – Tick fever	19%	28%
Vibriosis for bulls	28%	35%
3 day fever for bulls	7%	17%
Supplements fed	87%	94%
Supplement cost	$18 per head	$17 per head
Foetal aging used for management	16%	17%
Individual animal data recorded	30%	46%
Number of times stock handled per annum	2-4	4-5

Source: (Barbi, et al., 2016)

6.2 Stocking rates, groundcover and land condition management

Stocking Rate is defined as the number of stock (in Adult Equivalents, AE) per unit of area at a particular time (Chilcott, et al., 2005). The stocking rate describes the relationship between livestock and the forage resource. Higher stocking rates increase pasture utilization and grazing pressure and hence increase the risk of ground cover and land condition loss.

Ground cover is the non-woody vegetation (forbs, grasses and herbs), litter, cryptogrammic crusts and rock in contact with the soil surface. The quantity of ground cover present can have significant influence on pasture productivity, infiltration and runoff, therefore, ground cover maintenance is an effective action for minimising the impacts of wind and water erosion (Cork, et al., 2012). Due to these ecosystem benefits of ground cover, it is an important factor in maintaining and improving land condition (Karfs, et al., 2009).

Land condition is defined as the capacity of land to respond to rain, produce useful forage and is a measure of how well the grazing ecosystem is functioning (Chilcott, et al., 2005). Land condition has a significant impact on plant growth and animal production (Ash, et al., 1995), thus on the productivity of the grazing industry. The ABCD land condition framework (Chilcott, et al., 2005) classifies land conditions through pasture species composition, weeds, woodland thickening, bare ground and soil composition. Extreme grazing pressure on rangelands can deteriorate land condition with severe consequences for the future productivity of the industry (MacLeod & McIvor, 2007).

6.3 Using Landtype fencing, supplementary feed sites and water points to manage selectively grazed areas.

Landtype fencing, supplementary feed sites and watering point distribution has been suggested as mechanisms to improve management of selective grazing (Department of Agriculture and Fisheries, 2016). In a review of best bet management guidelines McIvor (2010) suggested the cause and the rationale for developing paddocks and watering points includes:

Causes of selective grazing

- the location of water points
- the location of preferred (or conversely non-preferred) plant species or communities
- the tendency for livestock to revisit previously grazed patches to consume nutritious regrowth (patch grazing)
- land condition
- soil texture
- soil fertility
- landscape features (riparian zones, hills, roads, creeks)
- weather/climatic conditions
- the location of feed supplements
- fire (especially when patchy)
- behavioural characteristics of different animals

Potential solutions

- Smaller paddocks and more water points can improve the effectiveness of pasture utilisation by making poorly utilised areas available, potentially allowing more stock to be carried and increasing total livestock production;
- Smaller paddocks and more water points may slow the expansion of heavily grazed areas within paddocks that are subject to degradation;
- Fences and water points can help to protect sensitive areas or different land types;
- Increasing the number of smaller paddocks facilitates the use of other management options and in some circumstances may reduce operating costs.

Source: (McIvor, 2010)

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