Watershed Evaluation of Beneficial Management Practices: On-Farm Costs and Benefits

Abstract

The objective of this study is to evaluate on-farm costs and benefits of adopting Beneficial Management Practices (BMPs) to improve water quality. BMPs tested include permanent cover, buffer strips, off-stream watering and fencing riparian areas. Farms in Lower Little Bow River watershed are very large and with relatively little debt. A stochastic and dynamic farm-level simulation model is developed to assess net farm benefits.

Model results indicate that implementation of these BMPs significantly reduces farm cash flow. Depending on desired level of riparian protection, increasing calf productivity and/or improving pasture utilization might in theory off-set off-stream watering costs. Fencing cost is prohibitive. Given vagaries of the cattle business, uncertainty about international border closures, high cost of fencing and no clear on-farm benefits to adoption, financial incentives may be required for voluntary implementation.

Keywords: Riparian, BMPs, Cost, Gross Margin or Cash flow, Adoption

Watershed Evaluation of Beneficial Management Practices: On-Farm Costs and Benefit

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Watershed Evaluation of Beneficial Management Practices: On-Farm Costs and Benefits

Introduction

There is increasing public concern about water quality in Canada's lakes, rivers and streams. Research studies indicate that intensive cropping near riparian areas (zones), particularly to the water's edge, and conventional livestock management within the watershed can degrade water quality. Degraded riparian areas and contaminated water have negative consequences for the environment as well as animal and human health.

Riparian areas in the Canadian prairies consist mainly of sedges, grasses and shrubs such as willows, dogwood and saskatoons (Figure 1). They are the transition zone between the edge of the water and the upland vegetation. Although these areas occupy a very small proportion of the landscape, they tend to be the most productive parcels of land (McIver and La Forge, 2005). As ecosystems, they are important for a variety of reasons. They sustain life of a multitude of diverse plant, animal, bird, microscopic and aquatic species. They provide food, shelter and shade for wildlife and birds. Debris from vegetation provide shelter, habitat and food for aquatic life. Indeed, due to its rich vegetative cover and access to drinking water, the riparian zone is very beneficial to cattle and wildlife habitation.

Figure 1
Riparian Area of Lower Little Bow River Watershed

Source: Boyle, Merle, AAFC, 2007.

Riparian vegetation serves as a natural buffer, intercepting sediments, nutrients and other contaminants that would otherwise be transported in surface water to the water body. Healthy riparian areas protect water quality, provide habitat and forage for cattle and wildlife, and also provide aesthetic and recreational benefits for society (Reedyk, 2000).

Several farming practices (BMPs) have been recommended to preserve the riparian health and minimize contamination of surface and ground water. This report assesses the on-farm benefits and costs of implementing several BMPs on farms in the Lower Little Bow River watershed in southern Alberta.

Objectives

General objectives of WEBs are to measure the effectiveness of BMPs in improving water quality in watersheds, and to evaluate the economic and environmental benefits and costs of implementing BMPs on farms in watersheds across the Canada. Specifically, the main objectives of this economic study are

1. To determine the on-farm benefits and costs of adopting selected BMPs to improve water quality in the Lower Little Bow River (LLB) watershed; and
2. To identify any barriers or impediments to adoption.

Method of Approach

Terms of reference for this study included literature reviews pertaining to riparian area management, water quality and cattle performance, and BMP adoption. Partial, enterprise and whole farm budgets, and cash flow analysis were used to assess the economic and financial status of the farms. A farm simulation model was developed to assess long term benefits and costs of BMP adoption at the farm level. This economic assessment focused on livestock management practices near riparian areas.

