Ecological Restoration in Southeastern British Columbia —Grasslands to Mountaintops

October 12–13, 2007
Cranbrook, British Columbia
Canada

Columbia Mountains Institute of Applied Ecology
British Columbia Chapter of the Society for Ecological Restoration

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Acknowledgements

This conference was co-hosted by the Columbia Mountains Institute of Applied Ecology and the British Columbia Chapter of the Society for Ecological Restoration.

The CMI and SER-BC are proud to work with these agencies, which have contributed financial or in-kind assistance in support of this conference:

- British Columbia Ministry of Environment
- British Columbia Ministry of Forests and Range
- Columbia Basin Trust
- Don Eastman (School of Environmental Studies, University of Victoria)
- Elk Valley Coal Corporation
- Keefer Ecological Services
- Polster Environmental Services
- Rocky Mountain Trench Ecosystem Restoration Steering Committee
- Swell Environmental Consulting
- The Land Conservancy of British Columbia

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

The members of the organizing committee were Patrick Daigle, Don Eastman, Michael Keefer, Lehna Malmkvist, and David Polster. Jackie Morris of the Columbia Mountains Institute provided guidance and administrative support for the conference.

Special thanks to our volunteer assistants: Adrienne Shaw, Heidi Bennett, and Carol Atherton. They helped with the registration desk and the many other details that keep a conference running smoothly. Adrienne's willingness and ability to run the conference computer and cue up the PowerPoint presentations was especially appreciated.

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

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Conference Description

The British Columbia Chapter of the Society for Ecological Restoration (SER-BC) and the Columbia Mountains Institute of Applied Ecology (CMI) co-hosted this regional conference. Southeastern British Columbia is a hotbed for ecological restoration. Themes covered at this conference included:

- Restoration of grasslands and forests at different elevations
- Rehabilitation of mine spoils
- Restoration of wetland and aquatic features

On October 11 conference participants heard from our keynote speaker, Wayne Choquette, about "Ecological Archaeology" and what it can tell us about sustainable land management. On October 12 we had a full day of presentations followed by a dinner with speaker Don Gayton of FORREX, and live music from the local band "Buffalohead." On October 13 we continued with presentations until noon, when four different field trips departed. Time was allotted for the short Annual General Meeting of SER-BC and participants were invited to attend a review of their strategic plan.

About 180 people attended the conference. This was a full house and last minute registrants were turned away. Participants were multidisciplinary, and included staff from various government offices, resource managers, public interest groups, consulting biologists, protected areas staff, and academics. College students from Vermillion College in Alberta and Selkirk College in Castlegar also attended the conference. The Columbia Basin Trust kindly subsidized registration fees for the Castlegar students.

The summaries of presentations in this document were provided by the speakers. Aside 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 Host Organizations

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. Our website offers many resources, including conference summaries for all of our past events. 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.

About the British Columbia Chapter of the Society for Ecological Restoration

www.ser.org/serbc

SER-BC is a not-for-profit organization, affiliated with the Society for Ecological Restoration International, a society of 2500 members worldwide. SER-BC aims to raise the profile and quality of ecological restoration in the province. SER-BC works to achieve this vision by focusing on these long-term goals:

1. Promote the advancement of the basic science of restoration
2. Promote interdisciplinary work in restoration
3. Support the work of restoration practitioners and raise the quality of restoration
4. Provide effective lobbying of government organizations
5. Make restoration economically relevant
6. Promote informed debate on key restoration issues
7. Promote mechanisms for adaptability in ecological and human systems

SER-BC is a diverse group of ecologists, researchers, and restorationists from all over British Columbia and western Canada. They come from the ranks of consulting, business, government, universities, interest groups, and the general public. The common bond is the concern for the health of British Columbia ecosystems, and direct involvement in projects to restore those systems.

Conference Agenda

Thursday, October 11, 2007

7:30 p.m.	**Welcome** to the public and conference attendees, and introduction of Wayne Choquette, by Patrick Daigle, CMI Director and Master of Ceremonies
7:40 p.m.	**Ecological archaeology,** Wayne Choquette, Archaeologist.

Friday, October 12, 2007

8:30 a.m.	**Welcoming remarks** from Patrick Daigle of the Columbia Mountains Institute, Lehna Malmqvist of the BC Chapter of the Society for Ecological Restoration, Elder Agnes McCoy, St. Mary's Indian Band Councillor, and Ross Priest, Mayor of Cranbrook.
8:50 a.m.	**Getting the words right: Restoration vs. reclamation vs. rehabilitation,** Patrick Daigle, BC Ministry of Environment
9:05 a.m.	**BC Hydro's revegetation programs on Arrow and Kinbasket Reservoirs,** Rian Hill and Eva Maria Boehringer, BC Hydro
9:35 a.m.	**Sedge revegetation trials in Leach Creek,** Michael Keefer, Keefer Ecological Services
10:05 a.m.	**Joseph Creek Restoration within the Kinsmen Park Reach, City of Cranbrook,** Gerry Oliver, GG Oliver and Associates Environmental Science
10:30 a.m.	*Coffee break*
11:00 a.m.	**The Mountain Legacy Project,** Eric Higgs, University of Victoria
11:30 a.m.	**Citizen stakeholders and ecological restoration in the Trench—How we got on the bus**, Maurice Hansen, Rocky Mountain Trench Natural Resources Society
12:00 p.m.	*Lunch, provided*
12:15 p.m.	**Annual General Meeting** for BC Chapter of the Society for Ecological Restoration (SER-BC)
1:00 p.m.	**Ecological restoration in British Columbia—Making it happen,** Greg Anderson, BC Ministry of Forests and Range
1:30 p.m.	**Ecosystem restoration: The Rocky Mountain Forest District experience,** Randy Harris, BC Ministry of Forests and Range
2:00 p.m.	**Whitebark pine restoration on the Continental Divide,** Brendan Wilson, Selkirk College
2:30 p.m.	**Fire history of the southern Rocky Mountain Trench: 1540–2005,** Lori Daniels, University of British Columbia
3:00 p.m.	*Coffee break*

3:15 p.m. **Ecological restoration as a tool to enhance economic value,** Cori Barraclough and Patrick Lucey, Aqua-tex Scientific Consulting

3:30 p.m. **Genesis of the Rocky Mountain Trench Prescribed Fire Council,** Bob Gray, R.W. Gray Consulting

4:00 p.m. **Plant community response following dry forest ecosystem restoration,** Tim Ross, Ross Range and Reclamation Services

4:30 p.m. *Finish for the day*

5:00 p.m. **Strategic planning and information session for SER-BC**; everyone welcome.

