The Benefit Cost Analysis of the Agricultural Producer's Position as it Relates to the Nitrous Oxide Emission Reductions Protocol

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Disclaimer

This document has been produced independently by Dr. Paul Thomassin and The Prasino Group at the request of the Climate Change Emissions Management (CCEMC) Corporation as specified under contract for the Protocol Validation Studies. It was produced according to the requirements in the Alberta Offset System's Nitrous Oxide Emissions Reduction in Agriculture Quantification Protocol v 1.0 October 2013[1]. The views expressed in this report are not necessarily the views of the Climate Change Emissions Management (CCEMC) Corporation.

[1] See http://environment.gov.ab.ca/info/library/8294.pdf

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1. Introduction

Changes in fertilizer management practices by agricultural producers can result in a decrease in the amount of greenhouse gas emissions being generated as compared to their baseline production practice. The Quantification Protocol for Agricultural Nitrous Oxide Emissions Reductions outlines the 4R Consistent Nitrogen Stewardship plan which can reduce the amount of nitrous oxide emissions that results from nitrogen fertilizer applications. The 4R Stewardship plan consists of applying the Right source of nitrogen fertilizer at the Right rate, at the Right time and the Right place.

The decrease in nitrous oxide emissions from the 4R Consistent Stewardship plan can be sold in the Alberta Offset System. An aggregator will work with the agricultural producer and the agricultural professional in order to ensure that the project that is developed will be in accordance with the protocol. This report will provide some information on the benefits and costs for an agricultural producer to take on a change of management that is acceptable to the Nitrous Oxide Emissions Reductions Protocol.

2. Role of the Agricultural Producer

The agricultural producer will work with an agricultural professional and the aggregator to undertake a change in management practice in the application of fertilizer that will decrease the amount of greenhouse gas emissions emitted from their operation. The reduction in greenhouse gas emissions are the result of using the right source of nitrogen, at the right rate, at the right time and the right place (i.e. the 4Rs). The agricultural professional will work with the producer to ensure that the producer receives the greatest benefit from the 4R's. The aggregator will work with the producer, with support from the agricultural professional to sell the reductions in greenhouse gas emissions into the Alberta carbon offset market.

The change in management by the agricultural producer will generate both costs and revenue for their operation. This study reports on the potential benefits and costs that could be received by the producer. It should be noted that these results are based on the scenarios that were developed based on information obtained from individuals in the industry. Agricultural producers can use the NERP Agriculture Producers Calculator to estimate their own costs and benefits.

3. Assumptions and Data Inputs

The economic analysis undertaken uses a scenario approach to estimate the costs and benefits of changing the fertilizer management on a farm to be in compliance with NERP. Since the amount of nitrous oxide that is reduced is a function of the soil zone and ecodistrict where the management change takes place, and the level of management change (i.e. basic level or intermediate/advanced); it was decided that three different soil zones and representative ecodistricts, within the ecozone would be included in the study. These locations were ecodistrict 788 in the dark brown soil zone, ecodistrict 812 in the brown soil zone and ecodistrict 738 in the black soil zone. Further, the economic analysis assumes that the 4R Stewardship Plan is implemented at the Basic Performance Level. According to the latest Census of Agriculture, each of these ecodistricts had greater than 50% of their area dedicated to annually cultivated crops, and had significant acreage dedicated to oilseeds, barley and spring wheat. It was assumed that the farms were of similar size, 3,000 ha, in each soil zone and that three crops were grown; canola, spring wheat and feed barley. Each of the crops was assumed to be grown on 1,000 ha of land (Table 1).

Table 1: Producer Farm Assumptions used in the Analysis

Soil Zones	Dark Brown	Brown	Black
Ecodistrict	788	812	738
Size of Farm	3,000 ha	3,000 ha	3,000 ha
Crop Mix			
Canola	1,000 ha	1,000 ha	1,000 ha
Spring Wheat	1,000 ha	1,000 ha	1,000 ha
Feed Barley	1,000 ha	1,000 ha	1,000 ha