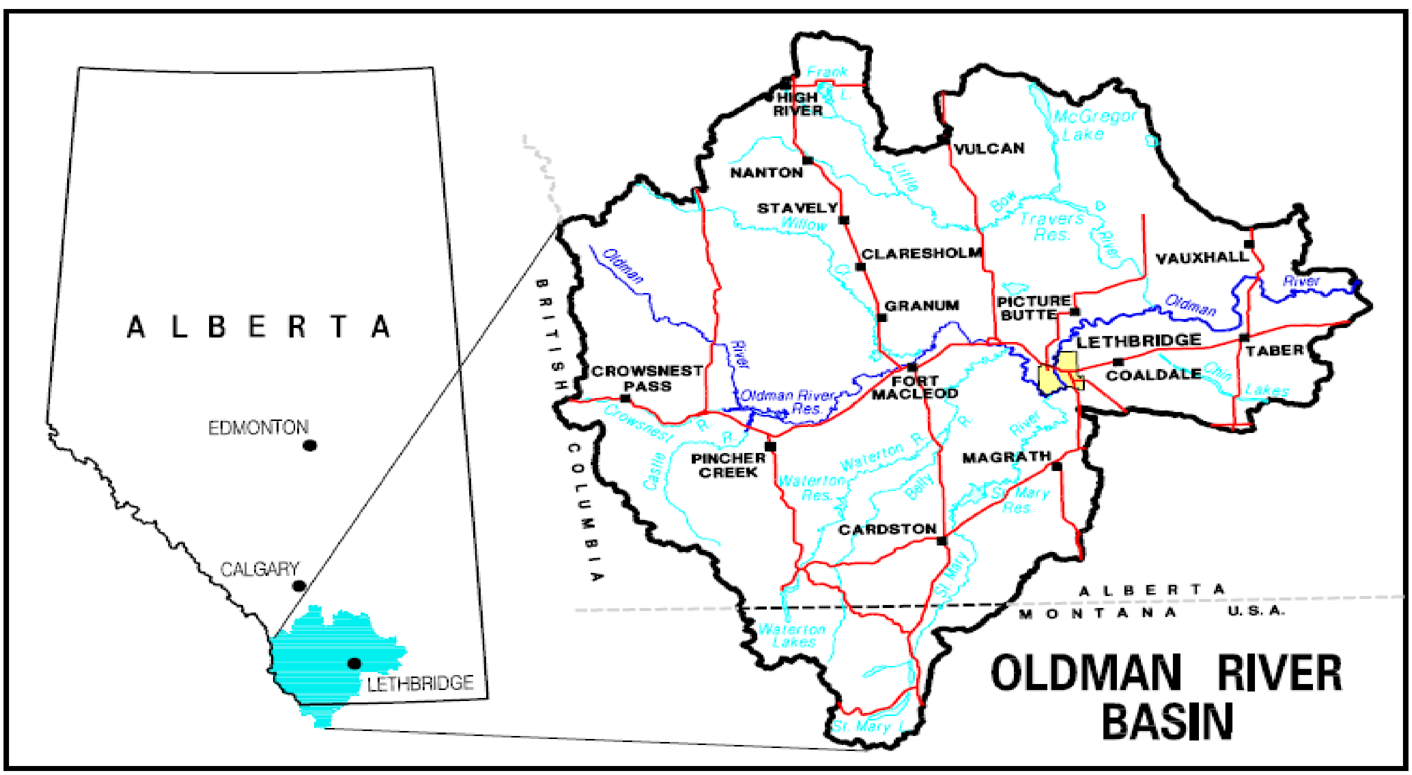
Sources of Data

Seven cow-calf farms were surveyed in Census Division 2 by Alberta Agriculture, Food and Rural Development (AAFRD) through its annual production cost and returns farm survey. Using a detailed questionnaire, field staff interviewed farmers on their farms in 2006 and 2007 to obtain information about farm performance. Once each individual survey was processed, the results were mailed to the study participant. Staff later telephoned each producer to ensure the data and information recorded and processed were consistent with farm records. These survey results were supplemented with 2004-2006 land use survey data of the micro-watershed. Other sources of data included AAFRD AgriProfit$, provincial enterprise and farm budgets, published statistics and research data, fact sheets and personal communication with related experts.

