COLUMBIA MOUNTAINS INSTITUTE OF APPLIED ECOLOGY

Ecology of the Columbia River Reservoirs
Revelstoke BC
May 9-10, 2000

The Columbia Mountains Institute of Applied Ecology (CMI) hosted this educational workshop about reservoir ecology. The workshop was attended by resource management professionals and residents of the Columbia Basin with a broad interest in fish and wildlife issues associated with this changing system. Presentations focused on key differences between the former natural riverine system and the current system of reservoirs now comprising much of the Columbia River. Overviews of ongoing and potential rehabilitation projects were also presented.

The first day of the workshop consisted of presentations at the Revelstoke Community Centre and a keynote speaker presentation in the evening. The second day included a choice of field trips: to the Columbia River Flats (near the Revelstoke airport) to hear about BC Hydro's revegetation program and the bird migration monitoring station; a tour of the revegetation work at the Illecillewaet Greenbelt; a tour of the Revelstoke Dam; or a canoe trip.

The Columbia Mountains Institute CMI) would like to thank Fisheries Renewal BC, through the Columbia-Kootenay Fisheries Renewal Partnership, for their financial assistance in hosting this workshop.

The CMI is are also grateful to our other workshop sponsors for their financial and in-kind support: Columbia Power Corporation, Sustainable Fisheries Foundation, the Columbia Basin Trust through the Affected Areas and Communities Initiatives, Parks Canada, and the Columbia Basin Fish and Wildlife Compensation Program.

List of Presentations

Speakers are listed in the order of presentation. Some speakers did not prepare summaries. For more information please call the speakers directly at the contact information provided.

The Value of the Columbia River to First Nations

(No summary provided)

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Big River Ecology

Jack Stanford, University of Montana

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To review Dr. Stanford's work on this topic:
Go to the web site for the University of Montana's Flathead Lake Biological Station and choose "Research".

http://www.umt.edu/biology/flbs/

Dr. Stanford gave a citation for his work during his talk. The citation was: Stanford *et al* 1996, "A General Protocol for restoration of regulated rivers" , published in the journal *Regulated Rivers.*

Also see the entire issue of the November 1998 *Freshwater Biology*, Stanford and Gonser (editors).

Sinixt Nation Perspective on the Columbia River

(No summary available)

Marilyn James, Sinixt Nation

Marilyn referenced the following books as essential reading:

Keeping the Lakes' Way: Reburial and Re-Creation of a Moral World Among an Invisible People (note chapter three in this book) by Paula Pryce, published by University Of Toronto Press, 1999

A River Lost – Life and Death of the Columbia River by Blain Harden, published by WW Norton Company NY, 1996

Cottonwood Floodplain Ecology - Current Status and Restoration Options

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Floodplain ecosystems, dominated by Black Cottonwood, historically were much more extensive in the upper Columbia Basin than they are today. These ecosystems have been heavily impacted by impoundment, flow regulation, cattle grazing, clearing for agriculture and human settlement.

The talk gave an overview of riparian cottonwood ecology in the Basin and identified the critical ecological functions within these systems. We also provided an overview of the values, for both fish and wildlife, associated with these ecosystems.

The recruitment strategy of black cottonwood is based on the release of very large numbers of very small seeds with minimal resources for initial establishment and growth. They therefore require a moist seeding environment. This environment is provided by point bars along major rivers as the spring

freshette recedes. As a result, Black Cottonwood depends on the spring freshette to provide conditions for recruitment of new seedlings. Where freshette no longer occurs due to the presence of dams and flow regulation on the system, recruitment is curtailed. Mary Louise Polzin, in recent work on the Kootenay River, found abundant cottonwood recruitment in 1996 and 1997, producing mean seedling densities of 536, and 142 seedlings/m^2 along the Upper Kootenay and Fisher Rivers. Both of these are free-flowing rivers. In marked contrast, no seedlings were established on similar sites along the Lower Kootenay River, downstream from the Libby Dam.

Flow regulation is a major factor affecting the long term survival of these ecosystems, as the life history and ecology of cottonwoods and other riverine organisms are dependent upon dynamic flow regimes. In other jurisdictions, work is now underway using artificial flow releases to mimic natural conditions and allow recruitment of cottonwoods along river reaches below dams. These naturalized flows have been also shown to benefit critical fish and wildlife species with minimal economic cost to dam operators since recruitment flows are not necessary in all years but can be provided during high snowpack years.

We are undertaking a study of riparian ecosystems in the Columbia Basin, focusing initially on the Upper Kootenay (above Kootenay Lake) and Yakima drainages. Funding has been provided by Bonneville Power Administration to work in both the Canadian and American portions of the Basin with the long term objective of:

- documenting the status of these systems throughout the Basin,
- documenting the need for management concern directed at these systems and;
- identifying practical alternatives for maintaining these systems in a 100-200 year time horizon, primarily through modified flow regimes.

This work is being carried out by an international team with expertise from four Universities (3 American and 1 Canadian), in partnership with several related projects concerned with related riparian and stream flow issues.

IN THE PRESENTATION WE ATTEMPTED TO ANSWER THE FOLLOWING QUESTIONS:

WHAT ARE FLOODPLAIN RIPARIAN ECOSYSTEMS?

Riparian floodplain areas dominated by deciduous trees, are a unique and important ecosystem. We haven't spent much time thinking about them, since we don't harvest timber in these systems. In the East Kootenay floodplain deciduous ecosystems are dominated by black cottonwood, aspen, birch, hawthorn and river alder; with a white spruce and Douglas fir component in some areas. These areas are in permanent dis-climax due to channel changes and annual flooding.

