Estimating the economic implications for broad acre cropping farms in the Fitzroy Basin catchments of adoption of best management practices

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Executive Summary

Representative grain farms in the Fitzroy Basin region are modelled to determine the costs and benefits of farm management practice changes based on the Grains BMP (Best Management Practices) program.

By comparing the results achieved for the farm management practices assessed it is evident that very significant dollar per hectare benefits may be achieved from the adoption of more sustainable farm management practices.

The dollar per hectare value of management changes within the Dawson/Callide and the Central Highlands catchments modelled are presented in the tables below. The dollar per hectare figures are determined from modelled changes to farm business profit for a representative 800 hectare broad acre cropping farm in the Dawson/Callide and a 2,000 hectare farm in the Central Highlands catchments.

Dawson/Callide Catchment

Management Level	Per Ha Profit	Change in Per Ha Profit
Conventional Farming System	-$74.44	
Zero Till (RWT) Farming System	$64.43	$138.87
Controlled Traffic Farming System	$115.23	$50.80
Controlled Traffic Farming System (12 crops in 10 years)	$182.78	$67.55

Central Highlands Catchment

Management Level	Per Ha Profit	Change in Per Ha Profit
Conventional Farming System	-$49.87	
Zero Till (RWT) Farming System	$37.15	$87.02
Controlled Traffic Farming System	$112.69	$75.54
Controlled Traffic Farming System (12 crops in 10 years)	$129.71	$17.02

These results demonstrate that improved management practices are cost effective, improve the efficiency of production and increase farm viability. Furthermore, improved management practices that also increase crop yields and/or cropping frequency will improve farm viability substantially.

An important component of Grains BMP involves minimising the offsite environmental impacts that result from broad acre cropping. In particular, the four key points of interest for broad acre cropping farms are: limiting soil loss, reducing water runoff, reducing nutrient runoff, and reducing pesticide runoff. An assessment of the value of environmental benefits achieved due to the current levels of adoption of BMP standards across the grains industry in the Fitzroy Basin, as well as the potential savings from catchment-wide adoption, are provided in the table below.

NRM Annual Benefits	Current Benefits ($M)	Potential Savings ($M)
Limiting Soil Loss	13.4	5.6
Limiting water runoff – production	28.1	11.7
Value of N & P losses	0.1	0.043
Limiting Herbicide use	-	5.0
TOTAL NRM Benefit	**41.6**	**22.3**

Investment in programs that will assist grain producing businesses to adopt best management practices will not only help improve the sustainability of the natural environment but will also increase farm business profitability.

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1 Introduction

Central Queensland's natural resource management (NRM) group the Fitzroy Basin Association is providing co-investment with landholders to encourage practice change to more sustainable farming systems.

This study assesses the economic implications for broad acre cropping farmers of practice changes in the Dawson/Callide and Central Highlands catchments in the Fitzroy Basin region. These catchments have been chosen as they are typical within the region and experience different soil types and management issues.

Information with respect to the costs and benefits of practice changes on grain farms is required in order to apply investment strategies that will effectively and efficiently facilitate change. Further, in promoting these practice changes it is also necessary to demonstrate the production benefits that may flow as a result of moving to best management practice. It is also recognised that farm management changes often involve substantial additional capital investment for on-ground works and/or for upgrading to new specialised machinery.

Part of the Fitzroy Basin Association's charter is to provide assistance to farmers to make the required changes that will provide environmental benefits, thus improving the overall health of the catchment. The health of the catchment is of particular interest because it feeds directly into the Great Barrier Reef. Programs that foster better management practices and deliver less nutrients and chemicals to the reef will benefit both farmers and the community as a whole.

2 Project Purpose

The purpose of this report is to determine the costs and benefits of changes to management practices for broad acre grain farms in the Fitzroy Basin region.

3 Project Methodology

The methodology used to evaluate the costs and benefits of on farm practice changes is to model representative farming businesses in each of two typical catchments according to the management practices set out in the Grains Best Management Practices (BMP) self assessment modules. The catchments selected are the Dawson/Callide catchment and the Central Highlands catchment. Once the farm models were constructed they were verified by agronomists and farmers in each of the catchments. This enabled the comparison of farm profitability criteria for farm management practice levels described in the Grains BMP self assessment modules.

The Grains BMP program is a voluntary, industry led process designed to help broad acre grain growers identify practices that can help improve the long term profitability of their enterprise. The program consists of five core modules that set out the farming practices that are suggested to be either below BMP standard, the minimum BMP standard or above BMP standard. A self assessment tool is used to help farmers identify practices that can be incorporated into their farming systems.

The five core modules that make up Grains BMP are:

1) Pesticide Application

This module focuses the safe and effective application of pesticides to help create a sustainable farming enterprise. The key components that contribute to best practice in pesticide application include:

- Effective communication with neighbours, employees and contractors.
- Correct product selection.
- The use of suitable application equipment.
- Application under suitable weather conditions to reduce drift.
- Using safe practices when mixing and handling chemicals.
- Keeping accurate records of applications.

2) Farm Design and Layout

The design and layout module covers four key areas relating to best practice, including:

- Development and use of maps with sufficient features.
- Examination of practices that can have impacts beyond property boundaries.
- Ensuring efficiency is maximised by property design.
- Incorporating practices which effectively deal with runoff.

3) Managing Rainfall

The central focus of this module is the idea of 'farming water' – that is, making the most of rainfall regardless of when it is received (in other words, opportunity cropping). Key elements include:

- Capturing in the soil as much rainfall as possible.
- Conserving stored soil moisture for future planting.
- Using soil water as efficiently as possible to produce grain.

4) Integrated Pest Management

The Integrated Pest Management (IPM) module aims to control pests (insects, weeds, diseases and pest animals) in crops and on the farm in general. IPM involves using a range of methods to control and manage pests, with a view to optimising farm profitability. Key areas of the IPM module include:

- Incorporating farm practices that best manage weeds, insects, diseases and pest animals.
- Correctly identifying and monitoring grain crop pests.
- Making correct pest control decisions.

5) Crop Nutrition and Soil Fertility Management

Sustainable crop production relies on both the availability of sufficient nutrients in the soil for crops (crop nutrition) as well as maintaining nutrient availability over an extended period of time (soil fertility). With these two factors in mind, the fifth BMP module focuses on the following key areas:

- Understanding the factors affecting the soil's ability to supply nutrients.
- Monitoring changes in production levels over time.
- Making profitable fertiliser decisions and minimising risk.
- Minimising the off site movement of fertiliser and maintaining soil fertility.

Using the practices described in the five BMP modules, three whole farm economic models for each catchment region were developed that broadly capture the practices relating to each practice standard level. The below standard is illustrated by a conventional tillage farming system. The minimum standard is illustrated by a zero till, random wheel traffic (RWT) farming system and the above BMP standard is illustrated by a zero till plus controlled traffic farming (CTF) system. It must be noted that in reality farm management practices may consist of varying BMP levels for different management areas, for example, a farm may for nutrient management apply a minimum level practice while applying an above level practice for chemical management. For this analysis the farm models have contained consistent management practice levels across the BMP management areas.

Further modelling analysis was conducted to assess the economic implications of dealing with herbicide resistance as this was noted as an issue within the Pesticide Management module.

The analyses have applied the QPI&F economic modelling resources by using an economic spreadsheet model designed specifically to assess broad acre grain farms. The model is a whole farm economic decision model that compares various farming options and tests the sensitivity of farm profitability to changes in gross margins, plant and equipment, fixed costs and income.

Risk analysis of each of the farm management systems is undertaken using the program @RISK. Risk analysis methodology captures and describes the possible, but unpredictable, variation that exists in yields and prices due to seasonal conditions and market fluctuations. This is achieved by incorporating the expected range of possible outcomes for each of the variables used in the analysis and applying probabilities of likely occurrence in the form of a cumulative distribution. The program @RISK uses random sampling techniques to define the distribution of the required output (farm business profit) in terms of the cumulative distribution and the probability allocated for each variable. The result is a distribution curve of farm business profit for each farm management system and the probability of likely outcomes.

Further, a standard discounted cash flow (DCF) investment analysis framework is used to evaluate the proposed farming practice changes where capital investment is required. The DCF analysis estimates the Net Present Value (NPV) or Lump Sum Present Value Equivalent of the incremental net cash flow stream over 10 or more years due to an investment. It arises directly as a result of estimating the difference in the annual cash flow pattern for the farm, with and without the proposed change.

4 Farm Model Assumptions

- Representative model farms were developed in two Fitzroy Basin catchments, the Dawson/Callide and the Central Highlands catchments. The farm models are based on broad acre dry land farms absent of any irrigation or livestock enterprises. The Dawson/Callide farm consisted of 900 hectares with a cropped area of 800 hectares. The Central Highlands farm consisted of 2,200 hectares with a cropped area of 2,000 hectares.
- The fixed costs for each farm model in each catchment are the same except for the depreciation costs of plant and equipment that vary depending on the farming system. In reality different farms in different locations within each catchment would have varying fixed costs depending on their individual circumstances.
- Included in the fixed costs is an amount of $50,000 allocated as farm drawings or an owner operator wage.
- The value of land in the Dawson/Callide catchment is modelled at $2,500 per hectare and at $1,350 per hectare for the Central Highlands catchment. It is recognised that there exists variation in land valuations due to real estate value, position and land capability. The value of land impacts upon the return on investment criteria only. The criteria used for comparison of the modelled farming systems are farm business profit and profit per hectare of farmed land.
- The list of plant and machinery is suggested as necessary for a farm of this size. It is accepted that farms will vary greatly in the plant and machinery present. The specific components of plant and equipment for each farm changes depending upon the farming system analysed. The plant and equipment was not determined based on a farmer moving from one farming system to the next, but rather, what would be necessary for a stand alone farm under a particular farming system.
- Within each catchment much of the variation between the modelled examples were held constant so that the effects of the changes to management practices were captured.
- The crop yields (expressed as a distribution) in each farming system were verified by growers.
- Grain prices (expressed as a distribution) were held constant for each of the modelled farming systems (Table 1).
- Application amounts of seed, fertiliser and chemicals were assumed to be 10% higher for conventional and random wheel zero till models compared to CTF. This reflects the decreased field efficiency of these systems (due to higher rates of overlap). This estimate was considered conservative by CT farmers in both regions.
- It is acknowledged that for a farmer to change from one farming system to another takes time, rotational changes and investment in plant and equipment. The modelled farming systems assume a steady state farm operating within the modelled farming system as described.
- The modelled representative farms have been tested with groups of farmers within each catchment area in order to verify the farming systems modelled.