The Study Area

The LLB watershed is a sub-basin of the Oldman River Basin (ORB) which is located in the south western corner of Alberta (Figure 2). It is located about 40 kilometres northeast of the City of Lethbridge and covers approximately 55,664 hectares or 137,545.7 acres, 2.14% of the ORB. The terrain is hummocky, ranging in slope from two to five per cent, dotted with poorly to well defined knobs and kettles. Glacial till dominates the surficial geology. The soils are primarily Orthic Dark Brown Chernozems, with some Orthic Brown Chernozems and Regosolic soils along the rivers. Strong Chinook winds are common in the watershed. Average daily temperatures range between -8°C in January to 18°C in July. Average annual precipitation is 302 mm; almost 78% of this precipitation, 235 mm, occurs between April 1 and October 31. There are 135 frost-free days and average Corn Heat Unit from May 15 is 2363 (AAFRD, IMCIN).

Figure 2
Long-Term River Network Monitoring Stations, Oldman River, Alberta



Source: http://www.oldmanbasin.org/orbwqi/index.html

Land use in the LLB is very diverse. It varies from extensive cow-calf operations on native pasture to dry land farming, intensive irrigated row crops and intensive confined livestock operations. Alberta is the hub of the cattle feeding industry in Western Canada. As most of this feeding activity is concentrated in southern Alberta, the potential for manure contaminating water supplies is greatly increased.

LLB stream flow is mainly controlled by the release of water from Travers Reservoir which is located upstream of the study area, south of MacGregor Lake. Run-off from irrigation and irrigation return flows also affect stream flow. It is believed that run-off from farm land transports sediments, organic matter, bacteria, nutrients, pesticides, metals and other chemicals which degrade water quality in the LLB (Depoe, 2004; Hebben, 2007).

Beneficial Management Practices (BMPs)

BMPs are broadly defined as those farm management practices that governments promote to reduce production risk, market or financial risk, environmental risk, risk to food quality and safety, or any combination of these factors. Scientists are assessing environmental risk, while this report addresses the production, market and financial risks. The BMPs considered may be divided into three classes: Cropland conversion to permanent cover and buffer strips, pasture land off-stream watering and fencing, and manure management. Results of the field experiments in the watershed are not available for this report; consequently the economic analysis draws on published research reports and field observations.

The Model Farm

Mixed beef cow-calf farms represent one of the dominant farm types in the watershed. Specific characteristics of this representative farm are shown in Table 1. The farm consists of 79 quarters or 5,115 ha (12,640 ac). About 72% of the land is in pasture, 18% cereal grains and oilseeds, and 10% forage crops. Just over one-third of the farm land is irrigated; all of the tame pasture and forage crops and two-thirds of the feed barley are irrigated. The riparian area occupies 102.3 ha (252.8 ac) of the farm.

Table 1
Model Farm Characteristics

400 Head Beef Cow-Calf Farm in LLB Watershed, 2006					
Crops	Acres	Hectares	Per Cent	Cattle	No. of Head
Cereals & Oilseed	2,240	907	17.7	Cows	400
Hay & Silage	1,280	518	10.1	Replacement Heifers	64
Tame Pasture	1,280	518	10.1	Bulls	25

Native Pasture	7,840	3173	62.0	Weaned Calves	392
				Calves Sold	328
Total	12,640	5115	100	Total Animal Units	605.5

The cow-herd consists of 400 cows. Cattle graze tame pasture in the spring and summer. Once the crops and forage are harvested in the fall, cattle graze the crop residue or aftermath. Most of the native pasture is grazed during the winter months, while some native pasture is set aside to support summer and fall grazing. Supplemental feed is provided for winter feeding and as needed to supplement fall grazing. Feeder calves are weaned in the fall and sold when they achieve the target market weight. When there is a shortfall in grazing, the calves are fed from inventory until market weight is achieved. However, when there is an excess of grazing, the calves are kept on pasture beyond the target market weight. Approximately 16% of the cow-herd is culled each year and replaced by heifers from within the herd. Only bulls are purchased from external sources.