Friday, October 12, Evening

6:00 p.m. Conference room doors re-open and the cash bar opens

6:30 p.m. Dinner Buffet

7:30 p.m. Don Gayton of FORREX will speak on **Eco-cultural approaches to restoration**

8:30 p.m. Dancing and partying with Tim Ross and *Buffalohead.*

Saturday, October 13, 2007

9:00 a.m. **Welcome back** and outline for the day, Patrick Daigle, Master of Ceremonies

9:05 a.m. **Assessing impacts on Ktunaxa Nation cultural resources from ecological restoration, timber thinning, and prescribed burning in the Rocky Mountain Trench,** Thomas Munson, Westland Resource Group

9:30 a.m. **Mine reclamation strategies in British Columbia,** David Polster, Polster Environmental Services

10:00 a.m. **Natural colonization of high-elevation mine exploration disturbances in the Elk and Flathead river drainages,** Clint Smyth, Matrix Solutions

10:30 a.m. *Coffee break*

10:45 a.m. **Reclamation at Elk Valley Coal's British Columbia operations,** Justin Straker, C.E. Jones and Associates

11:15 a.m. **Reflections on the conference and the future of ecological restoration in British Columbia,** Eric Higgs, University of Victoria

11:30 a.m. **Wrap-up comments** Patrick Daigle *(no lunch provided)*

12:00 p.m. **Field trips departed**

Evening Presentation, October 11, 2007

Ecological archaeology

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Wayne's paper expands upon versions presented in the Method and Theory Session at *From the past to a vision of the future*, the 38th Annual Meeting of the Canadian Archaeological Association, Nanaimo, British Columbia (May 12, 2005) and in the Plenary Session of the Society for Range Management Conference, Vancouver, British Columbia (February 12, 2006).

Characteristics of the Upper Columbia Bioregional Archaeological Record

The region drained by the upper Columbia River comprises a single huge watershed connected to the Pacific Ocean. Under continental climatic conditions of high pressure dominance, winds move north and south along the major trenches that subdivide the Rocky, Purcell, Selkirk, and Monashee mountain ranges. Otherwise, the flow of the prevailing maritime westerlies is perpendicular to the mountain ranges and is channelled through them by great fault gaps. Precipitation is high on windward slopes, which are typically forested. Topographic disruptions to the northeastward flow of moist air creates xeric rain shadows characterized by significant expanses of grassland and savannah. The terrain and geology are complex at the micro-topographic scale, creating a wide range of habitats and, consequently, very high biodiversity.

During pre-contact times, seasonal variations in the distribution and abundance of subsistence resources encouraged highly mobile human settlement patterns. The region has seen significant changes in hydrology and ecology since deglaciation, causing shifts in location of major ecological edges such as lakeshores, riverbanks, and the forest/grassland ecotone. Such changes would in turn have influenced the structure of the human seasonal subsistence patterns found over longer time periods. Evidence of such a dynamic past is demonstrated by the fact that very few of the thousands of individually known archaeological sites in the region have records of occupation spanning all of post-glacial time. Instead, upper Columbia region archaeological sites typically contain evidence of single or only a few occupational components, each spanning at most a few thousand years. The ecological diversity and dynamic habitat mosaic manifests itself in another distinctive characteristic of the archaeological record: sites are scattered widely across the landscape at all elevations and in a great diversity of settings.

Data frameworks

In British Columbia, the predominant archaeological paradigm conceptualizes cultural history in terms of inventories of so-called "diagnostic-" formed tools grouped into a linear framework of "phases" and "traditions" (for example, see Figure 1). The conventional approach focuses on locations of greatest artifact abundance and tends to place the highest value on accumulations of artifacts. This approach has not proven to be very useful in revealing the complexity of past human activities in the upper Columbia region, however, because large artifact concentrations are not common. The relatively ephemeral inhabitation of most archaeological sites typically produced only small amounts of physical remains, so it has been necessary to develop a different approach to allow the data from this unique bioregion speak for itself.

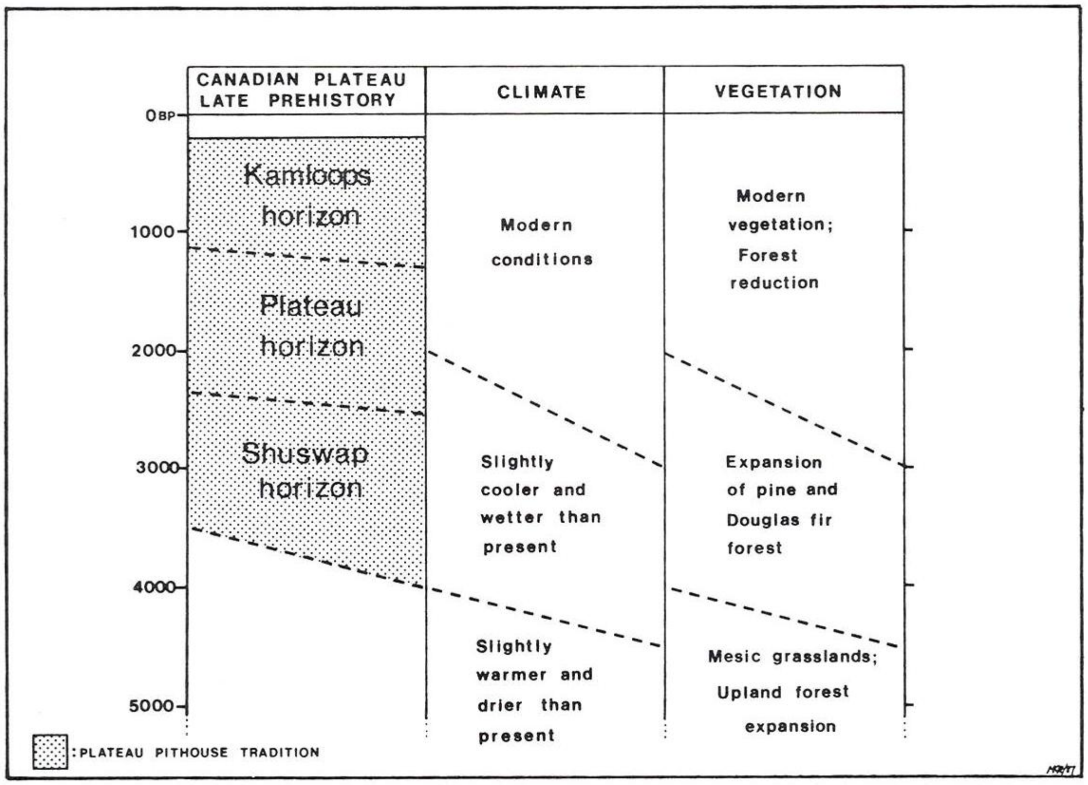

Figure 1. Conventional linear culture historical framework. Note the separation of environmental and cultural elements (from Richards, T. and M. Rousseau, Late Prehistoric Cultural Horizons on the Canadian Plateau. Simon Fraser University, Department of Archaeology, Burnaby, BC. Publication 16.).