They are a dominant feature in Rocky Mtn Trench on the Upper Columbia and Upper Kootenay. They are less obvious in the West Kootenays due to topography and reservoir flooding. In the American portion of the Basin cottonwood stands are often the only large tree type found along rivers in the drier portions of the Basin.

WHAT IS THE ROLE OF BLACK COTTONWOOD IN THESE ECOSYSTEMS?

Cottonwoods are a dominant feature critical to fish and wildlife in these areas. They are large and are generally located right on the river bank. They can survive flooding for 1-2 months. They provide a range of ecological services that are critical to riverine and riparian health.

WHY DO NEED TO BE CONCERNED ABOUT THESE ECOSYSTEMS?

Native cottonwoods provide critical habitat and support high levels of biodiversity within riparian corridors (Finch and Ruggerro 1993, Dunstone and Gorman 1998, Whitham et al. 1996). They enhance the quality of aquatic habitats by moderating water temperatures (Debano and Schmidt 1990), and supplying carbon, nutrients and large woody debris that provide habitat and sustenance for a variety of instream and streamside invertebrates important to fish diets. Cottonwood forests are commonly associated with major salmon spawning redds, while also providing important habitat for resident and migrating songbirds (Martinsen and Whitham 1994, Whitham et al. 1996). Recent research by the Canadian Wildlife Service and others have found that these habitats are critical for songbirds as resting and feeding areas during migration (R. Millikin, pers. comm.). The Pileated woodpecker is an important cavity excavator in these systems (Ohanjanian 1991), using large black cottonwood trees and snags for nesting. Their abandoned cavities are used by other cavity-nesters, such as waterfowl (wood ducks, mergansers, golden eye), flying squirrels and several species of bats (Dunstone and Gorman 1998). These systems are also important for otter, beaver, ruffed grouse, great blue heron (rookery sites), osprey, owls, bald eagle, golden eagle and peregrine falcon during migration.

Riparian cottonwood ecosystems also play an important role in the structure and function of riverine habitats. Quigley and Arbelbide (1997) among others have noted that riparian cottonwoods:
1. Dissipate stream energy associated with peak flows, stabilize riverbanks, reduce erosion and improve water quality (Debano and Schmidt 1990, Strahler and Strahler 1973);
2. Filter sediment, capture bedload and promote floodplain development;
3. Improve flood water retention and groundwater recharge,
4. Provide shade and reduce water temperatures which benefit a wide range of resident and anadromous fish (Debano and Schmidt 1990).

5. Promote a diverse mosaic of ponds and river channel habitats that are necessary for fish production, waterfowl breeding and other wildlife uses, and
6. Support higher levels of biodiversity than streamside conifers (Naiman et al. 1992, Whitham et al. 1996).

These systems provide complexity, flowing and standing water, dead wood and cavities in productive, low elevation habitats that are moist through much of the year. As a result, extensive biological processes occurs which generates, among other things, extensive insect live through much of the spring, summer and fall seasons.

WHAT ARE THE RISKS TO THESE SYSTEMS AS A RESULT OF HUMAN ACTIVITY?

The major factors are:
1. Major flow regulating dams
2. Settlement
3. Agricultural use
4. Grazing
5. Water removals
6. Dyking
7. Evasive plants
8. Beaver activity
9. Harvest for Timber

We did not go into these issues in detail due to time limitations.

WHAT IS THE DEGREE OF RISK TO THESE ECOSYSTEMS AS A RESULT OF HUMAN ACTIVITY?

Several studies from across western North America have revealed the steady decline of extent and health of riparian cottonwood ecosystems (Rood and Mahoney 1990; Bradley et al. 1991, Braatne et al. 1996, Mahoney 1996). The primary causes of these declines have been woodland clearing and impacts due to water diversions and damming (Braatne et al. 1996). Research has shown that declines in riparian cottonwoods are caused primarily by the suppression of seedling recruitment. Since cottonwoods are a relatively short-lived tree (100-200 years), declines in recruitment over the past century have lead to the widespread loss of riparian cottonwood ecosystems.

A major review of riparian ecosystems within the Interior Columbia Basin was recently completed by Manning and his colleagues (1998) that concludes … that “flooding disturbance has been virtually eliminated" … that “mid-seral stages have increased substantially". Further, the "….lack of recruitment by early seral riparian species and the senescence of larger, old trees in late seral riparian

woodlands" were emphasized as a significant long-term problem requiring systematic evaluation.

As a result, riparian ecosystems have been identified as a high priority in the 1994 Columbia Basin Fish and Wildlife Program (US side).

Riparian cottonwoods represent one of the most critical ecosystems affected by dam construction and operation within the Canadian portion of the Columbia Basin (Jamieson and Ohanjanian 1995, Cooley and Jamieson 1997). These ecosystems support important ecological components that have not received the level of management concern that would be suggested by their rarity, degree of risk and their importance to ecosystem function in relation to both terrestrial and aquatic resources. Black Cottonwood systems have been identified as being of concern under Forest Practices Code in BC and are included in regional and provincial lists of habitat types at risk.

WHY IS RECRUITMENT NOT OCCURRING?

The recruitment strategy of black cottonwood is based on the release of very large numbers of very small seeds with minimal resources for initial establishment and growth. They therefore require a moist seeding environment with minimal competition. This environment is provided by point bars along major rivers as the spring freshette recedes. As a result, black cottonwood depends on the spring freshette to provide conditions for recruitment of new seedlings.

Where freshette no longer occurs due to the presence of dams and flow regulation on the system, recruitment is curtailed. Mary Louise Polzin, in recent work on the Kootenay River, found abundant cottonwood recruitment in 1996 and 1997, producing mean seedling densities of 536, and 142 seedlings/m^2 along the Upper Kootenay and Fisher Rivers. Both of these are free-flowing rivers. In marked contrast, no seedlings were established on similar sites along the Lower Kootenay River, downstream from the Libby Dam. This means that the stands of large cottonwood one sees at Creston, and other areas below large, flow regulating dams are likely at long term risk since no recruitment is occurring.