Value of farm assets is estimated at $4,428,732. Excluding pasture land, 20.6 per cent of farm assets is attributed to beef cow-calf enterprise. The farm has very little debt, reflecting the low debt asset ratio (4%) reported in annual farm surveys. Estimated gross margins and net returns for cow-calf enterprise as well as the farm were positive in 2006.

On-Farm Economic Model

Investments in BMP generally occur up-front, while the benefits to producers and society occur over a period of time. Consequently, it is necessary to determine the present value of benefits and costs of adoption. The formula for estimating the net benefit of BMP adoption is represented as follows:

$$NPV = \sum_{t=1}^{N} \frac{C_t}{(1+r)^t} - I_0,$$

Where

NPV=Net Present Value

t=year (1, 2, 3….N)

N=number of years

C=net cash flow or net benefit

r=market interest or discount rate

I_0=initial cash outlay required to implement the BMP.

Crop yield estimation is derived through the following water use-water demand equation

$$y_t^x = \alpha_0^x + \alpha_1^x \frac{GS}{GDD} + \alpha_2^x \left(\frac{GS}{GDD}\right)^2 + \varepsilon_t^x$$

Where

y=yield

GS=growing season

GDD=growing degree days

t=year (1, 2, 3, x=50)

Crop prices are estimated as follows:

$$P_t^C = \beta_0 + \beta_1 P_{t-1}^C + \beta_2 P_{t-2}^C + \beta_3 P_{t-3}^C + \beta_4 P_{t-4}^C + \varepsilon_t^C$$
$$P_t^W = \beta_0 + \beta_1 P_{t-1}^W + \beta_2 P_{t-2}^W + \beta_3 P_{t-3}^W + \beta_4 P_{t-4}^W + \varepsilon_t^W$$
$$P_t^D = \beta_0 + \beta_1 P_{t-1}^D + \beta_2 P_{t-2}^D + \beta_3 P_{t-3}^D + \varepsilon_t^D$$
$$P_t^B = \beta_0 + \beta_1 P_{t-1}^B + \beta_2 P_{t-2}^B + \beta_3 P_{t-3}^B + \beta_4 P_{t-4}^B + \varepsilon_t^B$$

Where

P=Crop price (average annual price)

C=Canola

W=Wheat

D=Durum wheat

B=Barley

t=year (1, 2, 3, 4....34)

Beef prices are estimated by the following equations:

$$P_t^H = \gamma_0 + \gamma_1 P_{t-1}^H + \gamma_2 P_{t-2}^H + \gamma_3 P_{t-3}^H + \varepsilon_t^H$$
$$P_t^S = \gamma_0 + \gamma_1 P_{t-1}^S + \gamma_2 P_{t-2}^S + \varepsilon_t^S$$
$$P_t^C = \gamma_0 + \gamma_1 P_{t-1}^C + \gamma_2 P_{t-2}^C + \gamma_3 P_{t-3}^C + \varepsilon_t^C$$

Where

P=Cattle Price (semi-annual)

H=Heifer

S=Steer

C=Cow (cull cows)

t=year (1, 2, 3….34)

A positive NPV indicates that benefits from BMP implementation exceed the cost of implementation. Alternatively, a negative NPV indicates that from a farming perspective, adoption of the BMP is not economically feasible. A negative NPV also indicates how much financial incentive may be required for voluntary adoption.

A 400-Head Cow-Calf Farm simulation model was developed to assess economic feasibility of adopting BMPs. Capital investment in cropland conversion and riparian fencing is phased over three years. Investment in the off-stream watering system occurs in the first year. Discount rate is 10% and the planning cycle 20 years.

