Conserving Wetlands in British Columbia

May 28–29, 2009
Revelstoke, British Columbia
Canada

Columbia Mountains Institute of Applied Ecology

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- BC Hydro
- BC Ministry of Healthy Living and Sport
- Columbia Basin Trust
- Creston Valley Wildlife Management Area
- Ducks Unlimited Canada
- Fish and Wildlife Compensation Program
- Nature Conservancy of Canada
- Revelstoke Community Forest Corporation

Thanks also to our speakers and the people who brought posters and displays. We are grateful for your willingness to share your expertise with us.

Special thanks go to our volunteers Ernst Bevan (Thompson Rivers University, Kamloops), Caroline Heim (Carolla Environmental Consulting, Golden), and Marcia Woods (Revelstoke) for their help in keeping the event running smoothly.

Our presenters and participants travelled from various communities in British Columbia and Alberta. We are grateful for their participation and for the support of their agencies in sending them to our conference.

We are appreciative of the work of our conference organizing committee. The members of the organizing committee were:

- Doug Adama, BC Hydro
- Marc-André Beaucher, Creston Valley Wildlife Management Area
- Kevin Bollefer, Revelstoke Community Forest Corporation
- Martin Carver, BC Ministry of Healthy Living and Sport
- Kindy Gosal, Columbia Basin Trust
- Irene Manley, Fish and Wildlife Compensation Program
- Jackie Morris, Columbia Mountains Institute

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Conference Description

Reservoir creation, settlement, agricultural activities, transportation corridors, and other factors have eliminated many wetland complexes or diminished their natural form and function. At this conference we examined how a combination of management, restoration, and stewardship projects can improve the ecological values of our wetlands.

Our event included nineteen presentations, thirteen posters, and four field trips. About 90 people attended the conference. Participants were a multidisciplinary group of people, including: resource managers, public interest groups, consultants, researchers, and academics. We were joined by a Biology 11 class from Revelstoke Secondary School for some of the presentations.

The conference was held at the Revelstoke Community Centre, 600 Campbell Avenue, next to the Columbia River, on May 28–29, 2009.

The summaries of presentations in this document were provided by the speakers. Apart from small edits to create consistency in layout and style, the text appears as submitted by the speakers.

The information presented in this document has not been peer reviewed.

About the Columbia Mountains Institute of Applied Ecology

www.cmiae.org

The Columbia Mountains Institute of Applied Ecology (CMI) is a non-profit society based in Revelstoke, British Columbia. The CMI is known for hosting balanced, science-driven events that bring together managers, researchers, educators, and natural resource practitioners from across southeastern British Columbia. CMI members include resource managers, consultants, government staff, public interest groups, and academics, who share an interest in improving the management of ecosystems in southeastern British Columbia. Our website offers many resources, including conference summaries for all of our past events.

Conference Agenda

Thursday May 28, 2009

8:30 a.m.	Welcome by Master of Ceremonies, Doug Adama, CMI Director Welcome from the City of Revelstoke by Councillor Antoinette Halberstadt
8:50 a.m.	Valuing our wetlands: Making them relevant, Bruce Harrison, Ducks Unlimited Canada
9:20 a.m.	The contribution of wetlands to human health, Dr. Martin Carver, BC Ministry of Healthy Living and Sport
9:40 a.m.	Natural forms and functions of montane marshes in Jasper National Park: The effect of a transportation corridor vs. beaver on diversity and productivity of floodplain marshes, Dr. Suzanne Bayley, University of Alberta
10:10 a.m.	Coffee break
10:35 a.m.	Managing a diked wetland: Costs, implications, and future options for the Creston Valley Wildlife Management Area, Marc-André Beaucher, Creston Valley Wildlife Management Area
11:05 a.m.	The impacts of dam construction on wetland ecosystems in the Columbia Basin, Irene Manley, Fish and Wildlife Compensation Program
11:35 a.m.	An elegy to wetlands, Eileen Delehanty Pearkes
12:05 pm.	Introduction of people who brought posters
12:15 p.m.	Lunch
1:15 p.m.	Status and condition of Kelowna wetlands: A summary of an inventory on some of the rarest and yet most biologically significant and diverse communities in Kelowna using a new spatial inventory approach, Kyle Hawes, Ecoscape Environmental Consultants
1:45 p.m.	Creating shoreline management guidelines using the sensitive habitat inventory method on Windermere Lake, Heather Lescheid, East Kootenay Integrated Lake Management Partnership
2:15 p.m.	Wetland inventory and mapping assessment within the Okanagan Region, Kristina Robbins, BC Ministry of Environment
2:45 p.m.	Coffee break
3:00 p.m.	Chytridiomycosis in BC wetlands: How it has affected the endangered Northern Leopard Frog and what all wetland researchers need to be aware of, Barb Houston, Fish and Wildlife Compensation Program
3:30 p.m.	West Kootenay amphibian study, John Krebs, Fish and Wildlife Compensation Program
4:00 p.m.	Forest harvesting and the management of small wetlands and amphibians populations, Elke Wind, E. Wind Consulting
4:30 p.m.	Posters and “Social”

Evening speaker

Don Quixote challenges biodiversity—and meets wetlands

Dr. Fred Bunnell, Professor Emeritus, University of British Columbia
7:30 p.m. Revelstoke Community Centre

Friday, May 29, 2009

8:30 a.m.	Restoring wetlands: Rebuilding processes and patterns, David Polster, Polster Ecological Services
9:00 a.m.	An opportunity for rehabilitation: City of Vernon Waterfront Neighbourhood Plan, Darryl Arsenault, EBA Engineering Consultants
9:30 a.m.	Wildlife physical works for riparian and wetland habitat enhancement in Arrow Lakes Reservoir, Doug Adama, BC Hydro
10:00 a.m.	Coffee break
10:20 a.m.	Biology, ecology, and management of key aquatic invasive plants in British Columbia, Dr. Linda Wilson, BC Ministry of Agriculture and Lands
10:50 a.m.	Neighbour to neighbour conservation: The Upper Columbia River and wetlands, Bob Jamieson, Columbia Wetlands Stewardship Partners
11:20 a.m.	Wetland Stewardship Partnership, Andrea Barnett, Ducks Unlimited Canada
11:50 a.m.	Wrap-up comments
12:00 p.m.	Conference is over
12:30 p.m.	Field trips leave

During breaks and the poster session, we were fortunate to view two sets of slides. Thank you to Patrick Morrow and Peter Ballin for improving our ambiance!

Patrick Morrow of Wilmer, BC, allowed us to view his slide show from the online version of the "Columbia Wetlands—A Natural Inspiration" exhibit at the Art Gallery of Golden. Read more about Patrick Morrow at his website, http://www.patmorrow.com
View the complete online exhibition at http://www.kickinghorseculture.ca/agog/wetland

Peter Ballin of Vancouver brought us visuals of wetlands on the Wolf Ranch, near Pritchard, BC. Photos were taken in 2007 and 2008. In this rare BC landscape, in an ecosystem of provincial conservation concern, these agricultural wetlands along the South Thompson River are considered vulnerable, but amenable to stewardship to enhance wildlife values.

Summaries of Presentations

1. Valuing our wetlands: Making them relevant

Bruce Harrison, Ducks Unlimited Canada

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Bruce Harrison had his start as a landbird biologist in the early 1990s, and he has been with Ducks Unlimited Canada since 2001, and has worked throughout the province on a variety of inventory and research projects. Most recently, he has been co-leading a study of the effects of cattle grazing on wetland parameters important to waterfowl. Bruce also manages and evaluates a number of Ducks Unlimited's traditional and agricultural-focused projects in the BC Interior.

The general public's perception of wetlands is not always favourable. They are often perceived as mosquito infested swamps, or stagnant wastelands of no value hindering travel and development. Yet they provide ecosystem benefits, and benefits to our modern lifestyle, that are disproportionate to their abundance on the landscape. Unfortunately these values are not generally recognized, and other "uses" for wetlands have resulted in significant losses and alteration of their abilities to provide benefits, often to the detriment of our life style and economy.

As our society moves further away from a rural lifestyle and direct dependence on the land, we become increasingly disconnected to the values and functions of wetlands and the beneficial processes they perform. The greatest challenge to those of us working in conservation is making habitats and natural processes relevant to the vast majority of society that live in urban environments. Ducks Unlimited originated and thrived for many years on the support of the large part of our society that wanted ducks. Today, wetland conservation or any type of habitat conservation cannot succeed on the scale it needs to, based purely on wildlife values.

In our service-oriented, economically driven, consumptive society, the best thing conservationists can do to "make it relevant" is demonstrate the direct benefits, the

“Ecological Goods and Services” that natural systems provide to an urban audience. For wetlands, work on this topic has progressed significantly in the last few years. We in the conservation field need to spend more of our limited resources on developing the data sets and communicating outside our congregation.

Wetland research, specifically on carbon sequestration, water quality, and watershed hydrology along with associated economic values, has developed to the point where this information can be used to influence land-use decisions. Examples of these studies and associated economics were presented. More work needs to be done on quantifying the collateral benefits of wildlife habitat conservation projects and on reframing conservation of natural habitats under a purely economic valuation.

Referenced in the talk

The value of natural capital in settled areas of Canada
By Nancy Olewiler, Department of Economics and Public Policy Program,
Simon Fraser University, British Columbia
Available at:
http://www.ducks.ca/aboutduc/news/archives/pdf/ncapital.pdf

The impacts of wetland loss in Manitoba
This is a four-page summary of Ducks Unlimited Canada’s multiphase research project to determine the impacts of wetland loss and associated drainage activity in the Broughton’s Creek watershed located in southwestern Manitoba.
http://www.ducks.ca/conserve/research/projects/broughtons/pdf/broughtons-factsheet.pdf

2. The contribution of wetlands to human health

Dr. Martin Carver, BC Ministry of Healthy Living and Sport

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Martin Carver received his doctorate in Resource Management Science from UBC in 1997 with a focus on hillslope hydrology, soil and sediment dynamics, and land management. He has been a member of the Wetland Stewardship Partnership for eight years. He is currently Acting Director of Water Protection in the BC Ministry of Healthy Living and Sport.

Wetlands provide an impressive range of ecological goods and services including provision of water quantity, maintenance of water quality, climate regulation, and provision of essential habitats. Many of these functions contribute directly or indirectly to human well-being. Water, along with air, food, shelter, and freedom from disease, are considered fundamental determinants of health (World Health Organization). Across various spatial and temporal scales, wetlands contribute to this suite of factors and have particularly strong links through water-related processes. A goal of public health is to improve human lives through the prevention and treatment of disease. Wetlands buttress this objective by "smoothing" hydrographs, thereby reducing flood hazards, by influencing the cleanliness and availability of drinking water supplies, by regulating climate, and by shaping the effectiveness of vector-borne disease agents. This paper provides an overview of these influences within a public health context.

Water storage, flood reduction, groundwater recharge, and the maintenance of low flows collectively, modify stream hydrographs. These processes support public safety and provide water during otherwise droughty periods while helping to maintain moisture in aquatic and riparian environments. These changes save lives, protect property and improve the liveability of streamside and floodplain areas. They augment low flows, thereby maintaining water supplies during droughty periods. In addition, they improve water quality through greater dilution during low-flow periods. Beyond these rather explicit services to humans (and ecosystems), wetlands also contribute—often in less transparent ways—to other direct improvements in water quality.

Wetlands immobilise nutrients, particularly nitrogen and phosphorus, through adsorption and settling, and modify seasonal patterns of nutrient uptake, thereby reducing primary productivity (Verhoeven et al. 2006). These functions yield water quality benefits, particularly in agricultural areas where nutrient loadings can be problematic. Denitrification is generally the most important process for nitrate removal and involves the decomposition of dead organic matter by bacteria in the absence of oxygen. Nitrate is converted to nitrous oxide and subsequently to atmospheric nitrogen which is emitted by the wetland. Nutrient uptake in vegetation as water passes through the riparian zone is also important and results in long-term nitrogen storage, however, its removal from the system occurs only if the vegetation is harvested. Phosphorus removal in wetlands also occurs through the mechanisms of sedimentation, soil adsorption, and plant uptake.

In general, wetlands are considered "effective" in this nutrient-removal role if they are successful at removing at least 30% of the total nitrogen and phosphorus load (Verhoeven et al. 2006.) It has been shown that wetlands can contribute to these levels of water quality improvements at the catchment level if they account for between 2–7% of the catchment area. The quiescent wetland environment also promotes sedimentation of sand, silt and, in some cases, clay particles that would otherwise lead to a range of water quality concerns including treatment dangers (chlorination by-products), treatment costs, and a reduction in ecosystem function where loadings are excessive. Nutrient and sediment dynamics associated with changes in wetland extent in the Broughton's Creek watershed (near Brandon, Manitoba) provide a compelling example of the contribution of wetlands to stream nutrient and sediment levels (Yang et al. 2008). This modelling study determined that the 21% incremental loss of wetlands between 1968 and 2005 in this 251 km^2 catchment has resulted in a 31% increase in nitrogen and phosphorus load in addition to a 41% increase in sediment load.

Research on the nutrient removal capacity of wetlands in temperate areas suggests that the maximum potential rate of nitrogen and phosphorus removal is typically an order of magnitude higher than the fertilizer applications in intensively farmed areas (Verhoeven et al. 2006) and, hence, there is great potential for effective water quality remediation. Most ecosystems can incorporate these associated higher loading rates with only minor changes. If thresholds are crossed, the system typically moves to a new stable state with sharp changes in ecosystem function and species composition. It is interesting to note that these loading rates of nitrogen and phosphorus are several orders of magnitude lower than the typical loading rates in constructed wetlands used for improving water quality.

Most wetlands are dominated by naturally occurring populations of microbes and plant life, the biological processes of which remove pathogens. While natural wetlands support these remedial processes, designs of constructed wetlands have been developed to enable far greater effectiveness in reducing pathogens than natural wetlands. Effectiveness depends on the characteristics of the particular wetland of interest. In a survey of 60 constructed wetlands from around the world with emergent vegetation, it was found that removal of total and fecal coliforms was typically above 95% and reached beyond 99% (Vymazal 2005). The ability of a wetland to degrade or remove persistent contaminants (pesticides, metals, etc) occurs by degradative processes such as photolysis, abiotic hydrolysis, and biodegradation, and other loss mechanisms. Removal efficiency in constructed wetlands with emergent macrophytes is primarily influenced by hydraulic loading rate, the resultant hydraulic residence time, and the presence of vegetation. In the Walkerton enquiry, it was noted that wetlands could have played a greater role in reducing the presence of pathogens (Province of Ontario 2003). In addition to biological remediation, wetlands sequester heavy metals and other compounds, though more research is needed to connect design to removal efficiencies (Rai 2008). Constructed wetlands are used around the world to treat sewage to lower water treatment costs and to “polish” effluent prior to being released to natural surface waters (Schreijer 1997).

Wetlands act as carbon sinks, thereby assisting in regulating climate through the greenhouse effect. In the Broughton’s Creek study mentioned earlier, the pre-1968 wetland coverage prevented 125,000 tonnes of carbon from being released into the atmosphere (Yang et al. 2008). As climate warms, small wetlands tend to disappear while some permanent wetlands become seasonal. These changes exacerbate climate problems as less carbon can be stored in these lost or diminished wetland ecosystems.

Wetlands also provide indirect benefits to humans by supporting complex, biodiverse ecosystems. These benefits may be mixed at times, depending on the wetland type. Further study is warranted, particularly around vector-borne diseases that can be transmitted by only an invertebrate host. For example, West Nile Virus resides in birds and requires the mosquito as a vector to transmit it to humans. Conflicts may arise because some wetland design features such as shallow water and emergent vegetation that are essential for optimal polishing of water quality can result in undesirable increases in mosquito production. The attraction of large numbers of birds to constructed wetlands could also increase the risk of transmission of mosquito-borne viral infections to the humans in the vicinity of the wetlands. The conflict is typically highest in arid regions where natural mosquito populations have limited abundance and are found near newly urbanising areas (Knight 2003.) Studies show, however, that concerns over enhanced mosquito populations due to wetlands may be unfounded (for example, Anderson 2007). The relative outcome depends on a number of competing factors including wetland design (Batzer and Resh 1992) as mosquito species vary in their habitat preferences and only a very limited range of mosquito species carry the West Nile Virus. In a study in Madison, Wisconsin, Irwin et al. (2008) showed that the key mosquito habitats of concern for West Nile Virus were associated with constructed wetlands and degraded urban wet areas, and were uncommonly associated with the city's natural wetlands. Design adjustments to the constructed wetlands may make those sites unattractive to mosquitoes that carry the West Nile Virus. In general, careful design in constructed wetlands is needed to address potential conflicts in objectives between mosquito control, maintenance of ecological services, and biodiversity conservation.

In a Third World context, where pathogens are more abundant and the hydrologic cycle generally more extreme, the absence of wetlands contributes directly to income differences, poverty, and widespread disease. Wetlands often mean the difference between life and death (Millennium Ecosystem Assessment 2005.) In the British Columbia context, the effects of wetlands on human well-being is felt more indirectly through escalating healthcare and water treatment costs and, at some sites, in property damage. In addition, the loss of wetlands often means a decline in social, recreational, and cultural benefits.

As wetlands continue to be converted to other uses across British Columbia, we should continue to expect rising costs for maintenance of our present healthcare standards. Wetlands form an essential component in the multi-barrier approach to source water protection. In 2004, the Canadian Council of the Ministers of the Environment stated that the "destruction of wetlands … threatens source water quality by removing the pre-existing capacity for source waters to be buffered from pollution sources. The absence of wetlands means pollutants that would otherwise be effectively filtered by natural biological and physical processes readily enter source waters. Currently, many federal and provincial programs are trying to reverse this trend and reclaim areas around source waters as wetlands." (CCME 2004.) This focus on the protection of source areas (for human uses—drinking, recreation, and agriculture) is essentially a public health intervention to more effectively prevent disease rather than relying on (more costly) disease treatment. Viewed through this public health lens, it is clear that wetlands need to regain their place in the multi-barrier approach to source water protection.

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3. Natural forms and functions of montane marshes in Jasper National Park: The effect of a transportation corridor vs. beaver on diversity and productivity of floodplain marshes

Dr. Suzanne Bayley, University of Alberta

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The following three paragraphs describe Dr. Bayley's presentation at the conference. Dr. Bayley has published this information; refer to the two abstracts included below.

Riverine floodwater pulses provide water, nutrients, and sediments to freshwater floodplain wetlands, but flood pulses also act as a natural disturbance by removing biomass, scouring sediments, and delivering turbid waters. The flood pulses vary each year, sometimes favouring vegetative development, other times disturbing vegetative development. Along with the natural variation in hydroperiods, human impacts such as roads and railways can alter the stage, duration, and timing of flood regimes.

Figure 1. Floodplain complex in Jasper National Park.

We investigated nearly pristine montane floodplain wetlands with varying degrees of river connectivity in Jasper National Park, Alberta: three fully connected riverine marshes; three partially connected beaver-impounded marshes; and three completely disconnected railway-impounded marshes. Our objectives were to: determine how river connectivity affects plant diversity, plant production, and water and sediment chemistry; estimate impacts of nutrient limitations on plant production; and compare natural variations in river flooding on plant production, diversity, and nutrients.

The amplitude of water-level fluctuations, which is a measure of flood disturbance and river connectivity, was highest in flood years and in riverine marshes. Sites with river connectivity had significantly higher plant production than sites without river connectivity (railway-impounded marshes). Total phosphorus, NO_3^--N, and turbidity correlated positively with river floodwater pulses. A high flood year increased nutrient supply in the wetland water, but significantly decreased plant production on all sites. Moderate flood disturbance and nutrient inputs from floodwaters provided optimal growing conditions for plants and increased plant diversity in these montane floodplain marshes. Despite the beneficial effects of moderate flood disturbance on production and diversity, extreme flood events have beneficial effects over the long term, and activities which reduce this flood pulse will negatively affect floodplain marshes over the long term. Restoring the connection between the river and disconnected wetlands would increase diversity and productivity of the entire wetland complex.

Further reading

Bayley, S.E. and J.K. Guimond. 2008. Effects of river connectivity on marsh vegetation community structure and species richness in montane floodplain wetlands in Jasper National Park, Alberta, Canada. Ecoscience 15(3):377–388.

Abstract: Vegetation communities in floodplain wetlands in montane valleys are adapted to seasonal flooding, and natural and anthropogenic barriers to flooding can lead to changes in plant community structure. We assessed the plant community structure, species richness, and environmental variables in each of three riverine, beaver-impounded, and railway-impounded floodplain marshes of the Athabasca River in Jasper National Park, Alberta, Canada. We hypothesized that these variables differ significantly among the marsh types in response to varying degrees of disturbance from river flooding. Using TWINSPAN analysis, we defined eight plant communities in the three marsh areas. Regular flooding in the riverine marshes (no barriers to flood waters) led to very distinct plant community types characterized by *Eleocharis palustris*, *Utricularia minor,* and *Carex saxatilis*. Beaver-impounded marshes were defined by two distinct community types, both dominated by *Carex aquatilis*, *Carex utriculata*, and *Equisetum fluviatile*. Dominant plant species in the railway-impounded marshes (most extreme barriers to flood waters) were *Drepanocladus aduncus, C. aquatilis,* and *E. fluviatile*. Two of the railway-impounded sites had an increase in moss cover (43–48% versus 29%) and a decrease in emergent cover (51–56% versus 77%), pointing to a succession to a fen wetland. Overall, we identified 95 vascular and bryophyte species in the three wetland areas; species richness was highest in the beaver-impounded marshes (66 species), intermediate in the railway-impounded marshes (48 species), and lowest in the riverine marshes (37 species). Plant community types of these marshes were significantly correlated with water conductivity, water depth, organic content of the sediment, and absence/presence of hummocks. In addition, NO_3^- concentrations in the water had a significant inverse relationship on marsh species richness. Most of these marshes were N-limited, with N:P quotients below seven. Overall we showed that natural and anthropogenic barriers to water flow significantly affect plant community composition and species richness, water chemistry, and water levels in these riverine systems.

Further reading

Bayley, S.E. and J.K. Guimond. [2009]. Above ground standing crop and nutrient limitation in relation to river connectivity in montane floodplain marshes. Wetlands. In review.

Abstract: Riverine floodwater pulses provide water, nutrients and sediments to floodplain wetlands, but flood pulses also act as a natural disturbance by removing biomass, scouring sediments, and delivering turbid waters. We investigated nearly pristine montane floodplain wetlands with varying degrees of river connectivity in Jasper National Park, Canada: three fully connected riverine marshes; three partially connected beaver-impounded marshes; and three completely disconnected railway-impounded marshes. Our objectives were to determine how river connectivity affects plant biomass, and water and sediment chemistry; estimate impacts of nutrient limitations on plant biomass; and compare natural variations in river flooding on plant biomass and nutrients. The amplitude of water-level fluctuations, a measure of flood disturbance and river connectivity, was highest in flood years and in riverine marshes. Sites with river connectivity had significantly higher plant biomass than sites without river connectivity (railway-impounded marshes). Turbidity, NO_3^--N, and TP correlated positively with river floodwater pulses. A high flood year increased nutrient supply in the wetland water, but significantly decreased plant biomass in all sites. Moderate flood disturbance and nutrient inputs from floodwaters provided optimal growing conditions for plants in these montane floodplain marshes.

4. Managing a diked wetland: Costs, implications, and future options for the Creston Valley Wildlife Management Area

Marc-André Beaucher, Creston Valley Wildlife Management Area

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Marc-André Beaucher has been the Area Manager/Biologist for the Creston Valley Wildlife Management Area for the past four years. His current work in wetland management and nine-year involvement with the Northern Leopard Frog Recovery Team has given him good knowledge of freshwater inland wetland functions and characteristics. His work experience includes amphibian and waterfowl surveys, water quality monitoring, fauna and flora identification, management of wetland units through water-level manipulations, wetland restoration, and water control infrastructure management.

Until the late 1920s, the Creston Valley was one solid wetland stretching 32 km from the US border north to the south end of Kootenay Lake. This 170 km^2 of wetland shaped the valley bottom, and its associated fauna and flora. Today, at only 79 km^2, the area of wetland in the valley has been reduced to less than half its original size, and the valley bottom shape and functions have changed significantly.

The Creston Valley Wildlife Management Area was established in 1968, and formalized with the *Creston Valley Wildlife Act* (Revised Statutes of British Columbia 1996, see http://www.qp.gov.bc.ca/statreg/stat/C/96084_01.htm). Sixty-nine km^2 of the original wetland are conserved. With the primary goal of vegetation management for waterfowl habitat enhancement, the Area was diked to create wetland compartments, and water controls and pumps were installed. Providing stable water levels through active management became desirable due to major changes to the Kootenay River hydrology, caused by intense diking and damming along the river system.