Table 1: Crop Prices used in all farming systems models for both catchments

Crop Prices - On farm	**Price Parameters**					Price Probabilities			**Expected**
All Farming Systems	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	**Price**
Sorghum	$120	$140	$160	$220	$280	15%	50%	85%	**$176.00**
Wheat	$120	$160	$240	$270	$300	10%	50%	80%	**$227.50**
Chickpea	$300	$350	$400	$550	$700	10%	50%	90%	**$435.00**
Mungbean (graded)	$358	$408	$458	$538	$608	15%	50%	85%	**$469.25**

5 Farming Systems

5.1 Dawson/Callide Catchment

Three farming system models were constructed to represent the Grains BMP management levels in each catchment. The below BMP standard is illustrated by a conventional tillage farming system, the minimum BMP standard is illustrated by a zero till random wheel traffic (RWT) farming system and the above BMP standard is illustrated by a zero till plus controlled traffic farming (CTF) system. Furthermore, a fourth scenario comprising a zero till plus CTF system that grows 12 crops in 10 years (as opposed to 10 crops in 10 years in the other CTF system) is also modelled. This was included as it was suggested by a number of CTF growers that the long term aim under a CTF system was to achieve a higher cropping frequency.

5.1.1 Conventional Farming System (Dawson/Callide)

In each of the catchments modelled, the Conventional Tillage system describes the traditional farming system that is rarely seen on large scale broad acre cropping farms, however, still exists to an extent on mixed farms within the Fitzroy catchment. Figure 1 depicts the cropping rotations modelled for the conventional farming system that uses tillage practices for seed bed preparation and to control fallow weeds. It is suggested that a cropping intensity of 7 crops in 10 years would be the likely cropping frequency with a mix of summer and winter crops.

Figure 1: Conventional Farming System (Dawson/Callide)

Start	Paddock area 80	80	80	80	80	80	80	80	80	80
Jan-2005					chisel	chisel	chisel	chisel	chisel	
Feb-2005	off set dics	in crop spray	in crop spray							
Mar-2005		Spray out	Spray out		chisel	chisel	chisel	chisel	chisel	Scarify
Apr-2005	chisel	Harvest	Harvest	Scarify	scarify	scarify	scarify	scarify	scarify	
May-2005					Plant wheat	Plant wheat	Plant Chickpea	Plant wheat	Plant wheat	
Jun-2005	chisel	offset	offset							
Jul-2005					Incrop spray	Incrop spray	Incrop spray	Incrop spray	Incrop spray	
Aug-2005		chisel	chisel				Incrop spray			Scarify
Sep-2005				Scarify			sprayout			
Oct-2005	Scarify	Scarify			Harvest wheat	Harvest wheat	Harvest Chickpea	Harvest wheat	Harvest wheat	
Nov-2005	Plant	Plant	Scarify	Scarify	offset	offset	offset	offset	offset	Scarify
Dec-2005	Sorghum	Sorghum								
Activity Name	Sorghum 1	Sorghum 2	Sorghum 3	Fallow	Wheat 1	Wheat 2	Chickpea 1	Wheat 3	Wheat 4	Fallow

Table 2 describes the frequency and expected value of crop yields in the conventional tillage cropping system. For example, we expect sorghum to yield between 0 tonnes/ha and less than 1.2 tonnes /ha 20% of the time, between 1.2 and 2 tonnes/ha 40% of the time, between 2 and 3 tonnes/ha 20% of the time and from 3 to 3.5 tonnes/ha 20% of the time. The expected crop yields are the weighted average of the distribution of the yields according to the probabilities entered into the model.

Table 2: Yield parameters for a conventional farming system

Dawson Callide Catchments	**Yield Parameters (t/ha)**					Yield Probabilities			Expected
Conventional Tillage System	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	Yield (t/ha)
Sorghum	0	1.2	2	3	3.5	20%	60%	80%	1.91
Wheat	0	1	2	2.8	3.5	10%	60%	90%	1.83
Chickpea	0	0.75	1.35	1.65	2.25	20%	60%	90%	1.14

5.1.2 Zero Till (RWT) Farming System (Dawson/Callide)

The zero till (RWT) farming system uses direct drilling for planting and herbicide sprays for weed control. Tillage equipment such as a chisel plough and offset discs are no longer included in the capital equipment and a spray rig is added. Figure 2 depicts the cropping rotations modelled for the zero till farming system. It is suggested that a cropping intensity of 10 crops in 10 years would be the likely crop frequency in the Dawson/Callide catchment.

Figure 2: Zero Till (RWT) Farming System (Dawson/Callide)

Start	Paddock area 80	80	80	80	80	80	80	80	80	80
Jan-2005					Spray	Spray	Spray	Mung Beans	Spray	Spray
Feb-2005	spray	in crop spray	in crop spray	in crop spray	Spray			incrop spray		
Mar-2005		Spray out	Spray out	Spray out		Spray	Spray	incrop spray	Spray	Spray
Apr-2005	spray	Harvest	Harvest	Harvest	Spray	Spray	Spray	spray out	Spray	Spray
May-2005	Plant Wheat				Plant Chickpea (sp	Plant Wheat	Plant Wheat		Plant Wheat	Plant Wheat
Jun-2005		Spray	Spray	Spray	incrop spray			spray		
Jul-2005	Incrop spray				incrop spray	Incrop spray	Incrop spray		Incrop spray	Incrop spray
Aug-2005		Spray	Spray					spray		
Sep-2005				Spray	Harvest Chickpea					
Oct-2005	Harvest wheat	Spray	Spray			Harvest wheat	Harvest wheat	spray	Harvest wheat	Harvest wheat
Nov-2005	Spay at Plant	Spray at Plant	Spray at Plant	Spray	Spray	Spray	Spray		Spray	Spray
Dec-2005	Sorghum	Sorghum	Sorghum	Spray	Spray	Spray	Plant Mung Beans	spray	Spray	Spray
Activity Name	Wheat 1 Plant Sor	Sorghum 2	Sorghum 3	Harvest Sorghum F	Chickpea 1	Wheat 2	Wheat 3	Mung Beans	Wheat 4	Wheat 5

Table 3 describes the frequency and expected value of crop yields in the zero till (RWT) cropping system.

Table 3: Yield parameters for a zero till (RWT) farming system

Dawson Callide Catchments	**Yield Parameters (t/ha)**					**Yield Probabilities**			**Expected**
Zero Till System	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	**Yield (t/ha)**
Sorghum	0	1.5	2.4	3	3.6	10%	60%	80%	2.25
Wheat	0	1	2.2	3	3.5	10%	50%	85%	2.085
Chickpea	0	0.8	1.5	2	2.5	20%	60%	90%	1.29
Munbean (graded)	0	0.72	1.35	1.58	1.8	10%	50%	90%	1.2038

5.1.3 Controlled Traffic Farming System (Dawson/Callide)

The controlled traffic farming system utilises GPS technology with auto steer and has all farming equipment (tractors, planters, spray rig, harvester) on the same track width. The GPS and auto steer technology is added to the inventory of plant and equipment as well as an allowance for changing over the track width of machinery. It is suggested that this system will have a cropping intensity of 10 crops in 10 years in the Dawson/Callide catchment with a mix of summer and winter crops as depicted in figure 3.

Figure 3: Controlled Traffic Farming System (Dawson/Callide)

Start	Paddock area 80	80	80	80	80	80	80	80	80	80
Jan-2005	Spray			Spray	Spray	Spray	Spray	Spray	incrop spray	Spray
Feb-2005	Spray	in crop spray	in crop spray						incrop spray	
Mar-2005		Spray out	Spray out	Spray	Spray	Spray	Spray	Spray	spray out	Spray
Apr-2005	Spray	Harvest	Harvest	Spray	Spray	Spray at plant	Spray	Spray	Harvest Mungbean	Spray
May-2005	Plant Wheat			Plant Wheat	Plant wheat	Plant Chickpea	Plant Wheat	Plant wheat		Plant Wheat
Jun-2005		Spray	Spray			incrop spray			Spray	
Jul-2005	Incrop spray			Incrop spray	Incrop spray	incrop spray	Incrop spray	Incrop spray		Incrop spray
Aug-2005		Spray	Spray						Spray	
Sep-2005						Harvest chickpea				
Oct-2005	Harvest wheat	Spray		Harvest Wheat	Harvest wheat		Harvest Wheat	Harvest wheat	Spray	Harvest wheat
Nov-2005	Spray at plant	Spray at plant	Spray	Spray	Spray	Spray	Spray	spray at plant		spray
Dec-2005	Sorghum	Sorghum	Spray	Spray	Spray	Spray	Spray	Plant Mungbean	Spray	Spray
Activity Name	Wheat 1 + Sorghu	Sorghum 2	Sorghum 3	Wheat 2 + plant M	Harvest Mungbean	Chickpea 1	Wheat 4	Wheat 5 + Plant M	Harvest Mungbean	Harvest Mungbean

Table 4 describes the frequency and expected value of crop yields in the controlled traffic cropping system.

Table 4: Yield parameters for a CTF farming system

Dawson Callide Catchments	**Yield Parameters (t/ha)**					**Yield Probabilities**			**Expected**
CTF System	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	**Yield (t/ha)**
Sorghum	0	1.6	2.6	3.3	3.8	10%	50%	90%	2.455
Wheat	0	1.2	2.5	3	3.5	10%	50%	80%	2.275
Chickpea	0	0.8	1.5	2	2.5	10%	60%	90%	1.365

The adoption of CTF has provided farmers with the opportunity to increase crop frequency because:

- More water infiltrates the soil during rainfall (refer Figure 4)
- More water is stored in the soil (Plant Available Water Capacity - PAWC – increases). (Refer Figure 5)
- Wheel tracks in the paddock are in defined areas, thus having no compaction in seed beds. This means that the seedbed is uniform, which is particularly useful when deep sowing into moisture (refer Figure 6).
- Wheel tracks are hard, allowing for early access to paddocks which optimises available soil moisture.
- Disc planters work poorly in compacted soils, thereby reducing crop establishment.

For these reasons crops perform better under CTF systems, thereby reducing crop failures. This provides the farmer with greater confidence to optimise planting opportunities. (2009 pers. comm. Tim Neale, CTF Solutions)

Figure 4: Percentage of rainfall stored under different cultivation and traffic regimes in China and Australia, Source Dr. Jeff Tullberg, University of Queensland.