Gross margin, a financial indicator of farm performance, is the return over cash expenses. It is the cash left over for fixed overhead and debt payments, family withdrawals and farm profits. A modified gross margin is employed in this analysis. Values of home-grown feed and pasture use are treated as cash expenses. Consequently, the estimate understates the conventional measure of gross margin. But the very low farm indebtedness suggests that despite farm profitability, ranchers want to minimize debt exposure as a hedge for financial risk. It is noted that except for replacement bulls, practically all cattle feed are produced on the farm and unpaid labour accounts for 85 per cent of the labour costs. Therefore a more conservative measure of performance seems to be in keeping with rancher risk preference in the LLB watershed.

Model Results

Base case gross margin NPV is estimated at $\$4,607.5 \times 10^6$ or $900.72/ha or$364.51/ac, ($11,518.75/cow). The average annual equivalent is $538,988/farm or $105.37/ha or $43/acre, ($1,347/cow).

<u>Cropland Conversion to Permanent Cover:</u> BMPs assessed are permanent cover (BMP1), permanent cover, fencing & controlled grazing (BMP2) and permanent cover & cattle exclusion (BMP3). Typically, land is cropped right to the water's edge. In BMP1, a 20m or 66-foot strip of crop land is replaced by an 11-m or 36-foot hay crop and a 9m or 30-foot riparian buffer. With BMP2, cattle can graze the crop and hay aftermath or crop residue; a permanent fence permits controlled grazing in the riparian buffer zone and access to the river. Therefore, the net effect on the gross margin depends on the extent to which hay production compensates for the loss of grain and oilseed crop acres, the lost grazing in the riparian zone and fencing cost. With BMP3, a

permanent fence is erected between the cultivated acreage and the grass buffer. Therefore the farm sustains income losses from the 20m grass-riparian buffer plus cost of the permanent exclusion fence.

The main cost of converting cropland to grass cover directly depends on the required level of riparian protection, 25%, 50%, 75% or 100%. The corresponding riparian protected are 15.7, 31.3, 47.0 and 62.7 hectares, (38.7, 77.4, 116.1 and 154.9 acres), respectively. Cropland conversion cost is estimated at about $1,008/ha ($408/ac). Capital implementation cost varies between $15,783 for 25% protection and $63,130 for 100% protection (Table 2).

Table 2
Cost of Converting Cropland to Permanent Cover ($)

Land Use	Protection Level (%)							
	25		50		75		100	
	Hectares	Acres	Hectares	Acres	Hectares	Acres	Hectares	Acres
Riparian Zone	7.1	17.6	14.2	35.2	21.4	52.8	28.5	70.4
Permanent Cover	8.5	21.1	17.1	42.2	25.7	63.4	36.2	89.5
Total Converted	15.7	38.7	31.3	77.4	47.0	116.1	62.7	154.9
Total Cost ($)	15,783	15,783	31,565	31,565	47,349	47,349	63,130	63,130
Cost per Unit ($)	1,007.75	407.83	1,007.71	407.82	1,007.75	407.83	1,007.06	407.55

At the 25% level of protection, gross margins for BMP1, BMP2 and BMP3 decline by $14,591, $24,449 and $48,125, respectively (Table 3). At 100% protection, however, reduction in cash-flow climbs to $53,055, $92,489 and $200,121, respectively. In short, depending on level of protection, implementation without fencing reduces farm cash-flow by up to1.2%; adding buffer strip and fencing reduces cash-flow by up to 4.4%.

Table 3
Gross Margin NPV Change for Cropland Conversion ($)

Cropland BMPs	Protection Level (%)			
	25	50	75	100
BMP1 ($)	-14,591	-27,419	-40,254	-53,055
BMP2 ($)	-24,449	-47,136	-69,829	-92,489
BMP3 ($)	-48,125	-98,728	-149,532	-200,121

Pasture Land Management and Off-Stream Watering (OSW): Three scenarios were considered: off-stream watering (BMP4), off-stream watering and temporary fencing (BMP5) and off-stream watering and cattle exclusion (BMP6). For BMP4, an OSW system is installed in the pasture to entice the cattle to drink water from a trough instead of drinking directly from the LLB. Water is pumped from the river to a storage dugout that is fenced to keep cattle out of the dugout. No other change in management practices is envisaged. BMP5, a temporary fence is erected to permit controlled grazing in the riparian buffer, at which time cattle can enter the river. BMP6, a permanent fence is erected completely excluding cattle from the 9-m or 30-foot riparian buffer and the river. Unlike BMP5, the only source of drinking water is the trough.