In the last 40 years, active management has provided additional benefits to many wildlife species. However, activities to preserve the existing managed wetland compartments, such as drawdowns, pumping, and infrastructure maintenance, are posing financial and management challenges that directly impact the ecological characteristics of the wetland. This presentation gave an overview of some of the costs and implications associated with managing a diked wetland and suggested ways to reduce both the amount of necessary management and associated costs.

Introduction

The Creston Valley Wildlife Management Area (CVWMA), an inland freshwater wetland established in 1968, covers approximately 7000 ha of land between the south end of Kootenay Lake and the Idaho (USA) border. It is located within the very dry, warm variant of the Interior Cedar–Hemlock (ICHxw) biogeoclimatic subzone, and experiences very hot, dry summers and generally very mild winters with light snowfall of short duration. The Selkirk and Purcell Mountain ranges border the Area to the west and east, respectively, and the Area encompasses a significant portion of the Kootenay River floodplain.

Due to its important geographical location along the Pacific Flyway, and the high biological diversity of the Area, the CVWMA was added to the Ramsar List of Wetlands of International Importance in 1994. It was also added to the list of Important Bird Areas of Canada in 2000, as well as Important Amphibian and Reptile Areas of Canada in 2005. For the past 40 years, the CVWMA and surrounding area have provided foraging, nesting, and staging habitat for more than 280 species of birds, 55 species of mammals, 6 species of amphibians, 6 species of reptiles, approximately 20 species of fish, and probably thousands of species of invertebrates and plants, many of which are now at risk.

Figure 1. In British Columbia, Northern Leopard Frogs are found only at the Creston Valley Wildlife Management Area and Bummer’s Flat Wildlife Management Area. Photo by Marc-André Beaucher

While it has been recognized that species and populations have increased in numbers due to stabilized water levels resulting from the establishment of the Area through the construction of wetland compartments, many challenges have arisen over the years to maintaining the physical infrastructure that has helped provide suitable habitat for this rich biodiversity. The CVWMA is responsible for: the maintenance of 30 km of internal and flood protection dikes; the management of 17 wetland compartments; and the operation and maintenance of a complex network of 35 water controls and pumps. Most of the infrastructure was put in place from the early to mid-1970s and is now requiring significant attention, and presents significant financial and management challenges for the CVWMA.

Description of the Creston Valley Wildlife Management Area

The CVWMA is divided into seven large units: Kootenay Lake, Duck Lake, Duck Lake Nesting Area, Six Mile Slough, Leach Lake, Corn Creek, and Dale Marsh. Two of these units (Kootenay Lake and Dale Marsh) are unmanaged and consist of marshes, forest, rivers and creeks, and riparian habitats. The remaining five units are subdivided into 17 smaller wetland compartments and are considered as managed ponds. They consist primarily of marshes and lakes.

Figure 2 illustrates the extent of the CVWMA and Table 1 summarizes the number and status of each units and sub-unit or pond.

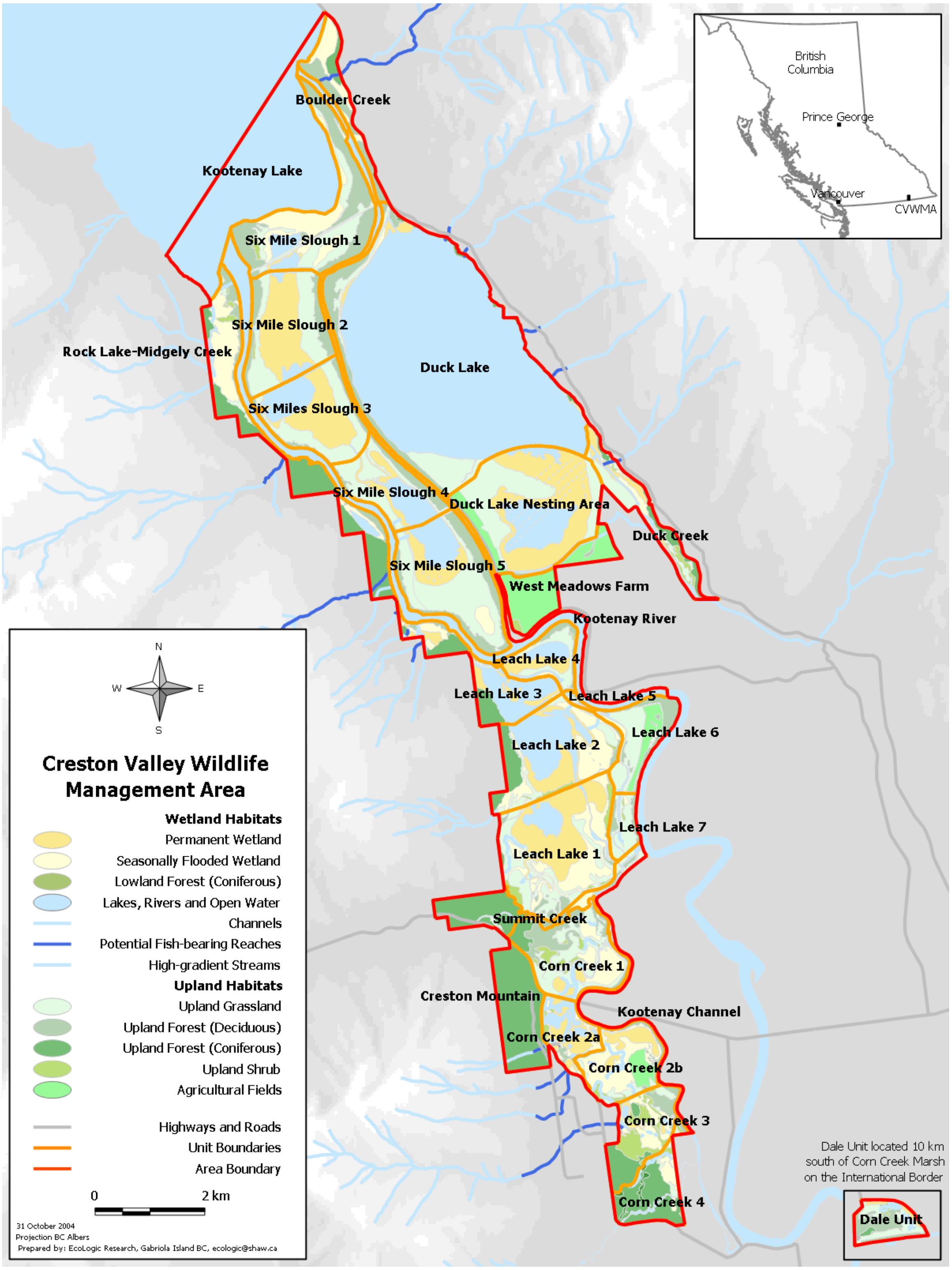

Figure 2. Map of the CVWMA identifying the wetland units.

Table 1. Size of CVWMA managed and unmanaged wetland units.

Unit	Sub-unit	Size (ha)	Status	Total Area (ha)
Corn Creek (CC)	CC pond 1	230	Managed	
	CC pond 2a	87	Managed	
	CC pond 2b	162	Managed	
	CC pond 3	117	Managed	
	CC pond 4	128	Unmanaged	
				724
Dale Marsh	–	75	Unmanaged	
				75
Duck Lake	–	1498	Managed	
				1498
Duck Lake Nesting Area	–	428	Managed	
				428
Kootenay Lake	–	829	Unmanaged	
				829
Kootenay River	–	293	Unmanaged	
				293
Leach Lake (LL)	LL pond 1	359	Managed	
	LL pond 2	273	Managed	
	LL pond 3	94	Managed	
	LL pond 4	100	Managed	
	LL pond 5	10	Managed	
	LL pond 6	143	Managed	
	LL pond 7	59	Managed	
				1,038
Old Kootenay Channel	–	22	Unmanaged	
				22
Roads	–	21	n/a	
				21
Rock Lake	–	110	Unmanaged	
				110
Six Mile Slough (SMS)	SMS pond 1	110	Unmanaged	
	SMS pond 2	280	Managed	
	SMS pond 3	244	Managed	
	SMS pond 4	186	Managed	
	SMS pond 5	317	Managed	
				1,137
Summit Creek Area	–	157	n/a	
				157
Agricultural Land	–	149	Managed	
				149
Slopes	–	500	Unmanaged	
				500
Total Area (ha)				6,981

Purpose of the Creston Valley Wildlife Management Area

Under sections 2 and 7 of the *Creston Valley Wildlife Act* [RSBC 1996] (Chapter 84):

> "The Creston Valley Wildlife Management Area is continued for wildlife conservation, management, and development, and is held by the government in trust for those purposes … the management area must be maintained and developed for the purposes for which it is established and, in particular, as a waterfowl management area."

Historically, the spring freshet brought widespread flooding over most of the Area, scouring away most of the growing vegetation. Receding water during the summer left extensive mudflats and sparse vegetative cover provided by moist-soil plants offered poor nesting and brood cover conditions as well as limited permanent water for brood rearing. Habitat management therefore became necessary to control water levels and encourage emergent and upland vegetative cover for waterfowl habitat. Over the years, maintaining productive marshes in the face of ecological succession became one of the focal activities on the CVWMA. Today, reducing flooding during the nesting period, encouraging and/or controlling the growth of persistent emergent and upland vegetation, and providing permanent water areas remain three of the main objectives of the CVWMA.

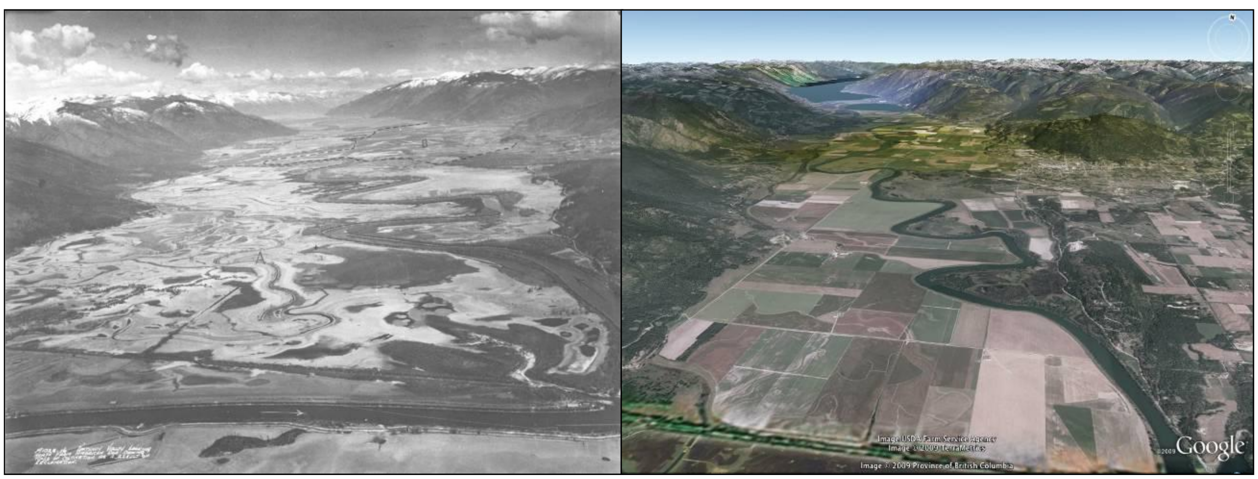

Figure 3. Creston Valley in 1929 and 2005.

Costs and implications of management methods and maintenance of infrastructure

Water-level management

The Area requires properly functioning water controls and pumps. Currently, approximately 20 water controls are in needs of repairs on the CVWMA. Since 2006, four deteriorated controls have been replaced in Corn Creek and Leach Lake, and a new one has been added in Corn Creek pond 2a to facilitate restoration of Corn Creek pond 1. Replacement costs for a regular one-way water control range from $30,000 to $55,000 while more sophisticated 3-way structures can cost up to $100,000. Site location, availability of on-site materials, distance to material sources, and weather can all affect overall costs. An estimated $1,000,000 will be necessary over the next few years to complete upgrades of all water controls needing repairs or replacement. New water controls are now built of concrete and high density polyethylene to increase their life span over previous water controls built out of corrugated galvanized metal (50+ yrs vs. 25–30 yrs).

Water control structures such as slide/screw gates, stop log structures, and electric pumps are used to manage water levels within the various units of the CVWMA. With exception of the pumps, staff operate all water controls manually. All water controls are accessible by car except for the water controls in the Six Mile Slough unit, which are only accessible by boat.

Figure 4. Installing a new 3-way water control structure at Leach Lake, October 2009. Photo by Marc-André. Beaucher.

Managing water levels can require weekly visits during normal periods and multiple visits during the spring freshet period, to adjust gates and read water levels. The main associated costs are staff time (30–50 days/yr), and vehicle-related expenses. Boat(s) and an off-road vehicle for winter access may also be necessary at additional costs. An old airboat has been used in past years to access water control in the winter.

Water control structures need to have accumulated debris removed. Debris such as branches and cattail mats can collect or be intentionally placed in the controls by beavers. Debris removal can often be accomplished manually, but sometimes requires a backhoe or an excavator. Depending on the size of the equipment required, cost can exceed $200/hr. Again, staff time and vehicle-related expenses are the main costs.

Managing water levels requires maintenance of channels used to move water between wetland units. This involves dredging sections of channels that have filled up with vegetation over the years, or removing beaver dams as well as trapping beavers that may build those dams. Dredging channels is most easily done with an excavator with a long-reach boom, and while removing beaver dams manually is feasible, it is very difficult, but sometimes the only way. In some locations it may be necessary to transport the dredged material away from the site with the help of a dump truck to prevent it from re-entering the channel during high water. This is only feasible if the area being dredged is accessible by vehicle. Hourly rates for a dump truck can be as high as $125/hr. Dredging sometimes requires draining ponds and channels; this can be costly and difficult to achieve at some times of the year. It may be wise to conduct dredging when conducting a drawdown.

Figure 5. Dredging a channel in the Corn Creek Marsh.

While rates to hire trapper services may vary regionally, the CVWMA has spent up to $2,000 in a year to remove problem beavers.

The CVWMA operates two 150 hp electric pumps (total capacity 60,000 US gallon/min) on Duck Lake, primarily for flood control during the spring freshet. While rates vary annually and with the time of day, operating the pumps can cost up to $200/day. In 1997, approximately $18,000 was spent in electricity costs over a five month period (March to July).

In addition to the cost of electricity, operating the pumps requires daily visits to ensure proper functioning and to lubricate the pumps as well as reading the water levels. The pumps are 32 km away from the CVWMA office and a round-trip takes on average 2 hours. Staff time, vehicle, and lubricant expenses are the main costs. Up to 150 hours of staff time is spent on managing water levels at Duck Lake every year.

Pumps require annual maintenance and inspection, as well as occasional refurbishing of the engines. Replacing the existing pumps with new pumps would likely cost well over $100,000.

Dike maintenance

Under the *Dike Maintenance Act* [RSBC 1996] (Chapter 95), the CVWMA is responsible for maintaining 13.5 km of flood protection dikes around and south of Duck Lake.

Dikes must be kept clear of vegetation from the toe to the crest of the dike. While brushing can be done manually with chain saws and brush saws, heavy machinery equipped with brush cutters is more cost-effective. Rates for such equipment can be as expensive as $180/hr. Many of the dikes within the CVWMA have overgrown vegetation on their slopes and could fail during flood episodes. Removing the vegetation as prescribed in the provincial guidelines could cost in the hundreds of thousands of dollars.

Dike crests must be kept in good condition. Annual grading is often necessary to remove washboard and ruts created by vehicle travel. Hourly rates for a grader can exceed $150/hr. Dike crests should be resurfaced when conditions have deteriorated to the point that grading is not effective any longer. In 2007, close to 10 km of dike along the western and northern sections of Duck Lake were resurfaced with approximately 15 cm of gravel. Total cost, including engineering services, came in at just under $200,000.

Damage (burrows) caused by rodents such as beavers and muskrats must be repaired.

The CVWMA also maintains 11 km of internal dikes and access roads through the Leach Lake unit, and 12.75 km through the Corn Creek unit, to provide safe access to the water controls and wetland compartments. While maintenance is not as strict as for the flood protection dike, similar activities are necessary to maintain the integrity of the dikes. Spring and summer mowing of the dike crest is conducted on the CVWMA using farm equipment. On average, 100 hours of staff time are required annually to control vegetation growth on the dikes and access roads. Repair and maintenance of mowing equipment adds to the staff time. Operating the vehicles is an additional expense.

Wetland restoration

While stable water levels benefit many species of wildlife, they also favour ecological succession or vegetation encroachment within the managed wetland units. Every 7 to 10 years, restoration activities must be conducted in managed units to set back succession; the aim is to maintain or create a 50:50 ratio of emergent cover to open water, for waterfowl.

Restoration activities consist of draining the ponds in early March and letting them dry up to approximately mid- to late July, then breaking up the vegetation stands (mostly cattails and bulrushes) by mowing, baling, and tilling and/or ploughing the soil over. Pumping may be necessary during the draining period to remove water in deeper areas. Re-flooding and maintaining high-water levels in subsequent year(s) will ensure good control of the vegetation. A reliable water source is necessary for re-flooding.

Restoration activities are expensive and can cost from $600 to $1,000 per hectare. Weather can interfere with these activities and increase costs. The last drawdown conducted on the CVWMA in 2005, in pond 2b of Corn Creek marsh, required well over 300 hours of staff time to treat 35 hectares of wetland.

Figure 6: Solid stand of cattails requiring restoration.

Options for the CVWMA to reduce operation and maintenance costs in the future

- Modernize some of the water control structures (e.g., Duck Lake gates and pumps) so they can be operated remotely—this will significantly reduce travel and staff time. It may be difficult to modernize other water controls, as power would be needed.
- Reduce and/or eliminate water controls that may not be necessary. For example, if hydrology allows, the Six Mile Slough unit could be reverted to a more natural system by opening up some of the dikes and removing some of the water controls.
- Reduce costs of vegetation control on dikes by removing vegetation as soon as it starts to grow. Large, tall trees are more costly and problematic to deal with than small, short saplings.
- Reduce dike maintenance costs such as grading and resurfacing by restricting access to dikes when conditions are not suitable.
- Investigate alternative methods (e.g., burning) to control vegetation within the managed units. Smoke is a controversial issue in the Creston Valley and it will be a challenge to find a window for burning the wetland.
- Draw down Duck Lake as much as possible in the spring to reduce or avoid pumping costs during the freshet.

Concluding advice

- Keep it natural…if you can.
- Intensive management does benefit wildlife, but it is not cheap.
- Secure maintenance money for the future…you will need it.
- Do not "cheap out" on initial building costs…it will pay off in the long term.
- Conduct monitoring programs to demonstrate the benefits of your projects.

5. The impacts of dam construction on wetland ecosystems in the Columbia Basin

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Co-authors

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Dams constructed on the Columbia River in Canada flooded more than 121,000 ha of terrestrial and aquatic habitats. The Fish and Wildlife Compensation program initiated a multi-faceted "Dam Impacts" study to quantify the impacts of reservoir flooding on habitat, ecosystem productivity, and biodiversity losses in both terrestrial and aquatic ecosystems. This presentation drew from the range of "Dam Impacts" studies to present the habitat productivity and biodiversity impacts associated with flooded wetland ecosystems (including forested floodplain habitats). Wetland ecosystems flooded by reservoirs were compared with the present day distribution of wetland ecosystems to evaluate the significance of these losses. Ecosystem productivity losses were calculated for terrestrial and aquatic ecosystem types using a modelling approach. The distribution and magnitude of impacts to net primary production, net ecosystem productivity, and carbon storage resulting from the flooded wetland habitats were presented by reservoir area. Impacts to terrestrial and aquatic vertebrate species were evaluated using the Columbia Basin database to link wildlife species to impacted habitats. Biodiversity impacts associated with the loss of wetland habitats were presented and compared relative to other terrestrial habitat losses. The challenges associated with implementing compensation options that address habitat, ecosystem productivity, and biodiversity losses were discussed.

6. An elegy to wetlands

Eileen Delehanty Pearkes

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Eileen Delehanty Pearkes is an artist and writer who has lived in the Columbia Basin for 15 years. She is the author of many published works, including two books that explore the Columbia Basin's culture, ecology, and landscape (*The Geography of Memory; The Inner Green)*. She was a contributor of Canadian content of poetry and prose-poetry to *River of Memory*, a pictorial history of the Columbia River from mouth to headwaters prior to dams. Eileen was project researcher, writer, and conceptual advisor for Touchstones Nelson Permanent Museum Exhibit (2006) and for three short films on hydro history in the Basin, including *The Course of History*.

Assessing cultural rather than biological losses of wetlands and river valley bottom lands requires us to look through the lens of history, to qualify wetland values, rather than quantify their ecology. This is the work of artists and historians. Fundamentally, it's the way I see and understand the landscape around me.

Part One: Screening of The Course of History

In 2006, I was approached by Touchstones Nelson's Museum of Art and History to assist them in research and development of three short films about the hydroelectric history of the region. As part of the project, I spent several days in the BC Hydro film and print archive in Burnaby, BC, gathering images, facts, and ideas to guide the project. Thanks to generous funding support from BC Hydro, Columbia Power Corporation, FortisBC, Nelson Hydro, and Teck Cominco, this wonderful project resulted in three films that fill an important cultural gap in the region. Today, I will screen the third of the three films, *The Course of History*. This film attempts to survey the cultural and ecological losses associated with the flooding of our region's major river valleys. It's a large subject to cover in a short time, but the film is a step toward qualifying what was lost.

All three films can be viewed in the permanent museum of Touchstones Museum in Nelson and are available for purchase as the DVD *HYDRO Electric* from http://www.touchstonesnelson.ca

Part Two: An elegy to wetlands

Eileen read her poetic text, accompanied by photos of intact wetland environments in the Columbia Mountains region.

An elegy to wetlands

Could there be such a thing as a dam that encourages rather than destroys
the lush disorder of our landscape?

Could there be industry that facilitates moist abundance
and supports the emergence of
a community of shining lanterns?

What are the lost values of the modest wetland corners that once thrived in these mountain valleys?

Places that offered a wet,
secretive complexity.

Places where rushes scoured
and settled
the passing water, where leaves
floated toward an imagined end.

Here, amidst the ooze and ripple of the seasons,
appetites could be satisfied
by spears of new cabbage
by eventual fruit of gooseberry,
by the beauty of charming coltsfoot.

Here, there were friends,
and foes.

Wetlands once entangled water and land
in tarnished chaos
allowing willows
to dream
of a larger purpose.

Imagine
the dense gatherings of cottonwood
that once crowded the littoral,
shining with new life
aching to replace
the lost qualities of landscape.

7. Status and condition of Kelowna wetlands: A summary of an inventory on some of the rarest and yet most biologically significant and diverse communities in Kelowna using a new spatial inventory approach.

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Kyle Hawes is a natural resource biologist and Principal of Ecoscape Environmental Consultants Ltd. He has completed numerous studies, inventories, and evaluations of wetland and aquatic ecosystems in Ontario, the Northwest Territories, and British Columbia. His research and conservation initiatives are in the Okanagan Valley, and he frequently works with local governments in areas of ecological land-use planning and development of environmental protection policies.

Introduction

Over 84% of the Okanagan valley bottom wetland and riparian habitats have been lost in the Okanagan and Similkameen Valleys (Lea 2008). Percentage losses of certain ecosystem types have been estimated to be higher in the Kelowna area than for the whole Okanagan valley. Many of the remaining water-dependent communities are highly fragmented and functioning poorly.

Wetlands provide ecosystem services that are disproportionate to their relatively small basal footprint in the landscape. Studies have shown that about 80% of wildlife are either directly dependent upon wetland and riparian ecosystems, or use them more frequently than most other habitat types. The community, and local and provincial governments, recognize the critical importance of wetland and riparian ecosystems, but these ecologically significant areas continue to be lost.

Recognizing the imperilled state of these ecosystems, those that remain should have high conservation priority irrespective of the condition of their current ecologic function. This rationale is premised simply on the fact that the hydrologic conditions support wetland development and that these disturbed and/or modified sites have a moderate to high capability of regeneration. In short, wetlands occur in areas where the nature and topography of the site are conducive to supporting this unique habitat type.

If we don't know where they are, how can we protect them?

Within Kelowna, it was acknowledged that many watercourses and critical wetland and riparian communities were not previously identified and/or mapped and in some cases do not fall within Natural Environment Development Permit Areas. Furthermore, some watercourse information that existed was spatially inaccurate.

Objective

The objective of this project was to provide a more definitive information base for future planning, particularly where urban development could affect natural wetland areas, and to provide policies that will enhance protection of significant wetland features. By combining resource information from a variety of sources, we provided a comprehensive GIS (Geographic Information System) baseline inventory of wetland communities for improving integrated resource management and planning within the City of Kelowna.