In order to obtain enough data to identify patterning in the distribution and associations of the cultural objects, the research perspective had to be broadened to consider the context and interrelationships amongst archaeological remains from *many* sparse sites as well as the evidence of the relationships of the cultural deposits with the surrounding landscape. Within this alternative paradigm, the quantity of formed tools, while of course desirable, is not the primary determinant of whether a given archaeological site has the capacity to yield relevant information. Instead, excavation methodology is geared primarily to uncovering and documenting site structure, that is, the spatial relationships amongst the cultural objects and the components of the palaeoenvironment as revealed by site geomorphology, natural depositional history, and soil development. The highest archaeological significance is accorded to cultural deposits with the greatest internal integrity and the least disturbed stratigraphic contexts. An additional source of data that this paradigm employs is provided by the region's lengthy and complex geologic history. The identification of spatially discrete outcroppings of distinctive minerals that were quarried for stone tool stock, such as tourmalinite and Kootenay Argillite, facilitates the tracking of humans across the landscape by following their trails of lithic debitage and discarded tools. Identification of changes in the patterning of the distribution of these stone tool remnants over time has proven to be invaluable in reconstructing seasonal movements and identifying probable subsistence pursuits at various times and in response to various environmental conditions.

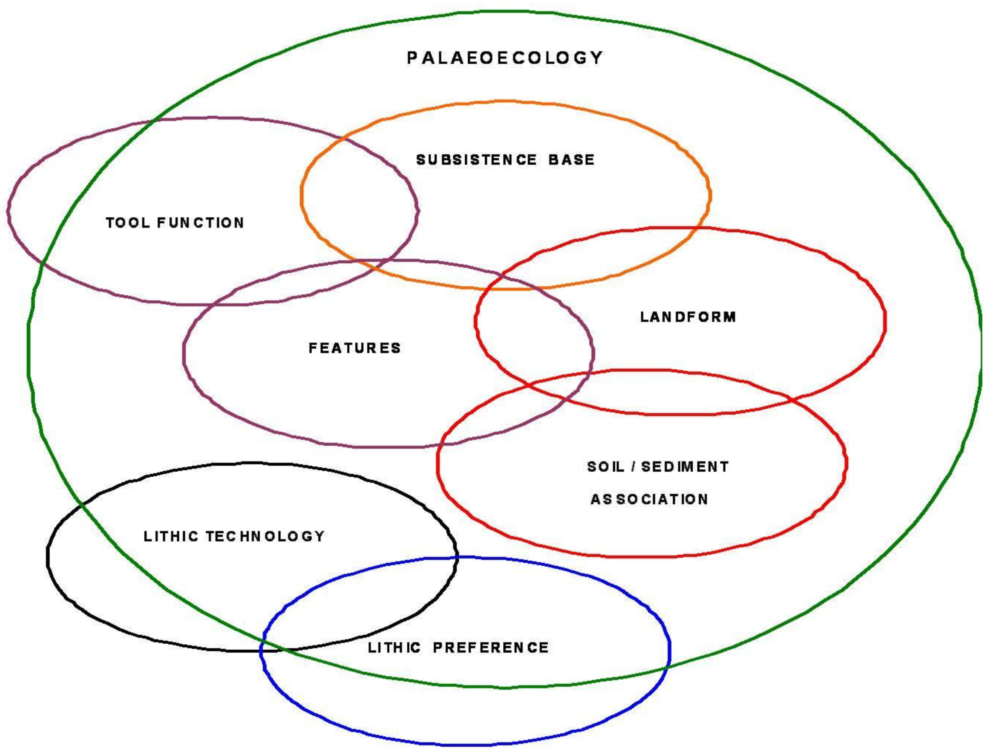

Figure 2. Schematic of archaeological complex definition in ecological archaeology.

Data synthesis within this paradigm uses a systemic framework of archaeological trait "complexes" consisting of settlement pattern (represented by landform, palaeohydrology, soil/sediment association, and geographic catchment demonstrated by the geographic distribution of the distinctive lithic types), technology, subsistence base, cultural features, and tool function (Figure 2). Lithic typology and technological attributes have been accorded primary artifact analytic status as opposed to the traditional emphasis placed on formed tool morphology because of their linkages to the objective geological data. Temporally diagnostic artifacts such as projectile points are used as "index fossils" to aid in chronology, but the ascribed "cultural" significance is not an important part of the explanatory paradigm. Rather, the archaeological trait complexes are interpreted as systemic models of past human land and resource use.

Ten such complexes have been defined so far within the region, spanning the entire postglacial period. By their very nature, these are spatial as well as temporal entities and are not necessarily linearly sequent; four are described here.

Human inhabitation began with the **Goatfell Complex** (ca. 11 000 to 8000 years before present [b.p.]), which encompasses evidence left by early post-glacial inhabitants of the drained basins of proglacial lakes. Goatfell Complex sites are associated with well-drained, often oxidized sediments on elevated landforms such as beaches, spillway terraces, and dunes, often associated with higher stands of existing lakes. The technology included quarrying tourmalinite, fine-grained quartzite, and Kootenay Argillite to reduce large bifacial cores by percussion following platform abrasion to produce large knives, stemmed and lanceolate spearpoints, and side-struck flake tools.

In contrast, the markedly aquatic and riparian adaptation of the **Inissimi Complex** (ca. 4000 to 2500 years b.p.) apparently reflects both the evolution of a canoe-based lifestyle as well as an adaptation to the peak of Columbia River salmon carrying capacity. Movement between winter deer ranges in the southern Purcell Mountains, summer fishing along the lower Kootenay River, and spring and fall hunting along the north arm of Kootenay Lake is clearly indicated by the predominance of distinctive Kootenay Argillite in the Inissimi Complex lithic assemblages.

Subsequent human adaptation to decreased fluvial discharge and increased herds of grazing ungulates (including local bison) in the Rocky Mountains and Kootenay River valley within the last two millenia is represented by the emergence of the **Akiyi'nek and Akanoho'nek complexes** from earlier, valley bottom oriented settlement/subsistence systems. These complexes are characterized by small tool technology and exploitation of distinctive sources of Rocky Mountain cherts.

The bedrock geology, landform, sediment, and soil evidence as elements of the archaeological record is emphasized within this paradigm because this information pertains to the environmental context of the artifacts and is independent of the cultural inferences of the archaeologist. The objective framework provided by the palaeoenvironmental data allows for the ability to use deduction and the application of the scientific method to the testing of cultural inferences framed as hypotheses or models. When these trait complexes are treated as models, they can facilitate research into processes of human adaptation to the environmental diversity of the region and to changes in that environment. Employing the non-anthropological classification units of lithology, geomorphological site setting, and palaeoecology as revealed by palynology, fire history, alluvial chronology, and pedogenesis to define the environmental context of archaeological remains allows for a relatively non-subjective, deductive scientific methodology to be applied to regional archaeological investigation. Independently reconstructed palaeoenvironmental contexts and hypothetical human responses to them can be tested by controlled archaeological data retrieval. The archaeological complexes thus allow hypotheses pertaining to past human activities and even more strongly "cultural" dimensions such as social organization to be developed and projected back onto the archaeological landscape. Through the use of multiple working hypotheses, predictions can be made about past human behaviour that would be revealed by potential presence or absence and character of distinctive classes of archaeological evidence such as type and reduction strategy of lithic debitage; location, arrangement, and density of cultural deposits and features; and functional artifact classes. As opposed to the inductive diagnostic artifact approach based on inference, testing of hypotheses via controlled archaeological data recovery allows for incremental expansion of our knowledge of past human activity, and increasing precision and detail in future hypotheses and predictive models.