In the presentation we provided a slide of the "recruitment box" which is a description of the flow pattern required for successful cottonwood seedling establishment. High water levels flood the recruitment sites on point bars and then, as the waters recede, they leave a moist seeding environment. After germination on these nursery sites, the roots of young seedlings must also keep pace with declining river levels (root growth averages 1.5 cm per day); Mahoney and Rood 1991, 1992, 1998, Selgelquist et al. 1993, Johnson 1994, Rood et al. 1995). If river levels decline too rapidly, young seedlings rapidly succumb to drought stress.

A further problem is created where dams reduce summer baseflows and induce significant levels of drought stress among all age-classes, and thereby promote a decadent age- structure among local populations (Fenner et al. 1985, Bradley and Smith 1986, Rood and Mahoney 1990, Stomberg and Patten 1991, Scott et al. 1996). These older and larger cottonwood trees are also dependent on periodic flooding and recharging of the alluvial water table (Johnson and Jones 1977; Rood and Heinze-Milne 1989; Rood and Mahoney 1990; Snyder and Miller 1991; Stromberg and Patten 1992).

RESTORATION: WHAT CAN WE DO?

In recent years, researchers have successfully applied their knowledge of the life history and ecology of cottonwoods to promote natural patterns of recruitment below dams on several western rivers (Rood and Gourley 1996, Rood and Kalischuk 1998). In these cases, high water volumes available during "wet years" were released in a manner that was compatible with seed dispersal and establishment of cottonwood seedlings. These practices are now widely accepted and promoted by resource managers in Alberta (Mahoney 1997) and Nevada (Rood and Gourley 1996). Actual recruitment has been documented on the Truckee River as a result of these practices.

WHERE DO WE NEED TO CONSIDER RESTORATION WORK?

In the Canadian portion of the Basin this is a concern in the Revelstoke area below Revelstoke dam, in the Castlegar/Trail area, below Duncan dam and in the Creston area. There are much larger areas potentially at risk on the US side of the Kootenay River and in several other rivers in the Lower Columbia. Stands in the Creston Valley Wildlife Management Area are critical, as they are in the other areas mentioned. The retention and management of cottonwood stands on the free-flowing sections of the Columbia and Upper Kootenay are also important concerns.

WHAT IS THE NATURE OF THE STUDY PRESENTLY UNDERWAY?

We are involved in a major international study of this issue. The study is being lead by Bob Jamieson on the Canadian side and Dr. Jeff Braatne on the US side. We have established an Overview Committee to guide the project, made up of world class experts on riparian issues. Members of this committee are Dr. Jack Stanford, Dr. Stu Rood and Dr. Mike Mergliano. The field crew that will do field inventory of cottonwood stands is made up of Greg Allen, Dr. Clint Smyth, Mary Louise Polzin and students from the University of Lethbridge.

The objectives of the study are:

OBJECTIVE 1: Document the pre-dam status of riparian cottonwood stands in the Upper Kootenay and Yakima sub-basins.

OBJECTIVE 2: Document the present distribution (circa 1995) and status of riparian cottonwood stands in the Upper Kootenay and Yakima sub-basins.

OBJECTIVE 3: Test satellite data options for applicability for extrapolating from sample reaches to entire Upper Kootenay and Yakima sub-basins.

OBJECTIVE 4: Document stand health and recruitment to riparian cottonwood stands in the Upper Kootenay and Yakima sub-basins.

OBJECTIVE 5: Document the present flow regime in the Upper Kootenay and Yakima sub-basins.

OBJECTIVE 6: Document flow management options for maintaining riparian habitats in the Upper Kootenay and Yakima sub-basins.

OBJECTIVE 7: Document other management options for maintaining riparian habitats in the Upper Kootenay and Yakima sub-basins.

OBJECTIVE 8: Provide an overview of this issue and restoration options for the entire Columbia Basin, Canadian and US portions.

The project will be accomplished through partnerships with:
Bonneville Power Administration and Northwest Power Planning Council
Yakima Reaches Project
Flathead Lake Biological Station
University of Lethbridge, AB
University of Montana, Missoula
University of Washington, Seattle

The Ktunaxa Tribal Council will also be involved through data sharing and data processing through Eagle Vision Ltd.

We will also work with related projects that include:

Surgeon restoration programs on the Yakima River
Salmon restoration programs on the Yakima River
A Univeristy of Oregon project on riparian process and salmon
The Upper Kootenay Landowners' Riparian Stewardship Group.

A more detailed description of the project is available through Bob Jamieson at bjamieson@cintek.com (250-422-3322)

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All the literature cited in our project proposal is provided below as a potential resource for those attending the workshop.

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Wildlife and Reservoirs in the Kootenay Region-Past-Present and Future

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COLUMBIA BASIN PAST: THE WILDLIFE INVENTORIES

Impounding streams and rivers for hydroelectric power generation is a Twentieth Century phenomenon. The first registered power dam in British Columbia was built in 1903 on Trout Creek in North Vancouver. At first, dams for power or water storage were small and located adjacent to the area of need. By 1951, there were only sixty-one registered dams in the province. By 1961 the number had increased by twenty-one, with a tenfold increase in capacity from 6.5 billion cubic meters of water to 66 billion cubic meters. Over the next twenty years the number of dams increased to one hundred and three with an overall storage capacity of 177 billion cubic meters covering some 426,000 hectares of valley bottom and riparian habitat within British Columbia. (Demarchi and Demarchi (1987).