Data application

The data collected is intended to:

- Identify wetlands not previously catalogued within the Kelowna city limits
- Integrate property boundaries, land parcels, and road networks with locations of wetlands to facilitate the Kelowna Official Community Plan and development permit application review processes
- Work within an interactive Geographic Information System (GIS) to provide useful map products for analysis and effective communication
- Establish partnerships with provincial and municipal governments, stakeholders, and the public to protect and manage wetlands and associated functions (i.e., riparian communities and linear corridors)
- Help guide management decisions and priorities with respect to wetland habitat restoration and enhancement projects
- Identify sensitive habitats for fish and wildlife
- Monitor spatial and community changes in habitat resulting from known disturbances, such as development, agriculture, and recreation
- Provide baseline mapping data for future monitoring activities
- Map and identify the spatial extent of wetland and floodplain associations
- Assess the status of each wetland under the Riparian Areas Regulation (RAR)

Technical approach

Field inventory, data processing, and data deliverables used Sensitive Habitat Inventory and Mapping (SHIM) Standards (Mason and Knight 2001), as at: http://www.shim.bc.ca/methods/SHIM_Methods.html

The data dictionary

The data dictionary was revamped to include more comprehensive wetland community classification elements (e.g., biodiversity, soils/substrates).

What is a wetland?

A wetland is defined as land that is saturated long enough to promote wetland or aquatic processes indicated by poorly drained soils, hydrophytic vegetation (>50 composition), and various kinds of biological activity, which are adapted to a wet environment. Within this project low-flood and mid-flood bench riparian sites were often included in the wetland area boundaries since, from an ecological perspective, it makes sense to include these sites with wetland sites and treat them as a larger ecological unit or as wetland mosaics (Banner and MacKenzie 2000).

The hydrogeomorphic setting (landscape position) of sites were recorded according to Mackenzie and Moran (2004):

- Wetland edatopic grid
- Hydrodynamic class
- Soil moisture
- Soil nutrient regime

General field measurements to assess surface water chemistry were recorded, including:

- Water temperature
- Total dissolved Solids
- pH
- Electrical conductivity

Wetlands were cored with a Russian peat auger. In drier sites, soils pits were excavated to obtain a profile and to characterize substrate/soils, adapting the Canadian Soil Classification System. Attributes recorded via the data dictionary included:

- Soil order
- Texture
- Depth to gley

- Depth to mottles
- Depth to water
- Organic class (Von Post level of decomposition)
- Organic depth

Primary biophysical attributes recorded
Classification methods adapted both the Canadian Wetland Classification System and the BC Wetland Classification System. Additionally, inventory and evaluation components have been adapted based upon protocols established by the National Wetlands Working Group (1994). Wetland and floodplain communities and associations were described using the Canadian Wetland Classification System (Warner and Rubec 1997) and the Guide to Identification of Wetlands of British Columbia (MacKenzie and Moran 2004).

Biodiversity of wetlands were considered based on taxonomic and ecosystem variety. Wetlands containing more habitats will contain more plant varieties and will in turn attract more fauna than wetlands containing more uniform vegetation communities.

Three main factors for assessing biodiversity
- Number of vegetation communities with a wetland unit
- Total number of vegetation forms (physical structure or shape of a plant) within a wetland unit
- Wetland Open Water Type (of the wetland unit) as per the National Wetlands Working Group (1994)

Wetland condition and surrounding habitat condition was recorded based on Riparian Class (e.g., natural, modified, and urban), wetland Functional Rating (Proper Functioning Condition, Functional at Risk, and Non-functioning Condition), and overall Level of Impact (0=Nil to 6=Extreme).

Summary of results

The total number of wetlands included in the inventory database is 278. Remaining wetlands and shallow open-water environments cover about 1% (~260Ha) of the Kelowna land base. Natural Condition sites have a combined wetland area totalling about 24% of the total wetland aerial coverage. Modified and Constructed Sites account for about 74% and 2% of the total wetland aerial coverage respectively.

- Hydrogeomorphic grouping
  The majority of sites (84%) are palustrine basins either being linked by ephemeral channels with other basins or themselves being geographically

isolated (no inlet or outlet). Riverine and riparian sites account for about 15% and slope/spring sites make up the roughly 1% balance.

- Proportion of wetland types with Kelowna
  Marsh (predominantly tall rush) = 28%
  Saline meadow/transitional associations = 2%
  Shallow water (predominantly submerged aquatic) = 46%
  Swamp (predominantly tall shrub) = 23%
  Riparian/mid flood bench (treed) = 1%

- Functional rating
  Over 50% of remaining wetlands are At Risk (functionally) from development encroachment, infilling, draining, fragmentation (from upland habitats and other functionally connected wetlands), contamination, alteration of hydrology, invasive plants and animals, or other causes.
    - Proper Functioning Condition: 40%
    - Functioning Condition/At Risk: 56%
    - Non-functioning Condition: 4%

Considerations and policy direction

Wetland dynamics

Appreciate the dynamic nature of wetlands and how they may change with fluctuations in climatic conditions. Many of these communities have poorly defined boundaries and, coupled with anthropogenic disturbance and hydrologic alteration, are transitional between wetland and upland associations. Potholes and shallow lakes in semi-arid regions such as the Okanagan often experience dramatic water table fluctuations in response to climatic cycles

Policy direction

- Carefully consider the hydrodynamic position of all wetlands, particularly dynamic/transitional sites, in land-use planning because of their potential importance for species at risk and other biodiversity values
- Maintain pre-development drainage patterns to ensure a continued and stable hydrological regime, without compromising or impacting the wetland communities from the potentially harmful effects of stormwater run-off (i.e., prevent direct discharge of untreated stormwater to a natural wetland)
- Emphasize the functional connections between wetlands, especially those that occur within 750 m of another wetland or that are considered linked basins, to maintain the biodiversity and complex wetland characteristics that occur in these diverse sites

- Establish and preserve buffers around wetlands
- Prioritize the retention or restoration of wetlands, rather than their creation
- Clearly articulate performance standards in policy and bylaw documents that reflect the structural and functional objectives of any project
- Require long-term monitoring and management responsibilities for created or restored wetlands
- Where mitigation is used, its focus will be on maintaining the functionality of the wetland
- Develop compensation ratios that reflect the high failure rate of certain types of wetland compensation projects
- Develop a wetland adaptive management strategy for wetland community enrichment to mitigate the loss of wetlands in urban/suburban areas from biomass accumulation and the absence of other natural processes

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8. Creating shoreline management guidelines using the sensitive habitat inventory method on Windermere Lake

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Heather is the Water Stewardship Program Manager with Wildsight, a non-government environmental organization based in the Columbia and southern Rocky Mountain region of British Columbia. Heather manages the multi-stakeholder water stewardship initiative, Lake Windermere Project, and chairs the East Kootenay Integrated Lake Management Partnership. Heather was delighted to be invited to present the work of Wildsight's Columbia Headwaters Legacy Program and the East Kootenay Integrated Lake Management Partnership recently at the 12th International Living Lakes Network conference in Umbria, Italy.

Figure 1: Lake Windermere at the town of Invermere.

Lake Windermere is located in the Columbia Valley between the Rocky Mountains to the east and the Purcell Mountains to the west. It is a three hour drive from Calgary and as a result has become a destination recreation area for Alberta residents who have established second or third homes here. The lake is heavily used for motorized recreation and sees pressures from faulty or non-existent septic systems, shoreline modifications, agricultural practices upstream, and nutrient inputs and water withdrawal from surrounding golf courses.

Lake Windermere borders the Columbia Wetlands, a Ramsar site of International Importance. Lake Windermere recently experienced a collapse in the burbot fishery. Because burbot are a top predator, the health of their population is a good indication of the health of the system as a whole.

Lake Windermere is a small, shallow lake. It is located at the headwaters of the Columbia River, the fourth largest river basin in North America, and the most dammed river in the world. Lake Windermere remains part of the only free-flowing portion of the river, and as a result has a flushing rate of approximately 50 days.

Recently there has been an intensification of development proposals in the Columbia Valley. In some cases there is conflicting policy information or direction from different agencies or poor communication between agencies. Interest in coordinating efforts led to the development of the East Kootenay Integrated Lake Management Partnership (EKILMP) in 2006.

EKILMP is a coalition of various agencies, local governments, First Nations, and non-government organizations with joint responsibilities to protect lakes and their beneficial uses for wildlife, drinking water, heritage, recreation, and aesthetics. EKILMP develops integrated, collaborative lake management techniques that address the current and future activities in the watershed to help sustain the ecological health, social, and economic values of East Kootenay lakes.

EKILMP represents an interest in coordinating efforts to address local issues and to establish lake management projects. In 2007, EKILMP produced a Terms of Reference approved by all participatory agencies and organizations. Partners agreed that EKILMP’s vision is for productive and healthy lake ecosystems in the East Kootenay Region, with balanced land and water uses that support and sustain traditional, environmental, community, recreational, and aesthetic values.

The Partnership works with local communities to engage residents in the protection of their water resources. Additional lakes in the East Kootenay that have been identified for SHIM (Sensitive Habitat Inventory and Mapping) projects include; Columbia Lake, Tie Lake, Rosen Lake, Wasa Lake, Jimsmith Lake, Moyie Lake, and Monroe Lake.

Windermere Lake was chosen as the pilot study lake due to the presence of a highly motivated local water stewardship group (Wildsight and their Lake Windermere Project), heavy development pressures, high fish and wildlife values, ongoing land-use planning processes, and source water issues. Results show that 62% of Windermere Lake's shoreline is classified as disturbed. Anthropogenic alterations include the construction of foreshore structures, riparian vegetation removal, wetland infilling, and modifications of the land base, including the construction of roadways and the railway.

The *Windermere Lake Shoreline Management Guidelines for Fish and Wildlife* (henceforth referred to as "the Guidelines") will be used as an initial step when reviewing, planning for, or prescribing alterations along the shoreline. The Guidelines have been developed using the technical results of shoreline assessments and fish and wildlife assessment reports commissioned by EKILMP (McPherson and Michel 2007; McPherson and Hlushak 2008). These reports have shown that the Windermere Lake shoreline has a diversity of important fish and wildlife habitats and species. The Guidelines are focused around the protection, conservation, and restoration of important fish and wildlife values. EKILMP believes the Guidelines will help focus where new development could be located on the lake while sustaining priceless natural public assets and maintaining the economic viability of the area.

The spectacular setting, which includes the fish and wildlife values of Windermere Lake, draw many people to the area. These values have slowly been eroded as a result of development activities throughout the years. Current development pressures are considerable, and without appropriate guidance, the natural values of the area could quickly be degraded. EKILMP wishes to prevent further degradation of the natural values along the lakeshore.

Guidance is provided through shoreline mapping, which outlines different color zones around the lake based on a Habitat Index Analysis and measured Key Habitat Area features. This approach provides a science-based assessment of areas of highest natural value requiring the highest level of ongoing protection. There are four colour zones ranging from red, which call for the highest level of shoreline protection and are identified as conservation areas, to grey zones, where there are already significant impacts from development and potential for redevelopment and restoration. The risks of selected development activities have been determined for each colour zone, identifying activities that require additional review or consideration. A flow chart has been developed based on activity risk, which outlines the review process at a broad scale.

The Guidelines include shoreline designation maps, risk rating for potential proposed activities and a flow chart that indicates selected preliminary approval procedures when making development applications. These are provided as tools to assist landowners and developers who want to propose shoreline development.

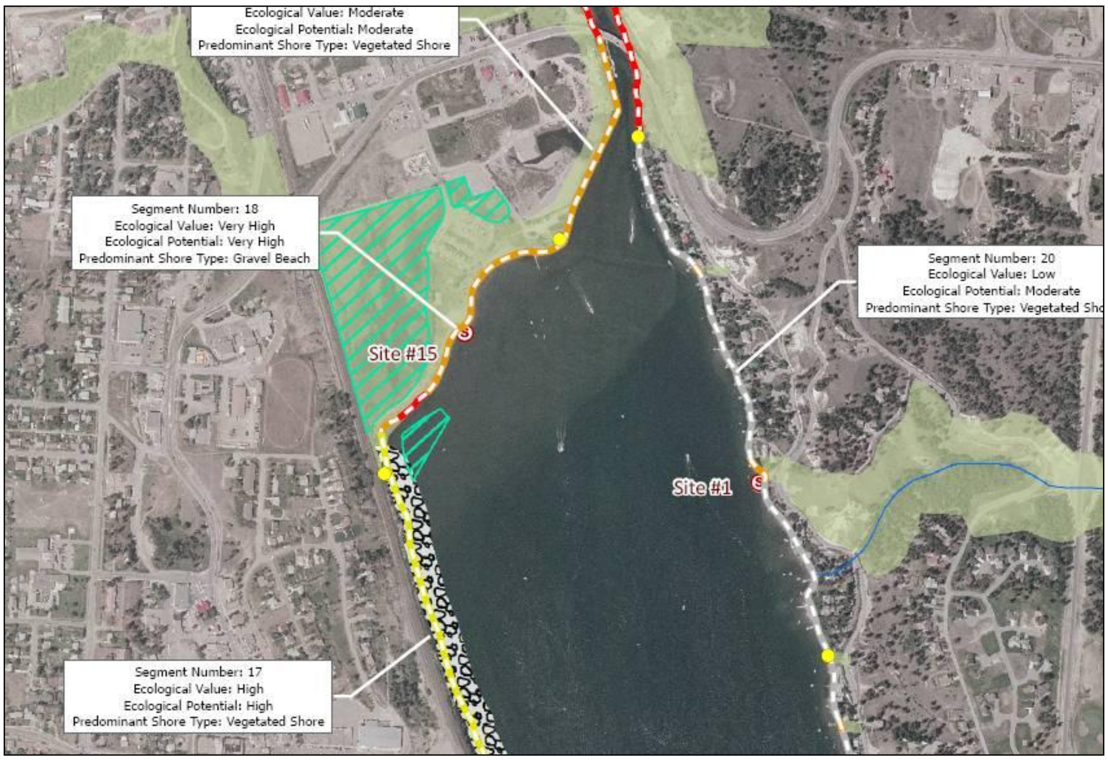

Figure 2. Shoreline designations for Lake Windermere, at the town of Invermere.

Red shoreline

These areas have been identified as essential for the long-term maintenance of fish and/or wildlife values through both the Habitat Index Analysis process and the Zones of Sensitivity Analysis. This zone includes most tributary outlets, unless substantially degraded, for 250 m along the lake, on both sides of the creek (or a topographic or other logical ecological break), wildlife corridors, contiguous wetlands, natural grasslands, cliff/bluffs, important gravel and cobble areas potentially used by burbot or other species for spawning and rearing, and areas of high productivity such as mussel beds. It also includes remnant natural areas. Red shoreline colour zone represents 49% of the total shoreline.

EKILMP recommends that these areas be designated for conservation use, and that no development occur within them. Low-impact water access recreation and traditional First Nation uses are permissible in these areas, but permanent structures or alteration of existing habitats is not considered to be acceptable. Habitat restoration may be appropriate in these areas where warranted. Invasive aquatic plant removal is acceptable, provided there is an approved aquatic plant removal program including trained persons.

Orange shoreline
These shoreline segments have been identified as Key Habitat Areas for fish and/or wildlife. These are made up of areas with one or more Zones of Sensitivity that do not overlap with areas of very high or high existing ecological value. These areas are sensitive to development and continue to provide important habitat functions, but may be at risk from adjacent development pressures. Restoration opportunities potentially exist in these areas. Orange shoreline colour zone represents 6% of the total shoreline.

Activity risks in the orange zones will trigger the requirement to have an environmental assessment conducted by a qualified professional.

Yellow shoreline
These areas have experienced relatively low development disturbance. No Key Habitat Areas have been identified, but there are shorelines with very high and high current ecological value. Overall they provide important fish and wildlife habitats, which could be affected by direct or cumulative impacts associated with development. Efforts should be made to maintain their high ecological values. Yellow shoreline colour zone represents 27% of the total shoreline.

Development could be considered on these shorelines, and may include those which incorporate protection of habitat features, are well above the high-water mark, and/or are outside of the riparian area. Restoration may be an option in some areas that have experienced some development. Development may proceed for low-risk activities.

Grey shoreline
These are shorelines identified during the Habitat Index Analysis as having lower ecological value. However, they still may contain valuable habitats requiring some protection, such as in-lake wetlands, or gravel and cobble substrate areas. Grey shoreline colour zone represents 18% of the total shoreline.

Residential development has been concentrated in these areas and has resulted in disturbances to the natural fish and wildlife habitat. In keeping with the objective of concentrating development in areas that are already disturbed or of low value, new developments may be considered in these areas. Redevelopment will also be considered. New developments or redevelopment proposals shall incorporate fish and wildlife restoration or improvement features where feasible and practical. For example, a retaining wall redevelopment may be moved back from the high-water mark and/or incorporate revegetation or other fish and wildlife features in the design.

Information generated by the Windermere Lake SHIM process is housed on the Community Mapping Network website (http://www.cmnbc.ca). This website was created to share information and assist communities in BC in mapping sensitive habitats and species distribution.

Typical shoreline activities have been assigned risk ratings based on the potential level of risk that they may have on fish and wildlife habitat values (see Table 1). Recognizing that the different shore zones have different habitat values and levels of sensitivity, the risk of each activity has been identified for each shoreline colour zone. In the table, each colour zone/activity combination has been rated as either: Not Acceptable (NA), High Risk (H), or Low Risk (L). A species at risk modifier column has also been provided, which should be used if a species at risk has been identified in the project area.

EKILMP fosters the collection of new data and knowledge about the aquatic ecosystems and related uplands in the East Kootenay region, and makes this knowledge available to decision makers and other stakeholders. By developing science-based coordinated management guidance for land and water uses associated with East Kootenay lakes we will have an improved understanding of the overall health of lake ecosystems in the East Kootenay.

Table 1. Activity Risk Table (NA = Not Acceptable, High = H, Low = L).

Activity	Shore zone colour and activity risk				Modifier
	Red	Orange	Yellow	Grey	Zone has species at risk
Over water piled structure (i.e. building, house)	NA	NA	NA	NA	NA
Boat house (below HWM)[1]	NA	NA	NA	NA	NA
Dredging (new proposals)	NA	NA	NA	NA	NA
Beach creation above HWM	NA	NA	H	H	H
Beach creation below HWM	NA	NA	H	H	H
Aquatic vegetation removal	NA	NA	H	H	H
Upland vegetation removal	NA	NA	H	H	H
Marina[2]	NA	H	H	H	H
Breakwater	NA	H	H	H	H
Boat launch upgrade	NA	H	H	H	H
New boat launch	NA	H	H	H	H
Infill	NA	H	H	H	H
Groynes	NA	H	H	H	H
Fuel facility[3]	NA	H	H	H	H
Boat house (above HWM with vegetation removal)[1]	NA	H	H	H	H
Waterline trenched	NA	H	H	L	H
Erosion protection hard-joint planted	NA	H	H	L	H
Erosion protection vertical wall or retaining wall[4]	NA	H	H	L	H
Invasive weed removal	H	H	H	L	H
Boat house (above HWM without vegetation removal)[1]	NA	H	L	L	H
Permanent rail launch system	NA	H	L	L	H
Removable rail launch system	NA	H	L	L	H
Dock[1]	NA	H	L	L	H
Erosion protection (soft-bioengineered)	NA	H	L	L	H
Elevated boardwalk below HWM	NA	H	L	L	H
Mooring buoy	NA	H	L	L	H
Maintenance dredging (previously approved)	NA	H	L	L	H
Boat lift - temporary	NA	H	L	L	H
Geothermal loops–open[5]	NA	H	L	L	L
Geothermal loops–closed	NA	H	L	L	L
Habitat restoration[6]	H	H	L	L	H
Public beach maintenance	NA	L	L	L	H
Waterline drilled	NA	L	L	L	L

[1] These Guidelines are to be used in the initial development planning stage and do not cover all legislative requirements. Docks and boathouses are an example of an activity that could require additional approval process through Transportation Canada or Ministry of Agriculture and Lands.

[2] Marinas or marina expansions in orange zones may not be acceptable depending on the key habitat area attributes – upland or aquatic.

[3] Fuel facilities are inherently high risk, and if approved will be subject to all other regulations.

[4] Retaining wall redevelopment should be designed to restore fish and wildlife values where feasible and practical.

[5] Geothermal loops open (water) versus closed (glycol) and associated risk must also be assessed and ranked for physical habitat and water quality aspects.

[6] Habitat restoration proposals are listed as high risk in red and orange zones because individual objectives and proposals must be reviewed.

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Key reference

A key reference used in developing this document was the 2008 BC Ministry of Environment document: *High value habitat maps and associated protocol for works along the foreshore of large lakes within the Okanagan* (MOE Region 8)

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- Fisheries and Oceans Canada
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- Regional District of East Kootenay
- District of Invermere

Project team

Many people reviewed and contributed to the creation of the Guidelines, including staff from federal and provincial agencies, and local governments. This project team included:

- Peter Holmes, BC Ministry of Environment
- Heather Leschied, Wildsight
- Bruce MacDonald, Fisheries and Oceans Canada
- Karen MacLeod, Regional District of East Kootenay
- Brian Wilkes, Brian Wilkes and Associates, Ltd.

9. *Wetland inventory and mapping assessment within the Okanagan Region of BC Ministry of Environment*

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Kristina has been working as an Ecosystems Biologist with the BC Ministry of Environment since 2007. Her work for the Ecosystems Section includes review of major development projects, effectiveness and compliance monitoring, species at risk stewardship outreach, conservation planning for parks and protected areas, leading regional implementation of the Conservation Framework, and wetland management and planning.

Summary

Wetlands are vital to many rare and endangered species and ecological communities in the Okanagan. Continued loss and degradation from urban development and agricultural expansion is occurring throughout the region and is of significant concern to land managers. It is thought that wetlands less that 1 ha in size are at the highest risk as their smaller size facilitates infill and current landscape mapping overlooks these less obvious features. In addition, small wetlands are documented as having a higher conservation value: vernal ponds host fewer predators and larger shallow edge areas support greater numbers of waterfowl and emergent vegetation.

The first step in wetland protection and management is to identify features on the landscape. The focus of this inventory project was to build on current wetland mapping and to identify mapping knowledge gaps. This was a broad inventory to flag wetlands and did not include detailed wetland classification. New, unmapped wetland features, specifically those within the habitat range of at-risk amphibians, were identified through an aerial-based GPS (global positioning system) inventory. An averaged point location, photograph, and basic attribute information, including type, ephemeral status, size, condition (below and above the high-water mark) and surrounding land use, was collected for approximately 600 wetland features. The study area was restricted to areas of high development pressure within the administrative boundaries of BC Ministry of Environment Region 8–Okanagan.

This new inventory information was used to quantitatively assess the number of features currently unmapped on provincial watershed base layers within the project study area. Recommendations were provided on mapping needs for the remainder of the region, scale required to capture the smaller high-risk wetlands, methodology improvements, and next steps.

Objectives

Quantify the number of wetland features currently unmapped within the given area. Identify new wetland features in areas of high development pressure.

Study area

The study area was restricted to low-elevation (approximately below 1,200 meters) or valley bottom areas within BC Ministry of Environment Region 8–Okanagan. This area was further reduced due to limited project resources. These areas were selected based on the following criteria: presence/absence of habitat mapping, range of target at-risk amphibians, development pressures, and regional distribution (refer to Figure 1). The total inventory area covered approximately 1,485 km^2. This is the estimated area surveyed for wetland features based on visual landmarks noted during navigation and track log recorded during inventory.

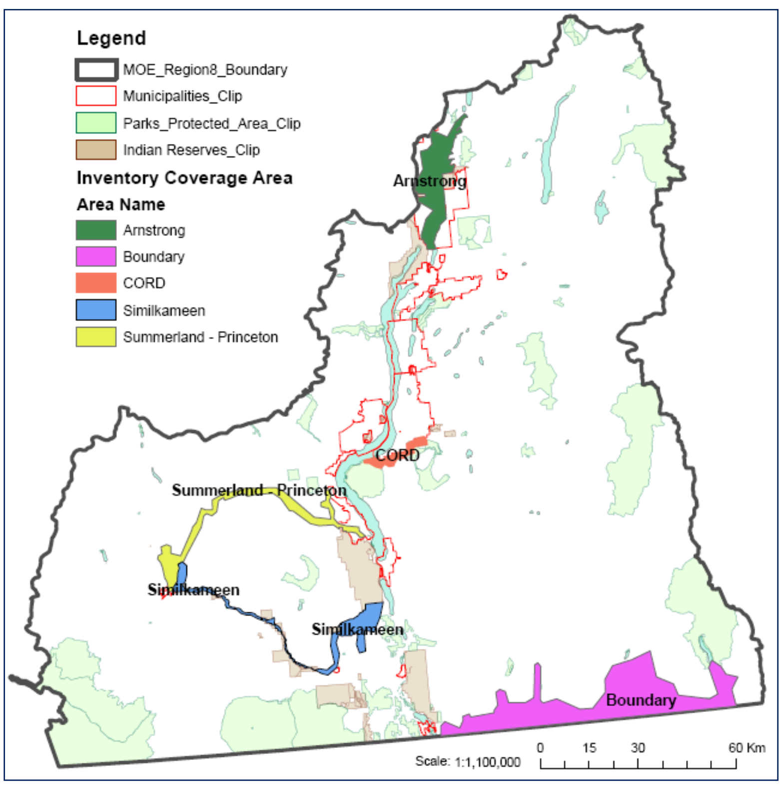

Figure 1. Study area.