Applications

Converting the archaeological trait complexes into deductive postulates that can be tested by fieldwork finds a significant application in cultural resource management. For example, in most of the Kootenay Region, these models and hypotheses have been operationalized as air photo-mapped GIS-based polygons of archaeological potential that identify locations to be avoided by land-altering development or where Archaeological Impact Assessments (AIAs) would be required. The polygons are linked to the archaeological models via landscape level attributes such as landform and relationship to water that are recorded in the database associated with each polygon. Provided that the AIAs are undertaken via appropriate sampling strategies, they can serve to test the models and hypotheses. In effect, this process represents a kind of "reverse engineering" of the archaeological trait complexes. It also represents added value in allowing for the undertaking of scientific archaeology within the context of impact assessment, an accomplishment well in keeping with the recently legislated scientific accountability mandated for forest practices. In addition, this "information value" represents a significance assessment measure that can greatly facilitate informed decisions regarding priorities for avoidance and mitigative strategies for cost-effective archaeological resource conservation. Within the cultural resource management context, site significance assessment and mitigative data retrieval are both more defensible and more cost efficient if carried out within this paradigm than if they are based on subjective inferences.

In addition to allowing for scientific archaeological research to be carried out within the context of cultural resource management, this approach has revealed much about the evolution of the region's landscape and ecology that is of importance to the broader realm of sustainable land and resource management. The testing by controlled archaeological data retrieval of hypothesized human responses to sets of environmental conditions reconstructed from independent data not only allows for confirmation, modification, or discard of the archaeological models, it also allows for the independent evaluation of the validity of the underlying environmental reconstructions.

Furthermore, by the very nature of the micro-techniques involved in archaeological investigation, archaeologists are in the position as scientists to provide a sensitive time scale to natural events as well as to the process of human adaptation to such events. Although the time frame of archaeology can be considered to be sensitive when compared to the geological time scale, it still spans more than 10,000 years in this region. From the perspective of the tiny length of time that western civilization has been present in northwestern North America, ecological archaeology represents an important means of extending our understanding of large scale environmental events that is not otherwise available. The potential for linkages with Traditional Ecological Knowledge and the advantages for improving resource management decision making are obvious, especially considering the need for much better understanding of longer term cycles in the present context of human-induced climate change.

As identified above, archaeological field investigation routinely encounters classes of easily retrievable information that have major pragmatic value beyond the strictly archaeological realm. Archaeological sites are situated on landforms, the human inhabitation of which was possible or optimal at certain times in the trajectory of the evolution of the landscape since deglaciation. These sites can be considered as “containers” of information, some of which directly pertains to the stability or dynamism of the surrounding environment. The sediment sequences encasing datable archaeological components can include information directly pertinent to, for example, terrain stability and flood hazard assessments.

Ages of landforms, and the character and extent of soil development in their constituent sediments, are also linked to understanding the evolutionary dynamics of the vegetal mosaic and of the wildlife populations supported by the plant communities. Archaeological data pertaining to human subsistence practices such as hunting, fishing, and gathering as well as to the structure and timing of seasonal use can provide insights into climate change, species range extensions, fire chronologies and, to the extent that may have occurred in the past, the degree to which components of the ecology were produced by or dependent upon human intervention. The relevance to wildlife management and especially to ecological restoration is obvious.

Two examples from my research are illustrative. Evidence is accruing which indicates that parts of the southern Canadian Rocky Mountains supported significantly higher human populations during the early post-glacial drought known as the "Hypsithermal" when compared to the last 5000 years. Communal hunting of ungulates such as mountain sheep was apparently practiced during the early Holocene when a fertile fine sediment cap of loess and volcanic ash mantled high elevations. However, the effects of much greater and longer-lasting snow cover associated with Neoglaciation in the latter half of the Holocene appears to have eliminated the vegetation holding this fine sediment in place, resulting in a major reduction in the carrying capacity of the alpine zone. The Little Ice Age of the last few centuries was the most severe Neoglacial event and its effect can clearly be seen in the weak soils and impoverished alpine vegetal communities as one moves north. The present distribution of mountain sheep herds and the association of their historic ranges with rain shadows is also explained by this shift in climate. The spatially extensive high elevation habitat fostered by drought and thermal inversions during the Hypsithermal continental regime gave way to increased maritime influence after 6000 years ago, when cool wet Neoglacial conditions resulted in the deflation of high-elevation soils and the habitat they supported, as well as the disruption and spatial restriction of grasslands in the Rocky Mountain Trench. Our management perspective on the surviving mountain sheep in this region must be tempered with the longer term perspective that the populations that were here when Europeans arrived were already the surviving remnants of what had previously been much larger populations; in this context, the threat to these animals of our modern land use practices assumes a much greater importance.

The second example also relates to the effects of the Neoglacial. The pollen data indicates that the period of time between about 5000 and 2500 years ago was a particularly cool and wet part of the Neoglacial. This was manifested in the upper Columbia drainage area by alluvial floodplains that stretched from valley wall to valley wall along many of the major watercourses. This interval ended with a slight return to warmer and drier conditions that peaked about 1000 years ago. The Arctic witnessed the flourishing of both the Norse and Thule Inuit cultures, and grapes were grown in Britain at this time. In the Kootenays, this climatic change was manifested by increased fire frequency and a marked decline in fluvial discharge. The latter resulted in the confinement of now smaller river channels to inner valleys bounded by terraces that previously had been active floodplains. In the Elk and Flathead valleys, these gravel-cored terraces, now elevated above seasonal water tables, became grasslands. In combination with the expanded grasslands on the surrounding lower valley sides, this enlarged xeric habitat resulted in increased populations of grazing ungulates and the expansion of bison into the middle part of the Elk Valley and up the Rocky Mountain Trench at least as far north as Joseph's and St. Mary’s prairies. The archaeological record of this time indicates significant changes in subsistence base and settlement patterns of the resident human groups that included a shift from a valley bottom orientation to a renewal of focus on hunting in the Rocky Mountains and the reorganization of small localized bands into a more complex seasonally fluctuating macroband/task group social system. This was accompanied by technological change such as the adoption of the bow and arrow and a shift in reliance on microcrystalline flake tools made from river cobbles to a small tool industry based on quarried cryptocrystallines.

