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Technical Report

Land regeneration in rangelands grazing:
exploring the economic implications
RRRD039



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Land regeneration in rangelands grazing: exploring the economic implications (RRRD039)

*An output of RRRD39: Integrated assessment of BMP cost-effectiveness and
decision tool for regions and landholders*

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Acronyms

GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
NRM	Natural Resource Management
QDAFF	Queensland Department of Agriculture, Fisheries and Forestry
RRRC	Reef and Rainforest Research Centre Limited
RRRD	Reef Rescue Research & Development

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Executive Summary

The impact of excessive sediment loads entering into the Great Barrier Reef lagoon from terrestrial runoff has led to increased awareness of improving land condition in extensive grazing lands. Improved ground cover and land condition have been identified as two important factors in reducing sediment loads. However there is currently limited information regarding the economic implications for landholders to adopt practices that influence these factors.

This report explores the economic viability of regenerating land using wet season spelling for four land types in the Burdekin and Herbert catchments, from land that was classified “C” condition to “B” condition in accordance with the ABCD land condition framework. A partial budget analysis was employed to estimate the private benefits and costs of land regeneration using wet season spelling over ten and twenty year periods. The land types selected were Black basalt, Goldfields, Narrow-leaved ironbark, and Red basalt. Due to the locations where each land type was modelled and the subsequent rainfall, the regeneration time period for all land types was estimated to be two years. Sensitivity testing was conducted to consider the effect of extending the required spelling time, as well as increasing and decreasing the discount rate and price used in the analysis.

The results demonstrate that if wet season spelling for two years can regenerate land condition to “B” condition, investing in land regeneration is profitable, on each of the four modelled land types. In general, land regeneration is more profitable for large areas of land, and when analysed over longer time periods. On the other hand, land regeneration is less profitable for smaller properties, for poorer land types, and when longer periods of wet season spelling are required to regenerate land condition.

The results provide insights into targeting sediment reductions and the implications for policy and programs, with education and extension able to be focused towards landholders with more productive land types and large property sizes with large areas to be regenerated. Financial incentives are likely to be required for smaller properties and those with small areas requiring regeneration.

These results focus on the investment in land regeneration, without taking cash flow implications into consideration. These cash flow implications at the beginning of a land regeneration project may be substantial, and may hinder landholders from regenerating land, even when the investment is expected to yield a positive return. Therefore, incentives may still be required to target sediment reductions even when there are private benefits to landholders from the land regeneration.

1. Introduction

The impact of pollutant sediment from grazing lands entering the Great Barrier Reef (GBR) lagoon resulted in the development of the Reef Water Quality Protection Plan (2009). The goal of the plan was to halt and reverse the decline of water quality entering the reef. To achieve this goal a number of water quality and land condition targets and management actions were developed. In 2008, the Australian federal government announced the Reef Rescue incentives program which provided financial incentives for landholders to make on-ground changes. For graziers, these on-ground changes include: pasture monitoring, riparian and gully fencing, land type fencing, installation of off-stream watering points, improvement of nutrient and chemical application methods, riparian management, and improvement of grazing land condition. Reef Rescue promotes change a faster rate of change and provides incentives where there had been little or no short-term private benefit for the landholder to make the change (Waterhouse *et al.*, 2012).

Sediment runoff increases sharply as ground cover and land condition declines (Karfs *et al.*, 2009). Improved land condition has therefore been a focal point for investment funding. A simple classification for assessing land condition is the ABCD framework, which classifies land according to pasture species, ground cover, soil surface condition and tree thickening (Chilcott *et al.*, 2003). “A” condition is considered land in good condition, through to “D” condition which is representative of land in poor condition. A key deficiency in increasing adoption has been the lack of understanding regarding the private benefits and costs of land regeneration.

The Burdekin river catchment covers 133,432 km² and is the second largest catchment draining into the GBR (Canstar, 2012). The dominant land use in the Burdekin basin is extensive rangelands grazing which comprises approximately 80 per cent of the land area (Karfs *et al.*, 2009). The Herbert catchment is 9,843 km² of which 7,330 km² is used for extensive grazing. Catchments with high levels of clearing for cattle grazing and cropping show the largest increases in sediment exported to the GBR compared with natural conditions (McKergow *et al.*, 2005). Fentie *et al.* (2006) also recognised that increased ground cover and improved land condition can prevent excessive amounts of sediments entering streams and rivers.

The Burdekin region includes approximately 91 different land types defined by their soil, vegetation and topographic characteristics (Dougall *et al.*, 2008). With such heterogeneity between land types regarding soil characteristics, land productivity and slope, the quantity of sediment exported varies significantly throughout the catchment and its land types (Silburn, 2011; Silburn *et al.*, 2011). Recent modelling estimates 4.7 million tonnes of annual suspended sediment is exported from the Burdekin catchment to the GBR lagoon, with almost an estimated 4.1 million tonnes of this attributed to human activity (Queensland Government, 2011).

The Herbert catchment is one of seven catchments that together make up the Wet Tropics region. Sediment loads for the whole Wet Tropics was estimated to be 1.4 million tonnes per year, and 1.1 million tonnes was related to human activity (The State of Queensland (Department of Premier and Cabinet), 2011).

Corals and seagrasses are affected by increases in suspended sediment, nutrient concentrations, and herbicide exposure (Haynes *et al.*, 2007). Increased sediment loads impact corals through physiological changes from smothering when particles settle out, and by decreasing light

availability, coral photosynthesis, and growth (Fabricius *et al.*, 2011). This can result in changes to the coral population structure and colony size, and decreased growth and survival (Haynes *et al.*, 2007). Increased sediment loads affect seagrass photosynthesis rates by decreasing the amount of light reaching the plants (Haynes *et al.*, 2007).

One of the actions under the Reef Protection Plan (2009) was the development of best management practices (BMP) for extensive grazing management. Grazing BMP training modules have been developed by AgForce, Queensland Department of Agriculture, Fisheries and Forestry, and the Fitzroy Basin Association. Identifying and managing “C” condition country is noted as critical for preventing its decline into “D” condition. (The State of Queensland (Department of Agriculture Fisheries and Forestry), 2013) details the actions to maintain or improve land condition:

- Setting stocking rates that are guided by the land’s carrying capacity and matched to forage availability, taking into account grazing by native and feral animals.
- Using appropriate grazing systems to enhance the desirable species in the pasture.
- Spelling pastures.
- Managing and/or controlling weeds.
- Matching introduced pasture species to soils and land type.
- Maintaining healthy native grassland on fragile soils.
- Locating waters and fences to ensure even pasture utilisation and minimise overgrazing.

The focus of this report is the economic implications of changed management practices, in particular wet season spelling to improve land condition from “C” condition to “B” condition. This report assesses the economic implications of a short period of wet season spelling to improve land in poor condition over ten and twenty year time frames. The ability to identify and discuss the economic implications associated with regenerating land allows cost effective targeting of future public funding projects and improved understanding of the trade-offs between best practice management, improved land condition and the subsequent financial outcomes for individual landholders.

1.1 Methods

The analysis comprised of three steps. Firstly, a literature review of previous land regeneration studies was undertaken. Secondly, workshops with graziers were held to further understand the practices and time frames for regeneration for various scenarios, followed by consultation with an expert panel. Thirdly, the economic analysis was conducted using a combination of data from the expert panel, grazer workshops, Beef CRC herd templates, and simulated GRASP data.