Methodology

Project design

A Trimble GeoXM data logger was used to inventory wetland location and input feature attribute information into a data dictionary. All position fixes required at least four satellites. A minimum of 30 individual position fixes were collected for each wetland feature at 1 second intervals. A continuous track log was recorded at 5 second intervals. Position fixes were collected as Lat/Long in WGS (World Geodetic System) 1984 datum.

The data dictionary was modelled on catalogue information from previous wetland inventory projects. Feature codes were based on non-vegetated unit codes defined in Standard for Terrestrial Ecosystem Mapping (TEM) in BC. The 30 m buffer was selected from the urban target buffer distance recommended in *Develop with care: Environmental guidelines for urban and rural land development in BC* (refer to Table 1).

Table 1. Data dictionary

Position	Automatically generated from GPS	
Feature number	Automatically generated from GPS	
Feature (Based on TEM codes)	OW	Shallow open water (<2 m deep)
	AK	Alkaline, shallow open water (<2 m deep)
	LA	Lake (>5 ha)
	PD	Pond (<5 ha, >2 m deep)
	RE	Reservoir (including sewage lagoons and dugouts)
	GC	Golf course pond
Inventory status	New/Existing/Unknown—completed during GIS analysis	
Permanent	Yes/No/Unknown—(Does it contain water year round?)	
Size	Dugout	<.25 ha
	Small	<1 ha
	Medium	1–5 ha
	Large	>5 ha
Condition (below high-water mark)	Unmodified/modified/infill (Infill is considered modified)	
Condition comments	Description of modification (i.e., retaining wall, dock, garbage) Percentage of infill and type of material	
Buffer % natural (within 30 m)	0% = all modified, 100% = all natural	
Buffer comments	Description of buffer modification (i.e., dirt road, house, soil disturbance)	
Land use (dominant)	Agriculture (includes rangeland), natural, rural residential, urban residential, industrial, recreation, resource (active mining, forestry, etc.)	
Date visited	Automatically generated from GPS	
Surveyors	Daily participants	
Photograph	Picture file number	
Comments	General comments of relevance	

Inventory
The inventory was conducted aerially from a Bell JetRanger helicopter based out of Penticton (Canadian Helicopters). Flight routes were planned to minimize ferrying time and maximize coverage within each inventory area and with consideration for fuel sources. The pilot was responsible for navigation per the discussed flight route. Continuous adjustment was required due to varying incidence of wetland features in each area.

A range of optimal fight speed, elevation, and visual spectrum were established based on literature review, Resource Information Standards Committee standards, canvassing staff experience, and a flight test. Ultimately flight details varied considerably between and within each inventory area primarily due to changes in topography and canopy cover. Flight altitude averaged from 300 to 450 m above ground level. Cruising speed averaged from 40 to 80 knots. Visual spectrum ranged from 500 m to 2,000 m.

The optimal crew setup was selected based on consideration for helicopter manoeuvrability, safety, fuel consumption, and trial. The pilot and recorder were seated in the front of the helicopter and the photographer located behind the pilot. The recorder was responsible for working the Trimble GPS unit. All participants were responsible for spotting. The pilot approached each wetland feature at an angle maximizing the opportunity for a photograph prior to positioning the helicopter above the feature to collect position data. If the wetland was spotted from the opposite side, this procedure was reversed. Once the photograph was taken, the photographer called out the image reference number to the recorder. Attribute information was mostly observed by the recorder; however, when the wetland feature was in a “blind spot” information was called out by the photographer.

Error analysis
Two wetland features were inventoried on the ground to provide a measure of the GPS accuracy. The ground-based position data was determined to be accurate when compared to 2007 ortho imagery. However, aerial-based position data was largely skewed from ortho imagery. Points were located anywhere from 0–400 m away from the ortho image location of the wetland feature inventoried. This skew likely resulted from human error and vertical shift. Feature positions were matched to ortho imagery using inventory photographs. (Feature images are not available for 35 points [F412–F446] in the Central Okanagan Regional District inventory area, resulting in a higher proportion of features with an “unknown” inventory status for this area.)

GIS analysis
The inventory data was exported to shape files in Pathfinder software and imported into ArcMap for editing. Position location was corrected to overlay the feature point with the corresponding wetland, and estimated size information in the attribute table was confirmed or corrected.

The wetland inventory shape file was compared to the Corporate Watershed Base (linear boundaries, stream network, lakes, wetlands, and man-made water bodies layers) to complete the "inventory status" attribution information. Features not included in the Corporate Watershed Base were designated as "new;" features included in the Corporate Watershed Base were designated "existing;" and features that could not be located on the ortho imagery were designated "unknown."

Results

A total of 592 distinct wetland features were inventoried, of which 382 (65%) were new features and 143 (24%) were existing (mapped on the Corporate Watershed Base). The inventory status of the remaining 67 (11%) mapped features was unknown as they could not be referenced to a feature on the ortho imagery. The distribution of new versus existing features was relatively proportional across each inventory area. Over the approximated inventory area of 1,485 km^2, wetland distribution was averaged at one feature per 2.5 km^2.

Over two-thirds of the wetland features mapped were less than 0.25 ha in size, called "dugouts." (refer to Figure 2). Correspondingly over two-thirds of the wetland features were only visible on 2007 ortho imagery at a scale of 1:5,000.

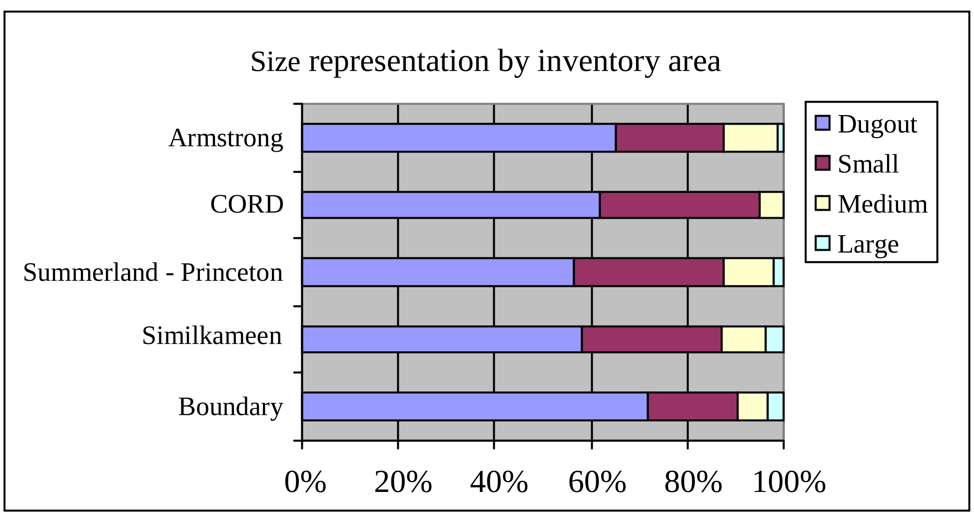

Figure 2. Size representation by inventory area.

Feature types were much more varied across the study area. Alkaline ponds were found exclusively in the Boundary, Similkameen, and Summerland–Princeton inventory areas, aside from one feature mapped in the Armstrong area. Shallow open water was mapped most frequently in each inventory area; however, this type of feature was especially dominant in the Armstrong and CORD areas (refer to Table 2).

Table 2. Feature counts by inventory area.

Feature	Number of wetland features					
	Armstrong	Boundary	CORD	Similkameen	Summerland–Princeton	TOTAL
Alkaline pond	1	13	0	7	10	31
Pond	27	67	7	32	36	169
Lake	0	1	1	1	0	3
Shallow open water	103	100	73	37	57	370
Reservoir	12	0	0	1	3	16
Golf course pond	1	1	0	1	0	3
TOTAL	**144**	**182**	**81**	**79**	**106**	

Modifications below the high-water mark occurred in just under 20% of the features mapped. They were noted across all feature types. Modifications included beaches, roads, docks, unrestricted livestock, garbage, fences, intakes, rock work, mud bogging, infill, and reshaping.

Buffer condition was heavily impacted. Wetland features with natural buffers (no disturbance within 30 m = 100%) were only observed for 33%. The remaining 67% of features were noted with varying degrees of disturbance within the first 30 m, including: roads (paved and dirt), hay fields, residential homes, farm buildings, pump houses, soil disturbance, garbage, residential landscaping, derelict cars, fences, and trails. Overall, the most common buffer modification was roads.

Follow-up

Mapping

- Verify inventory status of "unknown" wetland point features through ground-based field checks
- Convert wetland point features to polygons
- Incorporate "new" wetland features into the Corporate Watershed Base and/or community mapping network (after points have been converted to polygons)
- Pursue funding to complete inventory of remaining low-elevation areas in BC Ministry of Environment Region 8–Okanagan

Figure 3. Exclusion fencing helps to buffer nearby use.

Planning

- Develop a regional wetland strategy that identifies high-risk wetlands for management
- Encourage local governments to protect wetland buffer areas through development permit areas or other legislative tools
- Complete amphibian inventory on "new" wetland features with highest habitat potential

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10. Chytridiomycosis in British Columbia's wetlands: How it has impacted the endangered northern leopard frog and what all wetland researchers need to be aware of

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Barb began working with the Fish and Wildlife Compensation Program on the Northern Leopard Frog captive rearing project in 2005 as a summer student, while completing her B.Sc. at the University of Victoria. In 2007 she graduated with a major in biology and a minor in environmental studies, and in 2008 began working for the Fish and Wildlife Compensation Program full-time as a project biologist in charge of the northern leopard frog recovery project. Her work experience with wetlands has involved amphibian population and disease monitoring, amphibian habitat assessments, and wetland assessments. She is also a member of the BC Northern Leopard Frog Recovery Team.

Chytridiomycosis

Chytridiomycosis is a fungal infection of the skin and was first described in 1998. It has been linked to massive declines in amphibians of North America, South America, Central America, Europe, and Australia (Daszak et al. 2003). Most of the die-offs related to Chytridiomycosis have occurred in amphibians that breed in permanent water bodies, reflecting the aquatic nature of the disease (Lips et al. 2006).

The disease is caused by the pathogenic fungus *Batrachochytrium dendrobatidis* (*Bd*). It is not native to North America and is thought to have originated in Africa and spread worldwide through the trade of African clawed frogs (*Xenopus laevis*). Studies of museum specimens have determined that that the earliest case of chytridiomycosis in Africa dates back to 1938 (Weldon et al. 2004).

Bd thrives in cool, moist environments and grows best between air temperatures of 17° and 25° C (Piotrowski et al. 2004). It has two life stages, a sessile reproductive zoosporangium and a motile uniflagellated zoospore. The zoospore is active for a limited time period, has limited swimming ability, and appears to depend on water flow or host movement for long-distance dispersal (Garner et al. 2006). It is also capable of chemotaxis, which enables it to key in and move toward a variety of molecules present on an amphibian's skin, such as sugar, proteins, and amino acids (Moss et al. 2008). The waterborne zoospores of this fungus specifically attack keratinized tissues including the skin of post-metamorphic individuals and the mouthparts of tadpoles. The zoospores burrow into the host's keratinized tissue and within days matures into zoosporangia. Each zoosporangium produces up to 300 zoospores, which either re-infect the host or are released into the environment.

In post-metamorphic individuals, chytridiomycosis causes irregular cell loss, redness, lethargy, hyperkeratosis, and excessive skin sloughing. It is thought that this impairs cutaneous respiration and osmoregulation, which causes death. An alternative hypothesis suggests that the fungus may release toxic products, which cause death (Berger et al. 1998).

The fungus has been detected in the mouthparts of living tadpoles of some species, without causing death. It is believed that tadpoles of some species may act as a reservoir for the pathogen.

To date, no resting structures have been found (asexual or sexual), however *Bd* may live saprophytically in nature (Longcore et al. 1999). In Australia, it has been found that amphibians that breed in ephemeral water bodies (e.g., bromeliads) or terrestrial environments are not infected with *Bd*, and it seems that there is variation among and within species regarding susceptibility to the disease (Kriger and Hero 2007).

In British Columbia the disease was first discovered in 1998, at the same time that dead and dying Northern Leopard Frogs (*Rana pipiens*) were being observed by researchers in the Creston Valley Wildlife Management Area (Adama and Beaucher 2006). As a result of these observations, a tissue sampling program was initiated as part of an ongoing monitoring program led by the Fish and Wildlife Compensation Program.

How chytridiomycosis has affected British Columbia's endangered Northern Leopard Frog

In order to determine the prevalence of chytridiomycosis in the endangered southern mountain population of Northern Leopard Frogs, a tissue sampling program was incorporated into the ongoing monitoring program led by the Fish and Wildlife Compensation Program. A variety of sampling methods were employed to gather tissue to test for chytridiomycosis between 2003 and 2007, including ventral swabs, toe clips, and ethanol bag rinses. These samples were analyzed for the presence of *Bd* DNA using quantitative polymerase chain reaction techniques (qPCR) at the Animal Health Centre of the BC Ministry of Agriculture and Lands under the direction of Dr. John Robinson. A paper entitled *Prevalence of the pathogenic chytrid fungus,* Batrachochytrium dendrobatidis*, in an endangered population of Northern Leopard Frogs (Rana pipiens),* which is currently under review, summarizes the results (Voordouw et al., in review).

The results of this study indicate that prevalence of chytridiomycosis changes seasonally, with higher prevalence of the disease in spring and fall, when temperatures are cooler and animals tend to congregate. It was also found that prevalence varies between developmental stages, and that the rate of infection increased considerably as individuals got older. Interestingly, the data shows that Northern Leopard Frogs from the BC population rarely make it to their third spring, which appears to be a limiting factor as they usually don't reach sexual maturity until 2 years of age. At the population level it was found that the prevalence of *Bd* initially increased between 2003 and 2005 and then remained constant, but at a higher level for the duration of the study. Other interesting details arose from this study, including evidence suggesting that leopard frogs may have the ability to recover from the disease, and evidence that suggests that different tissue sampling methods may produce varying results (Voordouw et al., in review).

While the results of this study indicate that chytrid may be suppressing the BC population of *Rana pipiens*, it should be noted that there are many other factors that have likely contributed to the decline, including habitat loss and fragmentation, pollution, introduced predators, increased UV radiation and climate change. While researchers are working on finding solutions to deal with the disease, it is currently impossible to eradicate *Bd* from the environment, which makes recovery difficult. This is why it is especially important that all wetland researchers follow disinfection protocols to prevent the unnecessary spread of this disease.

What all wetland researchers should be aware of

In 2008, the Ecosystems Branch of the BC Ministry of Environment carried out a province-wide *Bd* surveillance program and results indicate that the fungus now occurs in most parts of the province in a variety of amphibian species. As researchers, we have a responsibility to avoid the unnecessary spread of disease, and therefore, anyone working in wetlands should take the necessary precautions to avoid contamination and the spread of the *Bd* fungus by following protocols developed by the Ecosystems Branch of the BC Ministry of Environment. The protocols outline various measures to be taken to ensure that researchers do not act as vectors for transmission of diseases such as chytridiomycosis and *Ranavirus* to new sites and naïve species.

The protocols address two levels of disease transmission: 1) the risk of disease transmission between sites; and 2) the risk of disease transmission among individuals within a site (Govindarajulu 2008).

In order to prevent disease transmission between sites it has been found that a bleach solution with 0.2% sodium hypochlorite and an exposure time of 15 minutes to disinfect all gear is effective against *Bd* (Johnson et al. 2003). Prior to soaking, a hand brush should be used to remove mud, algae, plants, snails, and other invertebrates from equipment. After soaking, the bleach solution should be rinsed off with clean water or the items allowed to fully dry so that the bleach evaporates completely from the equipment, as even a minor amount of residual bleach can be harmful to amphibians. When finished the bleach solution should be disposed of properly, away from any waterbodies. When possible, vehicles should also be rinsed down between sites. It should be noted that there are a variety of chemical disinfectants that can be used, however, household bleach works well to kill *Bd* as well as *Ranavirus* and it is readily available. For a list of other disinfectants see the provincial protocol.

To reduce the risk of disease transmission among individuals within a site, researchers must handle amphibians safely to ensure that they do not increase the risk of an animal being exposed to a pathogen. It is recommended that researchers ensure their hands are clean and free of residual chemicals such as sunscreen and insecticides. When handling amphibians a fresh pair of disposable gloves must be used for each different amphibian (vinyl or nitrile gloves are preferred as latex can be toxic to embryos and tadpoles).

Captured animals should be stored in single-use, disinfected containers or disposable plastic bags, and processing time should be kept to a minimum as this is stressful to the individual. Instruments that come into contact with the animal must be sterilized between animals, and gloves and storage bags properly disposed of to prevent cross-contamination.

If in doubt, use the precautionary principle.


Redness
Photo courtesy of Doug Adama


Abnormal body positioning
Photo courtesy of Marc-André Beaucher


Sloughing skin
Photo courtesy of Barb Houston


Vascularization and haemorrhaging
Photo courtesy of Doug Adama

Figure 1. Symptoms of chytridiomycosis.

Interim hygiene protocols for amphibian field staff and researchers (2008)

This PDF document is accessible through the Wildlife Health section of the BC Ministry of Environment's web page, at:

http://www.env.gov.bc.ca/wld/documents/wldhealth/BC%20Protocol%20-%20Amphibian%20field%20researchers%202008.pdf

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11. West Kootenay Amphibian Study

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The objectives of this base-level amphibian assessment were to determine the West Kootenay distribution all local amphibian species, provide a benchmark for future population monitoring, and to survey for the chytrid fungus. Surveys were conducted within the Interior Cedar–Hemlock Biogeoclimatic Ecosystem Classification zone in the Arrow–Boundary and Kootenay Lake Forest Districts, in southeastern British Columbia. Field protocols were a combination of methods used in the 1995 and 2005 East Kootenay Amphibian Surveys, provincial inventory standards, and the draft provincial Western Toad Monitoring Plan which is currently being developed. Visual encounter and dipnet surveys were conducted at 40 wetland sample sites from July 7 to August 1, 2008.

Amphibians were found at 90.0% of the wetlands sampled and breeding was confirmed at 77.5% of the sites. The Columbia Spotted Frog (*Rana luteiventris*) was found at most sites (72.5%) followed by the Pacific Chorus Frog (*Pseudacris regilla*) (42.5% of sites), Long-toed Salamander (*Ambystoma macrodactylum*) (40.0% sites), Western Toad (27.5% of sites), and Northern Leopard Frog (*Rana pipiens*) (2.5% of sites). Breeding-site encounter rate for the Western Toad was quite high (22.5%), suggesting that our region may be an important breeding region for the species.

Amphibian species richness was also relatively high. Eleven sites (27.5%) had one species present, 15 sites (37.5%) had two species, 7 sites (17.5%) had three species, and 3 sites (7.5%) had four species present. Amphibian species richness was greater at sites where fish were not observed.

Most (72.5%) of the sampled wetlands were small (<10 ha) and were classified as marshes according to the new provincial wetland classification standard. Forty-six chytrid samples were taken at 22 sites and samples from three sites tested positive.

Figure 1. Western Toad. Photo by Jakob Dulisse. http://www.jakobdulisse.com

Government agencies, conservation organizations, and consultants throughout British Columbia are initiating amphibian monitoring plans. Because of this, there is a great need for the roles and responsibilities of all groups with regard to leadership, co-ordination, communication, funding, data ownership, and standardization to be discussed and clarified. The completion of this base-level amphibian assessment is a first step toward mid-level amphibian monitoring, and we recommend continuing and expanding base-level amphibian monitoring throughout the Kootenays. If long-term monitoring reveals that regional amphibian species are in decline, more detailed, apex-level monitoring efforts may help determine the causes.

12. Forest harvesting and the management of small wetlands and amphibian populations

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Elke Wind has studied amphibians for the past 15 years. Her main focus and interest includes habitat management issues in relation to forest harvesting and development projects. She has been a self-employed, contract biologist since 2000. Some of her contracts have included co-authoring the *Best management practices for amphibians and reptiles in rural and urban areas* for the BC Ministry of Environment, and *Habitat management guidelines for amphibians and reptiles in the Northwestern United States and Western Canada* for Partners in Amphibian and Reptile Conservation. In the past year, her work has expanded to constructing small wetlands for amphibian populations.

Introduction

Studies have shown that forest harvesting can reduce the abundance of amphibians in terrestrial environments (e.g., deMaynadier and Hunter 1995), but few studies have investigated impacts on lentic habitats. Most temperate amphibian species live in forests and breed in standing water, often laying their eggs in small, seasonal wetlands that offer some protection from predation. However, in British Columbia small wetlands (less than 0.5 ha) are not afforded protection under the *Forest and Range Practices Act* and the effects of forest harvesting on these habitats and the importance of riparian buffers are unknown.

Three observations made at the onset of this study guided future work:

- During initial inventory work, small wetlands were often encountered on the ground that did not appear on forestry maps.
- Amphibians were observed breeding in small wetlands in cutover areas in what seemed to be a higher proportion than ponds in forested areas.

- The choice of small wetlands to receive retention of trees under a variable retention harvesting system did not always correspond with where breeding amphibians were observed.

The main objective of our work has been to identify and mitigate forest practices that affect aquatic-breeding amphibians and their small wetland habitats.

Figure 1. Waterline in May (left), waterline in June (right). Photos by Elke Wind.

Methods

In 2002, we began a study to investigate the impact of small wetland management practices on amphibian populations in a forestry context. The observations made early-on led to the development and implementation of a three part study:

1. An assessment of small wetland mapping capabilities and practices (2002)
2. A pre- and post-harvest study of small wetlands (2004, ongoing)
3. The development of a small wetland field card to identify priority sites for riparian protection under variable retention harvesting systems (2006–2007)

Small wetland mapping capabilities and practices

Using Geographic Information Systems (GIS), all small wetlands less than 1 ha in size were given a unique identifier and mapped on, what were then, Weyerhaeuser's forest lands on north and south Vancouver Island. Wetlands were randomly selected for ground-truthing based on criteria for stand age (i.e., previously unharvested stands) and access (within 300 m of a road). Transects were plotted through the forest stand in such a way that they intersected mapped wetlands. The location of all wetlands encountered was recorded (i.e., mapped and unmapped), an amphibian survey was conducted, and the wetland habitat was described.

Pre- and post-harvest study of small wetlands
Three previously unharvested forest stands containing over 70 small wetlands were identified in the Nanaimo Lakes area of Vancouver Island that were slated for harvest within the next year. Before and after harvesting, each small wetland was visually surveyed every two weeks from May through early September (or until pond drying) for amphibians, focusing primarily on confirming breeding. During the survey, water depth and temperature were recorded. The wetland and riparian habitat were also described (e.g., canopy cover, percent open water, percent vegetative cover, and riparian tree retention). This is a long-term monitoring study.

Small wetland field card
Based on the wetlands surveyed during the mapping exercise and data collected from the 70+ wetlands at the long-term monitoring sites, a field card was designed to help foresters categorize low-, medium-, and high-priority small wetlands for riparian retention for blocks where variable retention harvesting methods were being used. The card had to be designed with the user's time, abilities, and equipment in mind (e.g., observing the wetland from the shoreline only, minimal knowledge of wetland plant species or wetland classification). The field card was tested before a final version was completed.

Results and discussion

Small wetland mapping capabilities and practices (2002)
Using 1:5,000 base maps and GIS, 6,407 wetlands covering 663 ha were found in the South Island Division, and 2,160 covering 314 ha were found in the North. Close to 240 wetlands were surveyed over 55 km of ground-truthing, of which approximately 72% (n = 171) were unmapped. As might be expected, the size of the wetland, as well as hydroperiod, may affect the ability to map small wetlands—unmapped wetlands tended to be smaller and drier than those that were mapped. A re-evaluation of digital imagery of a sub-sample of 76 unmapped wetlands found that 16% may be detectable through re-evaluation, or they were inaccurately mapped originally. The analyses also suggested that small wetlands may be encompassed in other habitat features mapped for forestry purposes (e.g., canopy openings, indefinite drainages, and scrub habitat). The management of small wetlands requires the support and efforts of forestry personnel at all levels to ensure that they are mapped and factored into block layout and design. Crews working on the ground need guidance to ensure that the identification, mapping, and protection of small wetlands are a priority.