The relevance of these vignettes to the present conference is that grasslands have been a major component of the regional ecology since the first steppe tundra communities invaded the terrain newly emerged from beneath glacial ice and proglacial lakes, but their extent and arrangement have varied considerably. High-elevation grasslands today appear to be small relicts of previously much more extensive alpine range that was lost during the Neoglacial. It is apparent that in some locations such as on the floor of the Rocky Mountain Trench, the grasslands have persisted due to microenvironmental influences such as rain shadows. As “tiles” in the vegetal mosaic, grasslands have expanded and contracted in response to precipitation values and fire frequencies. There is an analogue here with forest communities, albeit of a much greater time span: these are "old-growth" grasslands with thousands of years of continuity. In other cases, however, such as along the Elk and Flathead rivers, the grasslands, by definition of the age of the landforms upon which they occur, are less than 2500 years old. To pursue the analogy, these might be considered as "seral" communities, although their ages are equivalent to the oldest trees.

Unfortunately, in contrast to the situation with forests which have been subject to rather intensive inventories, grasslands have not, and as a consequence managers have tended to treat them more generically. In this context, it is of considerable interest that while the archaeological record of the middle Elk River drainage area includes abundant archaeological evidence of the presence, hunting, and even drives over escarpments of resident bison, so far similar evidence is lacking in the upper Flathead Valley. Similarly, bison were part of the late Holocene ecology of the Rocky Mountain Trench south of Canal Flats. If there are grassland communities which survived hundreds if not a few thousand years of grazing by bison, but there are other grasslands which were beyond the limits of the late Holocene bison range expansion, it can be speculated that the former might be more resistant to grazing pressure than the latter. Such knowledge could inform more sensitive range management and tenure distribution, and is also worth considering when restoring grasslands. At the very least, it points to the need for a finer grained approach to inventory of the natural grasslands that are part of this region's heritage legacy.

Conclusion

At the 2001 British Columbia Archaeology Forum, concern was expressed by the non-native British Columbia archaeological community over the lack of public awareness and care for archaeology in the light of a perceived threat represented by the election of a pro-business provincial government. My response at that time was that perhaps archaeologists were not providing the public with relevant information—even amateur archaeologists want to know more from archaeological inquiry than a catalogue of diagnostic artifacts by time period. Through its *Forest and Range Practices Act*, the same British Columbia government has mandated greater emphasis on science and professional accountability for development approvals. It is apparent that more should be forthcoming from archaeological investigations than minimal generic descriptive information derived from tests of the hypothesis that humans did something in the past that was archaeologically detectable (i.e., presence versus absence of physical remains).

I would argue that in parts of the upper Columbia River drainage area where anadromous salmon did not provide external inputs, the archaeological record by its very nature provides a basic definition of sustainability in that it represents the level of human population that can be supported by the natural environment at a non-agrarian, non-industrial level. As such, archaeology is worthy of more serious regard than presently characterizes its practice and resulting status. At present, most archaeology in North America is carried out in the context of “cultural resource management,” whereby archaeological “resources” are inventoried, assessed, and mitigated in advance of land alteration. Archaeologists are often the last to document a particular location before it is altered, often drastically, by development. Archaeologists involved in these assessments must, by definition, record and study alterations of the archaeological landscape. By placing high importance on the natural and cultural depositional context of archaeological remains, one becomes adept at identifying disruptions in this context. By extension, the archaeologist then becomes the steward of information regarding the degree to which the given pre-contact land surface has remained intact, along with its accompanying natural soil and vegetation.

Within this context, archaeology has a most important role to play in documenting what I call "sustainability benchmarks." In addition to the evidence of human adaptation, these benchmarks are the record of the evolutionary trajectory of the natural conditions to the semblance of which we will likely be forced to return in order to gain a better balance of our lifestyles and what the environment can sustain. Indeed, this is already beginning to occur to a certain degree, as the theme of the present conference attests. While most of what I have discussed may be considered to be archaeology as palaeoecology, because so much modern archaeology is driven by development approvals, archaeology must begin to pay as much attention to the relationship between its own societal context and relationship with the land as to those of the pre-contact societies. In this way, if it is carried out within a relevant paradigm by properly trained practitioners, the special niche of archaeological inquiry gives it a vital role to play, both as recorder and as educator.

Presentations on October 12, 2007

The day began with welcoming remarks from Patrick Daigle of the Columbia Mountains Institute, Lehna Malmkvist of the British Columbia Chapter of the Society for Ecological Restoration, Elder Agnes McCoy, St. Mary's Indian Band Councillor, and Ross Priest, Mayor of Cranbrook.

1. Getting the words right: Restoration vs. reclamation vs. rehabilitation

Patrick Daigle, RPF, BC Ministry of Environment, Ecosystems Branch, Victoria, British Columbia
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This short presentation is designed to clarify terms used during the conference. We want presenters and participants to be consistent in their use of the terms so that communication is as clear as possible. In the past, some terms have commonly (and mistakenly) been used as if they are interchangeable.

Here are the terms to be clarified for this conference:

Restoration

- Process of returning ecosystems and habitats to original structure and species composition. Requires a detailed knowledge of the (original) species, ecosystem functions, and interacting processes (Dunster and Dunster 1996).
- Reinstatement of driving ecological processes (Society of Wetland Scientists 2000).

Ecological restoration

- Process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Practice of restoring ecosystems (Society for Ecological Restoration International [SERI] 2004).

Restoration ecology

- Science upon which ecological restoration is based. Ideally, provides clear concepts, models, methodologies, and tools for practitioners (SERI 2004).

Reclamation

- Making land fit for cultivation (Bradshaw 1997).
- Planned series of activities designed to recreate the biophysical capacity of an ecosystem. The resulting ecosystem will be different from the pre-disturbance ecosystem (Dunster and Dunster 1996).

Rehabilitation

- Restoration of ecosystem functions and processes in a degraded system or habitat (Dunster and Dunster 1996).
- Any act of improvement from a degraded state (Bradshaw 1997).

In this definition of rehabilitation, note the reference to "restoration" in Dunster and Dunster (2000). Perhaps it is in the techniques used. For example, moving native soil with its seed bank onto a tractor fireline could be considered a restoration treatment. On the other hand, moving soil onto a fireline and then seeding with non-native species could be considered a rehabilitation treatment.

Mitigation

- Making less severe or serious (Oxford English Dictionary [OED] 2003).
- Avoiding, minimizing, rectifying, reducing, eliminating over time, or compensating for by replacing or substituting (US Fish and Wildlife Service 1981).

Remediation

- Moderating the effects of a degrading action (Bradshaw 1997).
- Remedying something, in particular, environmental damage (OED 2003).

Enhancement

- Increasing the quality, value, extent (OED 2003).
- Concept of enhancement is subjective and depends on a context or point of view. To a large extent, this is an anthropogenic attitude (Dunster and Dunster 1996).
- No implication of making something that's bad, better, but of making something already good better (Bradshaw 1997).

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2. BC Hydro's revegetation programs on Arrow and Kinbasket reservoirs

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The flooding and inundation regime of the Kinbasket and Arrow Lakes reservoirs resulted in changes in a variety of ecological conditions. In the Arrow Lakes, the original driver for a revegetation program was the dust storms that were occurring when the reservoir was at low pool in the spring. A combination of light glacial sediments in the drawdown zone and local wind conditions resulted in airborne dust that created a nuisance for the town of Revelstoke, recreational users of the reservoir, and the local airport. Seeding of fall rye was implemented by BC Hydro in the late 1980s as a means of reducing dust and erosion.