During the late 1960s and early 1970s British Columbia's Omineca and Kootenay Regions were subjected to major perturbations resulting from massive hydroelectric impoundments. Land conversion from one form of use to another such as old growth forest to plantation forest results in changes to ecosystem functions, which in turn affects wildlife populations. Urban, industrial and agricultural conversions of natural habitats lead to losses and changes in wildlife populations varying from partial to total. Few modern land use practices including urbanization and transportation result in habitat losses as severe as those caused by hydroelectric impoundments.

Major alterations of ecosystems on a regional scale usually occur in time measured on the geological scale- occurring gradually over centuries or millennia. Yet in a brief interval of barely a decade, destruction of ecosystems occurred in the Kootenays, the likes of which had not been witnessed since the onset of the last ice age.

(Note: I define a lake as a body of water that fluctuates in elevation within a natural range. This includes artificially controlled water regimes that do not prevent the establishment of perennial riparian vegetation, such as Kootenay Lake. I use the terms reservoir or impoundment as a body of water that is caused by man to fluctuate in elevation outside of its natural range. Such features are exclusively artificially controlled and usually result in the destruction of all perennial vegetation within the drawdown zone.)

Demarchi and Demarchi (1987) describe the effects of hydroelectric reservoir impoundments on fish and wildlife resources as follows:

> "The impounding of a stream or river has a great impact on the movement of riverine fishes, especially adandromous fish. The dams are barriers to fish moving upstream, and fry moving downstream are often sucked through the turbines to die. The impacts on terrestrial wildlife may not be so dramatic, except when a reservoir blocks a migration route, and the animals try to cross, then drown. The direct impact on wildlife is the loss of critical habitat. The lower valley slopes, terraces and floodplains are the most productive forage-producing areas within our mountainous province, they are often the most snowfree in a valley system; yet those are the places that may be flooded. The direct influence of the a dam on a river is not confined to the reservoir; the downstream flood regime is also greatly altered."

The conditional water licenses issued for Duncan, Arrow and Mica all contained provisions that allowed the provincial water comptroller to order studies to measure the impacts of the impoundments on fish and wildlife and to develop mitigative measures to compensate for these impacts. These clauses, known as provisional water license clauses "N" and "O" were not included in the Libby Reservoir agreement. This project was included in the Columbia Treaty but because the dam was built in the US it did not come under the mandate of BC Hydro. The province formed the Libby Preparation Committee that included exclusively, provincial government agencies such as the Ministry of Forests, Fish and Wildlife Branch, Water Rights Branch and the Ministry of Highways with direct responsibility for land use in the British Columbia portion of the Libby Reservoir. The Kootenay Canal, Revelstoke, and Pend d' Orielle dams were strictly in-province BC Hydro projects and each was treated as a separate project.

Fish and Wildlife studies were based primarily on reconnaissance level field inventories. Studies were directed almost exclusively at game species and furbearers although brief mention was made of other vertebrates, which were categorized, as "non-game" in a sort of "important/non-so-important" hierarchy of species. Although the term biological diversity had been coined by at least one

Canadian biologist at the time (i.e. the late Douglas Pimlot) the concept had not yet been developed let alone applied and no attempts were made to quantify overall biological diversity. Had we had the same level of understanding of ecosystem function then as we do now, the entire approach towards quantifying environmental impacts would have been different. This is not to imply that all of the dams we see today would not have been built. However, the catalogue listing the environmental losses would have been a lot more comprehensive and thinking idealistically, perhaps some of the projects would have been significantly modified. At the very least, the form and size of any compensation packages would certainly have been different than they are today.

The following briefly describes the procedure followed in assessing wildlife losses in the Mica, Arrow and Duncan dam areas-of influence. Peterson and Withler (1965) describe their pre-flood field survey of the Mica dam area-of-influence as follows:

> "Investigations of wildlife resources were largely confined to exploration of habitat and counting of big game animals and waterfowl. Upland game birds and fur bearers were casually investigated. A helicopter was used for much of the survey because of the large size and remote location of the drainage area. "

Lists of species' numbers, which were expected to be impacted, were developed and debated by the Fish and Wildlife staff biologists. There was no statistical validation of their accuracy and estimates were based largely on the experience of the individuals conducting the surveys.

In the Libby (Smith 1969) and Pend d' Oreille Basins (Woods, 1984) estimates of impacted wild ungulate populations were made by extrapolating numbers seen during aerial winter surveys. An attempt was also made to improve population estimates in the Mica area-of-influence by Peterson and Withler (1965) utilizing the Canada Land Inventory Ungulate Capability ratings (Farquharson, 1974). This same technique was also utilized in determining estimates of wild ungulate populations impacted in the Arrow Basin. Supplemental aerial winter counts were also utilized to improve population estimates, particularly in the Libby and Pend d' Orielle reservoir areas-of-influence. Most of this work was done immediately preceding or during clearing and flooding of the reservoirs.

In some cases, pre-flooding land clearing activities greatly influenced wildlife population estimates. The best example of this was white-tailed deer which were attracted by availability of forage in the form of freshly fallen cottonwood trees in the Libby Basin. The only project, which involved both pre- and post-flooding population estimation attempts, was for white-tailed deer in the Pend d' Oreille, which sustained the least amount of habitat loss of all of the large projects.

Once the numbers of game animals lost were agreed to and depending on the project or the particular government in office, estimates were made of the economic worth of the predicted wildlife losses. As these were mainly game or furbearer species, estimates of net worth were based on projected losses in the economic value of hunting and trapping. Guides were left to their own initiative and some individuals negotiated directly with BC Hydro for compensation (B. Dean, pers. comm.). A separate program to compensate trappers was carried out by BC Hydro with each of the registered trap line holders affected.

