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Abstract

Vegetative buffers, if established around riparian areas, represent a type of beneficial management practice (BMP) that provide ecological goods and services in the form of improved water quality, improved wildlife/waterfowl habitat, etc. Establishing these buffers result in reduced area for agricultural production, with corresponding opportunity costs. This study builds on previous work from AAFC's Watershed Evaluation of Beneficial Management Practices (WEBs) project, to examine the direct farm-level economics of vegetative buffers for a representative mixed farm operation in the Lower Little Bow watershed. Simulation results suggest that the opportunity cost associated with vegetative buffers varies with buffer width, but can be as great as $600 per acre converted. The cost per acre varies inversely with the width of the buffer.

Keywords:	vegetative buffers, beneficial management practices, monte carlo simulation
JEL Classification:	Q12, Q15, D22, C63

The authors are, respectively, former research assistant, former graduate student, professor and professor

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Introduction and Objectives

There is increasing public interest in the role of the agricultural sector on a variety of environmental attributes (e.g., water and air quality, biodiversity, etc.). Water quantity and quality are of particular importance to society. Agricultural production practices such as application of chemical pesticides and fertilizers, tillage operations, etc. can have a significant impact on water quality.

Riparian areas represent an important "zone" in terms of management practices related to water quality. Riparian areas are lands that are adjacent to moving or standing water. Within this area, vegetative species are heavily influenced by their relationship with the adjacent water (Roath and Kreuger 1982). Riparian areas may be considered as transition zones between the body of water and upland areas.

Riparian areas are characterized by the presence of multiple ecosystem functions such as habitat provision and filtration of chemicals. These functions, in turn, lead to production of ecosystem services (Boyd and Banzhaf 2007); for example, bird populations and water quality. Conversely, these areas are also often characterized by high agricultural productivity, with uses including grazing by livestock or production of annual crops.[1] As a result there is a tradeoff in terms of decisions regarding the optimal use of riparian areas located on agricultural operations.

Certain agricultural practices have been identified as contributing positively to production of "environmental" ecosystem services. These are referred to as Beneficial Management Practices (BMPs). Boxall et al. (2008) define an

[1] It should be noted that production of crops also represents an ecosystem service (Boyd and Banzhaf 2007).

agricultural BMP as an agricultural management practice that "ensures the long-term health and sustainability of land related resources used for agricultural production, positively impacts the long-term economic and environmental viability of the agricultural industry, and minimizes negative impacts and risk to the environment" (p. 5). A consistent component of most definitions of BMPs is that the practices are economically viable. In fact, many agricultural BMPs have been shown to have a negative impact on farm performance (i.e., adoption results in a net direct cost to the producer). Results for recent studies done at the University of Alberta (i.e., Cortus 2005; Koeckhoven 2008; Dollevoet 2010; Trautman 2012) are consistent with this statement.

It is often the case that the benefits from "environmental" ecosystem services being provided by riparian areas do not accrue to the agricultural decision maker, resulting in them being external to the decision making process (i.e., an externality). As a result, if the direct effect of BMP adoption on financial performance for agricultural producers is negative then policy intervention may be needed in order to obtain socially optimal levels of ecosystem services. Pannell (2008) suggests that optimal policy decisions require estimates of both public (i.e., societal) and private (i.e., producer) benefits or costs associated with any land use changes.

This report contributes to the literature related to the economics of BMP adoption by providing results for simulation analysis of alternative riparian area agricultural Beneficial Management Practice (BMP) scenarios. The current study builds on earlier work by Koeckhoven (2008). In his study, Koeckhoven (2008) examined the farm-level economics of alternative cropping and pasture BMPs being adopted by a mixed cow-calf and cropping operation located in the Lower Little Bow watershed in southern Alberta.

The overall objective of this analysis is to examine the direct farm-level economics of alternative BMP scenarios involving establishment of a “buffer” around a waterway that is present on the farm operation. Alternative versions of each BMP are modeled in order to further examine the marginal economic effect of varying the width of this vegetative buffer. The analysis is done for the same representative farm and simulation as was developed by Koeckhoven (2008). Details regarding criteria and data used to define this representative farm operations as well as the simulation model structure and parameters are available in Koeckhoven (2008).