Several species of sedges, grasses, and woody plants have been planted in the reservoir drawdown zone over the years, specifically in Revelstoke Reach. Survival and establishment have been limited by reservoir operations that truncate the growing season and see plants completely underwater for several months in the summer. Perennial vegetation must be able to withstand the depth, duration, and timing of the flooding in order to survive.

Anecdotal reports indicated that there were several ancillary benefits being observed as a result of the seeding program in addition to the reduction of dust storms. In 1998 the BC Hydro Strategic Environmental Incentive Program set out to better quantify these benefits to fish, wildlife, and recreation through a series of studies and reports. The summary report is available on the CMI website (www.cmiae.org/BC_Hydro_CD-ROM.htm).

The Columbia River Water Use Planning (WUP) process was initiated in 2001 to find a better balance between social, environmental, and economic uses of water. During the planning process, the WUP Consultative Committee recognized the value of riparian vegetation surrounding the Kinbasket and Arrow Lakes reservoirs for enhancing littoral productivity, providing physical, structural, and biological attributes for wildlife habitat, protecting cultural heritage sites, and providing aesthetic benefits (for example, reduction of dust storms) within the drawdown zone.

As part of the final recommendations made in June 2004, the Committee recommended that BC Hydro implement reservoir-wide revegetation programs for the Kinbasket and Arrow Lakes reservoirs to maximize vegetation growth in the drawdown zones. The revegetation approach consists of multi-year programs with intervention over five years to facilitate long-term vegetative cover in those areas that have good potential to become self-sustaining. Key environmental and social objectives of the revegetation program are to expand vegetative cover in the drawdown zone and provide benefits to littoral productivity, wildlife habitat, prevention of shoreline erosion, and archaeological site protection.

In association with the revegetation program, the Consultative Committee recommended 10 year long inventory and effectiveness monitoring programs to ensure that revegetation efforts in both reservoirs are providing the intended environmental and social benefits over the long term. Inventory programs for both reservoirs began in the spring of 2007, while all effectiveness monitoring programs will be initiated in the spring of 2008.

The revegetation programs for the Kinbasket and Arrow Lakes reservoirs will be implemented in three phases, which are:

> **Phase 1** Verification and prioritization of revegetation locations, collection of seed stock, initiation of nursery stock
> **Phase 2** Detailed program planning and site specific prescriptions
> **Phase 3** Program implementation

Phase 1 was completed in summer 2007, and Phase 2 is currently being initiated. Implementation (Phase 3) will begin in spring 2008.

3. Sedge revegetation trials in Leach Creek

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This study investigated the success of several revegetation techniques on a disturbed sedge wetland along an upper elevation pipeline right-of-way near Sparwood, British Columbia. Results of other studies have indicated minimal natural regeneration of sedge species on disturbed wetlands due to highly complex environmental variables. In order to better understand how to re-establish disturbed sedge wetlands, seed and vegetative material of *Carex rostrata*, *C. aquatilis*, and *Scirpus microcarpus* was collected from adjacent wetlands and used to evaluate four revegetation methods: 1) transplanting greenhouse-grown sedge seedlings grown in 415B polystyrene blocks, 2) transplanting locally harvested sedge tillers, 3) direct seeding, and 4) natural revegetation. Data was collected for percent cover and survival over a three-year period beginning in the fall of 2004. Statistical analysis using split plot ANOVA indicates a significant (Pr=0.007) difference between the greenhouse-grown transplants and the locally harvested transplants over three consecutive years. The direct seeded and control treatments showed no establishment during this time. These results indicate that with adequate time to collect local seed, planting greenhouse-grown sedge species can be a successful tool for regenerating disturbed graminoid wetlands.

4. Joseph Creek restoration within the Kinsmen Park Reach, City of Cranbrook

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Restoration of stream channels and riparian areas that extend through urban centres offers a number of perplexing challenges due to the nature and magnitude of disturbances linked to urban development. Ecosystem services are particularly compromised where development plans are "forced" upon, rather than "fitted" to, the natural landscape; the all-familiar outcome includes restricted floodplains, impinged channels, and degraded aquatic and riparian environments that collectively contribute to a loss of ecosystem structure and function. Moreover, the cumulative impacts tend to be quite subtle since perturbations and alienations occur over long time scales and reflect highly dynamic development policy choices.

The Joseph Creek watershed provides one example where consumptive use and urban development within the City of Cranbrook have lead to water quantity and water quality challenges that impair ecosystem values. This presentation summarized the issues surrounding ecosystem recovery in the lower reaches of the watershed, outlined proposed strategies to meet those challenges, and described actions taken by a community-based group to increase issue awareness to both the community-at-large and local government. These actions include design and implementation of a stream restoration project as well as implementation of education/outreach and water conservation awareness programs.

5. The Mountain Legacy Project

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The Mountain Legacy Project is an interdisciplinary research group put together to advance the use of historical survey photographs in the Canadian Rockies. This is the largest systematic collection of mountain photos in the world, and it offers a unique and very powerful source of information for understanding landscape change. We investigate landscape ecology, ecological restoration, and social perspectives on the mountainous landscapes of western Canada through repeat photography and archival research. The project is based at the School of Environmental Studies at the University of Victoria, British Columbia.

To learn about the Mountain Legacy Project, visit: www.mountainlegacy.ca

6. Citizen stakeholders and ecological restoration in the Trench—How we got on the bus

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How did a non-technical, non-professional, non-aligned, non-government outfit become involved with ecosystem restoration? I'll explain why we wanted on the bus, tell you some things that happened, as well as how we charmed our way from the back to up nearer the front.

My colleagues have described the nuts and bolts of the East Kootenay Restoration Program (ERP). What I'm offering is more like a gossip column. Understand one thing: the Trench Society is one member of the group collaborating on the ERP in the Trench. We're more active than some, but not independent. The usual suspects are all in the game. The Forest Service is the big frog in the puddle but, in contrast with most other stakeholders, we do have members that are directly affected by restoration outcomes.

The Trench Society is a group of nine organizations banded together for the purpose of supporting ecosystem restoration on Crown land in the Trench. I'm the hired help. The members of the Society represent wildlife, ranching, hunting, naturalist, and environmental constituencies who in turn represent about 2800 individuals. We've been here for almost 11 years. Chiefly, what our members want from the ERP is recovery of the range resource: grasses, forbs, and shrubs in the zone below about 1100 metres, and the dry intermountain plain that is the valley floor. These are the ecosystem elements that have suffered most since the advent of fire suppression and forest ingrowth. Putting fire back into the ecosystem is the thing that catches the imagination, but that's not our primary game. The Society did conduct one prescribed burn in 1999, but almost immediately the Forest Service closed the door on citizen groups being able to continue that activity. Only government can conduct burns on Crown land. Now, our effort goes into the establishment of open range and open forest stands that will lead to the best recovery of the understorey vegetation. That's so burns can be as effective as possible—ample fine fuel makes for effective burns—as well as benefiting all the critters that need grass, flowers, and bushes.