Various compensation funds were established including a fund under the Libby Preparation Committee that served for about 20 years as the Libby Wildlife Compensation Fund. Initially, BC Hydro seemed reluctant to admit that they were paying compensation and initially no formal process was developed. Various projects such as Kootenay Lake fertilization, the Meadow Creek kokanee spawning channel and parts of the Creston Valley Wildlife Management Area were all developed in cooperation in one form or another with BC Hydro. Once the Columbia Treaty dams were constructed, and new projects were initiated separate compensation fund packages were created including the Pend d' Oreille and Arrow Basin compensation agreements.

COLUMBIA BASIN PRESENT: MISSING IN ACTION

Except for imprecise estimates of game species or other species of commercial value, wildlife species population losses in the Columbia Basin as a result of hydroelectric reservoir flooding remain largely unknown. The current situation is one where the most productive riparian ecosystems have been displaced by largely unproductive reservoir draw-down zones and cold water reservoirs, including in the winter months, an extensive and hazardous ice cover. Wildlife losses were major and should be considered significant in terms of social, cultural and economic value. Current compensation funds are based on incomplete and likely underestimated wildlife losses.

COLUMBIA BASIN FUTURE: TOWARD A COMPLETE ACCOUNTING

For all practical purposes, the accuracy of the numerical estimates for most of the impacted species, which have been considered and reported in provincial government documents, could be considered adequate. New habitat mapping techniques developed for grizzly bears and black bears could be utilized to improve the estimates, however. Additionally and perhaps more importantly, the list of species lost should be expanded and an ecosystem approach should be taken to assess overall losses to biological diversity.

New habitat inventory techniques developed by the Ministry of Environment's Resources Inventory Branch now make it possible to describe and quantify wildlife habitats lost to hydroelectric development. Once the habitat, which

formerly existed, is described and quantified, wildlife population estimates can be more accurately derived.

The technique for reassessing wildlife losses in the Columbia Basin is referred to as “backcasting”. It is a relatively new procedure based on the same mapping techniques employed in the Ministry’s Terrestrial Ecosystem Mapping (TEM) process (Ecosystems Working Group, 1995). By utilizing pre-flooding aerial photographs and BC Forest Service forest cover maps plus Columbia Basin topographical maps and applying the TEM procedure it is feasible that pre-flood habitat capability maps could be prepared for a large number of species, mainly those which still exist in the remaining habitats adjacent to the existing reservoirs. Because most of the riparian areas lost due to flooding were in a pristine or at least, largely unaltered condition, capability should reflect suitability, eliminating one major step in the mapping procedure. Using these new species lists and where possible, revised population estimates, conventional non-market economics can be applied to calculate a more realistic estimated economic value of the lost habitat and wildlife populations in the Columbia Basin. This same habitat information may then be interpreted by First Nations to determine the basis for their social, cultural and economic losses as well.

CONCLUSION

Original attempts to assess wildlife population losses in the hydroelectric reservoir impoundments in the Columbia Basin of the Kootenay Region of British Columbia were incomplete and occurred mainly at the reconnaissance level. Few attempts were made to assess habitat losses. Increased public awareness and concern for the environment coupled with public ownership of resources should motivate BC Hydro and the Provincial and Federal governments to re-inventory wildlife population and habitat losses which incurred in the past.

Providing that pre-flood aerial photographs are still available, new mapping techniques make it possible to obtain a more comprehensive and accurate assessment of wildlife species and habitat losses. Only in this way can the public be brought to more fully understand both the benefits and the costs of hydroelectric development and only in this way can ecologically, economically and socially relevant compensation programs be developed.

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Operational Regime of the Columbia River

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The Columbia River Treaty is an agreement between Canada and the United States on the coordinated operation of the Columbia River, and included the development of additional water storage and hydroelectric projects in Canada and the United States. The agreement was developed and formalized in the

early 1960's (1961, 1964) and is limited to optimizing the electrical power and flood control benefits. The environmental issues were left to each of the parties to deal with on their own. This limitation of the Treaty was a reflection of the social and economic values at that time, which are very different from the values now.

BCHydro, as the operator of the Canadian Treaty projects (Duncan, Mica, Arrow) must therefore manage the issue of Treaty commitments limited to optimizing the electrical power and flood control benefits, and a lack of Treaty recognition of environmental and other objectives. This issue is one that the United States Entity must also manage.

Hope is not lost however, since it is possible within the context of the Treaty to include environmental objectives, provided the Treaty Entities can agree. This has been done through Treaty detailed operating agreements, and is possible to continue to do in the future, but it requires a great amount of cooperation among the parties within each country, and with parties across the border. The Treaty infrastructure has traditionally provided this capability by focusing on a sharing of mutual benefits.

Biological Implications of the Current Operational Regime - Management Options

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Challenge of Managing Fisheries in the Columbia River

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Ecology and Genetics of Wild Fish and Their Interaction with Hatcheries

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Wild fishes become adapted to their local environments both genetically and developmentally and research during the past two decades has shown that even neighbouring streams can have, for example, genetically differentiated populations of the same species. Hatchery programs largely ignore genetic differentiation and adaptation of populations and create their own forces of selection which radically alter the fish released. The consequence has been that hatchery fish are both maladapted for the native environment and also impact negatively on wild populations. It is therefore extremely important to match the production of hatchery fish with the goal of the program, be it conservation, supplementation, or the introduction of novel fish species for harvest. I will discuss how populations become differentiated, why hatchery fish become maladapted for nature, and the kinds of techniques that can be used to improve the use of hatcheries for the various programs that may be of interest to you.

Fertilization as a Mitigation Option for Nutrient Depletion

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Two large water bodies within the Columbia River basin (Kootenay Lake and Arrow Reservoir) have experienced a series of major perturbations during the past 50 years that has resulted in the collapse of several native species of fish.