Reference farm

The BMP scenarios examined in this study are simulated by adapting the simulation model from Koeckhoven’s (2008) study. Dynamic Monte Carlo simulation is used, allowing both production and commodity prices to be stochastic.[2] The representative farm, located near Lethbridge in the Lower Little Bow watershed, has 14 quarter sections in annual crop production, an additional eight quarter sections in forage, and 57 quarter sections of pasture (combination of tame and native). The cow-calf herd has 464 cows over winter. Participation in public business risk management programs (i.e., CAIS and crop insurance) is assumed. Parameters used for the simulation of baseline scenario are summarized in Appendix A.

Baseline Scenario (no BMPs)

Based on the baseline farm parameters, a baseline scenario with no BMP implementation is conducted. Table 1 shows the descriptive analysis for the representative cow-calf farm. Figure 1 shows the modified net cash flow during the 20-year period with 90% confidence intervals. The modified net cash flow

[2] See Koeckhoven (2008) for a detailed description of the simulation model.

(MNCF) is calculated by including revenues and expenses related to the mixed farm, cash inflows and outflows from risk insurance program such as CAIS and crop insurance premium and a constant cash outflow for machinery depreciation to reflect maintenance of the total machinery book value. Statistical testing is done to confirm that the baseline results for the farm, as modeled in the current study, are not significantly different from those obtained by Koeckhoven (2008). See Appendix B for a summary of these tests.

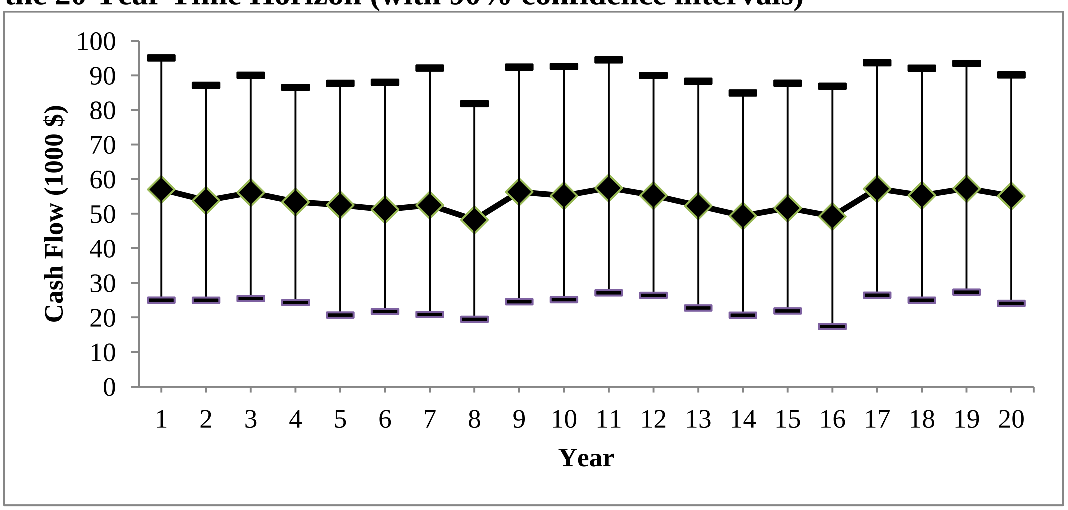
Table 1 Summary Statistics for the Representative Farm Baseline Scenario

Variable	Mean	Standard Deviation
Mean 20 Year Calf Weight (lbs)	576.52	18.92
Mean 20 Year Grazing Season (days)	300.92	11.47
Crop Enterprise NPV ($)	3087032.00	787484.76
Cow-Calf Enterprise NPV ($)	1162043.00	186769.29
Twenty Year Farm NPV[a] ($)	4590336.00	839355.96
Total NPV with Perpetuity[b] ($)	5409804.00	970340.68

[a] This NPV is calculated based on cash flows generated over the 20 year simulation time horizon.

[b] This NPV incorporates cash flows over the 20 year simulation time horizon, plus the present value of expected farm cash flows into perpetuity.

Figure 1 Annual Modified Net Cash Flows for the Representative Farm over the 20 Year Time Horizon (with 90% confidence intervals)



BMP #1: Vegetative Buffer Zone with No Fencing

In cropland BMP #1, a “natural” buffer zone between the stream and crop production is established. The buffer zone is not fenced and aftermath grazing is allowed in the buffer zone. The base version of this BMP involves setting aside an area equal to 100% of the riparian area assumed to be present on the farm; that is, the entire riparian area is “converted” to a natural buffer. Alternative scenarios for this BMP are also simulated by varying the width of the buffer strip (Table 2), thus only partially “converting” the riparian area away from crop production.

