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WEBs Fact Sheet #9

Cattle and Water Quality in the Salmon River Watershed

Cattle exclusion fencing and related studies in British Columbia's Southern Interior

The **Watershed Evaluation of Beneficial Management Practices (WEBs)** program is evaluating cattle exclusion fencing at several locations across Canada where the practice is deemed to address local needs. Since this beneficial management practice (BMP) may perform differently in each landscape or climate zone, study methods and results vary at each location.

Summary: Within the Salmon River Watershed in the mountainous British Columbia Interior, declining river water quality has been a significant concern in recent years. The challenge in this watershed is to protect water quality and aquatic and riparian habitat, while managing human uses of water for agriculture, recreation and domestic needs. A recent study assessed the environmental and economic effect of cattle exclusion fencing, a BMP employed to this end. The study also explored other possible contributions from agriculture to water quality in the Salmon River.

This work was conducted from 2004 to 2010 under the **Watershed Evaluation of BMPs (WEBs)**, a national Agriculture and Agri-Food Canada (AAFC) initiative.

Cattle return to the Salmon River Valley in the fall, after spending the summer in the mountainous uplands.

Salmon River Watershed

The 1,500-square-kilometre (580-square-mile) Salmon River Watershed drains northeast from its headwaters into Shuswap Lake, a popular recreational area. The watershed is more than 90% forested, contains a major salmon spawning river, and supports mining, agriculture and rural communities. Agricultural land comprises just over 8% of the watershed, with 325 farms located along the river valley. The main agricultural activities are ranching, dairy and irrigated forage production—a major consumer of water in the valley.

The regional climate is continental, characterized by warm dry summers and cool winters. Long-term mean annual precipitation is 475 millimetres (19 inches), and snowmelt contributes about 70% of the Salmon River's flow, often resulting in erosion and flooding in the spring. Periods of low flow occur from mid-summer to fall, coinciding with irrigation demand and salmon migration and spawning.

What is the Watershed Evaluation of Beneficial Management Practices?

A long-term research program initiated by Agriculture and Agri-Food Canada in 2004, the Watershed Evaluation of Beneficial Management Practices (WEBs) evaluates the economic and environmental performance of BMPs at a small watershed scale. To gain a regional perspective, this information is being scaled up to larger watershed areas using hydrologic models.

WEBs findings are helping researchers and agri-environmental policy and programming experts to understand how BMPs perform and interact with land and water. This knowledge will also help producers determine which BMPs are best for their operations and regions.

WEBs studies are conducted at nine watershed sites across Canada. These outdoor living laboratories bring together a wide range of experts from various government, academic, watershed and producer groups. Many valuable findings have emerged, and research continues at all sites.

Canada

How was cattle exclusion fencing studied in the Salmon River Watershed?

Beef production in this region involves seasonal cattle movement into and out of the valley bottom. In the summer, cattle are away from the river, grazing in the forested uplands. They spend the rest of the year in the river valley and may drink directly from the river.

Fencing cattle out of rivers and riparian areas is often promoted as a BMP to help producers minimize negative impacts on the environment. In spring 2004, four-strand barbed-wire fencing was installed along the Salmon River, on three beef farms that are typical of local cow-calf businesses. Where cross fencing perpendicular to the river was not already in place, it was installed to prevent cattle from entering into the newly fenced reaches.

Upstream fenced reaches were compared to downstream unfenced reaches on each farm. This was done to assess impact on riparian health and several water quality parameters (sediment, bacteria and nutrients) that are indicators of watershed health. On-farm economic effects were also studied.

After three years of data collection, the previously-unfenced reaches were fenced in spring 2007, and either off-stream watering or controlled points of river access were provided to cattle.

Each farm had different numbers of cattle (between 50-600 head), with on-farm streambank lengths varying from 700-1,600 metres (2,300-5,250 feet). During the study period, cattle density per metre of unfenced river reach was different for each farm (between 0.1-2.1 animals per metre). Study findings represent an average for the three farms.

What were the environmental and economic effects of cattle exclusion fencing?

Water quality from the fenced and unfenced reaches at the three farms (2004-2007) was compared to British Columbia's Water Quality Objectives for the Salmon River and to Provincial Water Quality Guidelines.

Sediment

Fencing the cattle out of the river decreased in-stream sediment disturbance while the cattle were using the pasture beside the river. Unfenced river reaches had finer suspended silt and clay particles, suggesting that these river bottom sediments may have been disturbed by cattle walking in the stream. There were no differences in sediment measurements between the unfenced and fenced reaches when cattle were grazing in upland pastures, away from the river.

Bacteria

Overall, *E. coli* counts in the Salmon River exceeded provincial water quality guidelines, regardless of whether cattle exclusion fencing was in place or not. When cattle were present, *E. coli* counts in sediment and water samples in the upstream fenced river reach were significantly lower statistically than in the downstream unfenced reach. However, total fecal coliform counts (*E. coli* and other coliform species) in sediments within the fenced reach were significantly higher, possibly due to non-agricultural sources such as wildlife. When cattle were not present in the river valley, *E. coli* counts were similar in fenced and unfenced reaches.

