Alberta Conservation Association
2011/12 Project Summary Report

Project Name: *A Fish-based Index of Biological Integrity for Assessing Ecological Condition of the Beaver River*

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Partnerships

Alberta Environment
Alberta Sustainable Resource Development
Alberta Tourism, Parks and Recreation
Beaver River Watershed Alliance
Municipal District of Bonnyville

Key Findings

- In total, caught 5,719 fish; catch was dominated by five species: white sucker (52%), lake chub (31%), longnose sucker (9%), fathead minnow (3%) and walleye (1%).
- Four of the five selected metrics (percentages of benthic invertivores, lithophils, carnivores and omnivores) are significantly linked to road density in basin.
- The Sand River had the highest IBI values and the lowest levels of human disturbance; the lower Beaver River had intermediate IBI values; the Amisk River and upper Beaver River had the lowest IBI values and were characterized by low flows and poor water quality.
- IBI results showed that the Beaver River watershed is highly affected by land-use changes linked to agricultural and industrial development.

Introduction

Urban development, agriculture and industrialization over the last century has resulted in land use modifications to Alberta's landscape that pose serious threats to the biological integrity of aquatic ecosystems in the province, including the Beaver River watershed (Timoney and Lee 2001, Stevens et al. 2010). Most of the Beaver River watershed is within the boreal central and dry mixedwood subregions in the northeast region of the province, a region that is experiencing rapid industrial growth. However, cumulative effects of human activities on aquatic health, including fisheries resources, are largely unknown. In this study, we develop a fish-based index of biological integrity (IBI) for assessing the health of the Beaver River in partnership with the Beaver River Watershed

Alliance, as part of their Aquatic Health Ecosystem Monitoring Program.

Methods

We collected data on fish community composition and a suite of physicochemical variables from 50 sites distributed throughout the Beaver River watershed during the summers of 2009 to 2011. We captured fish using boat electrofishing and expressed relative abundance of fish as catch-per-unit-effort (i.e., number of fish/100s). For all species, we recorded number captured, measured fork length and examined fish for diseases and other anomalies. We developed 13 candidate metrics based on the fish community and screened them for responsiveness to disturbance using multiple regression and an information-theoretic approach. Five metrics (percentages of invertivorous cyprinids, benthic invertivores, omnivores, lithophils and carnivores) were significantly related to human disturbance and were used to calculate the IBI. We used physiochemical and geographic information system (GIS) data to assess the level of disturbance of each site.

Results

We captured 5,719 fish representing 17 different species and six families. Of this total, 52% were white sucker (*Castostomus commersonii*), 31% lake chub (*Couesius auratus*), 9% longnose sucker (*Catostomus catostomus*), 3% fathead minnow (*Pimephales promelas*) and 1% walleye (*Sander vitreus*). Other species caught represented less than 1% of the total.

The IBI we developed was highly sensitive to anthropogenic disturbances. Road density had the strongest relationships to the IBI and its metrics, particularly percentages of benthic invertivores, lithophils, carnivores and omnivores. The omnivore metric increased while the other three metrics decreased with higher road density. Road density in the study area is mainly related to agricultural and petroleum sectors. Agricultural activity (i.e., cropland and cattle grazing) accounted for the majority of perturbation in the watershed. The upper Beaver and Amisk rivers had the lowest IBI values reflecting poor aquatic health characterized by high nutrient values, low flows and a high number of fish species tolerant of habitat degradation (Table 1; Figure 1). The Sand River had the highest IBI values and the lowest levels of human disturbance. The lower Beaver River had intermediate IBI values despite having high levels of agriculture and bank disturbance. However, this zone has high flows of good quality water (coming from the Sand River) and more diversified habitat than the Sand River.

Table 1. Mean (± standard deviation) values of selected metrics, environmental variables, and index of biological integrity (IBI) values for three zones of the Beaver River watershed, Alberta, 2009 – 2011.

Data	Beaver and Amisk rivers upstream of Sand River confluence	Sand River	Beaver River downstream of Sand River confluence
Metrics			
Benthic invertivores (n)	0.1 (± 0.2)	11.9 (± 10.8)	9.8 (± 5)
Invertivorous cyprinids (%)	2.8 (± 4.1)	21.1 (± 18.3)	40.9 (± 14.3)
Lithophils (%)	79.4 (± 31.3)	97.1 (± 5.6)	98.5 (± 1.9)
Omnivores (%)	87.7 (± 23.3)	29.7 (± 19.7)	45.7 (± 12.4)
Carnivores (%)	0.8 (± 1.5)	2.7 (± 3.4)	3.1 (± 3.1)
Variables			
Exposed soil (%)	3.4 (± 4.4)	7.8 (± 3.9)	10.5 (± 5)
Human disturbance on bank (0-10)	2.4 (± 1.3)	0.1 (± 0.1)	0.9 (± 1.5)
Dissolved oxygen (mg/L)	8.8 (± 1.3)	8.6 (± 0.7)	8.2 (± 0.6)
Total phosphorus (mg/L)	0.21 (± 0.1)	0.07 (± 0.02)	0.07 (± 0.03)
Ammonia (mg/L)	0.09 (± 0.1)	0.05 (± 0.01)	0.11 (± 0.1)
Total Kjeldahl nitrogen (mg/L)	3.0 (± 5.2)	1.0 (± 0.1)	0.9 (± 0.2)
Total suspended solids (mg/L)	5.9 (± 6.2)	39.3 (± 24.0)	44.5 (± 25.9)
Urban in basin (%)	0.04 (± 0.1)	0 (± 0)	0.3 (± 0.3)
Road density in basin (m/ha)	6.0 (± 0.3)	0.3 (± 0.1)	4.5 (± 0.6)
WQI	80.0 (± 13.3)	95.3 (± 6.9)	95.3 (± 3.8)
IBI	9.4 (± 2.5)	25.2 (± 2.9)	22.7 (± 4.5)