As shown in Table 2 all BMP #1 scenarios generate lower cash flows (and consequently lower NPVs) as compared to the base scenario with no BMP implementation. The greater the buffer area percentage and width, the greater the overall “cost” to the producer. The average loss per acre fluctuates downwards with increasing width of the buffer zone, as shown by the annualized changes of NPV per acre in different scenarios. This result suggests that the marginal cost per acre decreases as the total impact is spread over a greater buffer zone area. The difference in annual mean cash flow between the base case with no BMP and the base case for BMP #1 (i.e., 2% buffer zone; 30 feet width) is reported in Figure 2. The MNCFs under base case with no BMP are larger than those under base case for BMP # 1 in most years. The largest decrease of MNCFs is shown in the seventeenth year.

Table 2 Comparison of Mean Simulation Results for BMP #1: Base BMP and Alternative Buffer Zone Width Scenarios

Variable	Base Farm (no BMP)	BMP Scenarios (Buffer Area %; Buffer Width)					
			Alternative Buffer Width Scenarios				
		Base BMP scenario (2%; 30 feet)	0.43% (6.5 feet)	0.67% (10 feet)	1.1% (16.5 feet)	1.53% (23 feet)	2.2% (33 feet)
NPV[a] ($)	5409804	5369608	5395853	5386304	5384150	5370991	5364644
Change in NPV[b] ($)		-40196	-13951	-23500	-25654	-38813	-45160
Change in NPV/Acre[c] ($)		-571	-915	-1001	-663	-719	-583
Annualized Change/Acre[d] ($)		-57.10	-91.50	-100.10	-66.30	-71.90	-58.30

[a] The NPV is calculated in perpetuity; that is, it takes into account expected cash flows extending past the end of the 20 year time horizon used for simulation.
[b] In all cases the changes are calculated relative to the base farm (no BMP) scenario.
[c] The per acre is calculated using the area placed in the buffer for each BMP scenario.
[d] The annualized change is the perpetual annuity, calculated using the 10% discount rate.

Figure 2 Difference in Modified Net Cash Flow Between Baseline with no BMP and the Base Scenario for BMP #1

BMP #2: Vegetative Buffer Zone with Cattle Exclusion

In cropland BMP # 2, a “natural” buffer zone is established between the stream and crop production, similar to BMP #1. However, for the current BMP, a permanent fence is installed between the buffer zone and the crop production area. As a consequence, cattle are excluded from the buffer zone during aftermath grazing on cropland. This BMP is equivalent to implementing a “buffer strip” in the riparian zone area adjacent to the stream The base scenario for this BMP is to establish a 30 metre wide buffer zone. Alternative scenarios are also modeled, varying the width of the buffer zone/strip from zero to 33 feet. A summary of the simulation results for this BMP are reported in Table 3.

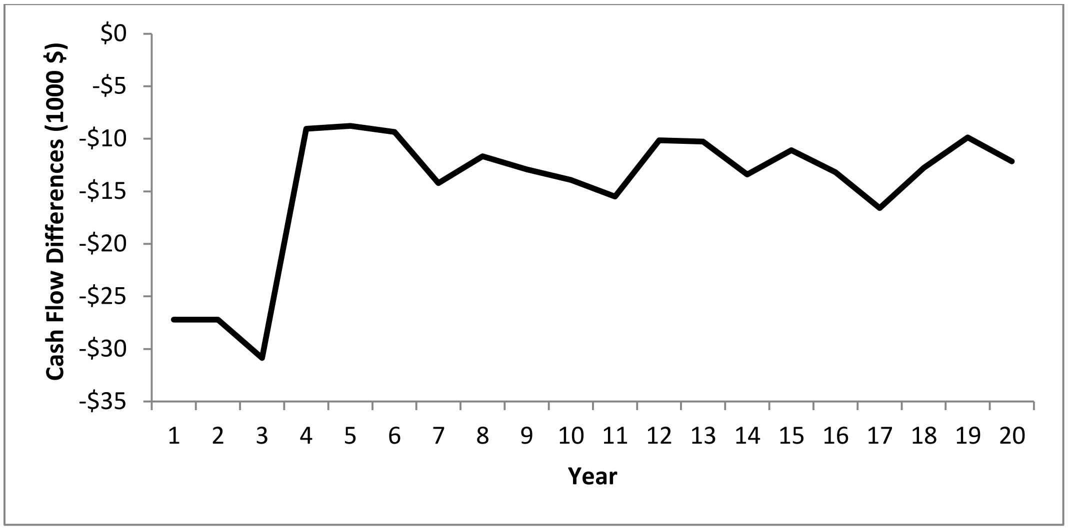
It is shown by Table 3 that all the scenarios for BMP # 2 generate less cash flow and consequently a lower mean NPV, as compared to the base scenario with no BMP. Similar to BMP # 1, the marginal losses per acre protected farmers face decline with the width of riparian area protected by the buffer, as shown by the annualized changes of NPV per acre in different scenarios. The difference in cash flow between the base case with no BMP and the base case for BMP #2 (i.e., 2% of farm area in vegetative buffer, which is 30 feet in width) is reported in Figure 3. The MNCFs under base case with no BMP are larger than those under base case for BMP # 2 in all years. The largest decrease of MNCFs is shown in the third year.