1.2 Background

The ABCD land condition framework has been developed as a simple, qualitative method of classifying land condition based on pasture species composition, weeds, woodland thickening, bare ground, and soil surface condition (Chilcott *et al.*, 2005). “A” condition land is described as good coverage of palatable, productive and perennial pasture species, less than 30 per cent bare ground in most years and few weeds, good soil condition with no surface erosion and no woodland

thickening. At the other end of the scale, “D” condition land has a general lack of any perennial pasture species, severe erosion or scalding resulting in a hostile environment for plant growth, severe erosion, and thickets of woody plants which cover most of the area. “B” and “C” condition land lie between these extremes. The ABCD framework is detailed in Table 1.

Table 1. ABCD framework used for classifying grazing lands in the GBR catchments.

	Perennial grasses: palatable, productive and perennial (3P)	Bare ground	Weeds	Soil condition	Woodland thickening
A	Good coverage	Less than 30% in most years	Few weeds and no significant infestations	Good, no erosion, good surface condition	No sign, or only early signs
B	Some decline in 3P grasses and increase in other less favoured species	More than 30% but less than 60% in most years	Increase in less favoured grasses or weeds	Some decline, some signs of previous erosion and current signs of erosion	Some thickening in density of woody plants
C	General decline of 3P grasses, large amounts of less favoured species	Greater than 60% in most years	Large amounts of less favoured species	Obvious signs of past erosion and/or susceptibility currently high	General thickening of woody plants
D	General lack of any perennial grasses or forbs			Severe erosion or scalding resulting in hostile environment for plant growth	Thickets of woody plants cover most of the area

Existing work on land regeneration is site specific and has focused on regeneration from “D” condition to “B” condition, and “C” condition to “B” condition (Star and Donaghy, 2009; Star and Donaghy, 2010; Star *et al.*, 2011). A key learning from this work has been that regeneration from “C” to “B” land condition often provides a positive return for the landholder (without external financial assistance) even for less productive land types. Similarly, modelling has illustrated that there is a significantly larger marginal reduction in sediments from improved land condition from “C” to “B” condition relative to land condition improvements from “B” to “A” condition (Star and Donaghy, 2009; Star and Donaghy, 2010; Star *et al.*, 2011).

The importance of understanding sustainable grazing thresholds in Northern Australian ecosystems and their impact on carrying capacity of various pasture species is highlighted by (Ash and Smith, 2003) and (Ash *et al.*, 2011). Grazing land must be able to support profitable animal production systems, and good land condition requires the maintenance of ecosystem processes such as water and nutrient cycling (Karfs *et al.*, 2009). The ABCD framework is focused on grazing land and so land condition is defined in terms of changes in pasture composition and associated ecological

responses. Understanding land condition not only helps to understand the land's potential, but is also important for deciding when to alter stocking rates, implement spelling, or modify infrastructure to minimise damage to degraded areas (Karfs *et al.*, 2009). Improvements to land condition are likely to improve the productive capacity of the land for grazing (Ash *et al.*, 2011), and simultaneously, improved land condition and ground cover result in decreased sediment run-off (Ash *et al.*, 1995).

Rangelands are complex ecosystems which vary significantly depending on variables such as: characteristics of the land type, rainfall, and land type resilience. Research discussed below strongly demonstrates that stocking rates and grazing strategies play a major role in the resulting land condition, and in the prevention of land degradation. These studies also reflect the heterogeneity of land types in Queensland and the wide variety of challenges that landholders face with regard to land degradation and land. Some of these studies have found rainfall to be the key determinant of land and pasture regeneration, while others have found stocking rates more important. Others have found a combination of wet season spelling and rainfall to be critical to land regeneration. Due to the complex rangeland ecosystem being analysed, rainfall, stocking rate and wet season spelling are all important factors to be considered in any land regeneration strategy.

One long-term rangeland grazing trial has investigated the impact of different stocking strategies on land condition, animal production and economic performance (O'Reagain *et al.*, 2009; O'Reagain *et al.*, 2011). The study concluded that a heavy stocking rate reduced live weight gain per head, and also increased costs of drought feeding and management costs in low rainfall years (O'Reagain *et al.*, 2009). (O'Reagain *et al.*, 2011) challenged the assumption that sustainable management is not profitable, and provides long-term empirical evidence to show that recommended grazing strategies such as moderate or variable stocking can be just as, if not considerably more, profitable than heavy stocking. The same trial also highlights rainfall variability as having a major impact on the dynamics of shorter-lived perennial grass species, and the impact of grazing on longer-lived perennial grass species, particularly when accentuated by drought (Orr and O'Reagain, 2011).

In a shorter term project, Orr *et al.*, (2006) researched the recovery of pasture after drought and the composition of pasture species. The study explored recovery of pasture following drought back to good pasture condition, defined as high yields and basal area of desirable perennial grasses. The results indicated that pasture condition will not improve following drought simply by excluding stock for short periods of time (of up to 12 months), especially during winter and in years when rainfall is average or below. Orr *et al.*, (2006) concluded that rainfall was a significant variable in pasture recovery.

Another longer-term extensive grazing study was designed to measure the effects of stocking rate on native black speargrass pasture (Orr *et al.*, 2010) as well as influences of over-sowing with legumes and spring burning. This study found that annual pasture utilisation rates greater than 30% were unsustainable because they reduced total yield and resulted in undesirable changes in species composition (Orr *et al.*, 2010).

Spelling during the wet season (from the first sufficient rainfall for new growth in 3P pastures) can improve land condition over time (McIvor, 2012). By completely destocking the paddock during the growing season 3P pastures have time to grow leaf canopy, rebuild root reserves and produce seed.

In order for this strategy to be effective, wet season spelling needs to be coupled with safe pasture utilisation levels i.e. stocking at long term carrying capacity (McIvor, 2012). For example, simulation modelling demonstrated that wet season spelling on poor condition Goldfields country in the Burdekin, when coupled with safe utilisation rates, improved land condition in cases where in the absence of wet season spelling, there would be little improvement (McIvor, 2012). The frequency and duration of wet season spelling required will be largely driven by seasonal conditions and land condition. (McIvor, 2012) noted that land in poor condition will require a minimum of eight weeks spelling in normal seasonal conditions and preferably, for the whole growing season in below average rainfall conditions.

The ECOGRAZE project was conducted in the Burdekin catchment to demonstrate the impacts of different pasture utilisation, wet season spelling, fire and rainfall on land condition at four sites in open eucalypt woodlands in the Burdekin catchment (Ash *et al.*, 2002). The research was conducted over eight years and demonstrated that grazing management in terms of utilisation rate and spelling is the key variable affecting land condition, although rainfall is also important (Ash *et al.*, 2011).