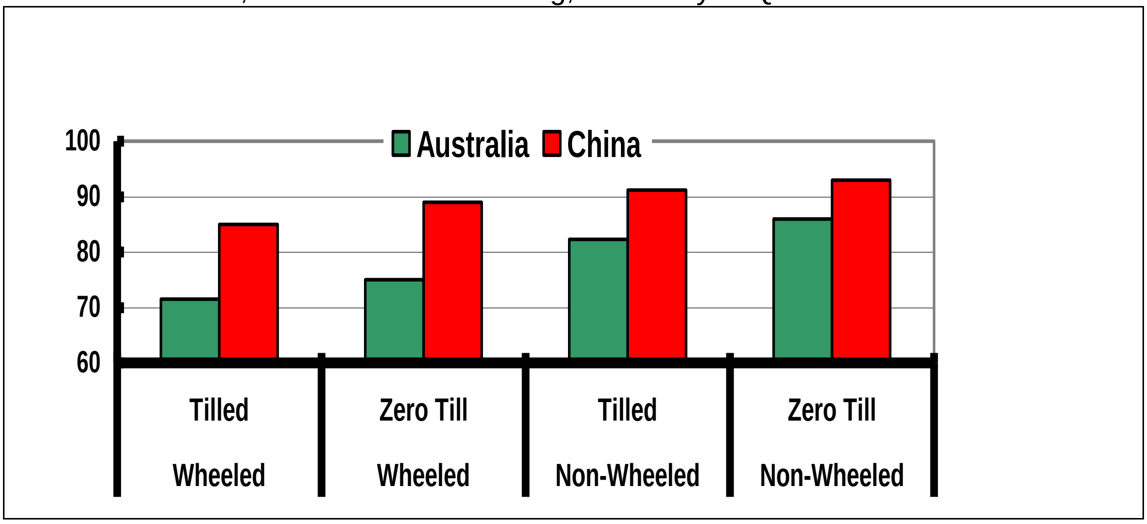


Figure 5: Effect of wheel traffic and CTF on PAWC (0-30cm). Source: Dr Jack McHugh, University of Queensland.

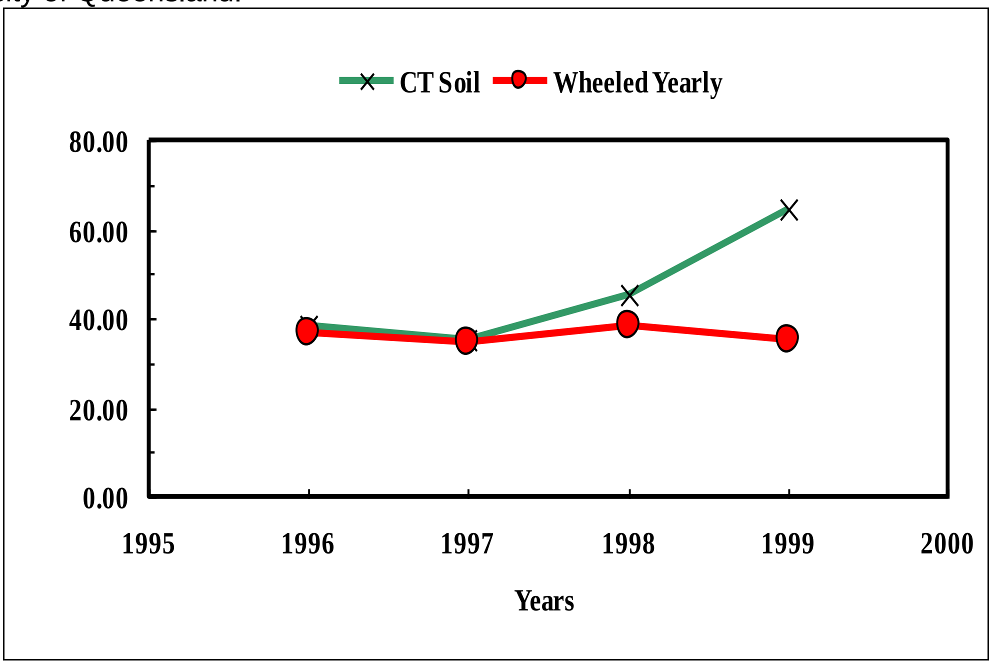


Figure 6: CTF system – defined wheel tracks. Source: Tim Neale, CTF Solutions

The controlled traffic farming system with 12 crops in 10 years is seen by farmers and agronomists to be achievable in the long term. Some growers indicated that this was being achieved at present. The inclusion in the model (depicted in Figure 7) of double cropping with a mungbean crop represents the greater possibility of 'opportunity cropping', making use of available stored water, rather than putting the land to fallow.

A consequence of increasing cropping intensity is fewer fallows, thus available water is utilised in the current crop rather than stored for a subsequent crop. As a result, yields in the extra crop and the subsequent crop may decrease depending on the amount of available water, primarily on the paddocks where 'double cropping' occurs. To account for this, four out of the twelve crops in the model have their expected yield reduced by 10% compared with the previous CTF model. However, in practice double cropping will usually only occur when opportunities of excess available water are available.

Figure 7: Controlled Traffic Farming System (12 crops in 10 Years) (Dawson/Callide)

	Paddock area									
Start	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**	**80**
Jan-2005	Spray			Spray	Incrop spray	Spray	Spray	Spray	incrop spray	Incrop spray
Feb-2005	Spray	in crop spray	in crop spray		Incrop spray				incrop spray	Incrop spray
Mar-2005		Spray out	Spray out	Spray	Spray out	Spray	Spray	Spray	spray out	spray out
Apr-2005	Spray	Harvest	Harvest	Spray	Harvest Mungbean	Spray at plant	Spray	Spray	Harvest Mungbean	Harvest Mungbean
May-2005	Plant Wheat			Plant Wheat	Plant wheat	Plant Chickpea	Plant Wheat	Plant wheat		Plant Wheat
Jun-2005		Spray	Spray			incrop spray			Spray	
Jul-2005	Incrop spray			Incrop spray	Incrop spray	incrop spray	Incrop spray	Incrop spray		Incrop spray
Aug-2005		Spray	Spray						Spray	
Sep-2005						Harvest chickpea				
Oct-2005	Harvest wheat	Spray		Harvest Wheat	Harvest wheat		Harvest Wheat	Harvest wheat	Spray	Harvest wheat
Nov-2005	Spray at plant	Spray at plant	Spray	spray at plant	Spray	Spray	Spray	spray at plant	spray at plant	spray
Dec-2005	Sorghum	Sorghum	Spray	Plant Mungbean	Spray	Spray	Spray	Plant Mungbean	Plant Mungbean	Spray
Activity Name	Wheat 1 + Sorghu	Sorghum 2	Sorghum 3	Wheat 2 + plant M	Harvest Mungbean	Chickpea 1	Wheat 4	Wheat 5 + Plant M	Harvest Mungbean	Harvest Mungbean

Table 5 provides the expected values from the modelled output data from each of the farming systems modelled in the Dawson/Callide catchment.

Table 5: Outputs of the modelled farming systems in the Dawson/Callide catchment.

Dawson/Callide Catchment	Conventional Farming System (7 crops in 10 years)	Zero Till (Random Wheel) Farming System (10 crops in 10	CTF Farming System (10 crops in 10 years)	CTF Farming System (12 crops in 10 years)
Total Value of Assets	**$2,862,000**	**$2,855,000**	**$2,917,000**	**$2,917,000**
Farm Gross Income				
Summer crop sales	$50,730	$134,829	$109,431	$197,882
Winter crop sales	$166,476	$225,473	$283,920	$277,395
Total Farm gross income	**$217,206**	**$360,301**	**$393,351**	**$475,277**
Farm Variable Expenses				
Fuel and oil for activities	$43,563	$19,954	$18,875	$21,062
Repairs & maintenance	$7,360	$5,513	$5,889	$6,364
Seed	$17,512	$25,278	$22,820	$30,220
Fertilizer	$28,222	$39,855	$40,392	$44,384
Herbicide	$17,480	$51,095	$46,175	$44,815
Insecticide	$4,732	$5,805	$4,757	$10,448
Fungicide & Other	$1,757	$1,757	$870	$1,740
Summer harvest (net of fuel)	$5,943	$12,861	$9,890	$17,783
Winter harvest (net of fuel)	$15,832	$18,804	$21,775	$21,775
Total Variable Expenses	**$142,401**	**$180,922**	**$171,443**	**$198,591**
Total Gross Margin	**$74,805**	**$179,379**	**$221,908**	**$276,686**
Operating Overheads				
Accountant	$3,000	$3,000	$3,000	$3,000
Administration	$500	$500	$500	$500
Bank Charges other than interest	$500	$500	$500	$500
Electricity - Farm	$2,000	$2,000	$2,000	$2,000
Fuel & Oil (other than farming)	$10,000	$10,000	$10,000	$10,000
Insurance - farm including crop insurance	$6,000	$6,000	$6,000	$6,000
Motor Vehicle Expenses - Farm	$5,000	$5,000	$5,000	$5,000
Rates and Rents - Farm	$3,500	$3,500	$3,500	$3,500
Repairs & Maintenance(other than farming)	$20,000	$20,000	$20,000	$20,000
Subscriptions	$1,000	$1,000	$1,000	$1,000
Telephone - Farm	$2,500	$2,500	$2,500	$2,500
Wages - casual				
Plant Replacement Allowance	$30,358	$23,837	$25,722	$26,463
Allowance for unpaid labour	$50,000	$50,000	$50,000	$50,000
Total Operating Overheads	**$134,358**	**$127,837**	**$129,722**	**$130,463**
Farm Business Profit	**($59,553)**	**$51,542**	**$92,185**	**$146,223**
(Return on Assets & Management)				
Profit per Hectare Farmed	**-$74.44**	**$64.43**	**$115.23**	**$182.78**
Percentage return on Assets	**-2.08%**	**1.81%**	**3.16%**	**5.01%**

Points to note:

- Gross incomes improve with higher yields and crop frequency.
- Conventional farming systems have significantly higher fuel costs, but lower herbicide, seed and fertiliser costs.
- Conventional farming systems have the highest plant replacement cost due to the heavy work load of the main tractor (which will need to be replaced more often), and the need for more machinery in a conventionally farmed system (chisel plough, scarifier and offset discs).

5.2 Central Highlands Catchment

In the Central Highlands catchment, four farming system models were constructed. Again, the below BMP standard is illustrated by a conventional tillage farming system. The minimum BMP standard is illustrated by a zero till (RWT) farming system and the above BMP standard is illustrated by a zero till plus controlled traffic farming (CTF) system. A fourth model, that is a zero till plus CTF system which grows 12 crops in 10 years is also modelled.

5.2.1 Conventional Farming System (Central Highlands)

Figure 8 depicts the cropping rotations modelled for the conventional farming system that uses tillage practices for seed bed preparation and to control fallow weeds. It is suggested that a cropping intensity of 7 crops in 10 years would be the likely crop frequency.