In order to estimate the costs and revenue for the change in management a calculator was designed to estimate the impact of the change in management. In order to undertake this analysis estimates of the change in the amount of nitrogen used on the farm was necessary. Agri-Trend agri-coaches were consulted to determine changes in nitrogen applied and resulting yields after growers enter into a 4R program. The agri-coaches indicated that on average, the nitrogen applied tends to be similar after implementing a 4R plan, because growers do not want to apply more fertiliser at today's high prices; however, yields increased about 20% on average. Therefore, this analysis assumed that applied nitrogen increased by two to four kg per acre depending on the soil zone, and yields increased by 20%. In the example input calculator sheet presented in Table 2 for the Black Soil Zone, the amount of actual nitrogen being applied increases from 60 kg per acre to 62 kg per acre with the change in management. The input data sheet allows the producer to include multiple types of nitrogen including manure. The producer can also include any other potential costs for the change in management. This could include such things as extra labour or tractor use. In addition, there are other costs that will be incurred with this change of management. This would include the cost of the agricultural professional and additional soil samples. In our examples, based on Agri-Trend's input, it was estimated that the agricultural professional would cost an additional $7.50 per acre for advice and administrative work. It was also expected that $1,000 would be needed for additional soil samples on the farm as a result of implementing the 4R plan. This cost was estimated as a per acre charge (Table 2).

The adoption of the 4R management system impacts not only the costs of the operation but also the yield and revenue of the farm. In our example, the yield was expected to increase from 45 bu/acre to 57 bu/acre (the average yield increase observed by the Agri-Coaches). This increased output, that is the result of increased nitrogen use efficiency, increases the revenue going to the operation.

The change in fertilizer management not only increases the yield but also generates greenhouse gas reductions that can be sold in the Alberta carbon offset market. A carbon calculator developed by The Prasino Group as part of the NERP Protocol Validation Study was used to estimate the potential carbon reductions from the baseline management practices and the 4R practice implementation. The data necessary to estimate the change in carbon emissions is given in Table 3.

Table 2: Input Data to the Economic Calculator for Producers

Soil Zone:	Black					
Ecodistrict:	738					
Size of Field (ha):	1000					
Off the field Moisture Content (in percentage: ex. 12.5 = 12.5%):			12.5			
Standard Moisture (in percentage: ex. 10.0 = 10%		10				
Production Information		**Canola**				
		Baseline			**4R (Project)**	
	$/ac, Cost/ac, or Quantity	**kg/ac, bu/ac or Quantity**	**Kg DM**		**kg/ac, bu/ac or Quantity**	**kgDM**
Nitrogen Fertilizer		**kg (actual N)**			**Kg (actual N)**	
Anhydrous Ammonia (average Price=$1,100.95/tonne)	$0.00	0			0	
Urea $600/tonne = $0.60/kg (46% N = $1.30/kg actual N)	$1.30	60			62	
Manure	$0.00	0			0	
Other N	$0.00	0			0	
Changes in Field Operations (Describe and put a cost per acre)						
1.	$0.00	0			0	
2.	$0.00	0			0	
Addition Costs of the 4R program						
Professional Agrologist ($/ha) 7.50/acre	$7.50	0			1	
Additional Soil samples (number of samples*cost per sample)	$0.14	0			1	
Other	$0.00	0			0	
Change in Revenue						
Price or Yield of crop (bushels/acre)	$13.00	45			57	

Table 3: Data Requirements to Estimate Carbon Emissions

Management Zone	Field 1		**Year**	2011
Crop	Barley		**Irrigated**	No
Ecodistrict	812			
Area MZ	1,000	ha		
Yield	2425.06	kg DM/ha		
Fertilizer N	61.78	kg N/ha		
Manure N	0	kg N/ha		
Other N Source	0	kg N/ha		

In order to estimate the carbon emissions, the crop yield had to be converted to kilograms of dry matter per hectare. This calculation is based on the yield, the amount of moisture when the crop comes off the field and the standard moisture content when sold. The following assumptions were made concerning the moisture content for the three crops (Table 4). These moisture content levels were assumed to remain the same across all three soil zones.

Table 4: Moisture Content of Crops

Moisture Content (%)	Canola	Spring Wheat	Feed Barley
Off the field	12.5%	18%	18%
Delivered to the Elevator	10%	13.5%	14.5%

Reductions in greenhouse gas emissions are another benefit of adopting NERP. Once the change in carbon emissions was estimated, they were multiplied by the producer price of carbon to estimate the carbon benefits of adopting NERP.

4. Results

The results for the three soil zones are presented separately. In each case the difference in the costs and benefits of the baseline and the change in management are presented.