Table 3 Comparison of Mean Simulation Results for BMP #2: Base BMP and Alternative Buffer Zone Width Scenarios

Variable	Base Farm (no BMP)	BMP Scenarios (Buffer Area %; Buffer Width)						
			Alternative Buffer Width Scenarios					
		Base BMP Scenario (2%; 30 feet wide)	0.00% (0 feet)[e]	0.43% (6.5 feet)	0.67% (10 feet)	1.1% (16.5 feet)	1.53% (23 feet)	2.2% (33 feet)
NPV[a] ($)	5409804	5251182	5333032	5315237	5311696	5286543	5274110	5243385
Change in NPV[b] ($)		-158622	-76772	-94567	-98108	-123261	-135694	-166419
Change in NPV/Acre[c] ($)		-2253	N/A	-6200	-4181	-3183	-2515	-2149
Annualized Change /Acre[d] ($)		-225.30	N/A	-620.00	-418.10	-318.30	-251.50	-214.90

[a] The NPV is calculated in perpetuity; that is, it takes into account expected cash flows extending past the end of the 20 year time horizon used for simulation.
[b] In all cases the changes are calculated relative to the base farm (no BMP) scenario.
[c] The per acre is calculated using the area placed in the buffer for each BMP scenario.
[d] The annualized change is the perpetual annuity, calculated using the 10% discount rate.
[e] This scenario involves constructing a fence immediately adjacent to the stream, excluding cattle from access to the water, but not creating a vegetative buffer zone.

Figure 3 Difference in Modified Net Cash Flow Between Baseline with no BMP and the Base Scenario for BMP #2



BMP #3: Permanent Cover with Vegetative Buffer Zone and No Fencing

In cropland BMP #3, a "natural" buffer zone is established between the stream and permanent cover and aftermath grazing is allowed in that buffer zone (i.e., no fence is constructed). Distinct from cropland BMP #1, in this BMP a area of permanent cover (36 feet width) is also established between the buffer zone and the area for annual crop production. The permanent cover is permanently seeded to an alfalfa-grass mix, which is harvested as hay. A summary of the results for this base BMP scenario is provided in Table 4. Also provided in Table 4 is a summary of simulation results for scenarios in which the width of the vegetative buffer zone is varied, from zero to 33 feet in width. In all of the scenarios for BMP #3, the permanent cover is maintained at a width of 36 feet. Thus, the BMP #3 scenario with no buffer zone represents establishing a 36 foot wide zone of permanent cover adjacent to the stream.

Consistent with the first two BMPs, the results presented in Table 4 indicate that all scenarios for BMP # 3 results in reduced (mean) net cash flow as compared to the base scenario with no BMP. This results in a lower NPV for these scenarios. Also consistent with the previous BMPs, the marginal losses on a per acre of buffer basis decline with increased buffer area (i.e., riparian area), as shown by the annualized changes in NPV per acre. The difference in cash flow between the base case with no BMP and the base case for BMP #3 (i.e., 2% of the farm in vegetative buffer, with the buffer zone being 30 feet in width) is reported in Figure 4. The MNCFs under base case with no BMP are larger than those under base case for BMP # 3 in most years. The largest decreases of MNCFs are shown in the seventh, fourteenth and seventeenth years.