1.3 Selection of land types and locations

Considering the heterogeneity both with climate and the biophysical parameters that exists in the Burdekin Basin and Herbert catchment, grazer workshops and a technical panel was formed. Discussions during the grazer workshops provided insight into preferred methods of land regeneration, with 70 per cent of participants preferring wet season spelling as the best management technique for land regeneration. A technical panel was also formed in order to select the land types for the analysis. The panel considered the percentage of the land type within the catchments, increasing bare ground, a range of productive capacities, varying climate, and consideration of work that is being completed through other reef related research. The technical panel consisted of:

- Department of Agriculture, Fisheries and Forestry, Queensland
 - Bob Shepherd - Senior Extension Officer
 - Mick Sullivan - Senior Extension Officer
 - Dr Terry Beutel - Senior Scientist
- Department of Natural Resources and Mines, Queensland
 - George Bourne - Senior Natural Resource Management Officer
 - Dr Mark Silburn - Principal Scientist
 - Cameron Dougall - Natural Resource Management Officer
 - Peter Donaghy - Regional Director of Mines, Central (formerly Manager, Strategic Projects and Planning, DAFF)
- NQ Dry Tropics
 - Dr Ian Dight - Planning and Integration Manager
 - Dianne O'Donnell - Project Manager
- Fitzroy Basin Association
 - Rachel Bryan - Healthy Waterways Coordinator

Based on the abovementioned parameters, consultation with the technical panel and consideration of previous work, the four land types that were selected were Narrow-leaved ironbark on deeper soils, Black basalt, Red basalt and Goldfields.

The Narrow-leaved ironbark land type can be described as undulating duplex plains, or deep red earth tablelands. The vegetation is narrow leaved ironbark in association with box, bloodwoods, silver leaved ironbark, lemon scented gum, poplar gum and ghost gum woodlands. The soil can be described as red or yellow earths or duplex, with the preferred species being black spear grass, kangaroo grass, desert bluegrass grass, hairy panic, and forest blue grass (Whish, 2011).

Black basalt can be described as level, to gently undulating plains. The woody vegetation that is typical includes treeless grass plains with scattered black tea-tree, or open mountain coolabah or bloodwood woodlands. Generally there is no understorey. The soil is described as self-mulching cracking clays, with variable surface stone cover. The preferred pasture species includes Queensland bluegrass, curly bluegrass, black spear grass, curly and hoop Mitchell grass and tall cup grass (Whish, 2011).

Red basalt can be described as level to gently undulating plains. With the woody vegetation consisting of narrow-leaved ironbark open woodland associated with ghost gums, bloodwood and grevilleas. The preferred pasture species includes desert bluegrass, black spear grass, kangaroo grass, curly bluegrass, giant spear grass, plume and brown sorghum. The soil is generally shallow, reddish brown clay loam grading to light clay (Whish, 2011).

Goldfields country can be described as gently undulating to undulating rises. The woody vegetation is narrow leaved ironbark and gum topped bloodwood woodland with occasional forest red gum and Reid river box along drainage lines. The preferred pasture species includes desert blue grass, forest blue grass, curly blue grass, cotton panic, black spear grass, and kangaroo grass. The soil can be described as brown loam over red clay duplex soil (Whish, 2011).

Climate was identified as a key driver of pasture production, therefore a range of locations varying in annual rainfall were selected by the technical panel (Table 2).

Table 2 Land type, GPS co-ordinates, and average annual rainfall.

Land type	GPS co-ordinates	Average annual rainfall (mm)
Black basalt	-19.5000 145.5000	640
Goldfields	-20.1500 145.5500	644
Narrow-leaved ironbark	-17.7000 154.1000	801
Red basalt	-17.9500 145.5500	748

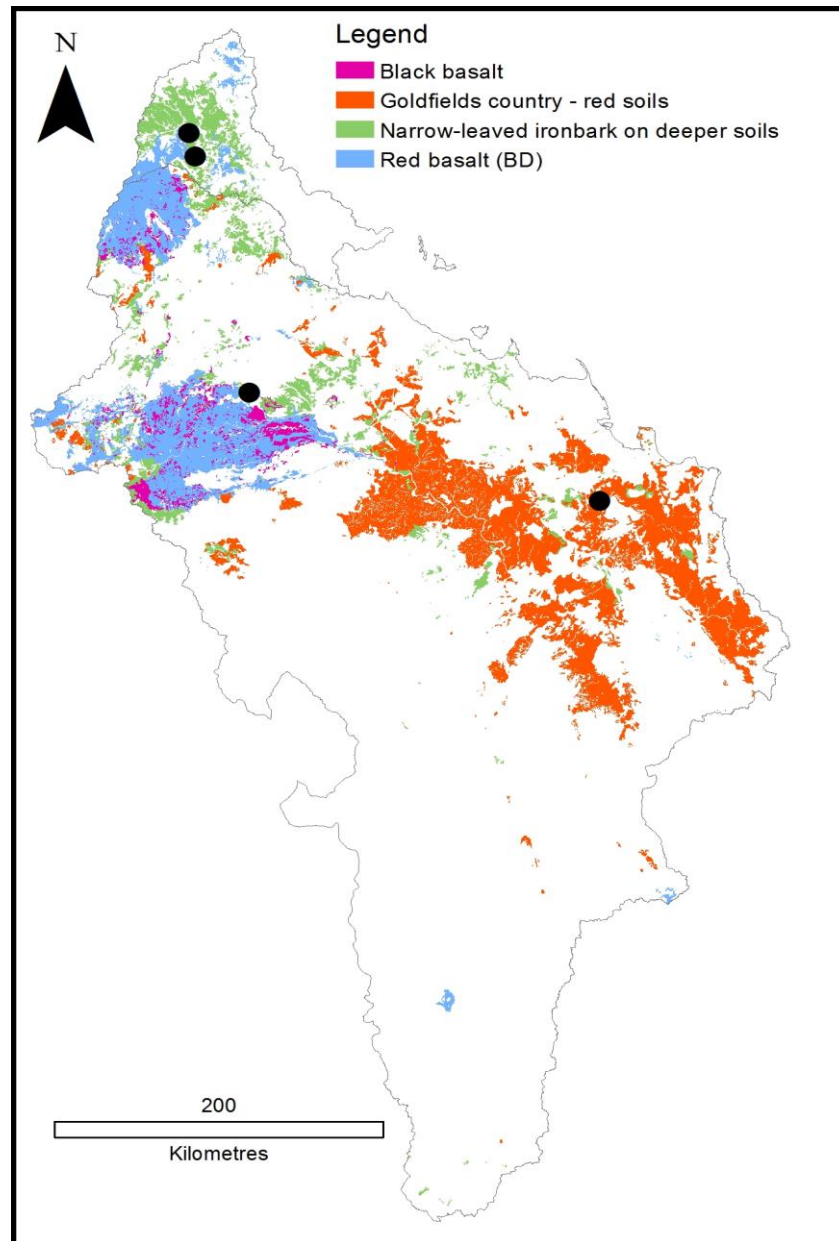


Figure 1 Selected land types and study sites for modelling in Burdekin and Herbert catchments.

1.4 Parameters for analysis

Carrying Capacities

The change in productive capacity as the land condition regenerates was estimated using an improvement in the carrying capacity (hectares per adult equivalent (AE)). The long term carrying capacities considered the land types inherit productivity, resilience and climate. Estimates of carrying capacities for both cleared or tree basal area (TBA) was considered using the average tree basal area for the respective land types. The carrying capacities for each land type were generated using GRASP (Littleboy and McKeon, 1997).

Table 3 Black Basalt carrying capacity.