A separate test conducted after both the upper and lower reaches of the river had been fenced showed no difference in the presence of *E. coli* at upstream or downstream sites when cattle were present. Results from both these studies showed that cattle exclusion fencing is effective at lowering *E. coli*.

Nutrients

Monitoring within this watershed has been unable to show a reduction in nutrient levels in the river, resulting from cattle exclusion fencing.

The comparison of river water with provincial water quality objectives showed that ammonia concentration objectives were not exceeded. However, the aquatic life standards for total phosphorus were generally exceeded. These findings applied regardless of whether or not cattle exclusion fencing was in place. As identified later in this report, findings for the Salmon River Watershed suggest that these phosphorus impacts may not be entirely due to farming practices. Hence, fencing alone may not be sufficient to address excess phosphorus issues.

Riparian habitat

Riparian health was compared from 2006 to 2008 on river reaches with and without cattle exclusion fencing (Figure 1). Plant cover, density and community type composition were recorded at two locations within each fenced and unfenced river reach.

Riparian vegetation recovered quickly after fencing was installed. The amount of bare soil in the riparian areas decreased and the amount of vegetative cover increased. On unfenced reaches, there was vegetation damage due to browsing and there were numerous cattle trails leading to and from the river.

Figure 1. Impact of riparian fencing evident with less bare soil and more vegetative cover on fenced reach (above left, summer 2008) compared to the same reach prior to fencing (above right, summer 2007).

On-farm economics

Many ranchers in the Salmon River Watershed say that they strongly support the concept of using cattle exclusion fencing and off-stream watering, likely because of its impact on riparian health or water quality. Yet WEBs on-farm economics studies found that adopting the BMP would be cost-prohibitive for a ranching industry struggling with fluctuating commodity prices and increasing input costs during the study period.

In discussions with local ranchers, WEBs economists developed a 'typical ranch' model for the watershed and determined that, in 2007 for example, the typical ranch was facing a net loss of $17,000 before BMP adoption was considered. Further economic analysis determined that it would cost the typical ranch about $19,000 to fence off the riparian areas ($8,400 per kilometre of fencing; $13,550 per mile) and another $6,000 to provide an off-stream water source.

Ranchers implementing this BMP would also face additional maintenance costs such as labour and materials to repair fence damage due to cattle, vegetation, flooding or weather conditions. Additional cross-fencing may also be required to prevent cattle from moving along a stream and entering unfenced areas. The local ranchers told the WEBs economists that they did not expect fencing to produce any economic benefits resulting from changes in herd health.

However, fencing may provide some on-farm economic benefits that could partially offset the costs. Fencing that results in recovered riparian vegetation may stabilize streambanks, thereby reducing slumping (collapse) of soils along the riverbank. This soil loss can add up to larger losses of agricultural land over time. Other research studies[1] have suggested that even though source water quality might not pose a health hazard, provision of an off-stream water source may result in increased cattle weight gains due to a desirable increase in water consumption overall.

Since sport fishing, recreation and domestic water use are highly valued in this area of British Columbia, significant off-farm benefits from adopting BMPs that improve water quality and riparian and aquatic health might be expected.

Additional watershed-scale studies

In addition to the fencing BMP studies conducted at three farms in the valley, other studies were conducted at a larger watershed-scale to understand the effect of agriculture on water quality.

Aquatic insect monitoring

Aquatic (macro-invertebrate) insect communities are another indicator of ecological health. Monitoring was conducted at 20 sites with varying agricultural intensity along a 75-kilometre (46-mile) length of the Salmon River, to determine how agriculture and riparian health influence these organisms. Results were compared with those at reference sites having minimal forestry activity and no upstream agricultural land use.

Agricultural sites with the healthiest riparian areas along this 75-kilometre transect also had insect communities most similar in species and abundance to the non-agricultural reference sites. These results suggest that fencing which enhances riparian vegetation due to reduced cattle activity is likely to promote the health of the adjacent aquatic insect community.

Bacterial source tracking

Monthly water samples taken at five representative locations along the Salmon River were analyzed by source tracking to determine the origin of *E. coli* bacteria in the watershed (Figure 2). Wildlife contribute over 60% of the *E. coli* bacteria in the river. Wild avian (bird) sources such as song birds, ducks and geese contribute 52% and 8% is from large wildlife such as moose, deer, cougar and bear. Other *E. coli* contributions are 5% canine, 7% unknown and 8% human. Domestic livestock sources contribute just 20% of the *E. coli* entering the river.