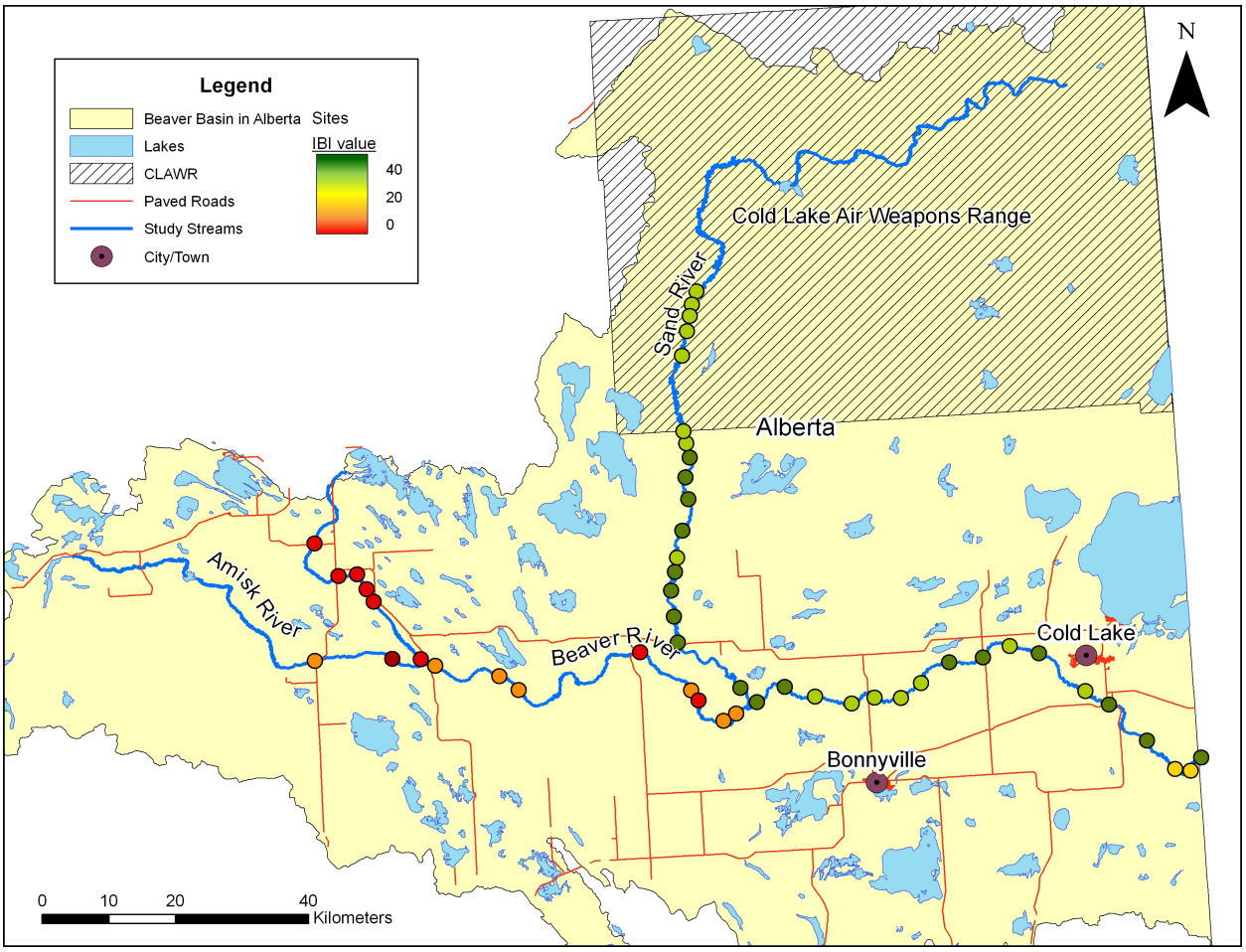

Figure 1. Colourometric representation of index of biological integrity (IBI) scores in the Beaver River watershed, 2009 – 2011. Red = poor, yellow = intermediate, green = good.

Conclusions

Our results corroborate those from previous studies (see Alberta Environment 2006) in identifying agriculture as playing an important role in the decline of aquatic ecosystem health in the Beaver River watershed. The IBI we developed is a useful tool for assessment and monitoring of the Beaver River watershed and could be used in the future to assess the effects of industrial development and remediation strategies on the health of aquatic ecosystems throughout the watershed.

Communications

- Presented project findings to the Beaver River Watershed Alliance.
- Distributed project report to partners.

- Presented results to the 141st American Fisheries Society Annual Meeting, Ariane Cantin and Tyler Johns, Seattle, Washington, September 5, 2011.

Literature Cited

Alberta Environment. 2006. Cold Lake – Beaver River basin surface water quality and aquatic resources state of the basin report, 2006. Pub No. T/846 produced by Alberta Environment, Edmonton, Alberta, Canada. 154 pp.

Stevens, C.E., T. Council, and M.G. Sullivan. 2010. Influences of human stressors on fish-based metrics for assessing river condition in central Alberta. Water Quality and Research Journal of Canada 45: 35–46.

Timoney, K., and P. Lee. 2001. Environmental management in resource-rich Alberta, Canada: first world jurisdiction, third world analogue? Journal of Environmental Management 63: 387–405.

Picture captions

Photo 1.
Aerial view of the Sand River. (Photo: Tyler Johns)

Photo 2.
Alberta Conservation Association staff members getting gear out of the helicopter to set up remote camp on the Sand River. Left to right: Emily Turton and Ariane Cantin. (Photo: Tyler Johns)