Figure 4 Difference in Modified Net Cash Flow Between Baseline with no BMP and the Base Scenario for BMP #3

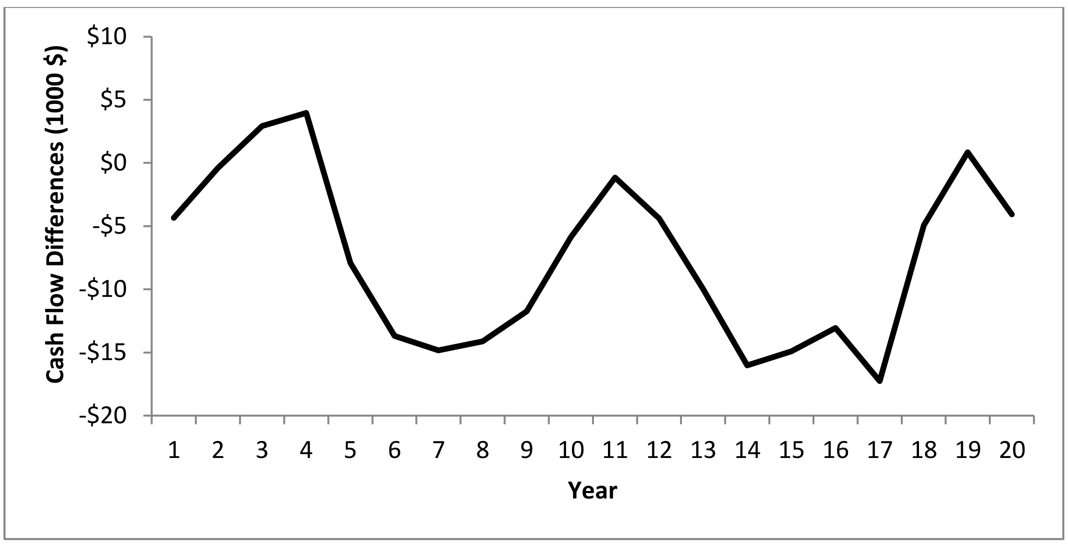


Table 4 Comparison of Mean Simulation Results for BMP #3: Base BMP and Alternative Buffer Zone Width Scenarios

Variable	Base Farm (no BMP)	BMP Scenarios (Buffer Area %; Buffer Width)						
		Base BMP Scenario (2%; 30 feet)	Alternative Buffer Width Scenarios					
			0.00% (0 feet)[e]	0.43% (6.5 feet)	0.67% (10 feet)	1.1% (16.5 feet)	1.53% (23 feet)	2.2% (33 feet)
NPV[a] ($)	5409804	5350280	5369587	5361763	5360601	5360242	5355216	5347262
Change in NPV[b] ($)		-59524	-40217	-48041	-49203	-49562	-54588	-62542
Change in NPV/Acre[c] with Perpetuity ($)		-846	N/A	-3150	-2097	-1280	-1012	-808
Annualized Change/Acre[d] ($)		-84.60	N/A	-315.00	-209.70	-128.00	-101.20	-80.80

[a] The NPV is calculated in perpetuity; that is, it takes into account expected cash flows extending past the end of the 20 year time horizon used for simulation.
[b] In all cases the changes are calculated relative to the base farm (no BMP) scenario.
[c] The per acre is calculated using the area placed in the buffer, for each BMP scenario.
[d] The annualized change is the perpetual annuity, calculated using the 10% discount rate.
[e] This scenario involves creating the zone of permanent cover, but not creating a vegetative buffer zone.

BMP # 4: Permanent cover with Vegetative Buffer Zone and Cattle Exclusion

In cropland BMP scenario 4, a "natural" buffer zone of between the stream and permanent cover is established. A permanent cover with 36 feet width is also established between the buffer zone and crop production. The permanent cover is permanently seeded to alfalfa-grass mix hay, which is harvested as hay. No aftermath grazing is allowed in the buffer zone, with a permanent fence being established to separate the permanent cover and the buffer zone. The results of cropland BMP # 4 scenarios with varying buffer area are reported in Table 5.