Some out there think we're bonkers; that the ERP is not ecosystem restoration, but rather some scheme cooked up by a bunch of cowboys and elk hunters primarily to produce grass for cows and elk. Maybe what we're doing isn't quite "pure" ecosystem restoration—is there anyone in the world that really knows how to do that? But I'd argue that restoring native range health and productivity is an element of ecosystem restoration. There is a social component to restoration and one element of that is the cow/elk constituency.

Cicero is supposed to have said "He who does not know history is destined to remain a child." Whatever you might make of that it seems a good idea be a grown up and how the Trench Society got to this juncture in the grand scheme of things is not understandable by grown-ups without some history.

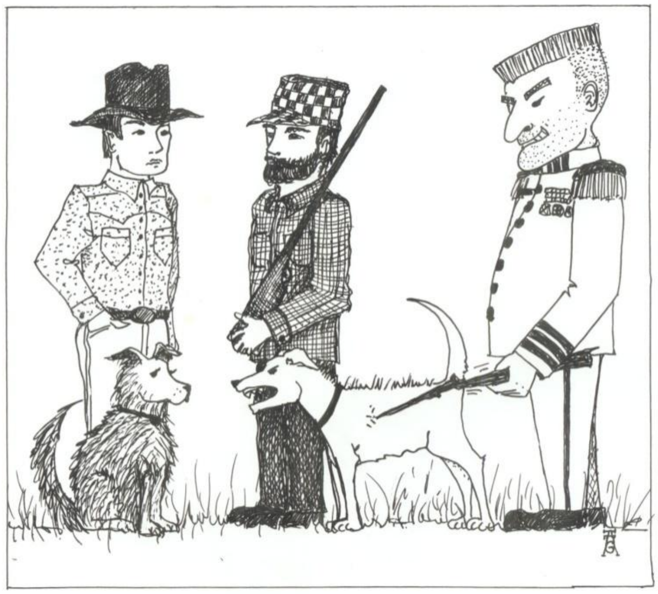
I first saw this place in May of 1965. I fell in love with the idea of the West at an early age and flying into the old downtown Cranbrook airport I saw country very different from what I was used to—here was that most lovely of landscapes, the ponderosa pine savannah. To put it mildly, the beauty of this mix of forest, grassland, and snow-capped peaks stirred my senses. I had grown up in the East. The landscape there is much more prosaic—and much wetter. This is a powerful landscape.

Since 1965 a lot of water has gone under the bridge. What I didn't know, as that old DC6 came in for a landing, was that there was chronic trouble in the valley over land use. By the early 1970s I'd acquired my own piece of ground and came into possession of a Crown grazing tenure. This was the ticket into the elk/cattle battle, which figures prominently in this story.

This area used to be touted as the Serengeti of North America and the hunting fraternity was numerous and aggressive. On the other side were the ranchers, who, I can tell you from personal experience, are a stubborn bunch. The conditions were right for war. But wildlifers were way ahead of ranchers in the public opinion game. The individual largely responsible for this was the regional wildlife biologist at the time, who had a genius for inflaming emotions while making gains for wildlife. Interestingly this same biologist, in 1972, described the crux of the elk/cattle issue with perfect clarity. Speaking to a cattlemen's group, (there was the occasional truce) he put it this way: the Fish and Wildlife Branch possessed no power to manage Crown land. Their only authority for was managing their critters. The Forest Service had all the land management authority and they weren't into power sharing.

This situation was a variation of what's called in traffic jams as "the Sicilian four-way deadlock." The Forest Service managed land but not critters; the Fish and Wildlife Branch managed critters but not land (Hmmm…). Anyway, the Fish and Wildlife Branch's short-term remedy was to mobilize public opinion in support of wildlife. This pressure, bubbling through the political system, would be the pointy stick motivating the Forest Service to implement land management schemes in favour of wildlife. The irony was that the ranching industry's problem was a mirror image. Ranchers likewise did not have the ability to implement land management strategies in their interests but—unlike the Fish and Wildlife Branch—they had no easy access to using public support for the purpose. They didn't have the numbers and they were a lot busier, but the biggest obstacle was the contrasting charisma between cows and elk: The elk have it. Even the most beautiful of Herefords has not appeared on the cover of *Bugle* magazine. The real problem was that Crown land was allocated in a way that rendered the needs of the range resource problematic for both.

I like to use this example to illustrate the situation. Imagine an encounter between two strange dogs, in this case one belonging to a rancher, the other to a wildlifer. Do you own a dog? You'll know how the animals often test each other to see who's going to give. If you were to poke one with a stick you'll likely get a dogfight. But, if instead the hurt canine took a moment to reflect, it might become obvious where the source of the pain originated and appropriate action could then be launched. Maybe with the help of his new canine buddy, he could teach that humanoid what to do with the stick. Metaphorically the stick was the land



allocation problem wielded by the Forest Service. Looking back, this was an embarrassing moment of revelation. Wildlifers and ranchers could not claim to be more evolved than canines in handling their disputes. Thus, the motto for the period: “the time for co-operation is now past… it is now time for senseless bickering.”

Rapid social change must be a rare phenomenon, but the beginning of a change was on the wind starting in 1968 and it really hasn’t stopped since, although the change has been heavily subject to the “molasses factor.” Here’s a look at the most interesting blips on the change continuum.

1968–Project Grassroots. Eight livestock/wildlife groups funded their own study. The conclusion: "A decision has to be made (whether or not) to maintain ranges at an agreed level of forest succession and range productivity. (If done), a distinct increase in total productivity of the range lands for all uses can be achieved."

1974–British Columbia’s Chief Forester of the day Bill Young implemented Co-ordinated Resource Management Planning (CRMP), a concept developed in Oregon. Consultant William Anderson from the US was hired as assistant range director and CRMP was established on most Crown ranges in the Trench. This was a major program. Contrary to the military model of planning in use at the time (and still healthy in some spots today), the central idea was that the folks whose interests were at stake on the ground would plan its use. What a revolutionary notion! The stakeholders had their first taste of consensus building, which is still a work in progress. Federal and provincial governments came up with a pile of cash for range fencing, which improved cattle management but didn’t kill any trees, which were the fundamental problem. Sad to say CRMP has pretty much faded away, and only a few artefacts linger. But CRMP probably helped inform the changes that were still to come. Art Crane, Assistant District Ranger at the time, articulated the big lesson from the exercise into one precise sentence: "Without timber management you can't have range management."

We can now say that without timber management you can't have ecosystem restoration, in the East Kootenays anyway.