Black Basalt		
Carrying Capacity (ha/AE)	TBA of 1.4m ² (ha/AE)	Cleared (ha/AE)
"C" condition	8.3	3.3
"B" condition	6	2.3
"A" condition	1.8	1.6

Table 4 Goldfields carrying capacity.

Goldfields		
Carrying Capacity (ha/AE)	TBA of 3.0 m ² (ha/AE)	Cleared (ha/AE)
"C" condition	11	7
"B" condition	7.1	4.8
"A" condition	4.5	3.2

Table 5 Narrow-leaved Ironbark carrying capacity.

Narrow Leaved Ironbark		
Carrying Capacity (ha/AE)	TBA of 3.5 m ² (ha/AE)	Cleared (ha/AE)
"C" condition	10	7
"B" condition	7	5.3
"A" condition	5.3	3.7

Table 6 Red Basalt carrying capacity.

Red Basalt		
Carrying Capacity (ha/AE)	TBA of 3.9 m ² (ha/AE)	Cleared (ha/AE)
"C" condition	8.3	5.7
"B" condition	6	4.2
"A" condition	4.3	3.1

Matrix of scale scenarios investigated

To understand the impact of scale on the economic viability to regenerate land, three different sized properties were considered (10,000; 20,000 and 40,000 hectares) in conjunction with three different proportions of land to be regenerated (20%, 40% and 60%) on each of the property sizes. Table 7 presents the matrix of scenarios that the economic analysis considers for each of the four land types selected over ten and twenty year investment periods. The table displays the hectares of land in “C” condition to be regenerated in each scenario.

Table 7 Property sizes (ha) and proportion of declined land condition.

Total property area (ha)	10,000	20,000	40,000
20% portion to be regenerated (ha)	2,000	4,000	8,000
40% portion to be regenerated (ha)	4,000	8,000	16,000
60% portion to be regenerated (ha)	6,000	12,000	24,000

Time required to achieve regeneration

The time required and methods to achieve regeneration from “C” condition to “B” condition were estimated using information gained through the grazer workshops, expert opinion of local extension staff, pasture scientists and the literature (Ash *et al.*, 1995; Ash *et al.*, 2002; Orr *et al.*, 2006; Ash *et al.*, 2011). Consideration was given to land type, location, climate and average rainfall. At present, there is no clearly defined length of time required for land regeneration across different land types, and rainfall variability across years complicates setting a standard number of years. Research is continuing to provide further information and expected timeframes for the length of wet season spelling required to improve land condition.

For the lower productivity land types (Narrow-leaved ironbark and Red basalt) combined with their average annual rainfall (Table 2), it was assumed that two years of wet season spelling would enable regeneration from “C” condition to “B” condition land (Ash *et al.*, 2002; Orr *et al.*, 2006). For the higher productivity land types (Goldfields and Black basalt) combined with their slightly lower average annual rainfall (Table 2), it was assumed that two years of wet season spelling would also be sufficient to regenerate land from “C” condition to “B” condition. It is acknowledged that this does not take variability in rainfall between years into account, and sensitivity analysis has been conducted to investigate the economic implications of longer periods of wet season spelling to achieve the improvement in land condition.

Gross Margins

To complete an investment analysis the gross margin per adult equivalent is required. To achieve this, a gross margin for the enterprise and land type was developed, based on the Beef CRC herd templates and local expert opinion. Table 8 displays the enterprise and gross margin per adult equivalent (AE) modelled for each land type in this analysis. The gross margins were then used to undertake an investment analysis to estimate the net present value of regenerating land in “C” condition to “B” condition using the two year wet season spelling strategy. It has been assumed

that cattle are sold when spelling takes place and re-purchased once land is regenerated and that the area of degraded land is completely destocked for the entire regeneration period.

Table 8 Gross Margin (\$) and enterprise for each land type.

Land type	Enterprise	Gross Margin \$ Per AE
Black Basalt	Breed/finishing	172.20
Goldfields	Breed/finishing	134.50
Narrow-leaved Ironbark	Breed/weaners	126.40
Red Basalt	Breed/finishing	134.50

Discount Rate

The benefit of regeneration was estimated in 2012 dollars (as a dollar today is not worth the same in twenty years); the marginal accumulated benefit was discounted at a 6% real discount rate. A real discount rate is without inflation. The current average business loan interest rate is 7.5% (Canstar, 2012), and inflation at 1.5%, giving the calculated 6% real discount rate (Reserve Bank of Australia, 2012).

Table 9 shows the major parameters on which the economic analysis is based.

Table 9 Major analysis parameters.

	Economic Analysis	Sensitivity Testing
Wet season spelling (WSS) required to regenerate	2 years	4 years, 6 years
Discount rate	6%	3%, 12%
Carrying capacity (hectares/AE)	See Tables 3, 4,5,6	N/A
Gross margins	See Table 8	25% above, 25% below

1.5 Economic analysis

An investment analysis allows the landholder to determine if the initial investment has a positive return. The change in annual whole property gross margin over a ten year, and twenty year period is discounted to bring the net benefits of the change into today's dollar terms. This allows the forgone income incurred at the beginning of the investment period to be compared to the stream of benefits over the investment period. The discount rate used in this analysis was six per cent. The aggregated benefits are termed net present value (NPV). If the NPV is a positive number then the investment is a viable investment option and the return is greater than the initial capital expense (or foregone income). If the NPV is negative, it indicates that the discounted marginal gain is not sufficient to cover the initial investment, and is therefore not a viable investment option.

To test the robustness of the results, sensitivity analysis was conducted for the price of beef, the discount rate, and the length of time required for the land to regenerate (Table 9). A 25% increase and decrease in price, an increase in the discount rate to twelve percent and decrease to three per cent, and an extended wet season spelling time period of four and six years were modelled. Only one parameter was changed at any one time, with all other parameters held constant. For example, when sensitivity testing was completed for six years of wet season spelling, the price of beef and the discount rate were not varied and vice versa.

2. Results

The results report the net present value for each of the four land types, over a ten and twenty year investment period, for cleared property (zero tree basal area) and with trees, for each of the three property sizes (10,000, 20,000 and 40,000 hectares) and finally for each proportion of land requiring regeneration (20%, 40% and 60% of the property). Afterward, sensitivity testing of the analysis parameters is reported.

2.1 Narrow-leaved Ironbark

The net present values were positive for all scenarios indicating that regenerating from “C” to “B” condition using two years wet season spelling is a viable investment option over a ten or twenty year period with a six per cent discount rate (see Table 10, Table 11). The marginal improvement in production during the analysis period was sufficient to cover the forgone income from reduced stocking rates in the first two years. *For example*, the 20,000 hectare property (cleared) scenario with 40% of the area initially in “C” condition (8,000 hectares), has an initial forgone income of \$56,000 due to de-stocking the declined area for the first two years during wet season spelling. The resulting improvement in land condition and subsequent increase in production, results in a \$46,000 per annum or 10% improvement in whole property gross margin for the remaining eight years over the whole 20,000 hectares. The resulting net present value over ten years is \$187,364 (Table 10).

Comparatively, the results for the cleared scenarios yielded higher net present to the scenarios with a tree basal area. This is attributed to the decreased competition between pasture, and trees for nutrients and water leading to a high carrying capacity.