Pre- and post-harvest study of small wetlands

Two and three years after harvesting, four amphibian species have continued breeding at small wetlands at the three long-term monitoring sites. Some species, such as anurans, used wetlands more often for breeding post-harvest than during pre-harvest year(s). Wetlands with no canopy cover appeared to have a greater influx of breeding post-harvest than wetlands with riparian tree retention. These trends reflect the preferences many anurans have for low to medium canopy cover ponds for breeding, which tend to be more productive than those with high forest cover (Kupferberg et al. 1994; Skelly et al. 1999; Werner and Glennemeier 1999; Halverson et al. 2003; Lauck et al. 2005). Reduced hydroperiod has not been a threat to amphibian breeding success at the three sites to date, as wetlands have retained water longer post-harvest than in pre-harvest year(s) as a result of deeper water and slower drying rates. In-pond conditions have been suitable for reproductive success, as metamorphosis was observed each year at the majority of wetlands where breeding was confirmed.

These are initial results and continued monitoring is required to determine whether conditions will remain suitable for breeding once green-up occurs and the forest canopy recovers. As well, the study needs to be expanded to assess survival rates and effects of forest harvesting on small wetlands under varying conditions. For example, larva may experience high survival rates due to suitable in-pond conditions, whereas newly metamorphosed young that emerge into recent cut blocks in midsummer may have high mortality rates. As well, small, isolated wetlands, in different biogeoclimatic zones and variants and those at higher elevations may respond differently to forest harvesting.

Small wetland field card

Habitat analyses indicated that wetland size, canopy cover, and in-pond vegetation were important factors influencing pond use by breeding amphibians. These habitat features were factored into a decision tree on the field card, which was field tested by Elke Wind and volunteer foresters and technicians in 2007 to ensure that it was user-friendly and effective before a final version was produced. Field testing consisted of a comparison of results from amphibian breeding surveys conducted by Elke Wind to those from assessments made by foresters using the field card only. Approximately 50% of wetlands with confirmed breeding had similar ratings between the amphibian surveys and the field card assessments. However, over 70% of wetlands matched or had an upward versus downward ranking between the two assessment methods, and 71% of Red-legged Frog (a species at risk) wetlands matched field card assessments and were ranked as having a high probability of breeding (i.e., should receive retention). Based on the assessment results and recommendations made by the volunteer foresters via a field card evaluation form, a new, final version of the field card was produced, extensively promoted, and distributed to foresters on the south coast in 2008. The development and use of a small wetland field card helps prioritize where retention should be allocated based on biological information versus an emphasis on wetland size or objectives for fish, which may be counterproductive for amphibian populations.

The field card has four pages, with the following content:

1. How to use card and do assessment
2. Dichotomous decision tree (Figure 2)
3. Recommended management guidelines re: wetlands ranked as having a low, medium, or high probability of breeding
4. Common management practices

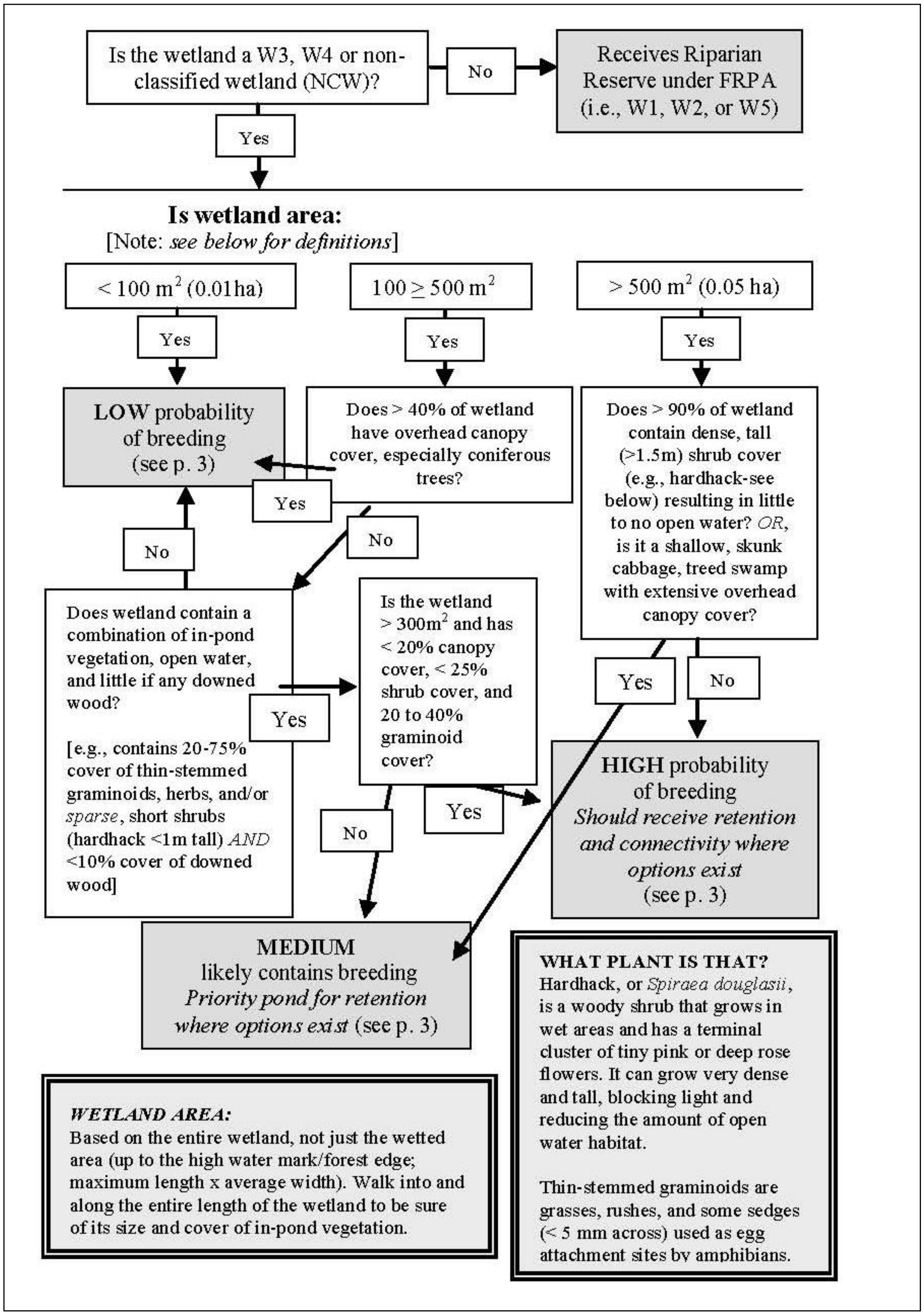

Figure 2. Dichotomous key (page 3) of the Small Wetland and Amphibian Assessment Field Card.

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13. Don Quixote challenges biodiversity—and meets wetlands

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Dr. Fred Bunnell is Professor Emeritus and founding Director of the Centre for Applied Conservation Biology at the University of British Columbia. His research and teaching career span 40 years, over 300 publications, about 100 graduate students, 8 books, and several awards for research. This, he claims, is driven by wanting to be a good ancestor (but he is also insatiably curious). His work on wetlands is an outgrowth of his work on climate change—many of British Columbia's wetlands are extremely vulnerable to climate change.

Introduction

An evening talk, particularly one sprinkled with levity, loses something in translation to text. The proposed contribution, which inspired the invitation to address the banquet, is presented as a poster by Wells et al. (this publication). Little of that is repeated here. This written contribution is a brief summary of some of the major points of the evening presentation.

Some context

The BC Freshwater Atlas indicates there are 378,426 wetlands in British Columbia (Gray 2009). The atlas is a powerful tool, but may underestimate the number of small wetlands, particularly in the northeast where TRIM (Terrain Resource Information Management) mapping appears incomplete. Many wetlands are small. In the Central Interior Ecoprovince, where we piloted our vulnerability model, we tallied 131,866 wetlands plus small lakes. A substantial majority (70.7%) of wetlands were found in the smallest size class (0 to 1 ha), though this accounts for only 22.9% of wetland area in the study area (Bunnell and Wells 2009). The large proportion of small wetlands is a warning—it is these smaller wetlands that often are more productive and also most vulnerable.

Across their range of sizes, wetlands provide well-used recreational opportunities and contribute disproportionately to sustaining biodiversity and other ecosystem services.

The Millennium Ecosystem Assessment (2005) defines ecosystem services as “the benefits people obtain from ecosystems.” The range of ecosystem services that wetlands deliver is wide, including fish and fibre, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities, and, increasingly, tourism. Water, fish, and recreational opportunities are well-known services. Less commonly understood ones are as important. Three merit mention:

Water purification and detoxification of wastes
Wetlands, particularly marshes, play a major role in detoxifying a variety of waste products, including trapping heavy metals. Some wetlands have been found to reduce the concentration of nitrate from fertilizers by more than 80%.

Climate regulation
An important role of wetlands is their contribution to the regulation of global climate change through sequestering and releasing a major proportion of fixed carbon in the biosphere. For example, although covering only about 3–4% of the world’s land area, peatlands are estimated to hold 540 gigatons of carbon, or about 1.5% of the total estimated global carbon storage and about 25–30% of that contained in terrestrial vegetation and soils.

Physical buffering of climate change
Climate change is already contributing to a rise in sea levels and storm surges. These increase the erosion of shores and habitat, increase the salinity of estuaries and freshwater aquifers, alter tidal ranges in rivers and bays, change sediment and nutrient transport, and increase coastal flooding. Wetlands act as a sponge, absorbing water from floods originating inland as well as at sea. Intact wetlands could play a critical role in the physical buffering of climate change impacts.

Basically, wetlands are a significant buffer in natural systems, absorbing water quickly and releasing it slower and cleaner.

Wetlands also are a major habitat. For example, we consider 292 bird species to breed regularly in the province; 24 of these are strictly marine, restricted to coastal areas. Breeding habitat of the remaining 268 are distributed this way: alpine and subalpine–11 species; grasslands and shrublands–36 species; forests–104 species; and wetlands and lakes–117 species. The pattern does not differ greatly for other groups of organisms, and in some instances a greater portion are limited to wetlands. For example, there are about 90 species of damselflies and dragonflies in the province—all of them restricted to wetlands.

The climate of British Columbia already has changed, and undoubtedly will keep changing for decades yet. Worse, in some areas of the province that rate will increase. Species in the province already are responding. We see this most clearly in birds, which are the most mobile and for which we have excellent historical data (e.g., Bunnell et al. 2009). Migratory species are arriving earlier and staying later, more species are overwintering, ranges and relative densities have shifted, species that did not do so formerly are now raising more than one brood. All of these changes have significant management implications (Bunnell et al. 2009). It is not just birds that are moving. *Cryptococcus gatti*, the fungus on Vancouver Island that has caused nine human fatalities, is supposed to be tropical. Apparently it arrived here years ago, lurking quietly, until it became warm enough to become actively lethal. Impacts of climate change on wetlands will be equally lethal to many species.

Vulnerability of wetlands

Wetlands are particularly vulnerable. As the climate warms, more of their water evaporates. As precipitation (either rain or snow) decreases, they receive less water to yield to evaporation. The smaller, shallower wetlands are the most vulnerable, and they often are the most productive. Predicting which wetlands are the most vulnerable is not straightforward, because both the inputs and outputs of water are important. Moreover, in many instances, and especially where drying is pronounced, we will attempt to intercept more of the water now entering wetlands for our own uses. The fate of our productive estuaries is equally threatened, but by rising sea water.

Wells et al. (this publication) describe the approach we have taken to estimate the vulnerability of wetlands by projecting the impacts of climate change on evaporation and water input. It is clear that the vulnerabilities to drying differ regionally as well as with size and depth of the wetland (Figure 1). The projection of future distribution of wetland types uses a different approach than that employed to project vulnerability of wetlands more generally. For projection of wetland types, we first extract the climate/moisture envelope that represents the distribution of that type in the 1960s. Climate is then projected using ECHAM5, the 5^{th} generation of the ECHAM general circulation model developed at the Max Planck Institute for Meteorology. The simplistic assumption is that projected climate reveals the likelihood of that type occurring in any given area. We are confident in the direction predicted by the drying index, but not the rate. Our next step is to attempt calibration of the rate.

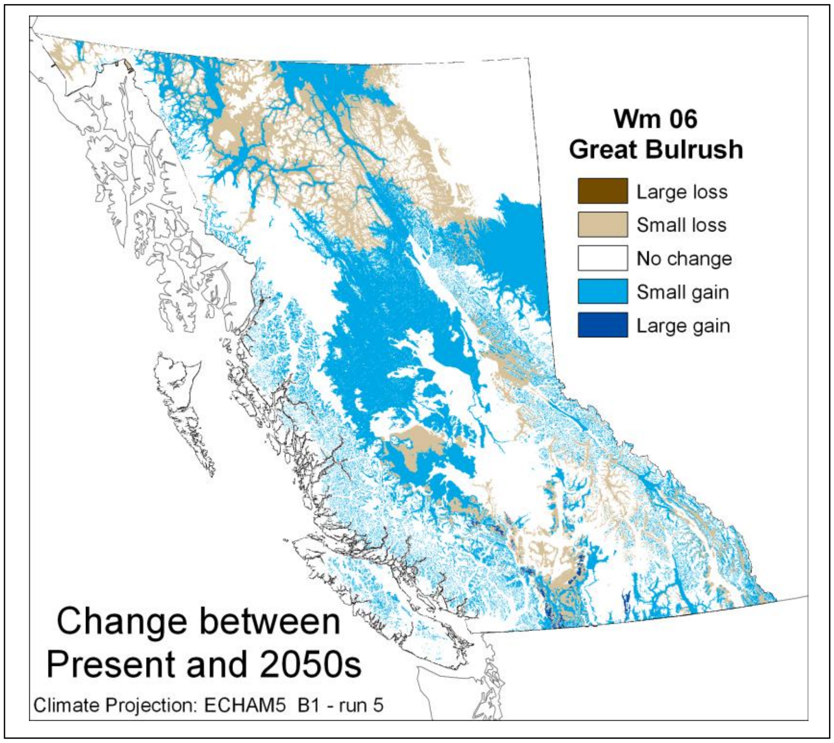

Figure 1. Current and projected distribution of the great bulrush marsh type in British Columbia.

Figure 1 represents one of the more optimistic projections and shows gains as well as losses; for some wetland types there is no opportunity for gain. Note also that the topography must permit any gain predicted by changing temperature and precipitation. Whatever the true realized rate of climate change, it is clear that using either form of projection (Wells et al., this publication; or that described here) we have few or no options of retaining all current wetlands in the face of climate change.

Adaptation

Given the certain demise of some wetlands and diminution of others, adaptation is necessary to retain as many of the values and services offered by wetlands as possible. We have no common terminology of what we mean by adaptation. In her review, Brooke (2008) concluded that most studies on climate change and conservation, if they consider adaptation at all, consider it the equivalent of species' ability to adapt naturally to climate change. That suggests we should just stand aside and watch; after all there has not been a show of this magnitude for eons. We can actually watch natural selection during our lifetimes. You cannot blame individuals who consider adaptation in this way; that is how adaptation is defined in Article 2 of the *United Nations Framework Convention on Climate Change.*

However, if we want to lessen the consequences of climate change, we must think about adaptation differently. The terminology used by the Intergovernmental Panel on Climate Change (IPCC) should ultimately win out. There are at least four important concepts; I have used the IPCC definitions for adaptation and mitigation.

Impacts

This is the most easily understood concept and what scientists are best at describing. Impacts include the shifts in arrival and departure dates, overwintering, and range expansions of birds that are occurring right now.

Vulnerability

Vulnerability is more difficult to assess because it involves a future we have yet to experience. Basically, it is an attempt to determine where a social-ecological system is most exposed, most sensitive, or least capable of adapting to the impacts of climate change. Ideally, it includes identifying barriers to adaptation.

Adaptation

Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Adaptation can assume a variety of forms—anticipatory and reactive, private and public, and autonomous and planned. Examples include raising dikes and encouraging plants more resistant to temperature.

Mitigation

Technological changes and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic, and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce greenhouse gas emissions and enhance sinks.

IPCC separates adaptation and mitigation. The separation ignores the common place definition of adaptation that indicates any serious attempt at mitigation also will require serious adapting. I believe that in our lives adaptation and mitigation are compellingly necessary and completely entwined.

A brief reflection on either adaptation or mitigation reveals that they represent a wicked problem. This is not wicked in a moral sense, but a class of problems that has certain attributes. Wicked problems have been defined as a "class of social systems problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Buchanan 1992).

Their features include:

- They can be described in different ways that have different solutions—there is no one way to formulate the problem.
- The problem is unique (for any given location).
- There is always more than one plausible explanation for outcomes.
- There is no single right or true test for a solution.
- The solutions cannot be true or false, although they can be more or less effective (see Rittel 1972; Rittel and Webber 1973, 1984).

Addressing the wicked problem of adaptation

Following are a few points intended to help us address the wicked problem of adaption.

Minimally the present

We have spent a great deal of time and effort collecting data from systems that will soon no longer exist as they did when measured. We cannot be good stewards if we plan and manage for a world that no longer exists. We must minimally be focused on the present, and ideally on the future.

The Cook County Rule

In *Blink*, Gadwell (2007) illustrates the phenomenon of rapid cognition with many examples, one from the emergency room of Cook County Hospital in Chicago, which was subject to long waits for appropriate diagnosis of suspected heart attacks. A new Chairman appreciated the hospital could not continue that route and reduced the approach to an ECG and three questions. The doctors of course opposed this; it reduced the significance of their expertise and expensive machines. But correct diagnosis increased by 70%—a huge benefit. The point is that with sufficient experience we do not need much data to arrive at the right conclusion. We clearly do not need any more data to tell us we have a major problem with climate change. If we need science at all, it is to help with solution.

Adaption couples natural and human systems

We will not implement mitigation and begin adaptation until we learn how to couple these two systems. So far, our track record is dismal.

Discursive methods help, but are limited

By discursive, I do mean passing from one thing to another; ranging over a wide field; roving. It has to be discursive, because the public has multi-faceted, often embedded views, and the public are a necessary part of the process. Adaptation means that the public is going somewhere they have never been before—they need to talk about that.

Alternative scenarios help
The discursive approach can create scenarios that are plausible, challenging, and relevant stories about how the future might unfold. Scenarios can effectively capture multi-faceted viewpoints. The science is uncertain and complex, but you are allowed to use data.

Some non-government organizations (NGOs) are well-positioned
Adaptation is too big a collection of things to leave solely to scientists, practitioners, policy makers, government, or the public. There has to be some forum that bridges scales and mediates relationships. It may well be that it is only an outward looking NGO that can do that.

Adaptive management works
When you have to learn by doing, and we do, there is no better approach than adaptive management. Among the features of wicked problems, there is one that saves us—we can tell what is better or worse. In other wicked problems (e.g., managing to sustain biodiversity; Bunnell and Dunsworth 2009), adaptive management has not delivered *the* correct solution (there isn't one), but has provided the rumble strips to keep us moving towards better. It also is the best way I know of providing a sense of being productive and getting the "fun" back into dysfunctional.

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14.Restoring wetlands: Rebuilding processes and patterns

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Restoration of wetland ecosystems can be complex, because often hydrologic as well as substrate changes can have profound effects on the ecological processes that sustain wetlands. Aldo Leopold noted that "To keep every cog and wheel is the first precaution of intelligent tinkering." If we understand the parts and processes and how they fit together we have a good chance of being able to rebuild them into a functioning ecosystem. Wetland succession provides us with a blueprint for how various types of wetlands come together naturally and, thus, how we can restore wetlands. Species such as bulrushes (*Schoenoplectus spp*.), spike-rushes (*Eleocharis spp*.), and in some cases cattails (*Typha spp*.) and pond lilies (*Nuphar spp*.) can serve as pioneers in aquatic systems and can be used to start the restoration processes. These species tend to damp waves and thus still the water allowing sediments to settle out. Over time these sediments combined with organic detritus build up and more terrestrial species such as sedges (*Carex spp*.), willows (*Salix spp*.), and in cases where the ecosystem is tending towards acidic conditions, hardhack (*Spiraea douglasii*) can establish. In truly boggy conditions *Sphagnum spp*. mosses and spike-rushes start the successional sequence from open water to peat bog.

The key to wetland development is to slow the flow or action of water to the point where vegetation can establish. Pioneering species can provide this function. Natural ecological processes (e.g., erosion control; nutrient cycling; sediment and carbon capture; hydrologic modulation; and succession) provide the building blocks of natural ecosystems. Understanding how these natural ecological processes operate allows us to incorporate elements of these building blocks (e.g., certain soil surface configurations; woody debris; natural mulches; and native species) in restoration design. Establishment of the conditions that foster development of natural processes is an important approach in the restoration of degraded wetland ecosystems. In many cases simple treatments such as the planting of cattail plugs can initiate processes that lead to healthy productive ecosystems. Natural successional models can serve as the foundation for design of restoration programs. Pioneering species can initiate successional trajectories that are responsive to a range of site and climatic conditions. By using natural successional pathways as the model for restoration, the pioneering ecosystems that are established can create conditions that are appropriate for a variety of successional trajectories.

Natural processes have been effectively restoring natural disturbances since the dawn of terrestrial vegetation about 400 million years ago. Less than 15,000 years ago Canada was still covered with a thick blanket of ice. Now we see a broad diversity of ecosystems, including wetlands of various descriptions. Understanding how these recovery processes operate, including the elements of the processes that serve as keystone parts, can help us design restoration programs that re-establish the natural successional trajectories that will ensure appropriate vegetation on the site into the future.

The Society for Ecological Restoration International (2004) defines ecological restoration as the process of assisting the recovery of ecosystems that have been degraded, damaged, or destroyed. The key aspect of this definition that we need to keep in mind when we are restoring damaged sites is that at best, all we can do is *assist* in the recovery process. We cannot make recovery happen any more than we can cause a scab to form on a cut. However, there are a diversity of things that can be done to assist the recovery of damaged ecosystems.

Identifying limiting factors

The first step in assisting the recovery of degraded sites is to determine what factors are preventing natural recovery from happening (Clewell and Aronson 2007). In wetland areas, changes in hydrology such as draining wetlands or maintaining a constant water level where fluctuations were the pre-disturbance condition may be the leading cause of wetland degradation. Erosion or changes in sediment deposition regimes can be important factors in preventing recovery. Sites that are actively eroding may have little chance of recovering naturally and some remedial action may be needed. Conversely, at sites where smothering layers of sediment are preventing vegetation, establishment may not begin until the sediment deposition is controlled. Changes in nutrient status can cause shifts in the vegetation that can be hard to rectify. In many cases, an increase in nutrients caused by sewage or agricultural operations, rather than a decrease in nutrients, is the limiting factor preventing natural recovery of an appropriate species assemblage.

There may be a complex series of factors constraining natural recovery. For instance, an increase in flows associated with clearing at the headwaters and/or paving in the watershed may result in increased erosion on upland streams, which results in an increase in sediment deposition in the wetland. This may shift the vegetation assemblage from one that functions best with limited sediment deposition to one that can accommodate increased sedimentation. A decision must then be made on the extent of the restoration program: whether the pre-disturbance ecosystem is desired or if a new, novel ecosystem based on the increases in sediment is acceptable (Hobbs et al. 2006; Hobbs and Suding 2009). Where large open pit mines create entirely new landforms, there is an opportunity to use restoration to establish new ecosystems, including wetland ecosystems (Polster 1989).

Erosion can be a significant factor in wetland and aquatic ecosystems. Shoreline erosion can prevent vegetation from establishing. Erosion may cause downcutting of feeder streams that may leave an oxbow type wetland high and dry with subsequent shifts in form and function. Although these are natural processes, when erosion is associated with human activities there may be obligations to develop restoration strategies to reverse these processes.

A lack of propagules for colonizing wetland sites may be an issue preventing recovery, although it is more likely that conditions for establishment are not appropriate for the propagules that are available. Many pioneering wetland species produce abundant seeds or other mechanisms for regeneration and with excellent means of distribution. However, the conditions of the receptor site may be preventing these species from establishing. Elements such as compaction, smooth surfaces, water depth, erosion, or wave energy may be causing establishment failures.

Identification of the factor(s) that may be preventing natural recovery is the initial step in assisting recovery.

Identifying natural recovery solutions

How have natural processes overcome the factors that limit natural recovery? This may be the central question in finding restoration solutions that work. Physical changes to the site (i.e., making seed beds rough and loose; reducing slope angles; adding woody debris) and use of pioneering species may provide the solutions for overcoming limiting factors (Polster 1991). Seeking out nearby natural systems that are analogous to the site to be restored can assist in the identification of natural recovery solutions.

Observing the details associated with the establishment of pioneering species can offer clues. Do cattail seedlings establish in the moose prints around the pond? Are willow seedlings found around the margins of puddles? Are pioneering grasses found in the old wheel ruts present on the disturbed site? Although each situation will provide different clues on establishment patterns, sometimes common elements can be determined.