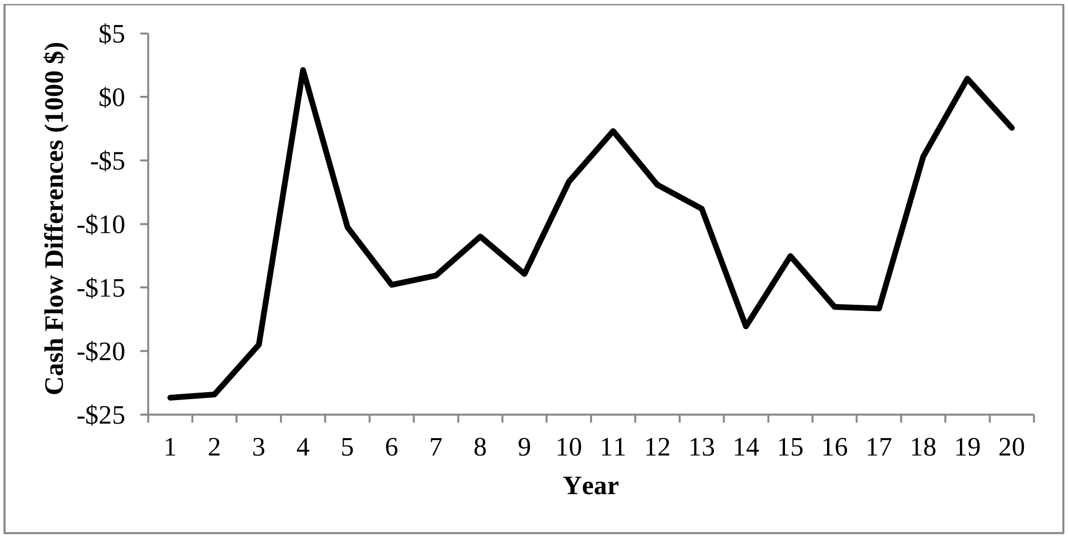
The results for this BMP are consistent with the previous three BMPs; that is, adoption results in a net "cost" to the producer in the form of reduced cash flows and mean NPV for the whole farm operation. Once again, if expressed on an annualized basis per acre of vegetative buffer, the marginal cost farmers face declines with increased riparian area being protected. The difference in cash flow between the base case with no BMP and the base case for BMP 1 (i.e., 2% riparian area protected as a vegetative buffer; vegetative buffer is 30 feet wide) is reported in Figure 5. The MNCFs under base case with no BMP are larger than those under base case for BMP # 3 in most years. The largest decreases of MNCFs are shown in the first and second years.

Table 5 Comparison of Mean Simulation Results for BMP #4: Base BMP and Alternative Buffer Zone Width Scenarios

Variable	Base Farm (No BMP)	BMP Scenarios (Buffer Area %; Buffer Width)						
			Buffer area percentage and width					
		Base BMP Scenario (2%; 30 feet)	0.00% (0 feet)[e]	0.43% (6.5 feet)	0.67% (10 feet)	1.1% (16.5 feet)	1.53% (23 feet)	2.2% (33 feet)
NPV[a] ($)	5409804	5295316	5319494	5308161	5303483	5298907	5295366	5291241
Change in NPV[b] ($)		-114488	-90310	-101643	-106321	-110897	-114438	-118563
Change in NPV/Acre[c] ($)		-1626	N/A	-6664	-4530	-2864	-2121	-1531
Annualized Change/Acre[d] ($)		-162.60	N/A	-666.40	-453.00	-286.40	-212.10	-153.10

[a] The NPV is calculated in perpetuity; that is, it takes into account expected cash flows extending past the end of the 20 year time horizon used for simulation.
[b] In all cases the changes are calculated relative to the base farm (no BMP) scenario.
[c] The per acre is calculated using the area placed in the buffer, for each BMP scenario.
[d] The annualized change is the perpetual annuity, calculated using the 10% discount rate.
[e] This scenario involves creating the zone of permanent cover, but not creating a vegetative buffer zone.

Figure 5 Difference in Modified Net Cash Flow Between Baseline with no BMP and the Base Scenario for BMP #4



Comparison of Results for the Alternative Vegetative Buffer BMPs

Table 6 provides summary statistics from the simulations for the different vegetative buffer BMPs. In each case, the results are for the "base" BMP scenario; that is, a total buffer area equal to 2% of the farm, with the buffer area being 30 feet wide.

Table 6 Summary Statistics for the Vegetative Buffer BMPs (Base Scenarios; 2% of Farm Area in Vegetative Buffer; Buffer Width of 30 feet)

Variable[a]	Base Farm (No BMP)	BMP #1: Vegetative Buffer with No Fencing	BMP #2: Vegetative Buffer with Cattle Exclusion	BMP #3: Vegetative Buffer and Permanent Cover with No Fencing	BMP #4: Vegetative Buffer and Permanent Cover with Cattle Exclusion
Farm NPV ($)	5409804 (970341)	5369608 (892561)	5251182 (872562)	5350280 (875532)	5295316 (875179)

[a] The values reported in this table are mean values, with standard deviations in parentheses.