Table 10 Narrow-leaved Ironbark: Net present value over 10 years, 2 years spelling, 6% discount rate.

Percentage in declined (“C”) condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$14,543	\$84,063	\$153,583
NPV Cleared (0 TBA)	\$19,352	\$93,682	\$168,012
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$29,085	\$168,126	\$307,166
NPV Cleared (0 TBA)	\$38,704	\$187,364	\$336,024

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$58,170	\$692,468	\$614,332
NPV Cleared (0 TBA)	\$77,408	\$374,728	\$672,047

Table 11 Narrow-leaved Ironbark: Net present value over 20 years, 2 years spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$59,070	\$173,117	\$287,164
NPV Cleared (0 TBA)	\$66,960	\$188,897	\$310,835
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$118,139	\$346,234	\$574,329
NPV Cleared (0 TBA)	\$133,919	\$377,794	\$621,669
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$236,279	\$692,468	\$1,148,658
NPV Cleared (0 TBA)	\$267,839	\$755,589	\$1,243,338

Sensitivity Testing – Narrow-leaved Ironbark

Sensitivity testing was conducted to consider the effect of a longer period of spelling to enable regeneration to "B" condition. When wet season spelling is extended to four years or six years, the NPV for regenerating land is negative for situations with 20% of the land area requiring regeneration, with the analysis over a ten or twenty year period, and for both treed and cleared scenarios. Similarly, over a ten year period, regenerating 40% or less of the land with trees if four years of wet season spelling is required results in a negative NPV. If six years wet season spelling is required to regenerate land to "B" condition, all scenarios result in a negative NPV over a ten year time period. The negative NPV's occur because the benefit accrued from smaller declined areas being regenerated, is insufficient to cover the larger opportunity cost from the longer period of spelling time. For analysis over ten years, this result is magnified because there is a shorter period for the benefits of the regenerated land to be accrued. All NPV's for Narrow-leaved ironbark scenarios with trees are lower than the cleared scenarios as there is a lower carrying capacity on treed land and hence, smaller accrued benefit of regeneration. Figure 2 illustrates the effect of scale and extending the spelling period upon the economic viability of regeneration of degraded land.

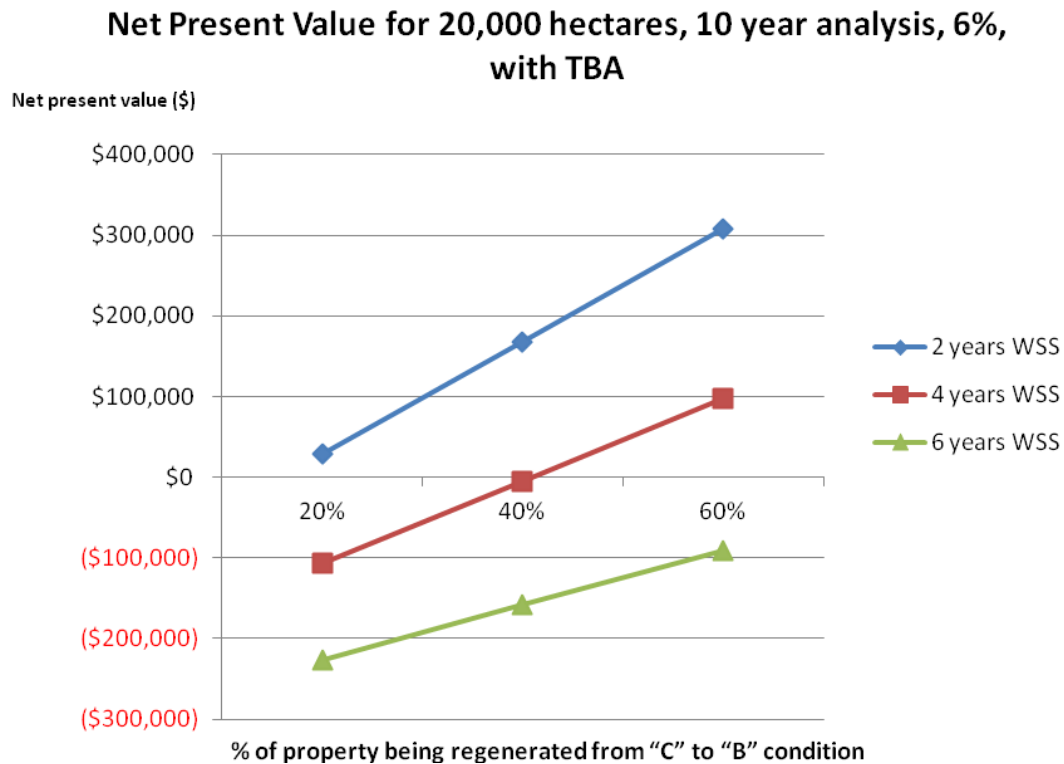


Figure 2 Effect of scale and length of wet season spelling (WSS) on economic viability to regenerate on Narrow-leaved Ironbark.

Sensitivity testing on the discount rate (down to three percent and up to twelve percent) and the price of beef (up and down by 25%) did not significantly change the positive NPV's for any Narrow-leaved ironbark scenario, and so are not presented.

2.2 Black Basalt

Black basalt also resulted in positive net present values over both the ten and twenty years for the cleared and non-cleared scenarios, indicating that regenerating land is a viable investment option for landholders when it can be achieved with two years of wet season spelling (Table 11, 12). The higher NPV's over 20 years reflects the ability for the benefits to accrue over a longer time period. For example, for the 40,000 hectare property with trees and 16,000 hectare (40%) to be improved, over ten years the NPV is \$465,284 while the twenty year time frame has a NPV of \$988,252.

Table 12 Black Basalt: Net present value over 10 years, 2 years spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$14,256	\$116,320	\$218,384
NPV Cleared (0 TBA)	\$203,353	\$494,513	\$785,674
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha

Percentage in declined ("C") condition	20%	40%	60%
NPV Tree Basal Area (TBA)	\$28,513	\$232,641	\$436,769
NPV Cleared (0 TBA)	\$406,706	\$989,027	\$1,571,349
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$57,027	\$465,284	\$873,540
NPV Cleared (0 TBA)	\$813,413	\$1,978,055	\$3,142,698

Table 13 Black Basalt: Net present value over 20 years, 2 years spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$79,627	\$247,063	\$414,498
NPV Cleared (0 TBA)	\$389,839	\$867,485	\$1,345,131
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$159,255	\$494,126	\$828,996
NPV Cleared (0 TBA)	\$779,678	\$1,734,970	\$2,690,263
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$318,511	\$988,252	\$1,647,993
NPV Cleared (0 TBA)	\$1,559,356	\$3,469,941	\$5,380,526

Similar to the other land types, the effect of trees on the economic viability of regeneration is apparent in these Black basalt results. Figure 3 illustrates this effect (Table 12Table 13) for Black basalt, showing significantly higher NPV's for regenerating cleared land than for land with trees (TBA). Trees reduce the carrying capacity of the land, which means slightly smaller benefits accruing to the landholder following regeneration. The impact of trees on the NPV results was consistent across all land types (figures not presented).