Figure 8: Conventional Farming System (Central Highlands)

Start	Paddock area 200	200	200	200	200	200	200	200	200	200
Jan-2005		at plant	at plant	Chisel		at plant	at plant	chisel	chisel	
Feb-2005	off set dics				scarify					
Mar-2005		Spray out	Spray out	Chisel		Spray out	Spray out	chisel	chisel	Scarify
Apr-2005	chisel	Harvest	Harvest	Scarify		Harvest	Harvest	scarify	scarify	
May-2005				Plant wheat	scarify			Plant Wheat	Plant Chickpea	
Jun-2005	chisel	offset	offset			offset	offset			
Jul-2005				Incrop spray				Incrop spray	Incrop spray	
Aug-2005		chisel	chisel			Chisel	Chisel			Scarify
Sep-2005										
Oct-2005	Scarify	Scarify		Harvest wheat	scarify	Scarify	Scarify	Harvest Wheat	Harvest Chickpea	
Nov-2005			Scarify	Offset				offset	offset	Scarify
Dec-2005	Plant Sorghum	Plant Sorghum			Plant Sorghum	Plant Sorghum				
Activity Name	Plant Sorghum	Sorghum 1	Sorghum 2	Wheat 1	Fallow + Plant Sor(	Sorghum 3	Sorghum 4	Wheat 2	Chickpea 1	Fallow

Table 6 describes the frequency and expected value of crop yields in the conventional tillage cropping system in the Central Highlands catchment.

Table 6: Yield parameters for a conventional farming system

Central Highlands Catchment	**Yield Parameters (t/ha)**					**Yield Probabilities**			**Expected**
Conventional Tillage System	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	Yield (t/ha)
Sorghum	0	1.2	1.8	2.5	3	20%	60%	80%	1.7
Wheat	0	1	1.5	2	2.6	20%	60%	80%	1.41
Chickpea	0	0.4	0.8	1.3	1.75	20%	60%	90%	0.7475

5.2.2 Zero Till (RWT) Farming System (Central Highlands)

The zero till (RWT) farming system uses direct drilling for planting and herbicide sprays for weed control. Tillage equipment such as a chisel plough and offset discs are no longer included in the capital equipment and a spray rig is included. Figure 9 depicts the cropping rotation modelled for the zero till farming system. Unlike the Dawson/Callide catchment, it is suggested that a cropping intensity of only 9 crops in 10 years (as opposed to 10 crops in 10 years) would be achievable under a zero till (RWT) system in the Central Highlands catchment.

Figure 9: Zero Till (RWT) Farming System (Central Highlands)

Start	Paddock area 200	200	200	200	200	200	200	200	200	200
Jan-2005					Spray	spray			Spray	Spray
Feb-2005	spray	in crop spray	in crop spray	in crop spray			in crop spray	in crop spray		
Mar-2005		Spray out	Spray out	Spray out	Spray	spray	Spray out	Spray out	Spray	Spray
Apr-2005	spray	Harvest	Harvest	Harvest	Spray	Spray	Harvest	Harvest	Spray	Spray
May-2005					Plant Chickpea (sp	Plant Wheat			Plant Wheat	Plant Wheat
Jun-2005	spray	spray	spray	Spray			spray	spray		
Jul-2005					incrop spray	incrop spray			incrop spray	incrop spray
Aug-2005	Spray	Spray	Spray				spray	spray		
Sep-2005				Spray	Harvest Chickpea					
Oct-2005	Spray	Spray	Spray			Harvest wheat	Spray		Harvest Wheat	Harvest Wheat
Nov-2005	Spay at Plant	Spray at Plant	Spray at Plant	Spray	spray	Spray at plant	Spray at plant	Spray	Spray	Spray
Dec-2005	Sorghum	Sorghum	Sorghum			Sorghum	Sorghum			
Activity Name	Fallow Plant Sorgh	Sorghum 2	Sorghum 3	Harvest Sorghum	Chickpea 1	Wheat 1 + plant so	Sorghum 5	Harvest Sorghum	Wheat 2	Wheat 3

Table 7 describes the frequency and expected value of crop yields in the zero till (RWT) cropping system.

Table 7: Yield parameters for a zero till farming system

Central Highlands Catchment	**Yield Parameters (t/ha)**					**Yield Probabilities**			**Expected**
Zero Till System	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	Yield (t/ha)
Sorghum	0	1.2	2.5	2.9	3.3	10%	50%	80%	2.23
Wheat	0	1	2	2.4	2.8	10%	60%	90%	1.72
Chickpea	0	0.7	1.1	1.5	1.9	20%	60%	90%	0.99

5.2.3 Controlled Traffic Farming System (Central Highlands)

The controlled traffic farming system utilises GPS technology with auto steer and has all farming equipment (tractors, planters, spray rig, harvester) on the same track width. This technology is added to the inventory of plant and an allowance for changing over track width of machinery is included. Further, a self propelled spray rig replaces the towed spray rig. It should be noted that a self propelled spray rig is included only for the Central Highlands CTF system and not the Dawson/Callide CTF system. It is assumed that the considerable investment in a self propelled spray rig is most economical in the Central Highlands region where average farm sizes are much larger and economies of scale exist. These changes are added to the overall value of the plant and equipment. It is suggested that this system will have a cropping intensity of 10 crops in 10 years (one crop per year) in the Central Highlands catchment. The rotation below (Figure 10) depicts an 8 year rotation, equivalent to a crop each year.

Figure 10: Controlled Traffic Farming System (Central Highlands)

	Paddock area							
Start	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**
Jan-2005					Spray	Spray	Spray	
Feb-2005	Spray	in crop spray	in crop spray	in crop spray				in crop spray
Mar-2005		Spray out	Spray out	Spray out	Spray	Spray	Spray	Spray out
Apr-2005	Spray	Harvest	Harvest	Harvest	Spray	Spray	Spray	Harvest
May-2005	Plant Wheat				Plant Wheat	Plant wheat	Plant Chickpea	
Jun-2005		Spray	Spray	Spray			incrop spray	Spray
Jul-2005	Incrop spray				Incrop Spray	Incrop spray	incrop spray	
Aug-2005		Spray	Spray					Spray
Sep-2005				Spray			Harvest chickpea	
Oct-2005	Harvest wheat	Spray	Spray		Harvest Wheat	Harvest wheat	Spray	Spray
Nov-2005	Spray at plant	Spray at plant	Spray at plant	Spray	Spray	Spray	Spray at plant	
Dec-2005	Sorghum	Sorghum	Sorghum				Sorghum	
Activity Name	Wheat 1 + Sorghu	Sorghum 2	Sorghum 3	Harvest Sorghum	Wheat 2	Wheat 3	Chickpea 1	Sorghum 4

Table 8 describes the frequency and expected value of crop yields in the controlled traffic cropping system.

Table 8: Yield parameters for a CTF farming system

Central Highlands Catchment	**Yield Parameters (t/ha)**					**Yield Probabilities**			**Expected**
CTF System	Minimum	Poor	Most Likely	Good	Maximum	Poor	Most Likely	Good	Yield (t/ha)
Sorghum	0	1.4	2.6	3.1	3.6	10%	50%	80%	2.395
Wheat	0	1.2	2.2	2.6	3	20%	50%	80%	1.91
Chickpea	0	0.7	1.2	1.6	2	10%	60%	90%	1.11

As with the Dawson/Callide region, a CTF system that achieves 12 crops in 10 years was modelled (shown in Figure 11) for the Central Highlands as this was suggested to be the long term goal of Controlled Traffic farmers in the region. As with the Dawson/Callide model, it is assumed that the increased cropping intensity will lead to reduced yields in some years. Because soil profiles in the Central Highlands are not as deep as the Dawson/Callide, the capacity to store water in the soil in general is lower. To account for this, expected yields in four out of the 12 crops are reduced by 20% (as opposed to 10% in the Dawson/Callide) compared with the previous CTF model.

Figure 11: Controlled Traffic Farming System (12 crops in 10 Years) (Central Highlands)

	Paddock area									
Start	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Jan-2005	Spray						Spray			
Feb-2005		in crop spray	in crop spray	Spray	in crop spray	in crop spray		in crop spray	in crop spray	Spray
Mar-2005	Spray	Spray out	Spray out		Spray out	Spray out	Spray	Spray out	Spray out	
Apr-2005	Spray	Harvest	Harvest	Spray	Harvest	Harvest	Spray	Harvest	Harvest	Spray
May-2005	Plant Chickpea		Plant Wheat	Plant Wheat			Plant Chickpea		Plant Wheat	Plant Wheat
Jun-2005	Spray at plant	Spray			Spray	Spray	Spray at plant	Spray		
Jul-2005	incrop spray		Incrop spray	Incrop Spray			incrop spray		Incrop Spray	Incrop Spray
Aug-2005		Spray			Spray	Spray		Spray		
Sep-2005	Harvest chickpea						Harvest chickpea			
Oct-2005	Spray	Spray	Harvest wheat	Harvest Wheat	Spray	Spray	Spray	Spray	Harvest Wheat	Harvest Wheat
Nov-2005	Spray at plant	Spray at plant	Spray	Spray at plant	Spray at plant		Spray at plant	Spray at plant	Spray	Spray
Dec-2005	Sorghum	Sorghum	Spray	Sorghum	Sorghum	Spray	Sorghum	Sorghum	Spray	Spray
Activity Name	Chickpea 1 + plant	Sorghum 2	Harvest sorghum +	Wheat 2	Sorghum3	Sorghum 4	Chickpea 2 + Plant	Sorghum 5	Sorghum 6 + Whea	Wheat 4

Table 9 provides the expected values from the modelled output data from each of the farming systems modelled in the Central Highlands catchment.