As noted earlier, all BMPs result in reduced cash flows relative to the baseline scenario without any BMP adoption. This in turn leads to lower mean NPVs. These results are largely due to the effect of the BMPs on land in crop production. By creating a vegetative buffer adjacent to the stream, the land available for crop production is reduced. This represents the "opportunity cost" associated with BMP adoption.

The largest impacts on farm NPV result from BMP #2 and #4. Both of these BMPs involve constructing a fence and excluding cattle from grazing in the vegetative buffer area during the aftermath grazing period. Both of these factors contribute to the reduced NPV, as a) there are direct costs associated with fence construction and maintenance, and b) the forage that would have been available to cattle through grazing in the vegetative buffer has to be sourced from elsewhere. The lowest mean NPV was observed for BMP #2; vegetative buffer with fencing. The mean NPV is slightly lower than that for BMP #4, which is the same BMP, with a 36 foot strip of perennial forage established as permanent cover. This result may be due to the economics of forage production within the model and the ability of the increased hay production from the permanent cover to offset the loss of forage from aftermath grazing.

Discussion and Conclusions

Adoption of four alternative vegetative buffer BMPs were modeled in this study, for a representative cow-calf cropping operation in the Lower Little Bow watershed. All four BMPs involved establishing a vegetative buffer adjacent to the stream running through the representative farm. In each case, the "base" BMP scenario was a vegetative buffer that was 30 feet in width. For all four BMPs, alternative buffer scenarios were modeled, varying the buffer width from 0 to 33 feet.

In BMP #1, cattle were allowed to graze in the vegetative buffer area during aftermath grazing. The annualized cost per acre converted to vegetative buffer for this BMP varied from $57 up to approximately $100, depending on the buffer width. If a fence is constructed to exclude cattle completely from the vegetative buffer zone (i.e., BMP #2), the impact on farm performance is greater; that is, there is a greater net cost associated with adopting the BMP. Depending on the width of the buffer zone, the annualized cost per acre converted to buffer varies between $215 and $620.

The results for these BMPs are not surprising, given that land is being removed from annual crop production and being given over to riparian area. Even with the ability to have cattle graze in this area for part of the year, the net impact on farm performance is negative. The difference in performance between the two BMPs is due to the direct costs of constructing the fence, and the difference in forages utilized through aftermath grazing.

In BMP #3, an additional 36 foot wide strip of land is converted from annual crop production over to perennial forage to create "permanent cover". This is done to provide protection and an additional "buffer" for the restored riparian area (i.e., vegetative buffer zone). Cattle are still permitted to graze both the permanent cover and the vegetative buffer, during aftermath grazing. The annualized cost per acre converted to buffer for this BMP ranges from $80 up to $315. Once again, if a fence is constructed between the permanent cover and the buffer zone in order to exclude cattle from the riparian area (i.e., BMP #4), the net impact is greater, for reasons consistent with the discussion for BMP #2 versus BMP #1. The annualized net cost per acre converted to buffer varies from $153 up to $666. As with the first two BMPs, the results for

BMPs #3 and #4 are to be expected. Land is being converted from annual crop production to vegetative buffer, and additional land is converted over to perennial forage. Both of these changes come with an “opportunity cost” in terms of foregone returns from annual crop production.

It may be concluded from the analysis presented in this report that restoring riparian areas by converting cropland over to a vegetative buffer adjacent to a waterway comes at a net cost to the agricultural producer. In some cases this cost is significant (e.g., >$600 per acre converted per year). The results suggest that the net cost per acre converted decreases as the width of the vegetative buffer increases. This is likely due to a spreading of some of the costs (e.g., fence costs for BMPs #2 and #4) over a larger area. However, despite the decreasing marginal cost of conversion, the net impact is still significantly negative. It is likely, then, that policy intervention (e.g., perhaps in the form of positive incentives) will be necessary to induce significant uptake of these types of BMPs by agricultural producers, at least in southern Alberta.