Off-Stream Watering (BMP4): Cost of installing the OSW system is estimated at $33,465 or about $84/head spread over three years (Table 4). The main input cost is dugout site preparation costing over $21,000. Cash flow is estimated to fall by $32,834 (0.7%) or $82/cow over the 20 year period (Table 5).

Table 4
Pasture Land Management BMP Cost ($)

Pasture Land BMPs	Protection Level (%)			
	25	50	75	100
Protected Hectares	25.6	51.2	76.7	102.3
Protected Acres	63.2	126.4	189.6	252.8
Off-Stream Watering ($)	30,421	30,421	30,421	30,421
Temporary Fencing ($)	25,503	51,006	76,509	102,012
Permanent Fencing ($)	56,674	113,347	170,021	226,694

Table 5
Gross Margin NPV Change for Pasture Land ($)

Pasture Land BMPs	Protection Level (%)			
	25	50	75	100
BMP4 ($)	Na	Na	Na	-32,834
BMP5 ($)	-88,465	-144,095	-199,725	-255,355
BMP6 ($)	-104,703	-176,750	-248,598	-320,193

Off-Stream Watering & Controlled Grazing (BMP5): As protection rises from 25% to 100%, implementation cost climbs from $55,924 ($140/cow) to $132,433 ($331/cow), respectively (Table 4). Over the 20 year period, the projected reduction in farm cash flow ranges from $88,465 ($221/cow) at 25% protection to $255,355 ($638/cow) at 100% (Table 5). In terms of riparian land protected, cash-flow drops by $3,459/ha ($1,400/ac) and $2,496/ha ($1,010/ac), respectively.

Off-Stream Watering & Cattle Exclusion (BMP6): The permanent fence prevents any farming activity in the riparian zone. Implementation cost ranges from $87,045 ($218/cow) at 25% protection to $256,356 ($641/cow) at 100% protection (Table 4). Projected reduction in farm cash flows are $104,703 ($262/cow) and $320,194 ($800/cow) at 25% and 100% protection, respectively. In terms of protected acres, related cash flow losses are $4,094/ha ($1,657/ac) and $3,131/ha ($1,267/ac), respectively (Table 5).

Pasture Land BMP Sensitivity Analysis

Cattle prefer to drink from a watering trough rather than drink directly from a river, pond or dugout (Miner et al., 1992; Veira and Liggins, 2002). Cattle prefer high quality water to low quality water; given a choice cattle avoid contaminated water (Willms et al., 2002; Lardner et al., 2005). Calves with access to clean water pumped to a trough gain significantly more weight than calves drinking directly from a pond (Willms et al., 2002). Further, cattle with access to clean water in a trough spend more time grazing, and less time resting than cattle served with pond water or with direct access to the pond. Calves with access to aerated and coagulated water pumped to a trough gain 0.9 kg and 0.8 kg, respectively, more than calves drinking directly from a pond (Lardner et al., 2005).

Porath et al., (1997) reported that cows and calves with access to off-stream watering and salt placement, gained an extra 11.5 kg and 5.9 kg over a 42 day grazing period relative to cattle with direct access to a stream. Fencing was not necessarily required to keep cattle out of the river (Godwin and Miner, 1996). Once cattle are trained to drink from a trough, they avoid drinking from the river and they spend more time grazing the uplands. OSW minimizes chances of cattle becoming stuck in the mud or drowning. Over-grazing, trampling, soil compaction and degradation of stream banks are reduced with relocation of watering facilities. Manure is better distributed about the pasture. Given the size of the LLB ranch, it is reasonable to assume that there is better pasture utilization and manure distribution within the pasture. Further, as Willms et al, (1994; 2002) have shown, water quality increases water consumption, grazing and feed intake, and hence, should also improve beef cattle performance.