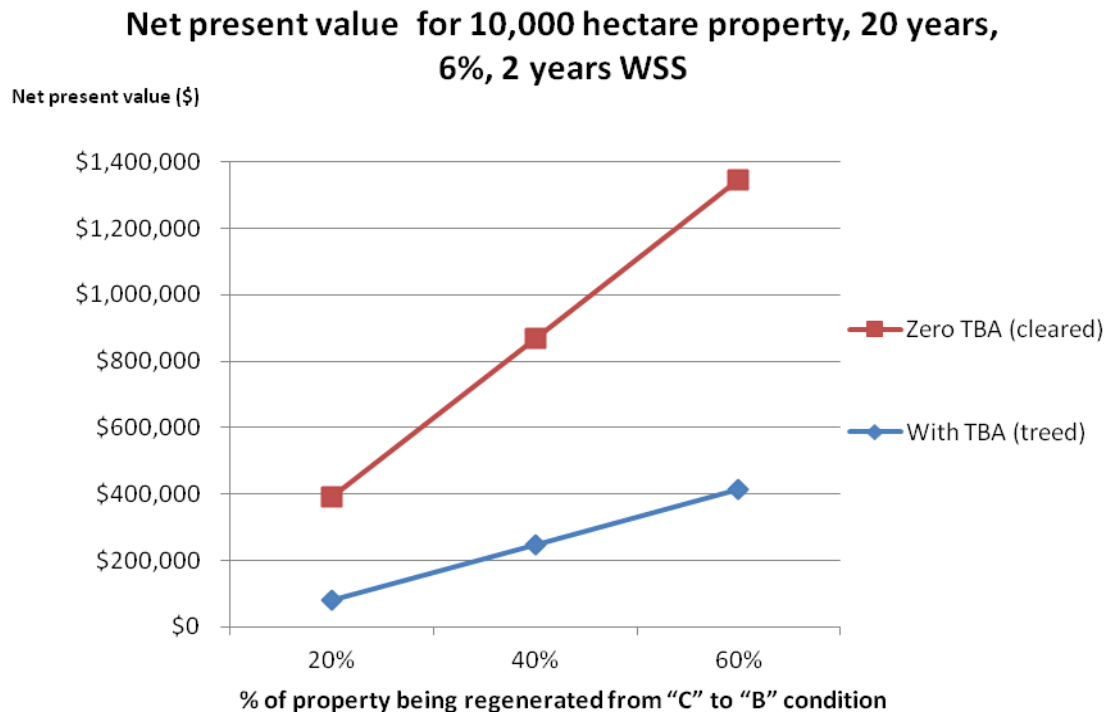


Figure 3 Effect of treed vs. cleared land on economics of regeneration.

Sensitivity Testing – Black Basalt

Over a twenty year investment period, testing for four and six year spelling periods, all regeneration scenarios achieve a positive NPV except for the scenario where only 20% of a 10,000 hectare property with trees is to be regenerated. This one scenario has a negative NPV because the marginal benefit accrued by regenerating a small area with trees is not sufficient to cover the additional opportunity costs of de-stocking for two years. Over a ten year investment period, all treed scenarios over six years and the majority over four years result in a negative NPV.

Similar to the Narrow-leaved ironbark sensitivity testing results, this demonstrates the effect of scale when considering the economic viability of regeneration, with larger scale regeneration having higher NPV's.

Sensitivity testing for the discount rate to 3% and 12%, or a 25% decrease in beef price, did not significantly change the positive net present values in any scenario.

2.3 Red Basalt

The Red basalt land type has positive net present values across all scenarios indicating that as long as two years of consecutive wet season spelling is sufficient to regenerate land to "B" condition, then the investment is sound across different property sizes and with different combinations of trees/no trees and area that needs to be regenerated. The net present values range from \$10,465 to \$961,841 over 10 years (Table 14) and from \$58,449 to \$1,743,019 over 20 years (Table 15).

Table 14 Red Basalt: Net present value over 10 years, 2 years spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$10,465	\$85,383	\$160,301
NPV Cleared (0 TBA)	\$37,165	\$138,823	\$240,460
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$20,930	\$170,766	\$320,602
NPV Cleared (0 TBA)	\$74,369	\$277,645	\$480,921
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$41,860	\$341,532	\$641,205
NPV Cleared (0 TBA)	\$148,739	\$555,290	\$961,841

The Red basalt land type also shows the impact of trees in Tables 14 and 15. The Red basalt NPV's for regenerating cleared land are much higher than for land with trees (TBA), as trees reduce the carrying capacity of the land, thus reducing the benefits accruing to the landholder following regeneration. The effect of scale was also evident with larger areas of land to be regenerated achieving the highest net present values. For example, the scenario of the largest property size (40,000 hectares) with the largest proportion requiring regeneration (60%) results in a NPV of \$1,214,017 over twenty years which is significantly higher than the scenario with the smallest property size (10,000 hectares) and smallest proportion to be regenerated (20%) which has a NPV of \$58,449.

Table 15 Red Basalt: Net present value over 20 years, 2 years spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$58,449	\$181,352	\$304,254
NPV Cleared (0 TBA)	\$102,283	\$269,019	\$435,755
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$116,899	\$362,704	\$608,509
NPV Cleared (0 TBA)	\$204,566	\$538,038	\$871,509
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$233,797	\$725,407	\$1,214,017
NPV Cleared (0 TBA)	\$409,131	\$1,076,075	\$1,743,019

Sensitivity Testing – Red Basalt

Sensitivity testing of the discount rate lowered to three percent improved all of the positive net present values, indicating that a decrease in the discount rate increases the attractiveness of the investment. On the other hand, an increase in the discount rate to twelve per cent lowers the NPV of all scenarios. Despite the higher discount rate, all scenarios maintain a positive NPV, except for the scenarios with trees and with 20% of the land to be regenerated over a ten year analysis. Price sensitivity analysis did not significantly change of NPV of any scenario with either an increase or decrease in beef price of 25%.

Sensitivity testing for length of spelling on Red basalt yielded similar results to other land types. If four years of spelling is required to improve land to “B” condition, most scenarios remain positive other than scenarios with a smaller area to be regenerated (20%) across a ten or twenty year analysis (Figure 4), and scenarios with up to 40% of the property to be regenerated when treed and if only a ten year analysis is considered (figure not shown). If extending spelling of six years is required to regenerate to “B” condition, 20% and 40% to be regenerated scenarios result in a negative NPV across twenty years (figure not shown) and all scenarios result in a negative NPV for a ten year analysis (Figure 4). Again this demonstrates the effects of scale on investment decisions regarding land regeneration.

In addition, the results illustrate the effect of lengthening the investment period under consideration. A twenty year analysis period allows a greater period of time to accrue the benefits of regeneration and outweigh the initial opportunity costs incurred due to stocking less.