Table 9: Outputs of the modelled farming systems in the Central Highlands catchment

Central Highlands Catchment	Conventional Farming System (7 crops in 10 years)	Zero Till (Random Wheel) Farming System (9 crops in 10 years)	CTF Farming System (10 crops in 10 years)	CTF Farming System (12 crops in 10 years)
Total Value of Assets	**$3,720,000**	**$3,878,000**	**$4,159,000**	**$4,159,000**
Farm Gross Income				
Summer crop sales	$229,160	$379,100	$403,558	$455,884
Winter crop sales	$241,840	$308,610	$429,506	$486,630
Total Farm gross income	**$471,000**	**$687,710**	**$833,064**	**$942,514**
Farm Variable Expenses				
Fuel and oil for activities	$115,893	$37,053	$29,941	$37,218
Repairs & maintenance	$24,963	$11,267	$8,213	$9,930
Seed	$42,900	$52,580	$54,250	$70,800
Fertilizer	$43,111	$113,784	$114,675	$129,160
Herbicide	$53,150	$128,269	$115,997	$122,161
Insecticide	$6,785	$4,983	$5,663	$9,060
Fungicide & Other	$2,000	$0	$2,500	$2,000
Summer harvest (net of fuel)	$29,714	$37,143	$37,143	$44,571
Winter harvest (net of fuel)	$24,724	$32,152	$40,190	$49,448
Total Variable Expenses	**$343,240**	**$417,232**	**$408,572**	**$474,349**
Total Gross Margin	**$127,759**	**$270,478**	**$424,492**	**$468,165**
Operating Overheads				
Accountant	$5,000	$5,000	$5,000	$5,000
Administration	$500	$500	$500	$500
Bank Charges other than interest	$500	$500	$500	$500
Electricity - Farm	$2,000	$2,000	$2,000	$2,000
Fuel & Oil (other than farming)	$10,000	$10,000	$10,000	$10,000
Insurance - farm including crop insurance	$6,000	$6,000	$6,000	$6,000
Motor Vehicle Expenses - Farm	$5,000	$5,000	$5,000	$5,000
Rates and Rents - Farm	$5,000	$5,000	$5,000	$5,000
Repairs & Maintenance(other than farming	$20,000	$20,000	$20,000	$20,000
Subscriptions	$1,000	$1,000	$1,000	$1,000
Telephone - Farm	$2,500	$2,500	$2,500	$2,500
Wages - casual	$45,000	$45,000	$45,000	$45,000
Plant Replacement Allowance	$75,005	$43,686	$46,618	$56,238
Allowance for unpaid labour	$50,000	$50,000	$50,000	$50,000
Total Operating Overheads	**$227,505**	**$196,186**	**$199,118**	**$208,738**
Farm Business Profit	**-$99,746**	**$74,292**	**$225,374**	**$259,428**
(Return on Assets & Management)				
Profit per Hectare Farmed	**-$49.87**	**$37.15**	**$112.69**	**$129.71**
Percentage return on Assets	**-2.68%**	**1.92%**	**5.42%**	**6.24%**

Points to note:

- Once again gross incomes improve with higher yields and crop frequency.
- Conventional farming systems have significantly higher fuel costs, but lower herbicide, seed and fertiliser costs.
- Conventional farming systems have the highest plant replacement cost, primarily due to the heavy work load of the main tractor (which will need to be replaced more often).
- The significant increase in farm business profit from the zero till (RWT) system to the CTF system is partly due to the increased cropping frequency from 9 to 10 crops in 10 years.

5.3 Herbicide Resistance

Recent sharp increases in pesticide prices, coupled with the widespread emergence of the hard to kill weed Feathertop Rhodes Grass (FTR) (a weed requiring increased amounts of herbicide application rates to control), is threatening the viability of zero tillage farming in the Dawson/Callide and Central Highlands regions. Furthermore, the continued use of glyphosate as the sole means of weed control presents the possibility that herbicide resistance will become widespread in the region. Speaking with a number of agronomists, the two options farmers are most likely to adopt in response to FTR and herbicide resistance are firstly, re-incorporating tillage into their farming systems, or secondly, purchasing ‘WeedSeeker’ spray technology. Because of the problems associated with moving back to tillage practices (lower water holding capacity of soils, decrease in crop yields and negative environmental impacts), the ‘WeedSeeker’ option is analysed here as it appears to be the more sustainable solution.

‘WeedSeeker’ technology is generally installed on a standard trailing boomspray and works by using sensors (installed along every 380mm of the boomspray) to recognise chlorophyll in weeds. Nozzles will only spray herbicide when the sensor recognises chlorophyll as the spray rig passes over the field. Farmers who currently use the technology suggested that the area of a paddock that is sprayed with a ‘WeedSeeker’ is between 5% - 30% of what would be sprayed in a broad acre application. With continued use and depletion of the weed seed stock it is likely that the lower end of the area spectrum will become the norm. From a weed resistance point of view, there is the potential to make use of more effective/expensive herbicides (such as paraquat) cost effective, thus reducing the reliance on Glyphosate as the only fallow management herbicide.

A herbicide resistance farm model was developed for both regions that incorporated a ‘WeedSeeker’ into the farming system. This model was based on the CTF system with 12 crops in 10 years, with the fallow sprays adjusted to account for the use of a ‘WeedSeeker’. Approximately 20% of fallow sprays were typical broad acre applications of glyphosate, with the remainder being performed by the ‘WeedSeeker’. A ‘Double Knock’ method was assumed, whereby a general fallow spray (either broadacre or with the ‘WeedSeeker’) was followed by a second spray of a more expensive paraquat chemical. The ‘double knock’ spray was done using the ‘WeedSeeker’ as a means of, ‘cleaning up’ any remaining hard-to-kill weeds. It was assumed that the ‘WeedSeeker’ would on average spray 20% of the area of a broad acre application. Farmers currently using ‘WeedSeeker’ technology were consulted to develop models for both regions.

It is assumed that the level of investment in ‘WeedSeeker’ technology differs between regions. This accounts for the different sized boom sprays that are likely to be used (18 metre width for Dawson/Callide, 24 metre width for Central Highlands) which reflects the average farm size in each region. It must be noted that in practice, the combating of FTR and/or herbicide resistant weeds may require a number of different strategies to be implemented in addition to the use of more effective herbicides (e.g. changing crop rotations). This model only looks at the costs and benefits associated with the implementation of a ‘WeedSeeker’ while maintaining the same rotations as previously modelled.

5.3.1 Dawson/Callide Catchment

The paddock layout for the herbicide resistance model for Dawson/Callide is shown in Figure 12. With the inclusion of a 'WeedSeeker', the total number of sprays increases compared with the CTF system, however most fallow passes only spray 20% of the area of a broad acre spray.

Figure 12: Paddock layout of Dawson/Callide Controlled Traffic Farming System (12 crops in 10 years) plus Herbicide Resistance measures. (WS = general 'WeedSeeker' spray, DK = 'double knock' application of paraquat).

Start	Paddock area 80	80	80	80	80	80	80	80	80	80
Jan-2005	Spray (WS)			Spray	Incrop spray	Spray (WS)	Spray (WS)	Spray (WS)	incrop spray	Incrop spray
Feb-2005	Spray (DK)	in crop spray	in crop spray	Spray (DK)	Incrop spray	Spray (DK)	Spray (DK)	Spray (DK)	incrop spray	Incrop spray
Mar-2005	Spray	Spray out	Spray out	Spray (WS)	Spray out	Spray (WS)			spray out	spray out
Apr-2005	Spray (DK)	Harvest	Harvest	Spray (DK)	Harvest Mungbean	Spray at plant	Spray (WS)	Spray (WS)	Harvest Mungbean	Harvest Mungbean
May-2005	Plant Wheat	Spray	Spray	Plant Wheat	Plant wheat	Plant Chickpea	Plant Wheat	Plant wheat	Spray	Plant Wheat
Jun-2005		Spray (DK)	Spray (DK)			incrop spray			Spray (DK)	
Jul-2005	Incrop spray			Incrop spray	Incrop spray	incrop spray	Incrop spray	Incrop spray		Incrop spray
Aug-2005		Spray (WS)	Spray (WS)						Spray (WS)	
Sep-2005		Spray (DK)				Harvest chickpea			Spray (DK)	
Oct-2005	Harvest wheat	Spray (WS)	Spray (WS)	Harvest Wheat	Harvest wheat	Spray	Harvest Wheat	Harvest wheat	Spray (WS)	Harvest wheat
Nov-2005	Spray at plant	Spray at plant	Spray (WS)	spray at plant	Spray	Spray (DK)	Spray	spray at plant	spray at plant	spray
Dec-2005	Sorghum	Sorghum	Spray (DK)	Plant Mungbean	Spray (DK)	Spray (WS)	Spray (DK)	Plant Mungbean	Plant Mungbean	Spray (DK)
Activity Name	Wheat 1 + Sorghum 1	Sorghum 2	Sorghum 3	Wheat 2 + plant Mungbean 1	Harvest Mungbean 1 + Wheat 3	Chickpea 1	Wheat 4	Wheat 5 + Plant Mungbean 2	Harvest Mungbean 2 + plant Mungbean 3	Harvest Mungbean 3 + Wheat 6

Table 10 compares the main points of difference for the CTF system and the CTF system with herbicide resistance measures in place. Points to note include:

- Farm gross income remains unchanged under the herbicide resistance model as there is assumed to be no change in crop yields or prices.
- Fuel and oil expenses are higher in the herbicide resistance model as the total number of spray passes increases.
- Repair and maintenance costs and the plant replacement allowance (depreciation costs) increase under the herbicide resistance model due to the additional machinery ('WeedSeeker').
- Herbicide expenses decrease with the addition of the 'WeedSeeker', despite the use of more expensive chemicals, as most fallow sprays only cover 20% of the area of a broad acre spray.
- Overall the savings in herbicide costs slightly outweigh the increase in Fuel, oil, repairs, maintenance costs for the herbicide resistance model, resulting in a higher gross margin for this system.
- However, after taking into account the increased fixed costs (overheads) for the herbicide resistance model (due to the additional machinery), the herbicide resistance model has a marginally lower profit per hectare and return on assets.

Table 10: Dawson/Callide modelled output data for CTF system (12 crops in 10 years) and CTF system with herbicide resistance measures.

Dawson/Callide Catchment	**CTF Farming System (12 crops in 10 years)**	**CTF Farming System (12 crops in 10 years) "Weedseeker"**
Total Value of Assets	**$2,917,000**	**$3,047,000**
Total Farm gross income	**$475,277**	**$475,277**
Farm Variable Expenses		
Fuel and oil for activities	$21,062	$22,832
Repairs & maintenance	$6,364	$7,986
Herbicide	$44,815	$41,410
Total Variable Expenses	**$198,591**	**$198,578**
Total Gross Margin	**$276,686**	**$276,699**
Operating Overheads		
Plant Replacement Allowance	$26,463	$30,417
Total Operating Overheads	**$130,463**	**$134,417**
Farm Business Profit	**$146,223**	**$142,282**
(Return on Assets & Management)		
Profit per Hectare Farmed	**$182.78**	**$177.85**
Percentage return on Assets	**5.01%**	**4.67%**

Note: The full array of variable and fixed costs are not included in this table, only those that varied between scenarios.

5.3.2 Central Highlands Catchment

Similar to the Dawson/Callide model, the Central Highlands herbicide resistance model (Figure 13) is based on the CTF system with 12 crops in 10 years. Once again, approximately 20% of fallow sprays are broad acre, with 80% done using the 'WeedSeeker'.

Figure 13: Paddock layout of Central Highlands CTF system plus herbicide resistance measures. (WS = general 'WeedSeeker' spray, DK = 'double knock' application).