4.1 The Dark Brown Soil Zone

The results for the dark brown soils would indicate that adopting the NERP program for an agricultural producer provides an increase in net farm income on a per acre basis. This increase in net farm income ranged from $106.10 per acre for canola to $72.73 for feed barley. Spring wheat had an increase in net farm income slightly above feed barley at $75.01 per acre. The greatest increase in economic benefit came from the increased yield from the crops. This increase in revenue went from a high of $117.00 per acre for canola to $82.50 for barley.

Given the assumptions in the model, the cost of adopting the NERP management system ranged from $10.24 to $11.54 per acre for feed barley and canola, respectively. This fairly small increase in costs over the baseline costs would indicate that additional costs could be absorbed by this change in management. A break-even analysis indicated that the costs of canola could increase by $106 per acre before net present value would go to zero. For spring wheat costs could increase by $75 and feed barley by $72 per acre before net revenue would equal zero.

Table 5: Cost and Benefits of NERP in the Dark Brown Soil Zone

	Canola	**Spring Wheat**	**Feed Barley**
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline)	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$0.64	$0.55	$0.47
Net Change in Revenue per Acre	**$106.10**	**$75.01**	**$72.73**

The revenue from the sale of carbon offset credits is small relative to revenue generated from better crop management at today's grain elevator prices. The NERP calculator estimated that on the 3,000 hectares, approximately 173 tCO_2e from the canola acreage, 148 tCO_2e from the spring wheat acreage and 127 tCO_2e from the barley acreage were reduced.

In the initial scenario the carbon price was assumed to be $13 per tCO_2e and the producer price was estimated to be 70 percent of this or $9.10 per tonne. A sensitivity analysis was undertaken on the price of carbon. In this case the price of carbon was increased to $23.00 per tonne and $37.00 per tonne. The producer price for carbon was still assumed to be 70 percent of the carbon market price. With an increase in price to $23.00 per tonne, the carbon revenue from the canola crop was $1.05 per acre, which was approximately $0.50 more per acre than the original situation. At $37.00 per tonne, the carbon revenue from the canola crop was $1.69, which was more than double the initial situation. The same type of relationship can be found for barley and spring wheat.

Table 6: Sensitivity Analysis around the Price of Carbon (Dark Brown Soil Zone)

Carbon Price of $23.00 per Tonne	Canola	Spring Wheat	Feed Barley
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline)	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$1.13	$0.97	$0.83
Net Change in Revenue per Acre	**$106.59**	**$75.43**	**$73.09**
Carbon Price of $37.00 per Tonne	**Canola**	**Spring Wheat**	**Feed Barley**
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline)	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$1.82	$1.56	$1.34
Net Change in Revenue per Acre	**$107.28**	**$76.02**	**$73.60**

4.2 The Brown Soil Zone

The costs and benefits of changing the fertilizer management plan on the brown soil zone are given in Table 7 below. The cost of the management change on the brown soil zone is similar to the dark brown soil zone. The increase in fertilizer use, the cost of the agricultural professional and the cost of additional soil samples are not large relative to the benefits from adopting the 4R management regime. The largest economic benefit comes from the additional revenue from the increase in yield from the crops. The largest economic benefit comes from the canola acreage followed by the spring wheat and feed barley. The increase in net revenue for canola was $106 per acre, followed by spring wheat at $75 per acre and then by feed barley at $73 per acre.

There is a substantial margin between the costs and the benefits for this management change. As was seen with the dark brown results, costs could increase substantially before the change in management would break-even. In the case of canola, costs could increase by over $106 per acre before revenue and costs would be equal. The margin for spring wheat and feed barley is not as large as for canola but they are substantial at more than $70 per acre.

Table 7: Costs and benefits of NERP in the Brown Soil Zone

	Canola	Spring Wheat	Feed Barley
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline)	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$0.95	$0.69	$0.68
Net Change in Revenue per Acre	**$106.41**	**$75.15**	**$72.94**

As expected, the greatest increase in revenue was from the increased output from the crop areas. The revenue from the carbon offset market was relatively small. However, the revenue from the carbon market was larger in the brown soil zone than in the dark brown zone. For the canola acreage, the carbon revenue was $0.95 (Table 7), which was 1.5 times as large as the amount coming from the canola crop grown on the dark brown soil zone. The carbon revenue for spring wheat and feed barley was higher than when grown in the dark brown zone, however, the increases were not as large as with canola.