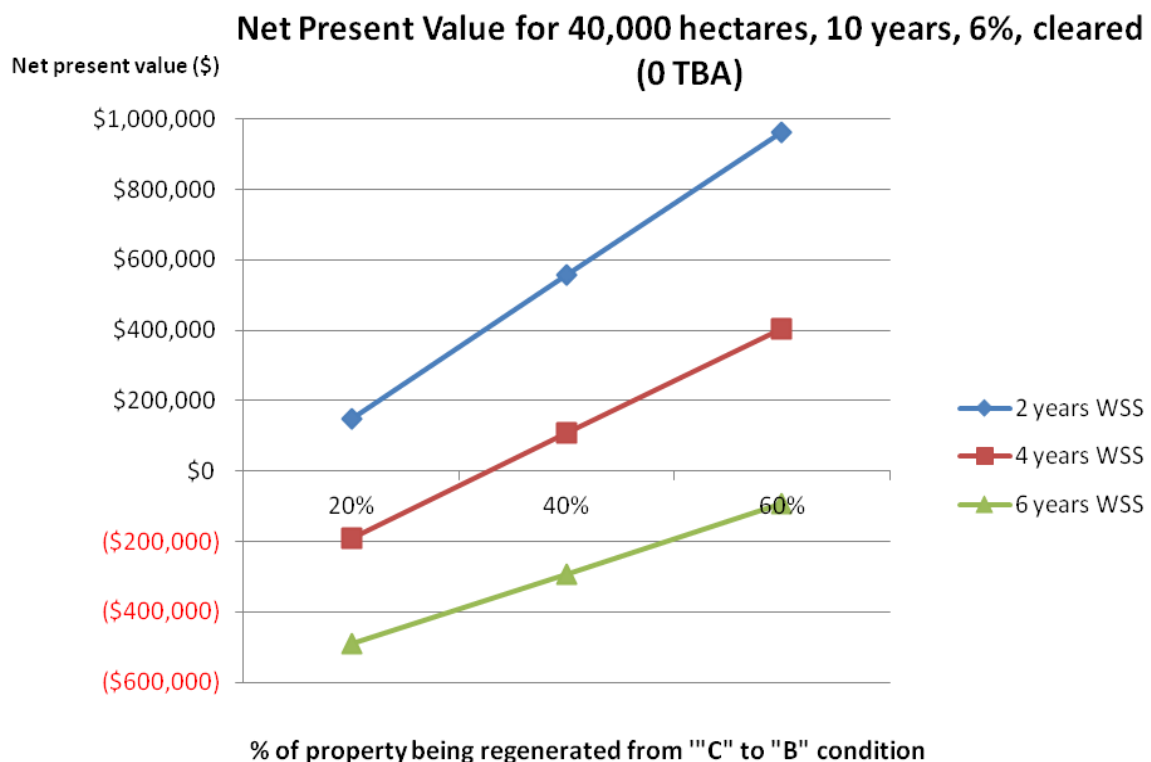


Figure 4 Effect of scale and length of wet season spelling (WSS) on economic viability to regenerate on Red Basalt.

2.4 Goldfields

The Goldfields results demonstrate positive NPV's for regenerating land from "C" condition to "B" condition. All scenarios had positive NPV's indicating that it is economically viable to regenerate land to "B" condition if it can be achieved with two years of wet season spelling. The net present values range from \$29,186 to \$1,128,183 over 10 years (Table 16) and from \$84,393 to \$1,996,826 over 20 years (Table 17).

Table 16 Goldfields: Net present value over 10 years, 2 year spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$29,186	\$115,380	\$201,574
NPV Cleared (0 TBA)	\$56,010	\$169,028	\$282,046
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$58,373	\$230,761	\$403,149
NPV Cleared (0 TBA)	\$112,012	\$338,056	\$564,092
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$116,746	\$461,522	\$806,298
NPV Cleared (0 TBA)	\$224,041	\$676,112	\$1,128,183

Table 17 Goldfields: Net present value over 20 years, 2 year spelling, 6% discount rate.

Percentage in declined ("C") condition	20%	40%	60%
Whole Property 10,000 ha	2,000 ha	4,000 ha	6,000 ha
NPV Tree Basal Area (TBA)	\$84,393	\$225,793	\$367,194
NPV Cleared (0 TBA)	\$128,397	\$313,802	\$499,207
Whole Property 20,000 ha	4,000 ha	8,000 ha	12,000 ha
NPV Tree Basal Area (TBA)	\$168,786	\$451,587	\$734,388
NPV Cleared (0 TBA)	\$256,794	\$627,604	\$998,413
Whole Property 40,000 ha	8,000 ha	16,000 ha	24,000 ha
NPV Tree Basal Area (TBA)	\$337,572	\$903,174	\$1,468,776
NPV Cleared (0 TBA)	\$513,589	\$1,255,207	\$1,996,826

Similar to the previous land types, the impacts of scale are evident in Tables 16 and 17 and Figure 5. In Table 16, the NPV increases from \$224,041 for cleared land when 20% of a 40,000 hectare property requires regeneration, to \$1,128,183 when 60% of the same property is regenerated. This increase is even larger when the analysis period is longer.

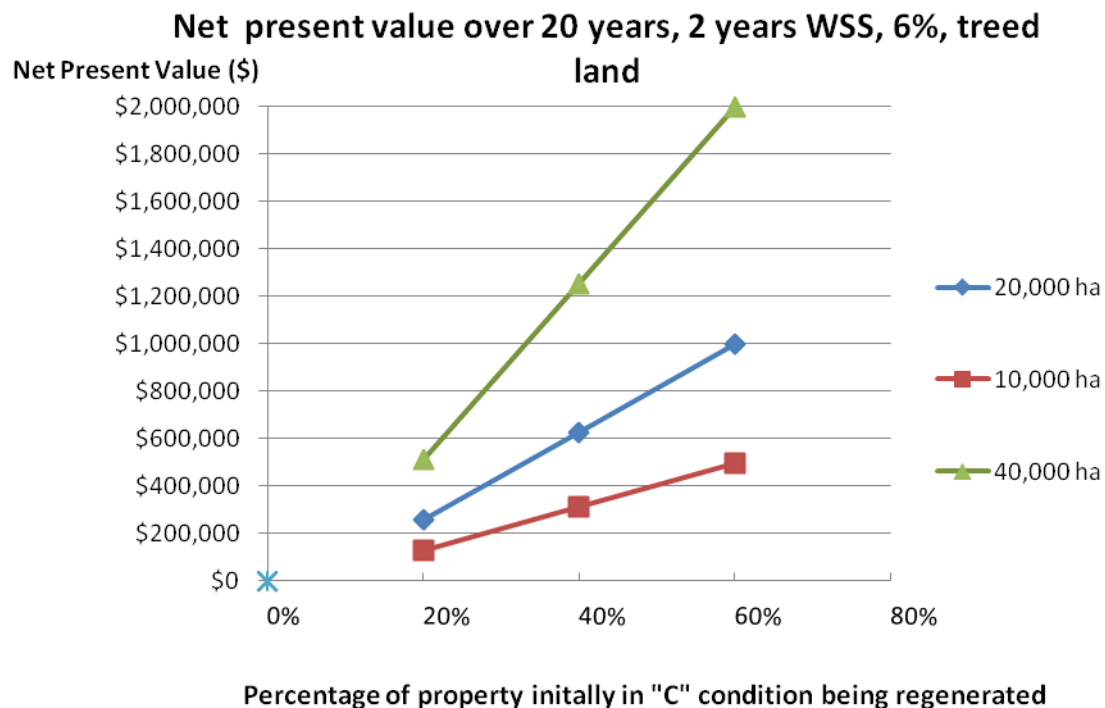


Figure 5 Effect of scale on economic viability to regenerate on Goldfields land with trees.