Mimicking the conditions that allow natural pioneering species to establish assists in the recovery of the site. Some wetland species such as cattails, bulrushes, and pond lilies form a barrier that damps waves, reducing shoreline erosion and allowing sediment to be deposited. Large woody debris can also aid in this process. On some high energy beaches, willows and other pioneering species that can tolerate flooding can be used to reduce erosion and initiate the natural successional processes.

Natural successional processes can provide powerful models for the design of restoration treatments (Polster 1991; Walker and del Moral 2003; Walker et al. 2007).

Figure 1. Creating a stream channel. Nature does not make a smooth surface; have your excavator operator create a slope that is loose and rough. Photos by David Polster.

Implementing restoration treatments

Once the natural solutions to revegetation problems have been identified, it is simply a matter of implementing these on the restoration site. For instance, it may be that shoreline erosion on a high-energy site can be mitigated by installing a series of willow and cottonwood cuttings, or on a less energetic site, planting cattails may be all that is needed to initiate the recovery processes. Many wetland species are rhizomatous and this feature can be used to establish a dense cover without having to plant each one. Consider the factors that are preventing natural recovery, observe how natural systems overcome these, and do what needs to be done to mimic these natural processes.

Monitoring

Monitoring is an essential part of any restoration treatment. Although there are a wide variety of monitoring systems that can be applied depending on the information desired, in many cases simply documenting the changes in the treatment site over the years is sufficient to illustrate the success of the restoration program. Sometimes collection of information on the spontaneous establishment of later successional species can be used to document the success of the program. Many wetland systems change very slowly, so a band of planted cattails may remain for many decades before sediments accumulate to the extent that more terrestrial species can establish. In these cases success can be measured by the stability of the created ecosystem.

Conclusions

Natural processes can be used for the restoration of wetland ecosystems. The key is to determine what factor(s) is preventing the natural recovery of the site and to provide treatments that mimic the natural processes for overcoming these factors. Changes in site hydrology need to be rectified or ameliorated prior to attempts to restore the site. Where hydrologic recovery is not possible or where new landscape elements are established, a novel ecosystem can be substituted for the original ecosystem. Where the natural solutions to addressing problems in vegetation establishment are slow, there may be opportunity to speed these up by providing suitable plants or structures that help the recovery process. Care should be taken to avoid introducing elements that might compromise the recovery over the long term. Non-natural structures such as rip-rap or steel and concrete can solve an immediate issue, but create a much more profound future problem. The application of natural solutions avoids this common mistake. The use of natural processes as models for recovery of degraded sites allows restoration of severely damaged ecosystems.

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15.An opportunity for rehabilitation: City of Vernon Waterfront Neighbourhood Plan

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Darryl Arsenault is a Principal Consultant with EBA Consulting Engineers and Scientists, and is based in Kelowna. He specializes in aquatic sciences, with an emphasis on freshwater fisheries habitats. He has worked for most of his career in the field of environmental consulting, and has undertaken work assignments on Vancouver Island, in northern Saskatchewan, NWT, Yukon, Alberta, and throughout British Columbia. Most of his experience is in south central BC, due mainly to his residence being in Kelowna, and given that he was raised in Salmon Arm. Since 1999, he has been a Director of the BC Lake Stewardship Society. Darryl's current project workload includes marina development environmental assessments to CEAA standards, environmental planning and permit facilitation for land development near water, gold mining baseline assessment, fish habitat compensation planning, and design of long-term monitoring programs.

In 2001, the City of Vernon identified an area of land at the end of the Vernon Arm of Lake Okanagan as a neighbourhood planning area that required environmental, economic, and social components balanced within a long-term vision of the area. Among many other components, the plan identified an opportunity to create a series of wetlands that would act as stormwater management areas and a visual amenity for the community. The location and study area are shown in Figure 1.

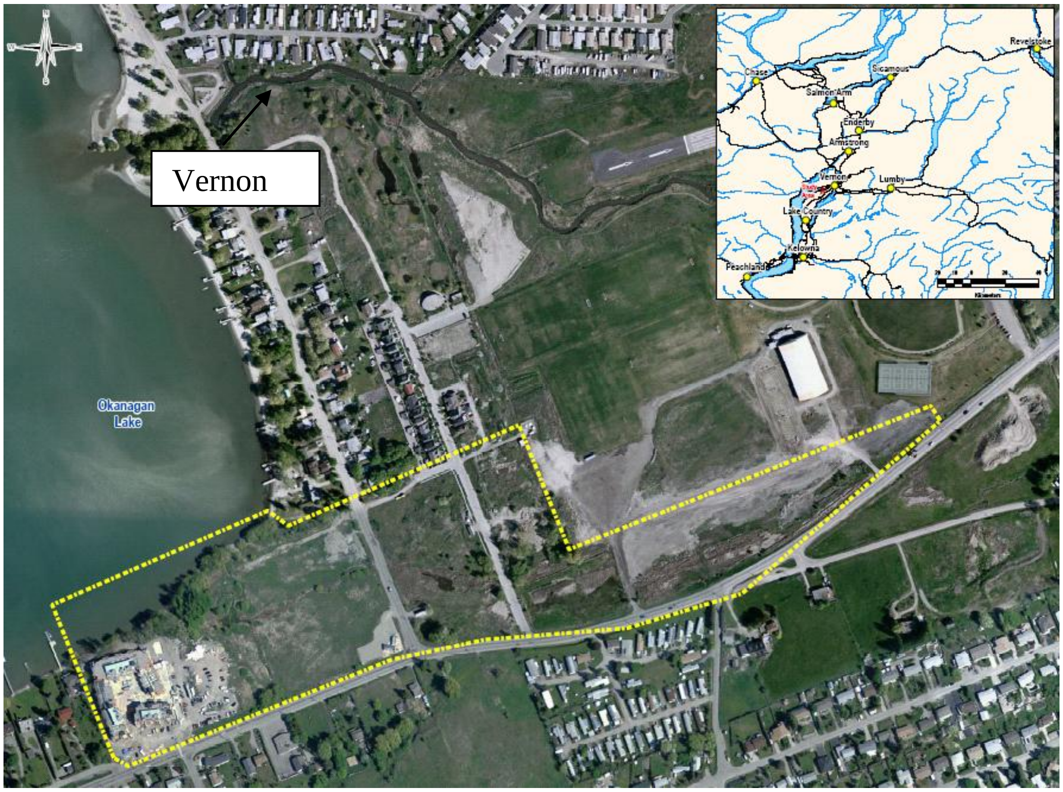

Figure 1. Location of study area on Vernon Arm of Okanagan Lake.

An earlier plan, called "Ribbons of Green," identified Vernon Creek to the north and the wetland series area as part of a naturalized path system that connected with the lake and other pedestrian hubs to the east of the wetland area.

After several years of planning and even more years of plans lying inactive, proposed development on some of the properties within the wetland plan area breathed new life into the wetland rehabilitation project. Prior to conversion of the low-lying land to its present day state of fields and road, the area contained numerous wetlands of various sizes. Figure 2 shows an air photograph of what the area was like in 1949, prior to agricultural development. There appears to have been numerous large wetland areas and meandering stream channels. Roads were already a dominant component of the landscape.

Figure 2. Air photograph of study area in 1949.

Figure 3. Wetlands in the study area, present day.

A ribbon of water still trickles through this area, and it is the existence of this ribbon that supports creation of several new wetland basins and the enhancement of several others. The plan was based on transportation planning, which allowed for pockets of land that could be used to incorporate stormwater ponds and wetlands as well as a water conveyance channel that would follow a route similar to what exists today.

Figure 4 shows the plan provided by the City of Vernon to the consulting group, consisting of Kerr Wood Leidal Consulting and EBA Engineering Consultants Ltd.

Figure 4. Plan as provided to consultants, by the City of Vernon. Numbers are soil testing locations.

Geotechnical engineering and hydrological modelling were completed to calculate soil stability, groundwater levels, and hydraulic capacity. Soil testing locations are indicated in Figure 4. Groundwater was encountered 0.2 to 1.0 m below the soil surface on July 23, 2008. There were underlying layers of clay encountered in the test holes. This information meant that the study area would provide good conditions for the creation of wetlands that would hold water, and when designed with a 4H:1V side slopes would remain stable. The slope angle did not account for vegetation establishment, which would increase slope stability. Five hydrological sub-basins were identified, each with consideration given to transference of 100-year storm events and treatment (storage or retention) of six-month events.

Rare and endangered plant and animal species have been recorded in the study area. These records are shown below. Wetland designs incorporated this information to provide habitat for Great Basin Spadefoot Toad, Painted Turtle, and other amphibians and reptiles. The design incorporated life cycle requirements for upland and in-water components, including connectivity between habitat types.

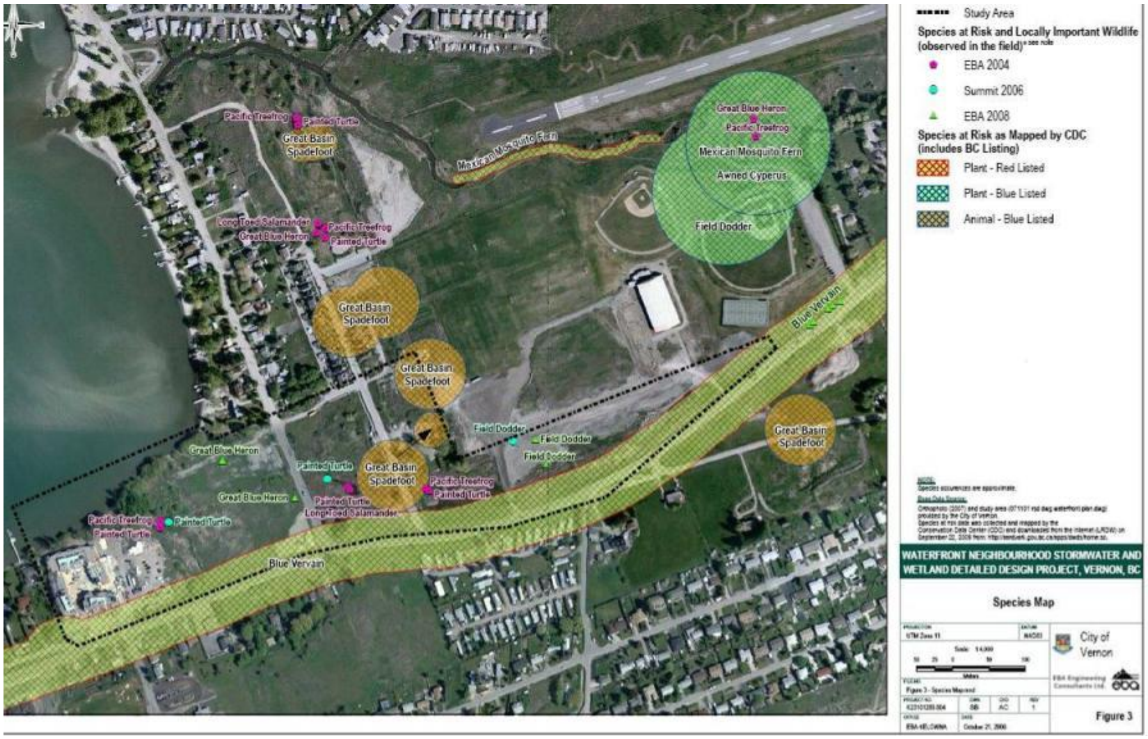

Figure 5. Rare and endangered plant and animal species.

The total area of wetland creation and enhancement would be 27,790 m^2. The following biological recommendations were provided to the design team:

- Control invasive species through appropriate design (plants and fish)
- Preserve and create linkages between Vernon Creek, uplands, and Okanagan Lake
- Separate stormwater management from wetlands so that maintenance is not a potential future issue
- Provide for life cycle habitat for wildlife species of interest
- Protect rare plants through design modification

The preliminary biological design is shown in the Figure 6. The resulting overview design is shown in Figure 7.

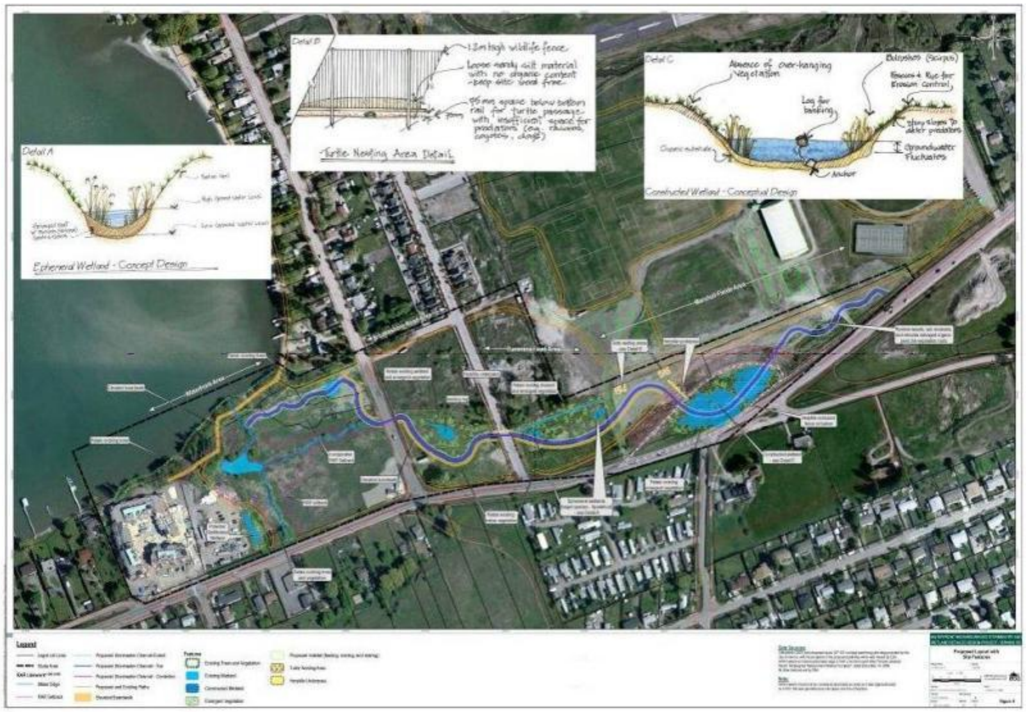

Figure 6. Preliminary biological design.

Figure 7. Resulting overview design.

Planting plans were detailed enough to provide drawings for tender to a landscaping company. The design focused on native plants such as cottonwood, red-osier dogwood, willow, and rose. It also incorporated turtle, Spadefoot Toad, and other amphibian life history requirements to meet environmental Best Management Practices. Other considerations included connectivity to the Vernon Creek corridor, a community desire for public access, and planting to respect public access. The following detailed landscape design (Figure 8) is an example of one wetland basin area near the middle of the study area.

Figure 8. Detailed design of one wetland in study area. (This graphic is meant to be plotted on large paper and readers are not expected to interpret the details.)

Some of the lessons to be learned from this wetland re-creation project include:

- Try to imitate the past by re-creating more wetlands in areas that have historically supported wetlands. In the case of the Vernon project, 2.78 ha to replace <1 ha of vestigial wetlands in an area that had >10 ha prior to 1950.
- Consider your plan on a neighbourhood basis to respect connections to other waterbodies and allow for future development via treatment of stormwater.
- Include geotechnical and hydrological information into design plans.
- Decide on species of interest but plan on providing maximum biodiversity—bird nesting, etc.
- Allow for development planning on a community basis. Incorporate ecological values at the municipal level to include people into the long-term sustainability mix.

It is expected that components of the project will be completed in conjunction with property development planning in the near future. The City of Vernon owns several of the properties that would be required to bring the plan to fruition. These City-owned wetland areas would be developed during road construction.

Acknowledgements

For their contributions to the study and design, I acknowledge the following:

- City of Vernon (Brooke Marshall, Rob Dickinson, Sonya Forsyth, and Dale Rintoul)
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- Angela Cormano, R.P.F., R.P.Bio. (EBA Project Manager)
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- Susan Latimer, R.P.Bio.* and Lisa Tedesco, B.I.T. (BC Ministry of Environment) * now retired

16. Wildlife physical works for riparian and wetland habitat enhancement in Arrow Lakes Reservoir

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Doug Adama has worked as a wildlife biologist in the Columbia Basin for over 15 years. He is a long time resident of the Columbia Valley and lives in Golden, BC. His work has entailed habitat enhancement, ecosystem restoration, and endangered species recovery. Recently Doug joined BC Hydro's Water License Requirements Team to initiate the wildlife projects indentified in the Columbia Water Use Plan. Current projects include monitoring the response of a variety of taxa to the operational regimes of the Kinbasket and Arrow Lakes Reservoir and to habitat enhancement through revegetation and physical works. Doug also continues to chair the national recovery team for the southern mountain population of the Northern Leopard Frog.

Overview

The goal of the Columbia Water Use Plan (WUP) is to accommodate environmental, recreation, power generation, culture/heritage, navigation, and flood control interests for the Columbia River; either through incremental changes to how water control facilities store and release water, or to undertake physical works in lieu of changes to reservoir operations to meet the specific interests.

As part of the WUP process, a Consultative Committee was established to provide stakeholders input into the WUP. During the WUP process, the Consultative Committee supported the implementation of wildlife physical works (habitat enhancement) in the mid-Columbia River in lieu of changes to reservoir operations, to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. Forty-four potential sites were identified between Revelstoke and Shelter Bay that might be suitable for wildlife habitat enhancement work. As there was some uncertainty related to the feasibility of the proposed projects, it was recommended that an adaptive approach be adopted to provide flexibility and opportunity for ongoing discussions in the formulation and implementation of the wildlife physical works. It was acknowledged that feasibility/risk assessments, detailed planning studies, and First Nations, agency, stakeholder, and public input would required to address the target wildlife species, ecological communities, engineering design, and potential impacts on other interests.

The goal of this study is to identify and assess wildlife habitat enhancement opportunities in Revelstoke Reach and provide guidance towards the implementation of those works by defining treatment options, describing treatment methods, and providing a realistic treatment schedule. The study has been divided into two phases. The first phase of the study called for a preliminary review to identify sites for immediate consideration, and included assessment of the sites in the context of risks, feasibility, the need for detailed planning studies, and public consultation. The assessment included targeted wildlife and habitat types, engineering design issues, and potential impacts on other interests.

Phase II will be undertaken in 2009 and focus on preparing site-specific treatment plans for sites recommended during Phase I. We will seek to implement these plans starting in 2010 upon receiving regulatory approval and approval from the Comptroller of Water Rights.

The objectives of Phase I of this study included:

- Review and summarize the existing environmental and engineering information pertinent to wildlife physical works in Revelstoke Reach.
- Review and assess preliminary environmental and engineering feasibility of wildlife physical works identified in the WUP report and from alternative sites identified during field surveys and input received from local stakeholders.
- Establish a Wildlife Physical Works Committee (WPWC) to assist in providing information and recommendations with respect to the preliminary feasibility study.
- Seek agency, stakeholder, First Nations, and public input to identify potential impacts on other interests in the community and to identify support for the proposed projects.
- Provide a final report summarizing the findings of the feasibility study, identify treatment sites and methods, identify target wildlife species and their ecological communities, and provide a preliminary cost estimates.

The objectives of Phase II of this study are to develop site-specific designs for wildlife physical works projects, supported by detailed environmental, engineering (civil, geotechnical, and hydrotechnical), and archaeological assessments, where necessary.

Status

Phase I of this two-phase study was initiated in April 2008. Phase II will occur in 2009. The next program report is expected in January 2010.

For 2008, project work involved five activities: conducting a review of existing literature; carrying out field surveys of the identified sites; consulting with stakeholders, agencies, the public, and First Nations; prioritizing sites; and providing preliminary cost estimates for the construction of candidate projects.

Relevant literature was identified, referenced, and presented in a catalogue. In total, 47 relevant documents were summarized and catalogued.

Field surveys were completed by a team of biologists and an engineer. Due to higher than anticipated water levels in April 2008, the team reviewed all but six of the 44 wildlife physical works sites identified in the WUP. An additional two sites were identified and assessed.

Wildlife and wildlife sign observed during field surveys were documented.

Geotechnical issues were identified.

It was concluded that that due to the porosity of the floodplain substrate, projects that call for extensive diking to retain water without a source of surface water are likely unfeasible; however, diking may be effective at holding back water where a water source exists, which may allow for the opportunity to create or expand flooded areas. Furthermore, there may be some opportunity to use the existing railway bed and old roadbeds as dike structures.

Options for raised land using local fill were also reviewed. These opportunities, where they exist, should target a minimum elevation of 437 MASL (metres above sea level) and include variable heights of land over a range of elevations between 437 and 440 MASL. These elevations will facilitate the establishment of riparian shrubs (e.g., willows) and trees (e.g., cottonwood).

A third type of wildlife physical work was reviewed, which would entail ancillary wildlife habitat structures that would seek to create specific habitat features required for target wildlife species. These structures could supplement diking and raised land physical works.

Figure 1. Cartier Bay (left side of photo) is a possible site for treatment. A designed structure would replace an old wooden box culvert that has created important habitat for waterfowl, amphibians, and reptiles. Photo by Doug Adama.

Consultation with agencies, stakeholders, First Nations, and the public was also an important component of this study. An advisory group, the Wildlife Physical Works Committee (WPWC) was established. Invitations were sent to members of the Columbia WUP core committee and to local stakeholders. Fourteen individuals agreed to participate in the Wildlife Physical Works Committee. Five committee meetings were held in Revelstoke on May 20, June 17, July 14, August 12, and December 2 of 2008. Representatives from Ducks Unlimited participated in the meetings and provided technical support throughout the study. The BC Ministry of Environment provided local and regional representation.

A one day meeting and field trip was held on November 25, 2008 between BC Hydro and the Traditional Knowledge and Language Sector of the Ktunaxa Nation Council as well as the Canadian Columbia River Inter-Tribal Fisheries Commission. During the meeting and field trip, Ktunaxa members and staff provided general comments on wildlife management and values that are important to the Nation. A presentation was given to the Okanagan Nation Alliance on December 5, 2008 during a regular bi-annual meeting between staff of the Okanagan Nation Alliance and BC Hydro, to discuss overall WUP implementation.

The Wildlife Physical Works Committee focused on developing and reviewing a weighted scoring system to rank wildlife physical works based upon biological and operational criteria. Biological criteria included seasonal availability, habitat type, target species group (guild), species at risk, and regional wildlife priority; operational criteria included cost, access, source of water, and fire interface. Five dominant species guilds were considered: water birds, songbirds, terrestrial mammals, aquatic animals, and fish. Terrestrial habitat within Revelstoke Reach was classified into three broad habitat types: native and introduced grasslands, shrub communities, and upland forest. Wetland and aquatic sites were classified into three broad habitat types: functioning wetlands, shallow depressions, and deep pools and channels. In addition to scoring the wildlife physical works, three principles were also applied during the selection of candidates: the potential for learning opportunities; the proximity of candidate wildlife physical works to one another; and a desire to see a range of treatment types for projects undertaken. A matrix was prepared, facilitating a means for scoring each proposed wildlife physical work. In this manner, projects were ranked from lowest to highest.

An initial screening for cost (i.e., those that were prohibitively expensive) and feasibility (i.e., those where there was a high likelihood that the specified objectives could not be met) allowed immediate exclusion of some of the proposed wildlife physical works. Of 44 works identified, nine were excluded from the scoring. A final list of 35 wildlife physical works were scored and ranked. Scores for the works ranged from a low of 12% to a high of 70% of the available points. Based upon the direction received from the Wildlife Physical Works Committee and the guiding principles, eight works were presented for immediate consideration. These include two sites near Airport Slough, one near Montana Slough, two near Cartier Bay, one site near MacKay Creek, one site near Drimmie Creek, and one near Downie Marsh.

An overview of risks, potential conflicts, regulatory and monitoring considerations, and further recommendation were also presented in the final report. A public open house was held at the Revelstoke Community Centre on December 3, 2008 to present the findings of the study to the community. The final report with recommendations was completed in March 2009.

Phase II of this study is planned to begin in April 2009.

17. Management of aquatic invasive plants in British Columbia

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Dr. Wilson has worked in the field of noxious weeds and invasive plants for 30 years. Linda joined the BC Ministry of Agriculture and Lands in January 2008 as Manager of the Invasive Plant Management Program. Before joining the Ministry, Linda was an invasive plant ecologist at the University of Idaho; teaching graduate and undergraduate courses, conducting terrestrial and aquatic invasive plant research, and providing technical and educational program support for agency field personnel, land managers, and Cooperative Weed Management Areas in Idaho, Washington, and Oregon.

Invasive species impacts and mediation efforts are often at the forefront during discussions about resource management and environmental protection. Non-native, invasive species are well-documented and widespread throughout BC; some of the most familiar invasive species across the landscape are plants. Many people think of terrestrial habitats when considering impacts associated with non-native, weedy plants, yet it is likely that aquatic plant invaders are even more harmful and ecologically destructive than their terrestrial counterparts.