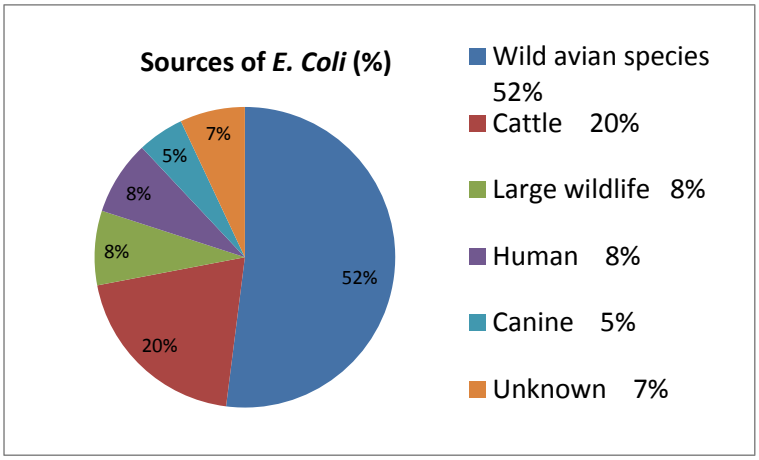

Figure 2. Proportions of *E. coli* sources in the Salmon River

Field nutrient study

The potential risk of water quality impacts caused by nutrient loss from agricultural soils (leaching or runoff of nutrients) increases with higher soil nutrient levels and decreases with lower soil nutrient levels. To assess the risk of field nutrients entering the adjacent river in this watershed, soil sampling was conducted on 15 farms, representing 32,000 hectares (79,000 acres).

Except for high-density paddocks for confined livestock (occurring mostly on hobby farms), fields adjacent to the river generally do not have high soil nutrient levels. Over 75% of the fields tested were deficient in nitrogen. Only 1% had excess nitrogen. Phosphorus levels were deficient on 11%, marginal on 20% and optimum for 67% of fields tested. Excess phosphorus was found on only 2% of fields tested (the high-density paddocks). Therefore, potential for water quality impacts due to excessive soil nutrient levels alone is unlikely from all but a small portion of the watershed.

[1]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.
Willms, W.D. et al. 2002. **Effects of Water Quality on Cattle Performance.** Journal of Range Management. 55 (5): 452-460.

Modelling hydrology and water quality

Two hydrologic models and a bacterial water quality model are being used to predict water quantity and quality changes in response to current and future BMP scenarios and to climate change.

Since forest cover makes up 90% of this watershed, hydrologic modelling takes into account defoliation and trees killed by the mountain pine beetle infestations that impact some of the Salmon River sub-watersheds. The model predicts that beetle infestations result in earlier spring runoff and earlier onset of low river conditions in late summer and fall, which will negatively affect the water supply for irrigation and natural processes such as fish spawning.

A bacterial water quality model[2] was developed to evaluate impacts of livestock operations (amongst other sources) and climate change on fecal coliform bacteria levels in the Salmon River Watershed. The model accurately simulated the observed field data, and predicts that 70-80% of fecal coliform bacteria are transferred to the river through snowmelt runoff. It also predicts that a one degree Celsius increase in daily air temperature may result in a slight decrease of fecal coliform concentrations in summer, but a slight increase during spring, fall and winter. The study drew no conclusions as to the probable long-term implications of such a modest change.

Conclusions

Fencing cattle out of the Salmon River was effective in preventing direct manure additions and disturbance of river sediments. Fencing was also found to have a positive impact on the health of riparian vegetation. However, monitoring within this watershed did not find a reduction in nutrient concentrations in the river resulting from cattle exclusion fencing.

Although costly for ranchers in this watershed, many of them strongly support the use of cattle exclusion fencing and off-stream watering. While not part of this study, it is anticipated that on-farm benefits could partially offset the costs of fence installation.

Additional watershed-scale studies found that healthier riparian areas have greater diversity and abundance of adjacent aquatic insect populations. Therefore, fencing that improves riparian health likely enhances aquatic insect populations and in turn may enhance the habitat and food supply of fish species such as the local salmon population. Watershed-scale studies also determined that most fecal bacterial contamination in the Salmon River comes from non-agricultural sources (i.e. wildlife), and that the moderate to low nutrient levels found in most fields in this watershed are unlikely to result in excess nutrient losses to the river.

The use of cattle exclusion fencing will help achieve some water quality objectives. However, findings on a watershed-scale suggest that phosphorus impacts may not be entirely due to farming practices. Fencing alone is unlikely to address phosphorus concerns in this watershed. A combination of both agricultural and non-agricultural BMPs may be needed to effectively address such a specific water quality issue.

[2]Zhu, Z., K. Broersma and A. Mazumder. 2011. **Model Assessment of Cattle and Climate Impacts on Stream Fecal Coliform Pollution in the Salmon River Watershed, British Columbia, Canada.** Water, Air and Soil Pollution 215:155-176.

AAFC leads the national WEBs program and provides funding under its Growing Forward *initiative. Ducks Unlimited Canada has been a key contributing partner. Other partners at the Salmon River Watershed project include: Salmon River Watershed Roundtable Society, University of Victoria, Fraser Basin Council Society, British Columbia Ministry of Agriculture and Lands, British Columbia Ministry of Environment, British Columbia Agriculture Council, Thompson Rivers University, Canadian Wheat Board and Westwold Livestock Association.*

For more information on WEBs, please visit www.agr.gc.ca/webs or contact WEBs at webs@agr.gc.ca.

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