<u>Calf Productivity:</u> Two sensitivity assessments were conducted, viz., increased average daily weight gains on pasture and increased pasture utilization. Improvements in calf productivity from 1% to 10% were tested for BMP4, BMP5 and BMP6. Results show that an increase in average daily gain of 5% or gross margin of about $43 per cow, is just sufficient to offset the cost of the OSW in BMP4 (Table 6).

Table 6
Gross Margin NPV Change due to Increased Calf Productivity ($)

Pasture BMPs	Protection Level %	Base Case NPV ($)	Average Daily Weight Gain (%)				
			1	2	3	5	10
BMP4	100	-32,834	-22,251	-12,178	-1,570	17,024	59,352
BMP5	25	-88,464	-77,881	-67,808	-57,201	-38,606	3,721
BMP5	100	-255,355	-244,772	-234,699	-224,092	-205,497	-163,170
BMP6	25	-104,703	-93,413	-82,715	-72,797	-52,579	-10,942
BMP6	100	-320,193	-308,135	-295,967	-285,122	-264,991	-222,120

For BMP5 and BMP6, a 5% increase in average daily gain is insufficient to recover the OSW and cattle exclusion costs (Table 6). Even a 10% increase in average daily gain is insufficient to fully recover the cost of the OSW and fencing for BMP5.

Pasture Utilization: Two scenarios are considered. It is assumed that during the first three years, pasture utilization increases annually by 1% and 2%. Therefore, by the end of year 3, pasture utilization expands by 3% and 6%, respectively. BMP4 achieves a net gain of $32,155 ($82/cow) with 3% increase in pasture utilization, and $95,151 ($238/cow) with a 6% increase in pasture utilization (Table 7).

Table 7
Gross Margin NPV Change due to Increased Pasture Utilization ($)

BMPs	Protection Level (%)	Base Case NPV ($)	Increased Pasture Utilization (%)	
			3	6
BMP4	100	-32,834	32,155	95,151
BMP5	25	-88,464	-23,475	39,521
BMP5	100	-255,358	-190,366	-127,370
BMP6	25	-104,703	-38,709	25,017
BMP6	100	-320,193	-250,793	-185,739

In contrast, a 3% increase in pasture utilization is insufficient to recover the additional fencing costs associated with BMP5 and BMP6 at the 25% level of protection. However, should pasture utilization rise by 6%, farm gross margins expand by $39,521 ($99/cow) and $25,017 ($63/cow), respectively. When protection level is raised to 100%, a 6% increase in pasture utilization is unable to recapture the implementation cost.

Conclusion

When crop land is taken out of production to protect riparian areas, direct losses to producers are significant. Cropland conversion cost of $1008/ha ($408/ac) significantly reduces farm cash flow and net farm returns.

Depending on protection level, converting cropland to permanent grass cover reduces gross margin or cash flow by up to 1%. However, gross margin falls by over 4% when cropland conversion is combined with buffer strip and fencing. Without significant financial incentives, ranchers will be reluctant to voluntarily take cultivated land out of production. Consequently, an incentive program might be essential for LLB ranchers to willingly implement this BMP.

Ranchers may be persuaded to invest in off-stream watering, OSW, given the relatively low investment required and potential indirect benefits. Adoption of OSW reduces cash-flow by less than 1.0%. The presence of an existing dugout or water source will significantly reduce implementation costs. Moreover, the analysis shows that >3% increase in average daily calf weight gains or a 3% increase in pasture utilization will recover the implementation cost of the OSW system. Clearly, improvements in pasture utilization can increase farm cash flow and farm net returns.