Aquatic invasive species are those that are introduced; not native to BC; are adapted to living in, on, or near water; and cause or have the potential to cause economic, social (including human health), or environmental harm. Once established, invasive plants often dominate the plant community or habitat, to the detriment of other species.

Aquatic invasive plants in BC occur in both marine and freshwater environments. They are found in coastal waters and estuaries, lakes, rivers, streams, canals, ditches, garden ponds, and all forms of wetlands. Aquatic invasive plants come in many forms and functional groups, and include grasses, forbs, shrubs and trees, rushes and sedges, ferns, and algae. They can be emergent, submersed, free-floating and flowering, riparian, or simply able to tolerate mesic or hydric conditions.

It is difficult to quantify the environmental, social, and economic impacts of aquatic invasive plants, and few studies are available to inform our management decisions. In other areas, aquatic invasive plants are known to have significant impacts. The greatest long-term impact, and probably the least understood, is the loss of biodiversity often associated with the transition from a diverse plant community to a monotypic infestation of an invasive plant. These include the degradation of riparian habitats, which provide food, shelter, and nutrients for many different, yet often ecologically interconnected species. Moreover, some aquatic invasive plants alter nutrient regimes and water temperature, and increase rates of sedimentation. These impacts can have serious impacts on fish, amphibians, and other aquatic organisms.

The greatest challenge we face in managing aquatic invasive plants is our often limited knowledge about the biology and ecology of these species, or in our lack of understanding the potential ecological, environmental, or social risks they pose. Unlike their terrestrial counterparts, aquatic invasive plants are considerably more difficult to control. Managers have fewer alternative approaches to manage even small incursions of invasive plants. Chemical control can be effective, but herbicides (even those approved for use in or around water) are often undesirable or prohibited in the management area. Mechanical control, from hand-pulling to machine dredging, is intensely laborious, can be prohibitively expensive, and often offers limited success.

The best approach to management of aquatic invasive plants is prevention. This means preventing unwanted plants from entering the environment or management unit in the first place. In order to succeed at preventing new incursions of invasive plants into aquatic habitats across our landscape, citizens of and visitors to BC need to be made aware of these non-native invaders and to understand the risks they pose to the values we cherish. Values may include recreation, fishing, water quality, conserving biodiversity, preserving rare or culturally important species, control of erosion and other forms of habitat degradation, clogging of waterways and irrigation ditches, and food production. Preventing entrance and establishment of invasive plants necessitates a sustained proactive approach to public outreach and education; this is key to the success of any local, regional, or provincial prevention effort.

Another important consideration when managing for prevention or containment is to understand the pathways by which invasive plants enter and move around BC's waterways and wetlands. Many areas in BC are susceptible to incursions and negative impacts of non-native invasive plants. Rivers and lakes flowing into BC from adjacent states and provinces are primary avenues of spread and contamination. A list of known invasive plants is provided in Table 1, as well as a "watch list" of additional plants we want to prevent from establishing in BC. Some aquatic invasive plants are known to originate in the aquarium and pond plant trade. Disposal of these plants into natural waterways, many of which are interconnected to larger water bodies, poses a serious threat to natural areas. Other pathways for invasion and dispersal include: horticulture, land- and water-based recreation; management practices for linear infrastructure such as highways, waterways, drainage ditches, marine/estuary dredging, and dikes; community-based freshwater management; riparian disturbance; shipping (ballast water, containers); international trade; and natural dispersal (wind, water).

Table 1. List of aquatic invasive plants A) Known in BC, and B) Extracted from Aquatic Invasive Plants Action Plan (2009–11), Invasive Plant Council of BC, April 2009.

Aquatic invasive plants known to occur in BC	**Aquatic invasive plants not known in BC ("Watch List")**
Butomus umbellatus, flowering rush	*Abutilon theophrasti*, velvetleaf
Didymosphenia geminate, didymo	*Arunda donax*, giant reed
Heracleum mantegazzianum, giant hogweed	*Azolla spp.* (excluding *A. mexicana*), water fern
Impatiens glandulifera, policeman's helmet	*Cabomba caroliniana*, fanwort
Iris pseudacorus, yellow flag iris	*Carex pendula*, hanging sedge
Lythrum salicaria, purple loosestrife	*Caulerpa taxifolia*, caulpera (killer algae)
Myriophyllum aquaticum, parrotfeather	*Cotula coronopifolia*, small marsh flower or brass buttons
Myriophyllum spicatum, Eurasian watermilfoil	*Cyperus esculentus*, yellow nut sedge
Phalaris arundinacea, reed canary grass	*Egeria densa*, Brazilian elodea
Phragmites australis, common reed	*Eichornia crassipes*, water hyacinth
Polygonum cuspidatum, P. Sachalinense and their hybrids, Japanese knotweed	*Epilobium hirsutum*, hairy willow herb
Ranunculus repens, creeping buttercup	*Hydrilla verticillata*, hydrilla
Sargassum muticum, Japanese wireweed	*Ludwigia hexapetala* and *L. peploides*, water primrose species
Spartina spp. (*S. anglica, S. densiflora, S. patens*), cordgrass	*Lysimachia procumbens*, golden loosestrife
Zostera japonica, dwarf eelgrass	*Myriophyllum heterophyllum*, variable-leaf milfoil
	Nymphoides peltata, yellow floating heart
	Plantago coronopus, buck's-horn plantain
	Schoenoplectus mucronatus, ricefield bulrush
	Spartina alterniflora, cordgrass
	Undaria pinnatifida, algae
	Utricularia inflate, swollen or greater bladderwort

In BC, the Invasive Plant Council of BC and the Inter-Ministry Invasive Plant Working Group are working with stakeholders and other jurisdictions to increase awareness of, and promote management of, invasive plants. The Aquatic Invasive Advisory Committee of the Invasive Plant Council recently prepared an Action Plan for Aquatic Invasive Plants in BC. Below is a list of selected websites that the reader can access for more information on the identification and management of aquatic invasive plants.

Suggested online resources:

BC Ministry of Agriculture and Lands
http://www.al.gov.bc.ca/cropprot/nonnativepests.htm

BC Ministry of Forests and Range Invasive Alien Plant Program Application
http://www.for.gov.bc.ca/HRA/Plants/application.htm

E-Flora BC
http://www.eflora.bc.ca/

Invasive Plant Council of BC
http://www.invasiveplantcouncilbc.ca/

Invasive Plant Strategy for British Columbia
http://www.fraserbasin.bc.ca/publications/documents/invasive_plant_strategy04.pdf

Washington State Noxious Weed Control Board
http://www.nwcb.wa.gov/

Washington Department of Ecology
http://www.ecy.wa.gov/programs/wq/plants/weeds/

Idaho Department of Agriculture, Aquatic Noxious Weed Program
http://www.agri.state.id.us/Categories/PlantsInsects/NoxiousWeeds/Aquatics_Home.php

Oregon Invasive Species Council
http://www.oregon.gov/OISC/

Montana Department of Agriculture, Aquatic Weed Program
http://agr.mt.gov/weedpest/aquatics.asp

California Invasive Plant Council
http://www.cal-ipc.org/resources/booksandcds/aquatic.php

Center for Aquatic and Invasive Plants, University of Florida
http//aquat1.ifas.ufl.edu/

18. Neighbour to neighbour conservation: The Upper Columbia River and wetlands

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Bob Jamieson is a systems ecologist with practical experience in a variety of fields, systems, and disciplines. His company, BioQuest International Consulting, has offered consulting services in the resource field for 35 years in the Pacific Northwest. He has long experience in both species specific management planning and systems planning here and in Africa.

Bob Jamieson talked about the Columbia River floodplain wetland systems in the East Kootenay and the novel approach that has been taken toward the management of these systems. Pre-settlement, two major floodplain wetland systems occurred in the Canadian portion of the Columbia River Basin. The Upper Columbia wetland/river floodplain complex is relatively intact; while much of the Bonner's Ferry to Creston and Kootenay Lake floodplain has been diked and converted to agriculture.

In the past, such systems have been managed as part of national parks (Peace Athabaska Delta) or as National Wildlife Areas in several other parts of Canada. The Columbia wetlands contain some National Wildlife Area lands, and some purchased conservation lands and private lands, with the majority of the area in a provincial Wildlife Management Area.

History, politics, and budgets were such that in 2006–2007 a total of half of a person year (all governments) was allocated to the management of this system. This problem was recognized and the province asked Gary Glinz, Paul Galbraith, and Bob Jamieson to look at alternative strategies for managing this system. The result was a very broad-based public group called the Columbia Wetland Stewardship Partners. This group assists all levels of government and private land owners in managing the Columbia wetlands.

The Columbia Wetland Stewardship Partners is made up of 32 interest groups, including all levels of government, non-government organizations, local industrial sectors, First Nations, and university researchers. The Partners are addressing a variety of issues and providing advice to government on several fronts, including a federal boating regulation, improved monitoring and science in the wetlands, regional scale linkage issues, species at risk management, and increasing the profile of the wetlands in local communities. The primary objective is to maintain the complex natural processes that drive the productivity of this system.

For more information, visit: http://www.columbiawetlands.org/

19. Wetland Stewardship Partnership

Andrea Barnett, Ducks Unlimited Canada

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Andrea Barnett is Head of Industry and Government Relations for Ducks Unlimited Canada in British Columbia. She has a background in political science and philosophy. Prior to working for Ducks Unlimited Canada, she worked for the BC Cattlemen's Association on industry-related issues.

Summary

The Wetland Stewardship Partnership (WSP) is a unique partnership of government, non-government, and industry groups that share a common interest in the protection of wetlands in British Columbia. Originating in government in the mid-1990s, the WSP expanded into the private sector in the early 2000s and has grown into a strong and diverse group. The WSP is guided by a vision and a mission as well as the *Wetland Action Plan*. This document addresses what key actions need to be done, which tools and information need to be generated, and outlines the role each group or agency can play.

WSP actions and interests are comprehensive involving everything from inventory and information needs to public education to legislative and regulatory reform that will enhance wetland protection. While taking into account the broad range of factors that will help generate a positive outcome for wetlands on the ground, policy-related actions and a move toward a comprehensive wetland policy has become much of the focus of this group.

This paper will explain the genesis of this group and how it has evolved. It will highlight some of the important projects that the WSP has taken on in recent times, including: the development and "roll-out" of the *Green Bylaws Toolkit*; the development of Wetland Best Management Practices; a thorough review of the provincial *Water Act*; and the development of a wetland mitigation discussion paper. It will highlight the way in which each of these individual projects relate to and

support a wetland policy, and work to achieve some of the goals that are part of *Living Water Smart*.

This presentation focused on what the WSP is and how it came to be. It looked at the history of the partnership, the *Wetland Action Plan*, and detailed some of the key projects that the group has worked on to date.

History of the Wetland Stewardship Partnership

Recognizing that wetlands were not being adequately considered in various BC ministry jurisdictions, and that wetlands needed to gain profile in the eyes of government and the public, the WSP began as the Wetland Working Group within the provincial government in the mid-1990s. The Wetland Working Group was committed to the conservation of wetlands for the wide range of values that wetlands provide to the environment, the economy, and society as a whole. Over time, the Wetland Working Group grew into a partnership that extended beyond the BC government and has come to include other levels of government, industry, and non-government organizations.

Current partners include:

- BC Grasslands Conservation Council
- BC Hydro
- BC Ministry of Environment
- BC Ministry of Forests and Range
- BC Ministry of Healthy Living and Sport
- BC Wildlife Federation
- Department of Fisheries and Oceans
- Ducks Unlimited Canada
- Environment Canada, Canadian Wildlife Service
- Federation of BC Naturalists
- Nature Conservancy of Canada
- Pacific Salmon Foundation
- The Nature Trust
- Union Of BC Municipalities

There is a provision in the partnership agreement that allows for the instatement of additional members provided there is consent from the group.

Vision of the Wetland Stewardship Partnership

> "A province where the functions and values of wetlands and the larger watersheds of which they are a part are appreciated, conserved, and restored for present and future generations."

Mission of the Wetland Stewardship Partnership

> "To work collaboratively with government and non-government organizations to maintain, restore, and protect wetland ecosystems throughout British Columbia by implementing the Wetland Action Plan."

Formalization of the Wetland Working Group into WSP

While the WSP has existed in various forms for over a decade, it is only recently that the group has taken the step to formalize as an official partnership. In spring of 2009, the partner groups signed a partnership agreement that details the scope and work of the group.

Excerpt from WSP partnership agreement

> (The signed partners) "…have agreed to form this partnership to stimulate discussion on options, tools, and mechanisms to conserve wetlands in British Columbia, to determine appropriate actions to be taken, and ultimately to implement activities that will have positive, enduring results."

The WSP meets at least twice annually, and more often if the work plan warrants. The WSP is currently chaired by Les Bogdan from Ducks Unlimited Canada and is coordinated by Ted Pobran from BC Ministry of Environment. The group is structuring project committees.

What does the WSP do?

As a partnership the WSP works in a systematic, efficient, and coordinated way to implement the *Wetland Action Plan*, which is the central guiding document for this partnership. The *Wetland Action Plan* is divided into two parts: the first establishes the rationale for added wetland conservation in BC; and the second sets out goals and key actions that will assist in achieving the goal of no further loss (and where appropriate, net gain) of wetland area and function in the province.

The following are the six goals of the *Wetland Action Plan.* These goals are further substantiated and supported by key action in the Plan.

1. Promote and participate in strategic planning processes in British Columbia that encourage the conservation of wetlands.
2. Work with all levels of government to promote the effective use of existing tools, and to promote stronger policies and legislation in support of wetland conservation.
3. Develop and promote the use of a wetland information base to assist in the implementation of plans, planning processes, legislation, and policy.
4. Improve the development and delivery of public education and stewardship programs that encourage the conservation of wetlands.
5. Support the securement of priority wetlands through fee simple acquisition, conservation covenants, and Crown Land reservations.
6. Support the restoration and enhancement of natural wetlands and, where appropriate, the creation of new wetlands.

While the goals are broad-ranging, many of the activities of the group are centred on building effective protection of wetlands at a policy level. The WSP recognizes the efforts of the various Habitat Joint Ventures under North American Waterfowl Management Plan, the Conservation Lands Forum, and the multitude of local and regional conservation partnerships that exist across BC.

Based on the *Wetland Action Plan*, the WSP has worked on several projects to date. The following are examples of projects led by the WSP and its partners.

- Working towards the goals of the BC government's *Living Water Smart: British Columbia's Water Plan* http://www.livingwatersmart.ca/
- Working toward no-net-loss outcome for wetlands for BC
- Developing and revising a Wetland Evaluation Guide
- Developing a Wetland Function Assessment
- Developing a "made for BC" Wetland Mitigation Sequence
- Developing and "rolling-out" the *Green Bylaws Toolkit for Conserving Sensitive Ecosystems and Green Infrastructure* http://www.greenbylaws.ca/
- Wetland and grassland primers for local governments
- Partnered with the Okanagan Basin Water Board on the development of a *Groundwater Bylaws Toolkit* that will be released in fall 2009 http://www.obwb.ca/157/
- Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia http://www.env.gov.bc.ca/wld/documents/bmp/wetlandways2009/wetlandways_docintro.html

For more information on any of these projects please contact one of the people listed below.

Value of the partnership approach

The WSP is a unique and exciting model that has gained recognition nationally as a progressive approach to ensuring that wetland conservation goals are met. There are numerous benefits to this approach, some of the main ones being:

- Promotes good communication between people making decisions and carrying out work on the landscape and the regulatory, policy, and operational levels
- Reduces duplication of effort
- Fosters a strategic and systematic approach to ecosystem conservation, rather than the proliferation of *ad hoc* activities
- Promotes cooperation
- Encourages looking at a broad range of needs, values, and approaches for wetland conservation in BC

If you have questions about the Wetland Stewardship Partnership, please contact:

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Ted Pobran, BC Ministry of Environment, ted.pobran@gov.bc.ca
Jan Kirkby, Canadian Wildlife Service, jan.kirkby@ec.gc.ca

Field Trip Descriptions

Wednesday, May 27

BC Breeding Bird Atlas: Helping wetlands and beyond

Peter Davidson, Bird Studies Canada
(Evening talk before the conference)

Peter Davidson of Bird Studies Canada talked about the BC Breeding Bird Atlas project and how the Atlas can be used to help the conservation of wetlands. This 5-year citizen-science project is mobilizing birdwatchers and wildlife professionals to map the breeding distribution of birds in Canada's most rugged province. Pete's presentation included a slideshow followed by a question-and-answer session.

Thursday, May 28

Coeur d'Alene salamanders in Mount Revelstoke National Park

Lisa Larson, Parks Canada
(Evening field trip after guest speaker)

Parks Canada researcher Lisa Larson took a group up the Mount Revelstoke Parkway to look at Coeur d'Alene salamander habitat and search for these nocturnal salamanders.

Looking at a Coeur D'Alene Salamander. Photo by Giles Shearing.

Friday, May 29

Western painted turtles

Ross Clarke, Fish and Wildlife Compensation Program

Ross Clarke from the Fish and Wildlife Compensation Program took a group to the south of Revelstoke near the airport to discuss the biology, distribution, and habitat requirements of painted turtles. They looked at issues specific to this population including safe nesting areas and efforts that have been undertaken to ensure the ongoing survival of the population. They looked for evidence of current-year nesting, and saw turtles basking at nearby ponds.

Western Painted Turtles on their basking log. Photo by Martin Carver.

Accidental bird habitat in a reservoir drawdown zone

Michael Morris, Revelstoke, BC

Local naturalist and birder Michael Morris took a group to the ponds near the Revelstoke Airport to walk on old roads and trails through the upper part of the Arrow Lakes Reservoir. Fragments of good bird habitat exist as a consequence of gravel excavation for the airport and the power of 40 years of plant succession. Michael talked about the history of land use in the valley bottom and its benefits and impacts to wildlife, with an emphasis on birds.

BC Hydro's plans for habitat improvements

Doug Adama, BC Hydro

Doug Adama of BC Hydro took a group to the south of Revelstoke toward Cartier Bay, to view a number of sites that BC Hydro is planning to treat in 2010. Their goal is to enhance habitat values for water birds, amphibians, and reptiles.

Viewing a possible site for habitat enhancement. Photo by Marc-André Beaucher .

Posters and Displays

1. Improving our knowledge of wetland breeding bird communities: BC Breeding Bird Atlas

Peter Davidson, Bird Studies Canada

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Collaborators

Rob Butler, Christopher Di Corrado, Dick Cannings, Denis Lepage, and Andrew Couturier (all with Bird Studies Canada and staff on the BC Breeding Bird Atlas project).

Breeding bird atlases and other forms of atlassing, developed over the past four decades, are increasingly important tools for conservation worldwide. The *British Columbia Breeding Bird Atlas* is a broad-based public/private partnership to map the distribution and abundance of all species of bird breeding in the province between 2008 and 2012. Breeding evidence (presence/absence) is assessed in 10 km x 10 km grid squares, of which there are approximately 10,000 in BC (the goal is to achieve a minimum of 20 hours coverage in 40% of these squares). Relative abundance is assessed through random point count sampling. Over 800 registered volunteers have already contributed approximately 10,000 hours of survey effort to this mammoth undertaking, in 1,300-10 km squares. The partnership is rapidly growing as more and more government agencies, environmental consultancies, and industry groups commit their datasets.

The project uses innovative internet technologies to provide tools that greatly simplify and speed up data collection, input, review, management, sharing, and interpretation. The products include near-real time projection of data in detailed grid maps illustrating species-by-species distributions, served up through publicly accessible web interfaces, and available for quick and easy download. These tools and products are designed for both the agencies and other stakeholder/interest groups that require the information, and for the volunteers who collect the data and the wider interested public.

The *BC Breeding Bird Atlas* will significantly advance our knowledge of the status and distribution of wetland breeding birds across the province. The Atlas has established a science committee of leading academics to begin investigating the ecological mechanisms underpinning landscape-scale bird distribution and abundance in BC using Atlas data, and is especially interested in developing ideas and partnerships to apply the concept to wetland ecosystems.

Participation in this citizen science initiative is strengthening public capacity to directly inform policy development and implementation (e.g., the BC Ministry of Environment's Conservation Framework, and Environment Canada's new regulatory approach to managing bird populations), building a stronger more engaged citizenry, and instilling a significantly greater sense of public ownership (of the resource/landbase itself as well as the policy guiding the management of that resource/landbase).

For more information about the *BC Breeding Bird Atlas*:
http://www.birdatlas.bc.ca/

2. *Oh that? That's not a wetland; it's just a low spot!*

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Wetland loss is increasingly recognized as an ecological issue in Canada. However, there is considerable uncertainty about what constitutes a wetland. Bogs, fens, marshes, swamps, and low areas with hydrophilic soils and vegetation, among others, are considered wetlands. However, many wetlands in agricultural areas are overlooked by landscape planners, developers, and landowners because they do not appear as a "typical" wetland, one with open water surrounded by cattails. Wetlands can take many forms.

Wetland classification systems, such as the Stewart and Kantrud Wetland Classification System (1971), subcategorize wetland types based on factors such as the length of time water is present, water depth, and common vegetation. In Alberta the *Provincial Wetland Restoration Guide* (2007) provides the following definition of a wetland:

> “…land that is saturated with water long enough to promote various kinds of biological activity which are adapted to a wet environment.”

Based on the Stewart and Kantrud System (1971) these would include temporary ponds (Class II), seasonal ponds and lakes (Class III), semi-permanent ponds and lakes (Class IV), permanent ponds and lakes (Class V), alkali ponds and lakes (Class VI), and fen ponds (Class VII).

Wetland policy in Alberta aspires for a “no net loss of wetlands;” thus, if land development seeks to alter or destroy a wetland, a thorough justification must be provided as well as a wetland compensation plan. With policy directives aimed at conserving wetlands, it is important that those involved in land-based development activities understand the true definition of wetlands. Only when this approach is adopted can one address the true decline of wetlands on every level and function.

The poster presentation depicted the issue of wetland loss, specifically relating to lower class wetlands often overlooked by developers and how these wetlands relate to wetland policy in Alberta. The poster provided examples from recent wetland work Golder Associates Ltd. has been involved with in Alberta’s agricultural regions. We show how regulators have begun to demand consideration for all classes of wetlands from low and ephemeral wetlands to deep-water marshes and also discuss some creative compensation requirements that have been proposed and designed for affected wetlands.

References:

Alberta Environment. 2007. Provincial wetland restoration/compensation guide. Edmonton, AB.

Stewart, R.E. and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, DC. Resource Publication 92. http://www.npwrc.usgs.gov/resource/wetlands/pondlake/index.htm (version 16APR1998).

3. Constructed treatment wetland integration into a floodplain riparian area when water quality improvement supersedes conservation

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Conservation is the first option when growth and development encroach upon riparian boundaries. This option is not always feasible from an engineering perspective and factors such as conflicting priorities among regulators and projected economic losses from interested stakeholders are often major obstacles. Constructed treatment wetlands provide an excellent alternative under these circumstances and offer an opportunity for stakeholder objectives to be met equitably in comparison with traditional approaches in the past. The Marshall Springs Storm Water Quality Retrofit Wetland (MS Wetland) is a successful example of this type of alternative.

The MS Wetland is a constructed treatment system located in Fish Creek Provincial Park, Calgary, Alberta, on a natural terrace approximately 5 m above the floodplain of Fish Creek. It was selected as a candidate site after the City of Calgary conducted a stormwater quality retrofit study on all existing outfalls discharging untreated stormwater into the Bow River. The primary objective of the wetland is to improve stormwater quality by reducing the concentration of suspended solids discharging into Fish Creek (and ultimately into the Bow River). The project was seen as an opportunity to enhance aesthetic appeal, create public education benefits, and compliment existing public recreation facilities within the park.

The feature of this constructed wetland that sets it apart from most others is the innovative hydraulic modelling technology used to predict and enhance the water quality treatment function of the system. As performance, reliability, and risk are often of primary concern to key stakeholders, this modelling capability produces predicted sediment removal results, which are based on the pattern of water hydraulics in the wetland, to offer the client some assurance that treatment performance expectations will be met. Design suitability, proper maintenance and operation, and regular monitoring will continue to affect treatment performance. However, this modelling capability takes us one step closer to placing more confidence and accountability in constructed wetland technology, an aspect that has traditionally been deficient in the past.

Constructed wetland systems are evolving rapidly and despite important advancements, they can lack the diversity and balance of their natural counterparts. Under this context, it must also be observed that the ecological benefits of a constructed system such as the MS Wetland far exceed that of any conventional water treatment system. This functional purpose, which is not too far off from what nature intended, becomes an important issue, particularly when considering the significant increase in frequency and complexity of remediation and water quality improvement measures required to safeguard our valuable water resources.