Start	**Paddock area** 200	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Jan-2005	Spray			Spray (WS)			Spray (WS)			Spray (WS)
Feb-2005	Spray (DK)	in crop spray	in crop spray	Spray	in crop spray	in crop spray	Spray (DK)	in crop spray	in crop spray	Spray (DK)
Mar-2005	Spray (WS)	Spray out	Spray out	Spray (DK)	Spray out	Spray out	Spray (WS)	Spray out	Spray out	Spray
Apr-2005	Spray (DK)	Harvest	Harvest	Spray	Harvest	Harvest	Spray (DK)	Harvest	Harvest	Spray (DK)
May-2005	Plant Chickpea	Spray	Plant Wheat	Plant Wheat	Spray	Spray	Plant Chickpea	Spray	Plant Wheat	Plant Wheat
Jun-2005	Spray at plant	Spray (DK)			Spray (DK)	Spray (DK)	Spray at plant	Spray (DK)		
Jul-2005	incrop spray		Incrop spray	Incrop Spray			incrop spray		Incrop Spray	Incrop Spray
Aug-2005		Spray (WS)			Spray (WS)	Spray (WS)		Spray (WS)		
Sep-2005	Harvest chickpea	Spray (DK)			Spray (DK)	Spray (DK)	Harvest chickpea	Spray (DK)		
Oct-2005	Spray	Spray (WS)	Harvest wheat	Harvest Wheat	Spray (WS)		Spray	Spray (WS)	Harvest Wheat	Harvest Wheat
Nov-2005	Spray at plant	Spray at plant	Spray	Spray at plant	Spray at plant	Spray	Spray at plant	Spray at plant	Spray	Spray
Dec-2005	Sorghum	Sorghum	Spray (DK)	Sorghum	Sorghum	Spray (DK)	Sorghum	Sorghum	Spray (DK)	Spray (DK)
Activity Name	Chickpea 1 + plant Sorghum	Sorghum 2	Harvest sorghum + Wheat 1	Wheat 2	Sorghum3	Sorghum 4	Chickpea 2 + Plant Sorghum	Sorghum 5	Sorghum 6 + Wheat 3	Wheat 4

Table 11 summarises the main points of difference between the CTF (12 crops in 10 years) system and the CTF system with herbicide resistance measures. As with the Dawson/Callide herbicide resistance model, fuel, oil, repairs and maintenance costs increase, whilst herbicide costs decrease. Farm business profit is once again slightly lower for the 'WeedSeeker' model due to the higher depreciation costs outweighing the savings in variable costs. Return on assets decreases due to the increased value of assets under the herbicide resistance model.

Table 11: Central Highlands modelled output data for CTF system (12 crops in 10 years) and CTF system with herbicide resistance measures.

Central Highlands Catchment	**CTF Farming System (12 crops in 10 years)**	**CTF Farming System (12 crops in 10 years) 'Weedseeker'**
Total Value of Assets	**$4,159,000**	**$4,339,000**
Total Farm gross income	**$942,514**	**$942,514**
Farm Variable Expenses		
Fuel and oil for activities	$37,218	$43,370
Repairs & maintenance	$9,930	$11,409
Herbicide	$122,161	$112,746
Total Variable Expenses	**$474,349**	**$472,565**
Total Gross Margin	**$468,165**	**$469,949**
Operating Overheads		
Plant Replacement Allowance	$56,238	$65,705
Total Operating Overheads	**$208,738**	**$218,205**
Farm Business Profit	**$259,428**	**$251,744**
(Return on Assets & Management)		
Profit per Hectare Farmed	**$129.71**	**$125.87**
Percentage return on Assets	**6.24%**	**5.80%**

Note: The full array of variable and fixed costs are not included in this table, only those that varied between scenarios.

The analysis of both the Dawson/Callide and Central Highlands herbicide resistance models presents a strong case for the adoption of 'WeedSeeker' technology to combat herbicide resistance from an agronomic and economic perspective.

Although expected profit per hectare decreases under the Dawson/Callide herbicide resistance model, this is only slight at $4.93/Ha. For the Central Highlands model, expected profit is also slightly lower with herbicide resistance measures in place, but only by $3.84/Ha. These are most likely to be smaller reductions in profit than what would occur under the alternative solution – resuming tillage practices, as there are numerous negative impacts associated with this option (increased fuel costs, reduced yields, water holding capacity and infiltration, increased runoff and soil loss).

In consideration of environmental outcomes, the adoption of 'Weedseeker' technology is positive as it decreases the volume of chemical herbicides applied. In theory, if less herbicide is applied then one would expect less to be leaving the property and making its way into the river systems. At present however, there is no data available that measures the reduction in herbicide runoff associated with the use of a 'WeedSeeker'

6 Results

Below are the summary tables of the modelled farming systems in each of the catchments. The tables contain the main financial data associated with each farming system (FS) modelled. The numbers are the expected outcomes based on the information supplied to the model. Expected outcomes are a weighted average according to the distribution of the variables and the probabilities applied. The primary farm financial output of interest is farm business profit. The significant results are the graphs displaying the distributions of farm business profit under the various farming systems. Farm business profit is the return to the business after variable costs and fixed costs are allocated. The fixed costs include, as well as the general fixed costs, a wage of $50,000 to the owner operator and an allowance for depreciation.

6.1 Dawson/Callide Catchment Results

Table 12 presents the farm financial results of the modelled farming systems for the Dawson/Callide catchment. Table 12 clearly illustrates that farm business profit and percentage return on assets increases as BMP management practices are adopted in the Dawson/Callide region.
Points to note:

- The investment required in a zero tillage (RWT) farming system is $7,000 less than a conventional tillage system (as machinery ownership requirements are changed) yet annual farm business profit for the zero tillage system is $111,095 ($138.87 per hectare) greater than a conventionally tilled farm (which according to the model is losing money).
- A fully controlled traffic system requires an initial investment of $62,000 more than a zero tillage (RWT) system, however, farm business profit is improved by $40,643 annually ($50.80 per hectare) under the CTF system.
- If the CTF target of 12 crops in 10 years can be achieved, the same additional investment ($62,000) results in a farm business profit $94,681 greater ($118.35 per hectare) than under a zero till (RWT) farming system.
- As management practices improve, so too does the percentage return on assets. For a CTF system achieving 12 crops in 10 years, return on assets increases by 7.09% compared with a farming system practicing conventional tillage.

Table 12: Results from the Dawson/Callide farming systems

Dawson/Callide Catchment - Farmed area 800 Ha	**Conventional Farming System**	**Zero Till (Random Wheel) Farming System**	**CTF Farming System (10 crops in 10 years)**	**CTF Farming System (12 crops in 10 years)**
Land Value - 900 Ha @ $2,500 per Ha	$2,250,000	$2,250,000	$2,250,000	$2,250,000
Plant & Equipment	$612,000	$605,000	$667,000	$667,000
Total Value of Assets	**$2,862,000**	**$2,855,000**	**$2,917,000**	**$2,917,000**
Number of Crops in 10 Years	**7**	**10**	**10**	**12**
Total Farm Gross Income	**$217,206**	**$360,301**	**$393,351**	**$475,277**
Total Variable Expenses	**$142,401**	**$180,922**	**$171,443**	**$198,591**
Total Gross Margin	**$74,805**	**$179,379**	**$221,908**	**$276,686**
Gross Margin per Hectare	**$93.51**	**$224.22**	**$277.38**	**$345.86**
Total Fixed Costs	**$134,358**	**$127,837**	**$129,722**	**$130,463**
Farm Business Profit (Return on Assets & Management)	**($59,553)**	**$51,542**	**$92,185**	**$146,223**
Profit per Hectare Farmed	**-$74.44**	**$64.43**	**$115.23**	**$182.78**
Percentage Return on Assets	**-2.08%**	**1.81%**	**3.16%**	**5.01%**

6.2 Central Highlands Catchment Results

Table 13 presents the farm financial results of the modelled farming systems for the Central Highlands catchment. Once again a very strong case is presented for adoption of best management practices.

Points to note:

- For the Central Highlands model, total investment in zero till (RWT) farming is greater than conventional farming, with a difference of $158,000. This increase is accounted for primarily by the addition of a spray rig and more powerful tractor (to pull the rig). Farm business profit for the zero till (RWT) farm is $174,038 ($87.02 per hectare) higher per annum compared with the conventional system (which is once again according to the model losing money).
- The investment required for a CTF system is $281,000 more than a zero till (RWT) system (this includes the self propelled spray rig). The resulting farm business profit is $151,082 ($75.54 per hectare) greater per year than a zero till farming system. It should be noted that in the Dawson/Callide model, a zero till farm achieves a 100% cropping frequency, whereas in the Central Highlands model only a 90% cropping frequency is achieved. Because the move from zero till (RWT) to CTF includes an increase in cropping frequency for the Central Highlands, the increase in farm business profit is greater relative to the Dawson/Callide region where the cropping frequency remains unchanged between zero till (RWT) and CTF.
- If 12 crops in 10 years is achieved under CTF, the increase in farm business profit is $185,136 ($92.56 per hectare) compared with zero till (RWT).
- As with the Dawson/Callide models, return on assets increases as management practices increase. The improvement to return on assets is 8.92% when comparing a CTF system achieving 12 crops in 10 years and a conventional system.