The kokanee collapse in Kootenay Lake was a product of dam construction in Canada (Duncan) and the US (Libby) together with subsequent impoundment and nutrient retention on both main inflow tributaries to Kootenay Lake (Duncan River into the North Arm and Kootenai River into the South Arm), and the introduction of an exotic mysid shrimp (Mysis relicta) which is an efficient competitor with kokanee for zooplankton. In addition, a large number of kokanee and a unique strain of trophy rainbow trout "The Duncan strain" were eliminated by the construction of the Duncan Dam.

The kokanee collapse in Arrow Reservoir was a product of extensive dam construction (Mica, Revelstoke, and Keenleyside), large seasonal drawdowns (up to 21 m) for hydropower generation and introduction of mysid shrimp. In addition, bull trout, rainbow trout, sturgeon and other fish species were negatively influenced by the combination of dam construction, reservoir operation and mysid introduction. Following the recommendations of a modeling workshop at UBC in 1991, the seasonal application of low concentrations of limiting nutrients has been experimentally tested on Kootenay Lake and now Arrow Reservoir in an attempt to restore reservoir productivity and rebuild native fish stocks. To date, the experimental fertilization program on Kootenay Lake has been effective at rebuilding native stocks, and the results from the first year (1999) of the Arrow Reservoir fertilization program are encouraging.

Citation: Ashley, K., L.C. Thompson, D. Sebastian, D.C. Lasenby, K.E. Smokorowski and H. Andrusak. 1999. Restoration of kokanee salmon in Kootenay Lake, a large intermontane lake, by controlled seasonal additions of nutrients. pp. 127-170. In: Aquatic Restoration in Canada. T. Murphy and M. Munawar (eds.). Ecovision Wold Monogaph Series, Backhuys Publishers, Leiden, Netherlands.

Ecological Benefits of Reservoir Drawdown Zone Revegetation

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Severe dust storms in Revelstoke originating from the reservoir bottom exposed during twenty metre drawdowns in the Upper Arrow Reservoir resulted in a dust control program. The long-term revegetation program in the drawdown zone of the Revelstoke Reach of Upper Arrow Reservoir has controlled the dust, and also has resulted in unplanned benefits to wildlife, fish, and recreational users of

the area. Many of these benefits are immediately obvious to even casual observers (e.g., bird activity, increased angling effort). A study was initiated in 1999 to evaluate the effects of shoreline revegetation on aquatic productivity in Upper Arrow Reservoir. A multidisciplinary team was assembled to define the study, undertake a literature review, develop a conceptual model, and undertake the required field studies. While the original focus of the study was on aquatic productivity, our intent is to expand the study in 2000 and 2001 to include benefits to the riparian and terrestrial ecosystems adjacent to the reservoir (i.e., benefits to wildlife and recreational users).

Living in the Aftermath of the Dams

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"The nice thing about apathy is that you don't have to do anything to prove you're sincere about it."

Many have been the ecological surprises emerging in the aftermath of big dams. You have heard a diverse set of presentations on that topic today. I commend you for your interest and congratulate the presenters for their articulate and informative deliveries. I now ask that you (and they) expand your collective horizons so as to include equal appreciation of the social and economic aspects of dam-building. It is my belief that these are equally as important as environmental or ecological concerns. Neglecting to include a social commentator in plenary session left two thirds of the dam aftermath story untold. That is about to change.

Here in the Kootenays we learned that the immediate consequences of various dam projects were in a way less disturbing than those that emerged more recently. Perhaps that is because the early ones were more predictable; less insidious. The ecological consequences that emerged later were gradual, inexorable and worse, *cumulative*. It is thirty years since we built the last big dam in BC and yet, negative environmental impacts continue to appear. As you will see from the film, drastic social inequity and economic uncertainty followed the dam-building binge of the sixties and seventies.

Today you have heard how live rivers distribute nutrients along their various reaches as regulated by the seasons and the weathers. The behavior of natural rivers is a marvelous process and one that seems to become evermore wonderful the more rivers we find it necessary to destroy. I admit to personal bias here. I have never met a river that I didn't like.

And just for the record: my long association with this story has made it possible for me to observe the operations of BC Hydro. That body came into being at the same time as the Treaty. The BC Hydro of thirty years ago was quite single use in its approach to things. It has developed a conscience over the years. And the people who work in its land use or environmental sections are listening to the call for better fish and wildlife management and responding. It feels good.

Dams trap nutrients in the upstream reservoirs. Enrichment of the receiving water bodies is diminished and declining fish numbers (and size) are manifestations of that. Because the Kootenay River is dammed (upstream) near Libby, Montana, adding fertilizer to Kootenay Lake (downstream) has become required.

Within the last few years, researchers in both the US and Canada found that containment of spring run-off behind the Libby Dam has greatly reduced the flows normally associated with spring. It so happens that sturgeon spawning is timed to coincide with those large flows and when they don't happen the big fish reabsorb their eggs and "that's it" for spawning. Of course the river moves the same amount of water it always did but it is at the wrong time of year. The result of this unnatural timing of flows is declining sturgeon numbers, lack of population recruitment, and banshee representation in age classes.

Sturgeon may live for more than century but it is the small and juvenile fishes, most lacking in the system. Remember, it is about thirty years since Libby Dam was built. Lo and behold, very few Kootenay Lake sturgeon are less than thirty years old. Recruitment is nominal to say the least. The US and Canadian power corporations, fisheries agencies in the US and Canada and native Indians of both nationalities are cooperating on a program to try and recover sturgeon populations in the Kootenay River basin. No international treaties, no trips to the White House. They just went ahead and did it. At the Libby Dam, they are now experimenting with changes in flow regulation to try and provide better conditions for sturgeon spawning.