In the brown soil zone, the carbon calculator estimated that the 1,000 ha of canola would generate 259 tCO_2e, while 188 tCO_2e were generated from the spring wheat and 184 tCO_2e from the feed barley acreage. As expected, as the price of carbon increases the revenue from the carbon stream in the model also increases. A carbon price of $23.00 per tonne has an impact on the carbon revenue generated by the model. Carbon prices of $23.00 per tonne and $37.00 per tonne could be possible in the near future (Table 8).

Table 8: Sensitivity Analysis around the Price of Carbon (Brown Soil Zone)

Carbon Price of $23.00 per Tonne	Canola	Spring Wheat	Feed Barley
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline)	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$1.69	$1.23	$1.20
Net Change in Revenue per Acre	**$107.15**	**$75.69**	**$73.46**
Carbon Price of $37.00 per Tonne	**Canola**	**Spring Wheat**	**Feed Barley**
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline)	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$2.72	$1.97	$1.94
Net Change in Revenue per Acre	**$108.18**	**$76.43**	**$74.20**

4.3 The Black Soil Zone

The results of the costs and benefits for the black zone are similar to those of the dark brown and the brown zones. The costs of implementing the change in management to better utilize fertilizer are small relative to the potential benefits from increased revenue from crop sales and carbon revenue. The costs fall in the same range as the previous estimates. As can be seen in Table 9, the greatest revenue comes for the increase in sales of crops, followed by the revenue from carbon sales. As with the previous results, the carbon revenue is substantially smaller than the increased crop revenue.

The net revenue per acre for all three crops is positive and quite large. This suggests that cost could increase substantially before net revenue becomes zero or negative. The break-even amount for canola is $106 per acre, while for spring wheat and feed barley it is over $70 per acre.

Table 9: Cost and Benefits of NERP in the Black Soil Zone

	Canola	**Spring Wheat**	**Feed Barley**
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline).	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$1.49	$1.24	$0.94
Net Change in Revenue per Acre	**$106.95**	**$75.70**	**$73.20**

The reduction in carbon emissions from the 1,000 ha of canola was 404 tCO_2e, while for spring wheat and feed barley it was 337 tCO_2e and 255 tCO_2e respectively. Increasing the price of carbon does increase the carbon revenue. Increasing the carbon price to $23 per tonne, and having the producer receive 70 percent of this value, generates carbon revenue per acre on canola of $2.64 per acre. The carbon revenue for spring wheat goes to $2.20 per acre while the revenue from feed barley increases to $1.66 per acre (See Table 10). At a price of $37.00 per tonne, the carbon revenue per acre from canola pays for more than 50 percent of the agricultural professional fee per hectare.

Table 10: Sensitivity Analysis around the Price of Carbon (Black Soil Zone)

Carbon Price of $23.00 per Tonne	**Canola**	**Spring Wheat**	**Feed Barley**
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline).	$11.54	$10.24	$10.24
Additional Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$2.64	$2.20	$1.66
Net Change in Revenue per Acre	**$108.10**	**$76.66**	**$73.92**

Carbon Price of $37.00 per Tonne	Canola	Spring Wheat	Feed Barley
Additional Costs for 4R Program on a Per Acre Basis (positive values are increased costs while negative values are decreased costs from the baseline).	$11.54	$10.24	$10.24
Additonal Revenue from 4R program from cropping on a Per Acre Basis (positive values are increased revenue while negative values are decreased values)	$117.00	$84.70	$82.50
Additional Revenue from Carbon Credits (per Acre Basis)	$4.24	$3.54	$2.68
Net Change in Revenue per Acre	**$109.70**	**$78.00**	**$74.94**

5. Conclusion

This study provides insight into the economics of a change in management that would reduce the amount of nitrous oxide emissions from agriculture, under a carbon offset protocol. The results would indicate that the 4R program could provide an increase in net revenue per acre. The costs associated with the implementation of the program are not large relative to the potential revenue that can be gained. Of the three crops included in the analysis, canola has the largest economic potential followed by spring wheat and feed barley.

An increase in the price of agricultural commodities or the carbon price could increase the economic potential. A carbon price of $37.00 per tonne could generate enough revenue on the farm that it could substantially go against the cost of the agricultural professional.

The results of the analysis are dependent upon the soil zone, ecodistrict, crop and management ability. Additional work could be undertaken to investigate these other factors on the economics. In addition, the impact of moisture content at harvest and when delivered could be investigated. These two variables have an impact on the greenhouse emissions that are reduced.