Table 13: Results from the Central Highlands farming systems

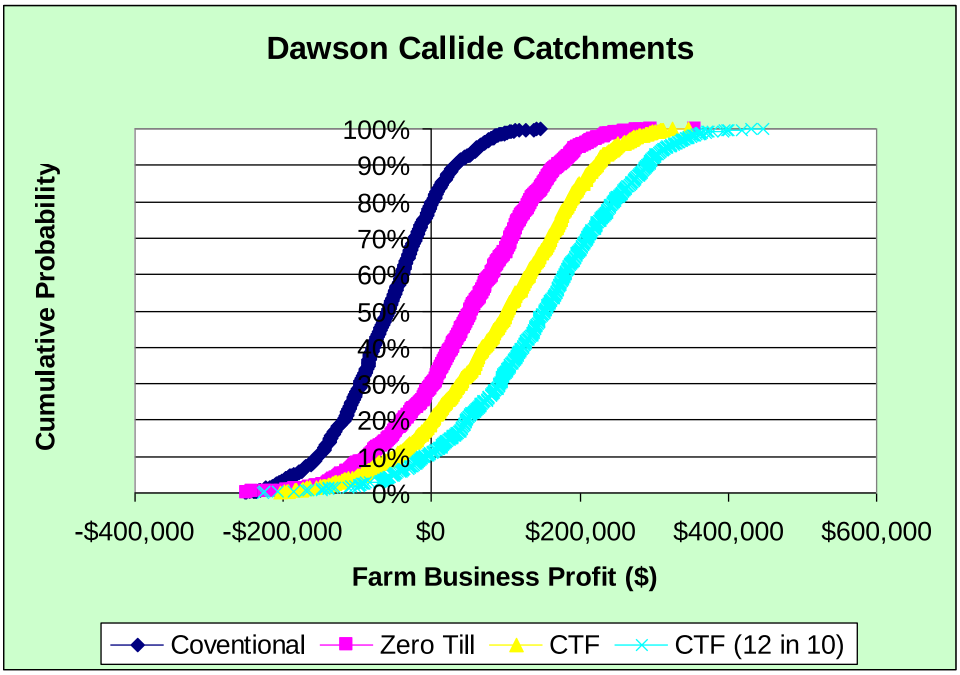
Central Highlands Catchment - Farmed area 2,000 Ha	Conventional Farming System	Zero Till (Random Wheel) Farming System	CTF Farming System (10 crops in 10 years)	CTF Farming System (12 crops in 10 years)
Land Value - 2,200 Ha @ $1,350 per Ha	$2,970,000	$2,970,000	$2,970,000	$2,970,000
Plant & Equipment	$750,000	$908,000	$1,189,000	$1,189,000
Total Value of Assets	**$3,720,000**	**$3,878,000**	**$4,159,000**	**$4,159,000**
Number of Crops in 10 Years	**7**	**9**	**10**	**12**
Total Farm Gross Income	**$471,000**	**$687,710**	**$833,064**	**$942,514**
Total Variable Expenses	**$343,240**	**$417,232**	**$408,572**	**$474,349**
Total Gross Margin	**$127,759**	**$270,478**	**$424,492**	**$468,165**
Gross Margin per Hectare	**$63.88**	**$135.24**	**$212.25**	**$234.08**
Total Fixed Costs	**$227,505**	**$196,186**	**$199,118**	**$208,738**
Farm Business Profit (Return on Assets & Management)	**-$99,746**	**$74,292**	**$225,374**	**$259,428**
Profit per Hectare Farmed	**-$49.87**	**$37.15**	**$112.69**	**$129.71**
Percentage return on Assets	**-2.68%**	**1.92%**	**5.42%**	**6.24%**

The results demonstrate that the adoption of best management practices make a significant improvement to farm business profit for both regions.

6.3 Results of Risk Analysis

Figure 14 & 15 below provide the results of the risk analysis of the farming systems modelled in the Dawson/Callide and Central Highlands catchments respectively. The graphs demonstrate the significant gains that are made from moving from a conventional farming system to a zero till (RWT) farming system. The gains from zero till (RWT) to a CTF system are less pronounced, however it is suggested that if a farmer adopts a CTF system then they would have a significantly better chance of increasing the cropping frequency and thus obtaining a higher probability of increasing farm business profit. The modelling demonstrates that significant gains to profitability are possible if a higher cropping frequency is achieved.

Figure 14: Results of Risk Analysis of the farming systems in the Dawson/Callide catchment

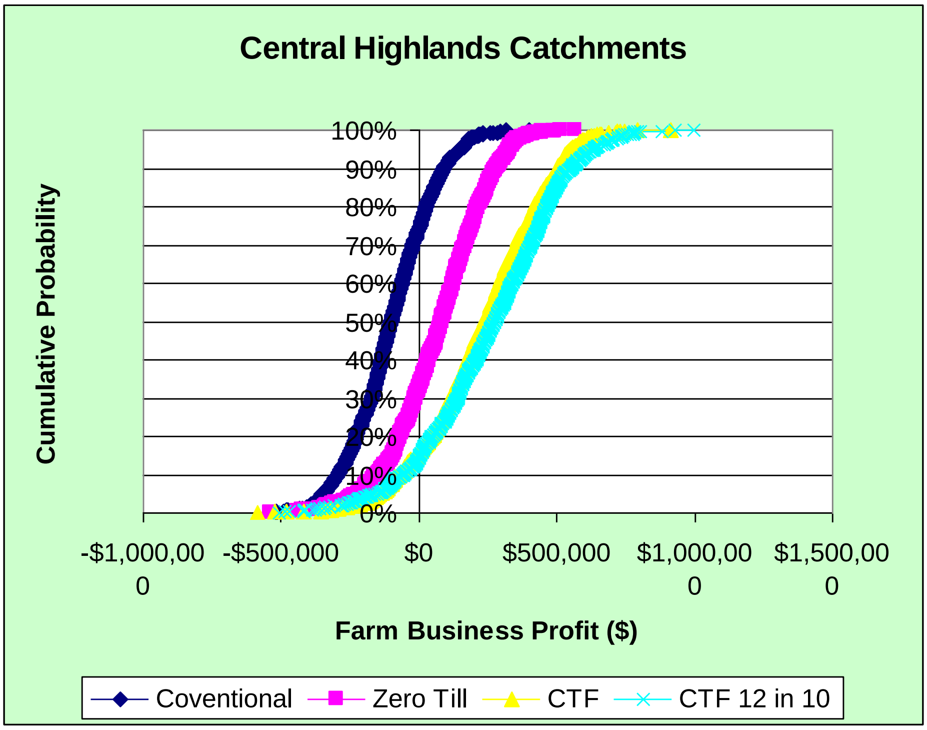


The probability of achieving a negative farm business profit for the various farming systems are:

- Conventional tillage farming system is 79.9%
- Zero Till (RWT) farming system is 29.1%
- Controlled Traffic farming system is 20%
- Controlled Traffic (12 crops in 10 years) farming system is 11.1%

The results demonstrate that the adoption of above standard BMP is the most profitable farming system and provides the opportunity for growers to increase cropping frequency which then has significant benefits to farm business profits. The risk analysis assessments demonstrate the adoption of BMPs increases the likelihood of achieving positive farm business profits.

Figure 15: Results of Risk Analysis of the farming systems in the Central Highlands catchment



The probability of achieving a negative farm business profit for the various farming systems are:

- Conventional tillage farming system is 74.5%
- Zero Till (RWT) farming system is 32.2 %
- Controlled Traffic farming system is 16%
- Controlled Traffic (12 crops in 10 years) farming system is 14.5%

As mentioned previously, for the Central Highlands catchment the move to CTF from zero till involves increasing the cropping frequency from 90% to 100%. This results in a more pronounced increase in farm business profitability for the Central Highlands than for the Dawson/Callide (where cropping frequency remained unchanged between zero till and CTF).

Comparing the results of the modelled farming systems for each catchment it is evident that very significant farm business profit gains may be achieved from the adoption of more sustainable farm management practices.

6.4 Results of Discounted Cash Flow Analysis of Alternative Farm Investments

The results of the discounted cash flow (DCF) analyses are presented in Table 14 below. The DCF analysis determines the benefit from the investment in the extra plant and equipment necessary to farm using a CTF system as opposed to a zero till (RWT) system. This is not the benefit from changing from one system to the other but rather, if a farmer had the choice between implementing a zero till (RWT) or CTF system would the extra capital required to set up a CTF system be compensated by the extra annual farm business profit generated by the CTF system over the zero till (RWT) system. For the purposes of this analysis, the zero till (RWT) system is compared with the CTF system producing 10 crops in 10 years (as opposed to the 12 crops in 10 years model) in order to produce a conservative estimate.

The criteria measured are net present value (NPV), benefit cost ratio (B/C Ratio) and payback period. The NPV represents the current value of the investment over a ten year period using a discount rate of 7%. If the NPV figure is negative then the investment is said to be unviable at the discount rate quoted and for the stated investment time frame. The benefit cost ratio is the ratio of the discounted costs of the investment to the sum of the discounted benefits over the ten year investment period. That is, the B/C ratio represents the return over a ten year investment period for every dollar spent in present dollar value. Therefore, for the investment to be viable the B/C ratio needs to be equal or greater than one. Discounting is used to bring all costs and benefits over the term of the investment to present values so that meaningful comparisons between investment options can be made.

Table 14: Results of DCF Analysis of investing in necessary plant and equipment for CTF system over a zero till (RWT) system

Catchment	Dawson/Callide	Central Highlands
P & E Value Difference	$62,000	$281,000
Discount Rate	7%	7%
Investment Time	10 Years	10 Years
NPV	$223,466	$780,137
B/C Ratio	4.6	3.8
Payback Period	2 years	3 Years

As noted previously, the increase in investment necessary to farm in a CTF system as opposed to a zero till (RWT) system is $62,000. The NPV of $223,466 is positive, suggesting that at the discount rate quoted (7%) and the investment time frame (10 years) the benefits generated from the investment outweigh the cost. The B/C Ratio shows that for every dollar invested, 4.6 will be returned over a 10 year investment period. The payback period of 2 years means that the cost of the extra investment will be recouped in 2 years.

The results for the Central Highlands catchment suggest that the investment of $281,000 for plant and equipment necessary to operate a CTF system as opposed to a zero till (RWT) system is an attractive one. The NPV is positive at $780,137 and the B/C Ratio shows that for every dollar invested, 3.8 will be returned over a 10 year investment period. Calculating the payback period shows that the extra investment cost will be recouped in 3 years.

7 NRM Benefits

An important component of Grains BMP involves minimising the offsite environmental impacts that result from broad acre cropping. In particular, the four key points of interest for broad acre cropping farms focus on limiting:

- Soil loss
- Water runoff
- Nutrient runoff
- Pesticide runoff

This section aims to analyse the changes in offsite environmental impacts as a result of changes made to farming system practices. Furthermore, an assessment is made of the value of environmental benefits achieved due to the adoption of BMP standards across the grains industry in the Fitzroy Basin.

Measuring the value of outputs for projects that provide environmental benefits is always a challenge as most of the benefits fall into the category of non-market goods, i.e. they are not traded in the market. The pricing of non-market goods remains and inexact science, with a number of methods available to value non-market impacts of different practices. Briefly, possible methods include; opportunity cost method, shadow pricing techniques, the travel cost method, benefit transfer methods and contingent valuation approaches.

For this analysis a shadow price technique is applied. This technique values benefits within the market which are attributed to the value of benefits to the environment due to adoption of minimal or above standard BMP. Thus, the benefit of total adoption will be the cost-savings or increased production that occurs as a result of the decreased soil loss and runoff associated with BMP adoption.

Up to this point, research comparing environmental impacts of different farming practices has focused on the differences between conventional and zero till farming. Research data that compares the different environmental impacts of zero till and controlled traffic farming is virtually non-existent at this stage. It is therefore assumed for these calculations that the NRM benefits derived from zero till farming represent best management practices with regards to controlling off site environmental impacts. This assumption is reasonable as the primary factors influencing the level of soil loss and runoff (the level of stubble retention and water runoff drainage management) are similar for zero tillage and CTF (as CTF is an extension of zero till farming).