Black cottonwood is a species that loves bottomland habitat. As some of you heard from Bob Jamieson this morning, he has learned that reproduction of black cottonwood is also linked to the timing of spring freshet. The black cottonwood and the aspen are both members of the willow family. In an earlier life, I referred to the young of the black cottonwoods as poplars, believing them to be two different species. Wrong again.

I wish people would stop using the “S” word, sustainability, at least until they learn what it means. According to the Brundtland Commission Report (compiled by the United Nations Commission on Environment and Development) we move closer to sustainability as we reach equilibrium between the requirements of environment, economy and social justice. On that last point we ain’t even started yet.

The Brundtland Commission defined sustainability as “that which meets the needs of the present without compromising the ability of future generations to meet their own needs”. Like others, I have a problem with that word “needs”.

People don’t need to go to Maui every year although I think everyone should go at least once. Once is enough to learn what happens to the social structure of a community in which tourism is basically the only resource. Hawaiians have no coal, no minerals, no petroleum, next to no wildlife, next to no agriculture and no forestry. The environment is deteriorating under a crush of people. The social gap between wealthy and poor is ever widening. It is made worse because the poverty split is also divided along racial lines. The resident poor are largely descended from natives. The middle class is almost non-existent. I’m NOT talking about British Columbia, am I?

In the Columbia Basin within Canada, we brought about sweeping environmental changes but the social impacts were just as devastating. The people affected were made to feel they stood in the path of a development the rest of the country wanted. The majority of the population felt that the benefits were worth the price. But the people who got the benefits were not ones who paid.

I gotta say it. One of the reasons I came up here is that I think it is happening again. The changing of our economy from resource oriented to service or high-tech oriented is causing massive disruption in rural communities. Once again, a generation of rural residents is being swept aside. We are witnessing a reinstatement of the class system. Resource extraction is resisted, whether by loggers, guides ranchers miners trappers etc. and seen as primitive, unsophisticated, undesirable -- and we should do the smart thing and go for high tech. Well first of all, resource management and extraction are all high tech. Look at satellite communications, GPS, DNA sampling, genetic fingerprinting and on.

I actually wanted to use the story of Revelstoke’s journey from boomtown to self-reliance as a theme for this presentation. The conference organizers wanted some of the Treaty history instead but I felt it would be wrong not to mention that the people of Revelstoke have gotten more deeply involved with resource extraction and are catering to eco-tourists, doing intensive forestry and high tech value-added.

Is the Revelstoke response perfect? Of course not. Has Revelstoke achieved sustainable development or "sustainability"? Forgive the pun, but not by a damsite. The people of Revelstoke are moving "toward sustainability". No flag waving or illegal blockades. Theirs is an attitude of calm. They already know that sustainability is not a destination; it is a direction. They are on their feet. Moving.

I have been covering the Columbia Treaty story for almost forty years. In the fall of 1964, when Lyndon Johnson signed that big cheque at Blaine, Washington I was there. Things are working out a lot better than I thought they would. The fertilization of Kootenay Lake is working. After nearly two cycles, run size is up at Meadow Creek where most of the kokanee spawn, and also at Gerrard where the big rainbow spawn.

It's too early to gauge the success of Upper Arrow fertilization. But already I've heard skeptics deriding the plan. What a surprise! "It costs too much". " We've never done it before". It reminds me of Hemingway who said that criticizing people for taking too many risks is nearly always done by people who never take any risks at all.

The Columbia River Trust remains a controversial body. And as it grows, it seems to be assuming some of the characteristics of a government agency; hard to reach, slow to react; perhaps I could use the word "ponderous". But the list of accomplishments is growing. Things we used to dream might happen are taking place. It is vastly more of an open process than anything we have known before. The dam days left us with a sustainability deficit. We are making slow progress in reducing it. It feels good.

My friend and fellow dam-hater Ray Demarchi once put that same thought into an even longer time scale. We were up on the Pickering Hills winter range surrounded by elk and talking about the environmental carnage wreaked upon the once wildlife rich habitats of the Duncan River.

Eventually we all deal with these matters in our own way. I got angry. Ray waxed philosophic. Sort of like the man would be Uncle. What he said conveyed the long-term approach to dams and damming. It went something like this: "Relax, Mikey," he said. "Those dams are all temporary. The next ice age will take them away."

Beginning about forty years ago the Columbia Treaty became law; since then, 350 lineal miles of the valley bottom have been sacrificed, a displacement of several thousand people occurred, and the great majority of the people in BC watched it all happen and did nothing.

Here in the Kootenays, a few stood up for their rights -- their neighbourhood, their community, their heritage, their environment, and their piece of land. I'd like you to meet some of them. And, if you have any questions, I would be happy to deal with those afterwards. Now, let's fun the film.

(The audience viewed a half-hour segment from the Westland television series that featured social and economic aspects of constructing the Columbia River Treaty dams.)

The Flow of Water, the Flow of Ideas

Eileen Delehanty Pearkes

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Developing an understanding of landscape can happen in many ways: through fieldwork, ground truthing, studying a map, reading text, or flying over in a plane. Being somewhat fearful of heights and prone to motion sickness, I rarely catch this last and biggest picture available in my own study of landscape, but when I do, such a view astonishes me with its rich, bird's eye perspective on how landscape functions as a whole. I liken the most recent CMI workshop, "Ecology of the Columbia River Reservoirs" to an ecological fly-over. It presented those who attended with an expansive overview of the reservoir system's ecological issues in the Basin and a chance to view the Basin's primary waterways -- the complex system of rivers, dams and lakes -- in a larger context than is usually available.