Implementation cost for OSW with fencing and cattle exclusion is prohibitive. Given the size of the LLB ranches, fencing both sides of a river can be a major impediment to adoption. Farm cash flow is reduced by 2-7% depending on protection level. Further, the on-farm environmental benefits of fencing are not immediately obvious to ranchers. Other options need further investigation before erecting expensive fencing to exclude cattle.

Most important, farmers need to see potential benefits of BMP adoption on their farms. Increased pasture utilization seems to offer a better option for promoting adoption. Benefits are more readily observed by the rancher. A modest 3-4% increase in pasture utilization would recover initial OSW investment and increase net returns. Additionally, eliminating direct river access reduces build-up of unwanted nutrients and contaminants, and minimizes loss of water holding/storage capacity due to bank breakdown and sediment build up. Water supply and maintenance costs are correspondingly reduced (Lewis, 2001). Losses due to foot-rot, drowning and stress on cattle recovered from falling through winter ice or stuck in mud can be reduced. These potential losses or indirect benefits can be measured and the results used to promote adoption of OSW.

List of References

AAFRD, Irrigation Branch. IMCIN Ag-Meteorological Data. Ropin' the Web. Iron Springs & Lethbridge Demo Farms.

Buchanan, B. 2000. Cattle wintering sites can affect water quality.
http://www.prairiewaternews.ca/water/vol10no1/story2a.html

Depoe, S. 2004. Water Quality Monitoring Program, 2002 Annual Technical Report. Alberta Agriculture, Food and Rural Development.

Godwin, D.C. and J.R. Miner. 1996. Potential of Off-stream Livestock Watering to Reduce Water Quality Impacts. Bioresource Technology 58:285-290.

Hebben, T. 2007. Analysis of Water Quality Conditions and Trends for the Long-Term Network: Oldman River, 1966-2005. http://www.environment.gov.ab.ca/info/home.asp

Kauffman, J.B.and W.C. Krueger. 1984. Livestock Impacts on riparian Ecosystems and Streamside Management Implications...A Review. Journal of Rangeland Management 37(5):430-437.

Lardner, H.A., B.D. Kirychuk, L. Braul, W.D. Willms and J. Yarotski. 2005. The Effect of Water Quality on Cattle Performance on Pasture. Australian Journal of Agricultural Research 56:97-104.

Lewis, R. 2001. Water Quality Will Improve Cattle Weight Gain.
http://www.prairiewaternews.ca/water/vol11no1/story9.html

McIver, S. and K. LaForge, 2006. Water Quality Matters: Riparian Grazing and Off-Stream Livestock Watering. Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration.

Miner, J.R., J.C. Buckhouse and J.A. Moore. 1992. Will a Water Trough Reduce the Amount of Time Hay-fed Livestock Spend in the Stream (and Therefore Improve Water Quality)? Rangelands 14(1):35-38.

PFRA. The Effects of Water Quality on Cattle Weight Gain-Results of Study Years 1999-2003. Agriculture and Agri-Food Canada and the Western Beef Development Centre, Alberta Agriculture, Food and Rural Development.

Porath, M.L. et al. 1997. Offstream Water and Trace Mineral Salt as Management Strategies for Improved Cattle Distribution. Journal of Animal Science 80: 346-356.

Reedyk, S. 2000. Many benefits in healthy riparian areas.
http://www.prairiewaternews.ca/water/vol10no1/story4a.html

Veira, D. and L. Liggins. 2002. Do cattle need to be fenced out of Riparian Areas? 1999-2002. Agriculture and Agri-Food Canada, Kamloops, British Columbia.

Willms, W. et al. 2002. Effects of Water Quality on Cattle Performance. Journal of Range Management 55: 452-460.

Willms, W. and D. Colwell. 1994. Water From Dugouts Can Reduce Livestock Performance.
http://www.prairiewaternews,ca/water/back/vol4no1/v41_st1.html