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Appendix A: Parameters used for the Simulation of the Baseline Scenario

CROP ENTERPRISE				
Number of quarters under crop	14			
Average Acreage/All Quarters	160			
Crop rotation	Durum HRS Oats Canola Barley Fallow			
CROP INSURANCE OPTIONS Coverage Level	Coverage level 4 (80%)			
Discount Rate	10% (farm-level parameter)			
COW/CALF ENTERPRISE				
Initial Cows Exposed/wintered	464			
Bulls	24			
Average Cow weight (lbs)	1,200.00			
Conception Rate	89.00%			
Calving Rate	98.00%			
Weaning Rate	97.00%			
Cow Death loss	1.00%			
Cows Wintered/Exposed Cull Rate	16.2%			
Additional Pre-Exposure Cull Rate	0.0%			
Total Cull Rates	16.2%			
Birth weights	80			
Daily weight gain	1.65			
Selling Weight	550			
CAIS (Canadian Agriculture Income Stabilization) Options	Coverage level 3 (70%-85% of the reference margin)			
GRAZING OPTIONS				
Pasture Type	Quarters	% of land Riparian	Upland Stocking Rate (AUM's)	Riparian Stocking Rate AUM's)
Alfalfa/Grass	0	2%		
Tame	8	2%	1.54	2.25
Native	49	2%	0.26	0.33
Aftermath	22	2%	0.15	0.3
Average Acreage	160			
Total Riparian Region	252.8			
Proper Grazing Factor	0.5			
Proper Utilization Factor	0.5			
Total Number of Quarters under Grazing without Aftermath	57			
FORAGE OPTIONS				

	Quarters	Average Acres/Quarter	Market price/ton
Alfalfa		0	63
Grass		0	75
Alfalfa/Grass Mix	3	1	97.46
Grain Silage	5	1	25
Greenfeed			67.55
Silage Inventory Holdings (% of feed needs)	100%		
HAY Inventory Holdings (% of feed needs)	100%		
BENEFICIAL MANAGEMENT PRACTICE PARAMETERS			
% of Acreage Riparian Land	2%		
% of Riparian Acreage that is cropped in the baseline scenario	100%		
Acreage on both sides of water	yes		
Range of Width Permanent Cover or Buffer strip (feet)	0		
average width of riparian along waterway (feet)	30		
% of Riparian Area to be Protected	100%		
Time Span of Implementation (years)	3		

Appendix B: Comparison of Baseline Model Results with Koeckhoven Baseline Results

While the results for the current study were generated using the same model as used by Koeckhoven (2008), the analysis was done using different computers and different versions of @Risk (Palisade Corporation). As a result, the simulated results were not identical. In order to ensure consistency between the results for the two studies, baseline results (i.e., no BMP adoption) were compared and tested for equivalence using t-tests. The values used and resulting t-statistics are reported in Table B1. The small values of t-statistics in the comparison suggest that there is no significant difference between the results from this study and Steve's study. None of the t-statistics shown in Table B1 are statistically significant using any meaningful level of significance (e.g., 1%, 5% or 10%). Therefore, it can be concluded that the baseline results generated in the current study are consistent with those from Koeckhoven (2008).

Table B1 Comparison of Baseline Simulation Results; Current Study versus Koeckhoven (2008) Study

Variable[a]	Baseline scenario with no BMP	
	Current study	Koeckhoven study
Mean 20 Year Calf Weight (lbs)	576.52 (18.92)	577.52 (18.95)
Mean 20 Year Grazing Season (days)	300.92 (11.47)	301.53 (11.48)
Crop farm NPV ($)	3087032 (787485)	3098460 (722466)
NPV for cow-calf operations ($)	1162043 (186769)	1173295 (182402)
Total farm NPV ($)	4590336 (839356)	4607467 (711811)
Total NPV with perpetuity ($)	5409804 (970341)	5433749 (898903)
T-test statistics[b]		
Mean 20 Year Calf Weight (lbs)	-0.0373	
Mean 20 Year Grazing Season (days)	-0.0376	
Crop farm NPV ($)	-0.0107	
NPV for cow-calf operations ($)	-0.0431	
Total farm NPV ($)	-0.0156	
Total NPV with perpetuity ($)	-0.0181	

[a] The values represent mean values with standard deviations provided in parentheses.

[b] The t-statistic is calculated based on the t-test for two samples with unequal sample variances, as follows:

with d.f.=

where is the difference of means based on results of matched scenarios from the current study and Koeckhoven's study, is the standard deviation of mean difference, and are standard deviations of two means. The sample size is 1000 based on number of iterations in simulation.