The workshop was not for the faint of heart. Much of the information we received detailed a landscape injured critically and in need of triage. After more than fifty years of human control of the Columbia Basin's vast water flow, it is not surprising that the CMI ecological fly-over revealed countless injuries and scars to human and wildlife habitat, some permanent, some not yet even healed.

The First Nations perspective offered information on historical cultural loss. Wilfred Jacobs (Ktunaxa-Kinbasket Tribal Council) spoke of traditional ice fishing in Creston becoming memory after the installation of the Libby Dam; Marilyn James (Sinixt Nation) detailed the loss of salmon fishing to her culture, the impact of mercury poisoning in fish harvested by her people from Roosevelt Lake and the accumulation of wood fibre discharged by the Celgar pulp processing

plant into the river bed, which damages fish habitat.

Then we heard from an array of biologists. Bob Jamieson highlighted the failure to establish recruit cottonwoods in Kootenay River floodplains in the trench, a failure he sees as a "canary" for the eventual loss of the dynamic cottonwood ecology; Ray Demarchi spoke of the immeasurable depletion of critical and highly productive terrestrial wildlife habitat; Jay Hammond described the current state of the fisheries in the Basin, a sad story of fish struggling for spawning habitat and healthy water conditions; Mart Gross warned of the undermining of genetic variation and local adaptation in wild fish stocks when hatcheries are used for supplementing stock; Ken Ashley described the "immense" overall impact of human activity on the habitat for the region's landlocked salmon, the kokanee. By the end of the day, it was clear that the region will spending at least the next fifty years repairing damages inflicted on the watershed system in the past five decades.

Though much of the information contained judgement and loss, some of what we heard was plain old interesting. Jack Stanford (University of Montana) described how a 10 square meter plot of river wetland could host 100 species of vascular plants, and told a fascinated audience about his research into the vertical flow of rivers, the exchange of water flow between deep underground aquifers and the water flowing on the surface. We learned that a hatchery-produced fish costs $60 by the time it is caught. And throughout the day, we heard various speakers take sides in a complex debate over whether Kootenay Lake is a reservoir or a lake as a result of impoundments.

Speed was a theme. In a brief interval of one decade (1960s-70s) said Ray Demarchi, the development of hydro impoundments in the Basin resulted in rapid and thorough landscape destruction for this region not seen since the last ice age. And the speed of water as it exits the dams, as well as its slow down when held back, dramatically affects the ability of fish to survive. Jack Stanford pointed out that rivers typically change in base flow no more than 5 -10% in a day. His measurements of the Columbia on the day of the workshop showed a 20% flow change in four hours. Flow and its regulations, Stanford reminded those in attendance, is a critical part of fisheries restoration.

Water mass flux model. Riverene. Back-casting. Load-shaping. Recreational capture. Assortative mating bias. Mercury mobilization. Turbidity plumes. Ecological insults. Carbon sequestration. Silt scour.

After a day of thinking about fish and other wildlife, about silt scouring, load-shaping and turbidity plumes, it was refreshing to return in the evening to hear journalist Milk Halleran speak eloquently about the dams' human impact. He commended the scientists for "finally starting to get their acts together," complimented B.C. Hydro for developing a social conscience over the years, and

then reminded us that 2/3 of the story of the dams had been left untold by leaving social and human cultural commentary off the plenary for the workshop.

Thank you for the reminder, Mike. As the CMI continues with its much needed and well-executed examinations of the ecology of the reservoir system, we must be sure to broaden the definition of science, to remember that it is a method of inquiry as well as subject matter. The Oxford dictionary says science can be broadened even more to be defined as "skillful technique." I await the next reservoir workshop, at which I expect a musician, a poet and a visual artist, demonstrating through their own skillful technique the cultural and social messages related to the reservoir system and our place in it.

BC Hydro Revegetation Work Adjacent to the Reservoir

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Brian led a field trip on the river flats near the Revelstoke airport to look at features of the revegetation work adjacent to the reservoir.

Monitoring Forest Birds by Migration Counts in the Columbia Basin

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John Woods led a field trip to the location of the bird migration monitoring station near the Revelstoke airport. Because so much bird habitat has been lost to the reservoirs, the ponds near the Revelstoke Airport are one of the last remaining staging areas for migrating birds on the Columbia River between the USA border and the northern reach of the Columbia Basin.

For a summary of the songbird monitoring project, visit this web site:
http://www.livingbasin.com/monitoring/

Illecillewaet Greenbelt Restoration Work

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Frances led a trip through the Illecillewaet Greenbelt. The volunteer Illecillewaet Greenbelt Society is overseeing the rehabilitation of this area. The following is a list of objectives for the rehabilitation project:

- To stabilize surface and ground water levels at an elevation that will allow for the development of a diverse and productive wetland ecosystem.
- To increase the diversity of habitat types and ecological conditions within the area of the nature park.
- To create off channel fish rearing habitat that will provide high water quality and abundant food resources for salmonids and other fish species.
- To create wetland habitat capable of providing food resources and nesting opportunities for waterfowl, song birds, fish predators (Blue Heron, Osprey, Kingfisher), and shorebirds
- To create wetland habitat as well as over-wintering and nesting areas for Western Painted Turtle.
- To provide a ground water supply that would be readily available for terrestrial and riparian vegetation within the park at a stable minimum level during the growing season.
- To create opportunities for public education and promote the appreciation of the value and significance of the wetland areas near Revelstoke.
- To aid the diversification of the local economy, promoting the park lands and the project as an ecological attraction for tourists seeking nature oriented experiences within the community.
- To provide excellent research opportunities to monitor development, function and responses of wetland and fish rearing habitats within a water storage reservoir.
- To protect the park area and habitat as well as a nearby community dike from loss or damage from erosion resulting from channel instabilities related to sediment accumulation in the Illecillewaet River adjacent the park.