Sensitivity Testing – Goldfields

Sensitivity testing of the beef price used in the analysis (25% increase and 25% decrease) did not significantly change the positive NPV results for the Goldfields scenarios. Sensitivity testing of the discount rate used in the analysis also had a minor impact on the results, with all scenarios still achieving a positive NPV.

Sensitivity testing on length of the wet season spelling period indicated that if four years are required to regenerate land, positive NPV's are maintained across all scenarios except when only a small proportion (20%) of the property is to be regenerated over a shorter time period (10 years). If six years spelling is required to regenerate land to "B" condition, almost all scenarios reduce to negative NPV's, except when larger areas (40% and 60%) of the property is being regenerated over a longer time period (20 years).

This reiterates the significance of the proportion of the property to be regenerated. A larger proportion of the property to be regenerated creates greater marginal benefit from the regeneration and thus, can cover the greater initial opportunity cost involved if longer spelling periods are required.

3. Discussion

Four land types have been modelled to analyse the benefits and costs associated with regenerating land from “C” condition to “B” condition under various scenarios. For each land type, three property sizes and three different proportions of the property to be regenerated have been considered both with and without trees. In addition, sensitivity analysis on longer wet season spelling periods, higher/lower discount rates and beef prices has been included to determine their individual effects on the results. The following discussion delves further into the scenarios modelled and highlights the key factors driving the results presented in the previous section.

The preceding section details the net present values for a range of scenarios of land regeneration from “C” to “B” condition on four land types. For each of the land types, some or all of the scenarios achieved a positive net present value, indicating that for landholders who have a property similar to the modelled property, investment in land regeneration through two years of wet season spelling will result in improved property gross margins and overall a positive investment. This indicates that some land regeneration by landholders in the Burdekin region is possible through private landholder investment, particularly for landholders with larger property sizes and with large areas of cleared land that requires regeneration. For these landholders, the net present value of investing in land regeneration may be quite large. Therefore, education and extension efforts may encourage these landholders to invest the time and financial resources to improve their land condition and property gross margin, which is likely to simultaneously reduce the quantity of sediment exported from their property. For landholders with smaller properties, smaller areas of land in “C” condition, or with more trees, the net present values may not be high enough to warrant investment in land regeneration. For these landholders, some financial incentives may be required to assist landholders undertake land regeneration.

There are six key factors that interact to influence the economic returns of investing in land regeneration. These are: the method used to regenerate land, the annual variability in rainfall, the opportunity cost to the landholder of de-stocking land for spelling, the amount of increased productivity following land regeneration, scale effects, and the time period considered in the analysis. Variations in any of these six factors impact either positively or negatively on the viability of investing in land regeneration.

In this report, all land types were modelled with areas to be regenerated being fully de-stocked and combined with wet season spelling over eight weeks in two consecutive years to regenerate land from “C” to “B” condition. Assuming that two years of wet season spelling is sufficient to enable land to improve to “B” condition, all property sizes and proportions of the property to be regenerated have a positive net present value over both a ten or twenty year time frame. However, for low productivity land types such as Narrow-leaved ironbark, the net present values are lower than for higher productivity land types. In addition, the average annual long term rainfall (801mm) used in this modelling for Narrow-leaved ironbark, is higher than many other regions where this land type exists. Therefore longer wet season spelling time periods and/or a combination of other land regeneration practices may be required to regenerate land. The sensitivity analysis highlighted the impact of extended wet season spelling time periods to enable regeneration, with the six year time period resulting in negative results for most scenarios.

Differences also exist between landholders about the best methods for improving land condition and the length of time required if wet season spelling is the chosen management option. This demonstrates the variability and heterogeneity that exists among individuals within the industry, and within businesses. Although some other management practices were discussed at the landholder meetings, this analysis has focused solely on wet season spelling for improvements in land condition.

The natural differences in productivity of each land type modelled results in different opportunity costs of reduced stock numbers for wet season spelling, due to differences in the average gross margin per adult equivalent for the different land types. This analysis has not considered capital costs for change in infrastructure (fencing) that may be required to enable the areas for regeneration to be separated from areas not needing regeneration. The opportunity costs included in this analysis are solely the forgone income through de-stocking for the spelling period. Therefore, the full costs of regenerating land may be higher than the costs used in this analysis. However, costs associated with fencing will outlast the duration of the regeneration and are also likely to bring other benefits to the landholder in addition to allowing regeneration to occur.

The scale and the time period over which the analysis is undertaken are also key determinants of economically viable land regeneration and observed previously by Star and Donaghy (2010, 2011). The larger the area regenerated or the greater the time period analysed, the greater the marginal increase in property gross margin as the land condition improves. For all land types the net present values are higher when 60% of the property is regenerated than when 20% is regenerated. This scale effect is due to the ability for additional benefits in terms of gross margin to accumulate over a larger proportion of the property resulting in a significant change in whole property gross margin, and offsets the initial forgone income through two years of wet season spelling. Conversely, for smaller areas requiring regeneration, it may not be economically viable for the landholder to undertake as a private investment. Therefore incentives may be required to enable reductions in sediment exported through improved land condition.

This analysis has explored one of many potential practices to regenerate land condition. Other practices may result in different estimates of economic implications. Similarly, this analysis has assumed that the land type occurs across a whole property, however in reality, this does not occur. Therefore, an economic analysis of an individual's property may have higher or lower net present values associated with land regeneration than presented here. There is also extensive heterogeneity in businesses and therefore gross margins will vary according to various parameters such as marketing, animal health practices, and distance to markets, which will also vary the investment potential of regenerating land.

This analysis has focused on the economic implications of investing in land regeneration. There are significant initial costs for a landholder to undertake wet season spelling, including foregone income through de-stocking and any required fencing costs to allow stock exclusion. The majority of scenarios presented in this analysis have a positive net present value, indicating that the investments are beneficial for the landholder. However, even strategies that result in a large net present value may have cash flow implications that the landholder may not have the financial capacity to bear in the early years of the investment period. Therefore, extension and education may encourage some landholders to undertake land regeneration, extension and education may

not be sufficient if landholders are financially stressed and are unable to manage the period of forgone income while wet season spelling is in progress.

This modelling has not captured all the biophysical factors such as site specific effects and property planning and infrastructure effects. The study presents one of many options for land regeneration, however, other practices with a different climate and location may also be suitable.

4. Conclusions

This analysis highlights the profitability for land regeneration using wet season spelling under most scenarios for the four land types modelled. Profitability is greater for more productive land types, and larger sized properties and larger areas for regeneration. For landholders that fit this group, extension and education are a cost effective method for improving land condition and reducing sediment exportation. Profitability is lower (or negative) for less productive land types, smaller properties, smaller areas for regeneration, and land that requires longer periods of wet season spelling to regenerate. For landholders in this group, financial incentives may/will be required if land condition improvement is to be achieved.

This report has not included the costs of property infrastructure, as it would be significantly different for each landholder depending on the amount and condition of current fencing on their property. In addition, this report has focused on the return associated with investment in land regeneration. It is possible that projects that have a high net present value may not be able to be implemented by an individual landholder due to the cash flow implications associated with fencing and de-stocking for spelling at the beginning of the regeneration period. This situation may extend the quantity of incentives required to achieve large reductions in sediment exportation.

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