Assumptions made in the following calculations have used figures from the ABS Land Management & Farming in Australia 2007/08 (released May 2009).

- The Fitzroy catchment has a total area of 143,000 square kilometres.
- Total cropping area is 579,000 hectares. It is assumed that this includes fodder crops for livestock, cotton, pasture establishment and other non grain crops.
- The break up of cropping management practices is:
    - no cultivation - 54% or 312,660 ha;
    - one or two cultivations - 33% or 191,000 ha; and
    - 3 or more cultivations 12% or 69,480 ha.
- For the purposes of this analysis it will be assumed that all of the no cultivation area is grain cropping. For the areas cultivated one or two times

and three or more times, it will be assumed that half of this area is grain cropping (ie. 130,240 ha) and the remaining half is fodder crops, cotton, pasture establishment and other non grain crops.

- Using these assumptions, the total area for cereal grain production is 442,900 hectares.
- Conventional farming practices total 29.4% of the grain producing area (130,240 hectares) in the Fitzroy catchment
- Zero till and CTF practices total 70.6% of the grain producing area (312,660 hectares) in the Fitzroy catchment.

7.1 Value of Limiting Soil Loss

The environmental value of limiting soil loss is assumed to be the nutrient value held in the soil. It is suggested that the environmental cost of soil loss is the cost farmers bear to replace the nutrients held in the soil, primarily nitrogen and phosphorous. It is recognised that continual soil loss will eventually lead to a point where no further production can occur, however, until such a threshold is reached, farmers will continue to farm their land and only replace the inputs required to maximise yields.

Table 15 summarises the average amount of soil loss determined from studies of soil loss levels for conventional farming practices and from zero till farming systems. The difference between the two farming systems on average is determined to be 23.52 tonnes per hectare less soil loss under zero till management.

Table 15: Summary of soil loss results from the Fitzroy Basin. (Sources: Freebairn & Wockner 1986, Carrol et al. 1997).

Farming Practice	Conventional FS	Zero Till FS	Difference
Soil Loss Range	4.01 – 46.3 t/ha	1.42 – 1.95 t/ha	
Average Annual Soil Loss	25.2 t/ha	1.68 t/ha	23.52 t/ha

The value of nitrogen and phosphorous in a tonne of soil is calculated to be $1.83 (this was derived from the cost of fertilisers containing these nutrients, and the average level of nitrogen and phosphorus content in a tonne of soil). The value per hectare of decreasing soil loss is calculated to be $42.94 per hectare. With the adoption of zero till and CTF management practices in 70.6% of the catchment (312,660 hectares), the environmental benefit achieved so far from adoption of best management practice with regards to stubble retention is $13.4 million per year. If the remaining 29.4% of grain cropping area is converted to zero tillage, a further $5.6 million benefit can be derived annually.

7.2 Value of Limiting Water Runoff

A number of environmental benefits are achieved through limiting water runoff from grain producing areas. These include reducing soil loss (valued above), reducing loss of applied nutrients (nitrogen and phosphorus) and reducing the amount of herbicide and pesticide chemicals from leaving the farm and entering water ways. Furthermore, there is the potential to increase the production levels of cropping land if less rainfall is lost as runoff and instead stored in the soil.

Freebairn & Wockner (1986) found that average water runoff was reduced from 81 mm/ha/yr under a conventional tillage system to 63 mm/ha/yr under a zero till farming system. This equates to a reduction of 18 mm/ha/yr in runoff, which is instead stored in the soil to be used for grain production. Assuming marginal water use efficiency to be 25kg/ha/mm, 18 mm/ha of water is estimated to produce 447 kg/hectare more grain each year. Using a grain price of $201 per tonne (the average of the wheat and sorghum prices used in previous analyses), this increase in production is valued at $89.85 per hectare.

With the adoption of zero till and CTF management practices in 70.6% of the catchment (312,660 hectares), the benefit to the catchment of limiting water runoff and therefore increasing grain production is found to be $28.1 million per annum. Furthermore, if the remaining 29.4% of area (130,240 hectares) adopts BMP, the benefit would be a further $11.7 million per annum.

7.3 Value of Limiting Nutrient Runoff

Table 16 contains the figures used to value the reduction in nutrient runoff. The percentages of applied nutrient lost to runoff are sourced from Chichester and Richardson (1992). These percentages were applied to the conventional and zero till models for the Dawson/Callide and Central Highlands, with the resulting nitrogen and phosphorus runoff levels used in Table 16 being an average for the two regions. Levels of nutrient applied annually were calculated to be 16.6 kg/ha of nitrogen and 1.22 kg/ha of phosphorus for a conventional system and 33.45 kg/ha of nitrogen and 1.5 kg/ha of phosphorus for a zero till system. It should be noted that these averages are calculated using the total farm area, which includes areas of the farm in fallow and therefore have no fertiliser applied during the year.

Table 16: Summary amount of applied nutrients lost due to runoff per annum from conventional and zero till farming practices in Fitzroy Basin.

Farming Practice	Conventional FS	Zero Till FS	Difference	$ per Ha
Nitrogen	6.2%	2.8%	3.4%	
	1.03 kg / ha	0.94 kg / ha	0.09 kg / ha	$0.1244
Phosphorous	11.8%	6.3%	5.5%	
	0.144 kg / ha	0.095 kg / ha	.049 kg / ha	$0.2034
			Total:	**$0.3278**

The adoption of zero till and CTF management practices is assumed to have occurred in 70.6% of the catchment (312,660 hectares). The current benefit to the catchment of adopting BMP's that limit water runoff and therefore reduce the loss of nutrients is valued at $102,500 per annum. Furthermore, if the remaining 29.4% of area (130,240 hectares) is converted to zero till or CTF then the benefit is further $42,700 per annum.

7.4 Value of Limiting Pesticide Application

At present, there is limited data available comparing pesticide runoff levels for conventional and zero till dryland grain farms. Rattray et al. (2004) used computer modelling to compare runoff levels of atrazine using rainfall and soil data for Greenmount (located on the Darling Downs). Computer simulations found that expected atrazine runoff was 0.18% of the total amount applied for a conventional tillage system and 0.15% of the total amount applied for a zero tillage system. These levels are extremely low in the first place and only differ 0.03% between systems, hence no analysis was done using this data.

It was instead decided to measure the possible savings in pesticide use that would arise from catchment-wide adoption of 'WeedSeeker' technology. Whilst this technology is still in relatively early stages of development and some current users have experienced problems (e.g. spray nozzles turning on and off at incorrect times), there is potential to reduce the level of pesticide application significantly assuming the technology becomes more reliable in the near future.

The benefit derived from decreasing chemical use on farms is determined by the savings that could be captured from the adoption of 'Weedseeker' technology. It is assumed that decreasing the amount of chemical application will have an environmental benefit resulting in less chemical residues leaving the farm and entering the water ways during runoff events.

A CTF model with 10 crops in 10 years in the Dawson/Callide region was adjusted to include a 'WeedSeeker' and compared with the standard CTF model. To isolate the potential benefit of reduced pesticide application, the rates and types of herbicide used are not changed (unlike in the 'herbicide resistance' model). The total number of fallow sprays is increased as this was suggested to be a likely requirement under 'WeedSeeker' adoption. Once again, 20% of fallow sprays are broad acre, with the remainder performed by the 'WeedSeeker'. It is assumed a 'WeedSeeker' will apply 20% of the amount of herbicide compared with a broad acre application. The 'WeedSeeker' benefits are considered conservative estimates as the smaller farm size of the Dawson/Callide model reduces potential benefits that arise from economies of scale (i.e. the benefit of herbicide reduction compared with the increase in fuel, oil, repairs and maintenance costs).

Table 17 shows the difference in costs between a standard CTF and CTF + 'WeedSeeker' system in the Dawson/Callide region. As with the models in section 5.3, fuel and oil expenses and repairs and maintenance increase due to the increased number of spray passes with a 'WeedSeeker'. However, this increase is more than compensated for by the reduction in herbicide expenses. In total, an increase in farm business profit of $11.77 per ha is realised with the adoption of a 'WeedSeeker' based on the modelled results in the Dawson/Callide catchment.

Table 17: Differences in variable and fixed costs and farm profitability from the adoption of a 'Weedseeker' in a CTF system in the Dawson/Callide catchment.

Farm Variable Expenses	Difference
Fuel and oil for activities	-$1,050
Repairs & maintenance for activities	-$1,213
Herbicide	$14,571
Total Variable Expenses	$12,308
Plant Replacement Allowance	-$3,280
Operating Return (Return on Assets & Management)	**$9,028**
Profit per Hectare	**$11.29**

With the adoption of precision spray application technology annual cost savings of $11.29 per hectare are realised. As there are currently only a minimal number of 'Weedseeker' spray units operational in the Fitzroy catchment, it is assumed that the adoption of this technology over the entire catchment would provide a benefit of $5 million per annum.

Table 18 provides a summary of the value of the environmental benefits that are being achieved and which could be achieved in the future with the adoption of BMP standards over the Fitzroy catchment.

Table 18: Summary of the value of annual NRM benefits from grain farms in the Fitzroy Basin.

NRM Annual Benefits	Current Benefits ($M)	Potential Savings ($M)
Limiting Soil Loss	13.4	5.6
Limiting water runoff – production	28.1	11.7
Value of N & P losses	0.1	0.043
Limiting Herbicide use	-	5.0
TOTAL NRM Benefit	**41.6**	**22.3**

8 Conclusion

The results from the modelled representative farms demonstrate that the adoption of best management practices not only achieves sustainable management and reef protection but also more profitable businesses. The results of the modelled risk analyses demonstrate that the profitability of grain farms is highly sensitive to grain prices, yields and cropping frequency.

By comparing the results of the modelled farming systems in the catchments it is evident that very significant dollar per hectare benefits may be achieved from the adoption of BMPs. Furthermore, the adoption of BMPs will also have a significant positive impact on the natural environment of the Fitzroy Basin.

Undertaking analysis to value the environmental benefits to the catchment from the adoption of BMPs on grain farms is a difficult task given that the impacts are on non-market goods and therefore difficult to value in dollar terms. However, using the shadow pricing technique for valuation of the environmental benefits, it is clear that significant negative environmental impacts are currently being avoided due to the adoption of BMPs, with further reductions to be made from catchment-wide adoption. On the whole, the adoption of BMPs provides a win-win outcome with respect to farm business profit and the health of the natural environment.

Investment in programs that will assist grain farm businesses to adopt best management practices will improve the long-term sustainability of grain cropping in the Fitzroy Basin from both an environmental and economic point of view.

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