4. *Raising the young you never wanted: Impacts of Brown-Headed Cowbird brood parasitism on Yellow Warbler breeding productivity in Revelstoke*

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The Brown-Headed Cowbird (*Molothrus ater*) is a generalist brood parasite thought to lower reproductive productivity in neotropical host species. In many species, annual productivity has been further reduced by habitat degradation and an increase in Brown-Headed Cowbird density in highly fragmented habitats has exacerbated this effect. The Brown-Headed Cowbird has therefore been implicated as a factor contributing to the decline of several host species. In many songbird species, female age affects breeding productivity and older, more experienced breeders have higher reproductive success than younger females. We examined how host age and parasitism by Brown-Headed Cowbirds affects Yellow Warblers breeding in riparian habitat in Revelstoke, BC between 2004–2008. After controlling for Yellow Warbler age, we found no relationship between parasitism rates and habitat characteristics at the nest or territory scale. We described age-specific responses to brood parasitism and examined the effects of Brown-Headed Cowbirds on clutch size, hatching success, nestling condition, fledgling success, and annual productivity in Yellow Warbler hosts. Future work will estimate population-level impacts of brood parasitism on breeding Yellow Warblers.

5. Preliminary assessment of wetland vulnerability to climate change in the Central Interior of British Columbia

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Co-authors

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British Columbia is experiencing similar climate warming trends as have been documented globally and these warming trends are expected to continue under most future scenarios. Habitat-based duck surveys (Canadian Wildlife Service and Ducks Unlimited Canada, unpublished data) indicate that the most important waterfowl breeding areas of British Columbia consist of small wetlands, expected to be vulnerable to future climate warming. This study explores how and where increases in temperature and decreases in precipitation could impact wetland and duck populations for an 11 million ha study area in the Central Interior of British Columbia. We found that General Circulation Model (GCM) projections of climate suggest a considerable proportion of both area and number of wetlands will experience decreasing input from snowfall and greater summer drying trends in the future. Many small or shallow wetlands may experience significant drying trends, which in turn could impact waterfowl populations in the region, because small wetlands provide some of the most productive waterfowl habitat. Examination of the spatial distribution of drying trends suggest that these trends vary with elevation and latitude.

Future work will initially focus on calibrating and validating current projections and how waterfowl and other waterbird populations are likely to be affected. The calibration will help us to refine approaches to water output from and input to wetlands. Ultimately we hope to address potential ways to adapt to the increasing vulnerability of wetlands.

6. *Field fitting and enhancing ecological value of stormwater wetlands in the Resort Municipality of Whistler*

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Requirements for stormwater management, and sediment and erosion control in new developments provide an opportunity for creation of new wetland habitat and for enhancement of existing man-made drainage ditches or natural, but disturbed watercourses and wetlands. When public funds are involved in developments, environmental enhancement opportunities are often considered and even desired. In the Resort Municipality of Whistler, development directly and indirectly related to the 2010 Olympic Winter Games has provided opportunities to create new wetlands and enhance stormwater settling ponds.

Paving of day-use parking lots in Whistler Village required a stormwater management plan to handle increased run-off from impervious surfaces. Initially consisting of a new settling pond with connection to an existing manmade ditch, the management plan was revised to relocate the settling pond and create wetland habitat with submergent, emergent, and terrestrial vegetation along the length of the ditch. Construction of the Whistler Athlete Village also required a stormwater management plan. Designs for a large settling pond were modified to create a large wetland area with both high and low marsh habitat. In addition to improving on stormwater design, field fitting can also provide important enhancement opportunities. Equipment operators prefer to leave works with smooth, finished edges, but environmental monitors can encourage placement of large, woody debris, rocks, and general roughening of bank areas to "naturalize" the works and improve habitat value to wildlife. Engineered features may also benefit from field fitting to avoid loss of relatively valuable habitat features such as veteran conifers.

7. British Columbia Wildlife Federation's Wetlands Program

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http://www.bcwf.bc.ca/programs/wetlands/index.html

The BC Wildlife Federation's Wetlands Education Program was created in 1996 to deliver quality wetland education that builds the capacity of individuals and groups to assess their wetland assets, and, using this new knowledge, increase community health. The BC Wildlife Federation prides itself on community-based wetland education programs that increase the capacity of individuals to steward wetlands in their own backyards.

The BC Wildlife Federation's wetland activities result in habitat restoration, enhancement, and conservation at each project site throughout British Columbia. When a host community invites the BC Wildlife Federation's Wetlands Program to deliver a course in their community, the chosen site will benefit from enhancement or restoration during the course. Not only do participants learn about wetland processes and habitat restoration, they also embark on the physical work required to restore wetland habitat.

The Wetlands Program consistently collaborates with BC Wildlife Federation clubs and members, non-government organizations, local community groups, naturalist clubs, First Nations groups, and other interested parties in the communities that host our courses. This ensures for an inclusive and highly informative program.

It has been said many times that change at the community level is most effective and long lasting. The combination of intensive wetland education paired with field-based restoration makes the BC Wildlife Federation's Wetlands Program unique and effective across British Columbia. Thanks to the BC Wildlife Federation's interest in conserving wetlands, communities can ensure that wetlands will be enjoyed for recreation and habitat for future generations.

8. *FORREX's Ecosystem Management and Conservation Biology Extension Cluster*

Pedro Lara Almuedo, FORREX

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What is extension?

Extension is the series of actions that moves knowledge along a learning continuum—from questions to answers. It is a process that extends knowledge and information to bridge the gap between people with natural resource problems and people with solutions. It combines various sources of information into synthesized products that can improve understanding and decision making.

Who do we serve?

The Ecosystem Management and Conservation Biology Cluster of FORREX serves natural resource managers, decision makers, and practitioners; natural resource developers; First Nations; provincial and federal governments; environmental non-government organizations, forest and range licensees; wildlife and forestry consultants; recovery teams; and engaged citizen groups in the natural resource community locally and globally.

What can we do for you?

The Ecosystem Management and Conservation Biology Cluster can work with you to:

- Identify client needs and information gaps through surveys, assessments, focus groups, and client meetings
- Facilitate local problem-solving through forums, think tanks, communities of practice, workshops, consultation, co-operative conferences, and partnerships
- Collect, analyze, and manage scientific data that helps people make present and future resource-use decisions
- Provide up-to-date information through research publications, newsletters, social networks, and websites
- Evaluate the effectiveness of your projects and programs

Guided by our Board of Directors, and in collaboration with our Partners, working group members, and volunteers, the Ecosystem Management and Conservation

Biology Cluster will increase understanding and use of conservation biology and ecosystem management innovations in resource policy, planning, and operational decision making. The program strives to ensure that natural resource planners and decision makers have the information and innovative solutions they need to:

- Maintain healthy and functioning ecosystems and landscapes
- Support the recovery of declining species and their habitats
- Ensure natural resource development activities are balanced with ecosystem conservation objectives
- Adapt natural resource conservation and management practices to climate change

Programs within the Ecosystem Management and Conservation Biology Cluster are made possible with funding and delivery support from the FIA–Forest Science Program, Okanagan College, Simon Fraser University, and management and research colleagues in our partner institutions who generously share their knowledge.

FORREX offers extension programs in these areas of interest:

- Aboriginal forestry and knowledge of Indigenous peoples
- Conservation biology
- Early stand dynamics
- Ecosystem productivity
- Ecosystems and stand management
- Forest operations and engineering
- Grasslands and dry forest ecosystems
- Landscape ecology and conservation biology
- Socio-economics
- Watershed management

Visit http://www.forrex.org/

Learn more about FORREX, sign up for a listserv,
or view the many online publications and reports.

9. Northern Amphibian Monitoring Outpost Society: A non-profit amphibian conservation organization in the Central Interior of British Columbia

Mark Thompson, Northern Amphibian Monitoring Outpost Society

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Amphibians are important because they provide keystone ecological functions in forest soils and wetlands. In recognition of their importance there is growing scientific concern and a sense of urgency about the rapid decline in species, distributions, and population numbers on a global scale. Little is known about the extent, distribution, or ecology of amphibian populations in northern British Columbia.

NAMOS (Northern Amphibian Monitoring Outpost Society) is a non-profit society created for the purpose of monitoring, researching, and educating about the conservation ecology of amphibians and their habitats in the Central Interior of British Columbia. Our objectives are to yield and synthesize scientifically defensible results for conservation management of amphibians in BC; to lead and to inspire a conservation movement in our community; and to contribute to a growing network of local initiatives that can pool data to monitor global rates of amphibian decline.

Populations of Long-toed Salamanders, Western Toads, Wood Frogs, and Spotted Frogs are monitored and ecosystems are classified where they are found. Our study sites are located at the Aleza Lake Research Forest, the John Prince Research Forest, and forested lands adjacent to the University of Northern British Columbia. Estimates of occupancy in wetlands and forest ecosystems are measured using random sampling techniques and are studied in relation to other parameters that are relevant to conservation ecology. Captured individuals are weighed, measured, and digitally photographed to record the skin patterns that identify individuals, so that we can trace their movements and gather data on life history. In addition to ecological research, our organization provides outdoor education programs designed to highlight the value of conserving amphibians and their ecosystem services. We plan to host eco-schooling outdoor programs where children can learn to identify, monitor, and map amphibian populations in relation to their schoolyard and community.

10.Assessing rangeland resources: Wetland monitoring

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This poster described the BC Ministry of Forests and Range method of monitoring wetland health on Crown range. The purpose of the health assessment is to monitor the impacts of management and disturbance on plant communities and compliance with government's resource objectives for soils, forage, water, fish, wildlife, and biodiversity. Assessments are used to gather information about plant community structure and composition (seral stage), soils, and wetland function. Often permanent photo points are established. Data are collected electronically on handheld computers using ArcPad software. A final report is generated in Microsoft Access describing wetland functionality, forage use, site limitations, and the impacts of grazing and haycutting. The report can promote awareness, indicate trend, and support decision making about range use. Separate forms are available to monitor upland health, stream health, and compliance with range-use plans.

11.Parksville's shallow water wetland: Preliminary assessment for conservation of this important bird and amphibian habitat

Christopher Stephens, student

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Christopher Stephens is working to preserve a shallow water marsh located on a 34 ha undeveloped Agricultural Land Reserve property near Parksville on southeastern Vancouver Island. This wetland and surrounding upland area is a highly significant bird habitat that is regionally important for a great diversity of songbirds, marsh birds, raptors, and other species. It is also the breeding ground for amphibians living in the adjacent forested park. His project has so far involved conducting bird inventories, compiling a bird checklist, photo documentation, invertebrate and amphibian observation, plant surveys, and the creation of a presentation on the wetland. The goal is to have the property acquired and preserved, possibly by a conservation organization, land trust, or local government.

12.Lentic and lotic mapping of the Elk River Watershed

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Co-authors

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The Elk Valley Selenium Task Force through Teck Coal Ltd. retained Interior Reforestation Co. Ltd. to determine the relative proportion of lentic (standing) and lotic (moving) waters in the Elk River Valley downstream of the mines. Data was gathered from a helicopter using Red Hen geo-spatial video technology in the fall of 2007. Following video analysis and field reconnaissance, lentic and lotic areas were delineated on orthophoto maps using GIS (Geographic Information Systems). Lotic areas were in the active channel where water had a short retention time (seconds to minutes), while lentic areas had a longer retention time (hours to weeks). Lentic areas were distinguished as either:

Lentic 1 areas: standing water apparent at base stream flow conditions; or
Lentic 2 areas: not wetted at base flows, but likely wetted under mid- to high flows, and included standing water when not visible because of vegetation or they were too small to delineate accurately.

The study area was comprised of approximately 139 ha of lentic and 976 ha of lotic habitat, respectively representing 12% and 84% of the aquatic area assessed. The Elk River sub-basin had the greatest extent of aquatic habitat assessed (838 ha) and the greatest extent of lentic area (94 ha). The Fording River had the second largest area assessed (180 ha) and lentic habitat (33 ha).

This project was completed for Teck Coal Ltd.

13. Development of shoreline management guidelines for fish and wildlife habitats at Windermere Lake

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Windermere Lake, located in the East Kootenays of British Columbia is biologically diverse, yet has been experiencing unprecedented development. Understanding the environmental values of lake foreshores, the impact of development on these values, and providing guidance aimed at improving management are priority objectives for the East Kootenay Integrated Lake Management Partnership (EKILMP).

The EKILMP, which is made up of regulatory agencies and stakeholders (e.g., Fisheries and Oceans Canada, Regional District of East Kootenay, BC Ministry of Environment, and Wildsight) commissioned Interior Reforestation to complete three stages of foreshore studies and planning at Windermere Lake in order to meet these foreshore management objectives. The work was a pilot project for the East Kootenay Region and was completed over a two-year period (starting in January 2007 and finishing in September 2008). The three stages of assessment and planning completed by Interior Reforestation were:

1. Foreshore inventory and mapping
2. Fish and wildlife habitat assessment
3. Development of shoreline management guidelines for fish and wildlife habitats

Newly developed foreshore methods used in the Okanagan Region were followed as a guideline for Windermere Lake, with fine-tuning and appropriate site-specific modifications employed. GIS (Geographic Information Systems) mapping was integral to each of these stages.

Stage 1 methods

In order to complete the foreshore inventory and mapping, Interior Reforestation used the physical foreshore characteristic data collected by the EKILMP and existing literature to report on the physical conditions and environmental values. The foreshore was divided into contiguous segments based on the physical characteristics (e.g., shore type, riparian type, and level of impact).

Stage 2 methods

The fish and wildlife assessment involved comprehensive reporting and analysis of qualitative and quantitative values, using field data collected by EKILMP and information available in the literature. The following key activities were completed by Interior Reforestation:

- Historical air photo analysis of shoreline disturbance
- Fish habitat assessment, including summary of fish species life history and determination of relative abundance by segment
- Wildlife assessment and summary of values by segment
- Zones of sensitivity feature identification and mapping (e.g., wetlands, creek mouths, native grasslands, wildlife corridors, gravel/cobble areas, and remaining natural areas)
- Habitat index analysis, which scored existing and potential habitat conditions for each segment, using a quantitative GIS modelling analysis

Stage 3 methods

Finally, the shoreline management guidelines for fish and wildlife habitats were developed in close co-operation with the EKILMP, using the science-based results from the fish and wildlife assessment. The guidelines are a tool intended to provide an upfront, consistent approach for agency decision making, and for landowners and land developers planning to help protect the natural shoreline values. Shoreline areas were attributed to a clearly defined colour zone of either red, orange, yellow, or grey based on the habitat values. The risks for specific activities in each zone were identified and process flow charts were developed.

This project was completed for the East Kootenay Integrated Lake Management Partnership.

Summary of Conference Evaluation Forms

There were 90 people at the conference, and 35 evaluation forms were returned. Not all forms had a response for each question.

1. How well did the conference meet your expectation?

Fully met: 21 people
Met most: 12 people
Met only a few: 1 person
Did not meet any: 0 people

2. Do you have comments about any of the presentations?

- General, positive comments: 18 people
- Good idea to have poster presenters say their names so we could talk to them during the day
- Liked Fred Bunnell's presentation (2 people)
- Good to have municipal management issues includes, liked Arsenault's and Hawes' topics
- Liked the non-science outlook that Eileen Delehanty brought. Scientists often have a narrow view of their "community." Historical and artistic viewpoints are relevant and often overlooked (2 people)
- Liked Dave Polster's presentation
- Like the order of presentations
- Wanted topics mixed up more so my interest was kept up
- Could have arranged the presentations around themes (2 people)
- Would have liked less time per presenter
- Wants presenters to discuss topics among themselves to avoid overlap
- Some materials presented were redundant
- Would like more presentations that highlighted new research
- Appreciated the mix of government, community, and science presentations
- Good to have associated material available via email and web access
- Wanted some panel discussions to get brainstorming happening
- Some presenters could benefit from training in presentation skills

3. We'd like to know if what you've learned at this event will make a difference to you in the future. Can you suggest a few things you will do differently when you are back at your office?

- Good networking opportunity, met new people, made contacts (5 people)
- I will keep it simple in terms of wetland design (i.e., Creston Valley Wildlife Management Area good in concept, but a nightmare to maintain)
- Stormwater and wetland design—there are options
- Definitely more aware of importance of conserving and protecting remaining wetland systems and restoring degraded systems
- Will join Central Kootenay Invasive Plant Council and be more active in managing invasive plants in wetland and terrestrial systems
- I will learn more about invasive species
- Better understanding of wetland ecology and restoration approaches, and wetland issues
- I will be more aware of the spread of Chytrid disease and change my field methods (2 people)
- New concern for Chytrid and how not to spread it, what I should look for when doing amphibian surveys (2 people)
- Good to learn about new forestry practices in wetlands
- Good insights into components for monitoring amphibian populations
- Recommend to community reservoir managers to assess how wetlands around reservoirs are managed
- Will recommend research into design features that mitigate mosquitoes
- Educate staff dealing with mosquito complaints on the benefits of encouraging mosquito predators in wetlands
- Preserve and protect wetlands, rather than mitigate afterward, due to the costs
- New focus on social aspects of my work
- I have lots of topics to Google
- Importance of even the small wetlands: they are even more important than I thought
- The workshop, the materials, and associated networking have provided tools and example of forward thinking approaches, which I will take back to my advocacy work and consulting services
- This conference has inspired me to host a similar event in Prince George
- I had some good input into my study designs
- Good ideas regarding ecological restoration, and First Nations consultation and social planning in reference to ecological management
- I need to learn more about wetland classification systems

- I need to network more with experts so I understand my wetland better
- Learned to look at things from a landscape perspective and landscape interaction
- Consideration of wetlands as part of urban planning
- I hope to encourage City of Cranbrook to look into mapping small wetlands of various types
- It is important to involve and educate regional governments
- Use some of this information to de-bunk myths, e.g., mosquitoes
- I will broaden my planning perspective to consider the effects of climate change on my long-term monitoring program
- I will think more about climate change
- I will consider wetlands more holistically (wildlife habitat, vegetation, hydrology)
- Try to develop more extension products on wetland conservation and management
- Appreciation for the many issues surrounding wetland conservation

4. Do you have other comments about this event or suggestions for how we can improve future CMI events?

- Well-organized and run, appreciated keeping on time (7 people)
- Positive comments on food (4 people)
- Graphics on some slides cannot be understood in such a large room
- Presenters need coaching on using a microphone
- Need two microphones—one for presenter, one for questions (2 people)
- Keep trying to get the presenters to keep words/slide to a minimum
- Liked the 20-minute length of time per speaker
- Have some presentations take longer, maybe an hour, fill in with smaller ones
- Mix it up with breakout sessions where a problem is thrown out to a group of tables
- Don't have nighttime talk; many people leave and do not come back
- More time for questions and general discussion (2 people)
- Avoid May for conferences, it's a busy time for biologists
- Looks forward to receiving presentation summary
- Hillcrest Hotel too far from community centre
- Wants more vegetarian servings
- Need more focus on pro-active approaches to ecosystem protection
- Liked to have the field trips as well as the presentations
- Field trip was great hands-on activity

- Early morning birding trip would be a good idea
- Wants regional districts and municipalities to attend and learn about this topic
- Liked informal atmosphere
- Wanted First Nations presenter
- More opportunities to discuss and debate within the group
- Arrange small group forums to discuss current issues and report back
- Wanted some longer anchor presentations with more meat
- Have all presenters meet just before conference starts to go through the technical set up of equipment
- Posters were great, wish more were left set up on second day
- Need more information on social marketing for wetlands messages
- Incorporate even more networking time
- Venue is a bit sterile
- Need smaller room with better acoustics
- Wants list of participants after event
- Audiovisuals could be improved

5. The papers at this conference were assembled from a "call for papers," and we know there were some topics that were missed. In a few years we will consider holding a sequel to this conference. Which topics would you like to hear about at our next conference? Can you suggest people we can approach to cover these topics when we send out the call for papers?

- Control of off-road vehicles, mud-bogging, and enforcement issues (8 people)
- How to manage recreational values
- How to manage and mitigate range values
- What are agricultural impacts and what can we do?
- What are the issues around wetlands in different parts of the province?
- Habitat joint ventures (Bruce Harrison, DU to speak to this)
- How to incorporate the spiritual aspects into wetland restoration
- How to better address the subjective or social aspects of wetland management
- Conference focusing on floodplain ecology (alluvial: J Stanford, siltband floodplains: Derald Smith, Suzanne Bayley)
- People to report back on results of specific projects we just heard about
- Effectiveness of BC Hydro's physical works—follow-up talk
- How to monitor effectiveness of restoration of wetlands
- More presentations on wetland restoration
- More specific examples from David Polster on restoration and rehabilitation

- How should wetlands be managed differently with what we now know about climate change? i.e., we have heard they are in danger from climate change, what to do about it?
- Mosquitoes, West Nile research, and keeping wetlands functional
- Effects of *Bt* on wetland ecosystem balance
- Discussion on public perception of mosquitoes and wetlands
- Role of wetlands in carbon sequestration
- International initiatives for wetland conservation
- What is progress on preventing loss and alienation of wetlands
- Examples of wetlands built and maintained by communities
- Strathcona County near Edmonton has some great environment people who have been instrumental at involving some municipal environment policy, including a wetland policy. Contact Jocelyn Thrasher-Haug
- How to do social marketing for wetlands
- Need for better integration (e.g., BC Ministry of Environment advocates protecting of wetlands, but Interior Health is impacting wetlands)
- More presentations on how aquatic species can remove/uptake certain contaminants or nutrients.
- Wetland assessment methods
- Wetland classification
- Wetland mapping
- More on wetland restoration (2 people)
- How to set management objectives for wetlands
- Profiles for specific indicator species and threatened species
- Wants to hear from representative from a province or state with better water policies; we can learn from them
- First Nations' perspectives
- Effectiveness of stormwater treatment using constructed wetlands
- How to influence policy toward wetland protection
- Talks from the regulators
- Wants a follow-up to climate change conference

6. The Columbia Mountains Institute is always looking for suggestions for courses and workshops. Our niche is providing continuing education for ecologists, resource managers, foresters, biologists, and educators. We offer skill upgrading and workshops that address current ecological issues. Do you have suggestions for events or courses you'd like to see us organize?

- Hands-on restoration courses
- Wetland restoration (3)
- General ecological restoration (2 people)
- Sediment and erosion control workshop (2)
- Wetlands classification (5)
- Plant identification for difficult taxa (2)
- Statistics for community-level analyses
- Course on use of Climate BC software along with review of different global circulation models
- A conference devoted to solutions to environmental problems through community education, case studies on issues ranging from riparian removal to wetland impacts, impacts from urban growth, and recreation. All the human-related perspectives
- Keep having stats for biologists courses
- More on invasive species management
- Nest box program development and implementation
- Identification of aquatic invasive plants
- The value of long-term datasets
- Adaptive management: retrospective on earlier projects that included this, has it worked and why
- Riparian enhancement course
- How to reach out to policy makers
- Occupancy modelling
- How to set up an Access database for a long-term biological study
- Project management
- Consequences of independent power projects
- Use of prescribed burns in ecosystem restoration

7. In your opinion, what are the biggest threats to environmental integrity in British Columbia? and specifically in southeastern BC? Your opinions will guide us in putting our efforts where they are most needed.

- Habitat alienation
- Habitat fragmentation, landscape integrity (3 people)
- Urban/suburban development, and lack of planning for this (5 people)
- Uncontrolled growth in human use and development, residential development (4 people)
- Lack of landscape-level planning
- Giant infrastructure projects
- Anti-planning sentiments prevent policy development
- Directors in some regional districts need to be better educated
- Lack of ecological understanding by decision makers
- Development does not consider ecological issues, usually just economic issues. Need sustainable development (for environment) (2 people)
- Loss of habitat, and fragmentation, due to development (2 people)
- Apathy of general public
- Need to engage disinterested stakeholders, e.g., mud boggers, high school students, tourists
- Biggest threat is our human resistance to change (3 people)
- Natural resources extraction
- Climate change (6 people)
- Climate change adaptation
- Climate change and the interlinked social and ecological dimensions
- Energy development
- Unintended consequences of being green—transmission lines from power projects, issues with wind generators, etc. (3 people)
- No federal or provincial laws protecting wetlands
- Transportation corridors
- BC's lack of wetland policy and compensation/mitigation planning. Learn from Alberta
- Definition for what is a "healthy" wetland
- Certification is needed for restoration practitioners
- Invasive species (6 people)
- Reduction in ecosystem resilience
- Planning based on the past rather than adapting our expectations for the future
- Poor management of wild spaces
- Mitigation of recreational impacts of all terrain vehicles, 4x4 users, etc.

- People don’t act until a species is at risk .We fail to address the larger ecological framework
- Pollution
- Backcountry access
- ATVs and associated disturbance
- Human encroachment into undisturbed areas
- Conflicting ideas for conservation
- Lack of policy