1990–East Kootenay Trench Agriculture/Wildlife committee (EKTAWC). This was BC Environment Minister John Reynolds' major initiative to solve the problem once and for all. All stakeholders were on board with a million government dollars—the John Murray committee. This was the next generation of consensus building or kinder, gentler negotiation. The naturalist/environmental constituency made their first appearance into the fray. They brought with them the notion that ecosystems possessed intrinsic value and should function in their own right as opposed to being only a source of commodities. That notion informs the program today. We need a new cartoon to show how inclusive this game has become. The duration of this exercise was 1990 to 1997, encompassing seven years and three governments. The central recommendation was, surprise: we need to recover the range resource, and we need a restoration program. The monotony of the findings was offset by good gains in stakeholder cordiality.

1992–Commission on Resources and Environment (CORE). Mike Harcourt's scheme to end the wars in the woods, based on a consensus model of negotiation. You're probably aware that consensus is favoured by those who have no power, like us. The powerful generally are okay with the *status quo* as a starting point. The CORE exercise was wonderfully instructive. Where else could you see the interaction between the likes of the hired guns of big industry and some volunteer citizen representing non-motorized outdoor recreation? It was, occasionally, a lot of fun. Ecosystem restoration in the Trench was a dominant theme. The CORE table did produce a land-use plan. Upon its release all heck broke loose in opposition, complete with a yellow ribbon parade, demonstrations, speeches, and no end of other nonsense. Out of the ruckus emerged the Kootenay Boundary Land-Use Plan (KBLUP) and its offspring the KBLUP Implementation Guidelines that contained the framework for a Restoration Program.

1996–The Rocky Mountain Trench Natural Resources Society was formed, including the same stakeholders as the EKTAWC, but without the government representatives. The background material that constituted our ammunition was the EKTAWC report and the CORE report, to name a few from the pile of reports generated during 40 years of declining range resources. The stakeholder conflict was on hold. As wildlifer Ray Wilson put it, "we can fight for nothing or work together and get paid." Some change from the two dogs scenario. The new game was to use the collaborative power of grassroots range stakeholders to push, shove, and otherwise encourage the already agreed-to recommendations into life. The vehicle for this would be a program based on the Implementation Guidelines—tailored to the dry forests of the Trench—as already set out in the KBLUP.

A consequence of all this churning was a brighter outlook. There was some optimism among the grassroots that something real and significant might actually happen. It's a good thing that hope springs eternal because the results to this point were equal to dropping a custard pie off a six-foot stepladder.

1997–East Kootenay Ecosystem Restoration Program launched by the Forest Service as directed by the regional Inter-Agency Management Committee. The inaugural meeting was in July 1997, and the Trench Society was invited to participate along with the usual players from other government agencies and the timber industry. I think we all got put at the back of the bus. The Invermere Forest District took the initiative on how to plan this stuff because without administrative infrastructure nothing is going to happen on Crown land. The time was fast approaching when something would actually have to happen on the ground.

That was 10 years ago. What's happened since? The Trench Society's big thing has been the Waldo Project, a long story in itself. The short version: A 1600 ha ecological restoration project was funded, planned, and executed by the Trench Society. It's not all done yet, but a big chunk is complete. The major thing learned on the project? Patience. For the program in general, speakers Randy Harris and Greg Anderson presented the numbers of hectares treated, dollars spent, and the like. The idea of ecosystem restoration is now a provincial program. The Rocky Mountain Forest District now has a full time program manager for ecosystem restoration (Randy Harris)—with assistants (Carol Atherton, Heidi Bennett). This is quite a change on the government side, from Denis Petryshen working part-time off the corner of his desk. The effort put into this issue by many stakeholders, agency personnel, and MLA Bill Bennett has produced a pretty solid program that looks like it has a future here and perhaps for other parts of the province as well. Our own Greg Anderson is manager of the provincial program. The program here continues to be a work in progress. Situation normal.

Results from the social side

The effects have not been what the Trench Society initially hoped for. Among our membership, the ranching industry has been the most disappointed. That sector is undergoing much change, hit hard by the bovine spongiform encephalopathy (BSE) crisis and now the high value of the Canadian dollar relative to the American dollar. It's hard to predict where the ranching industry here will be 10 years from now. Perhaps sold out as amenity properties to Alberta oil money? The wildlife sector is not far behind in concern, and fears a return to the dog days. There were a lot of expectations placed on the program.

Personally, I'd like to see a plan developed for the restoration of Sharptail Grouse, now extirpated from the Trench. In my mind, Sharptails are like the canary in the coal mine. If we can figure out how to get a viable population re-established, that would be evidence of pretty successful restoration. Those charismatic megafauna, elk, have flourished for a number of reasons; the ecosystem restoration program was probably of fractional benefit for elk.

The present reality

As Randy put it the other day, the low hanging restoration fruit has been picked. We're now face-to-face with Art Crane's one sentence analysis from 30 years ago, paraphrased for the present "without timber management you can't have ecosystem restoration." Timber management supportive of restoration is happening, but the increase in the scale of timber management needed is the next hurdle to clear. This brings us back to the land allocation problem. I think we can fix it. After 10 years, I say working relationships within the program are good and I daresay getting better, giving us a better chance of making a deal with the timber industry.

To wind up let's get back to the bus:

How did we get on the bus?

We were asked, but really, given our membership, it was an offer the Forest Service sort of had to make. We weren't very popular for the first few years.

Why did we get on the bus?

Because our membership had the most to gain or lose. Looking at results of the previous 40 years, not getting on the bus would have been an abdication. The grassroots stakeholders had to move up the food chain if we were to influence the program in ways to meet the needs of our members. If you always do what you've always done, you'll always get what you've always got.

How did we improve our popularity?

With great difficulty. We went to charm school. Actually it was through good luck and some hard work that we became valuable to the program—a fair exchange since it is obviously valuable to us.

Along with the others on the bus, we want to feel we own the program. In the final analysis it's that key ingredient, stakeholder ownership, which will be the most help in getting the job done. There is still much to do.

7. Ecological restoration in British Columbia—Making it happen

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Decades of wildfire suppression and changes in forest management practices have contributed to trees encroaching onto historic grasslands, as well as excessive ingrowth in previously open forests. The province's fire-maintained ecosystems, which occupy about 2.7 million hectares of Crown land, are being affected by this ecological change, causing: degradation of forage for wildlife and livestock; increased risk of catastrophic wildfire; poorer timber quality and quantity; loss of critical grassland habitat; reduced opportunities for gathering of First Nations traditional-use flora; decreased forest health; and diminished recreational and aesthetic values.

To mitigate these adverse ecological effects, a strategically directed ecosystem restoration program targeting fire-maintained ecosystems (initially) has been identified as a key priority of the BC Ministry of Forests and Range. Subsequently, in the fall of 2006, the Minister announced a new $2.0 million provincial ecosystem restoration program to help recover historic grasslands and open forests. Funding has since been extended for an additional two fiscal years at a base amount of $2.0 million per year.

The program will continue to build on the successful ecosystem restoration work in the East Kootenays that has been underway since the mid-1990s. As well, two other ecosystem restoration "pilots" have now been designated in the province. The Cariboo-Chilcotin pilot will focus on implementing the so-called "grasslands benchmark" designated by the regional land-use plan. A third pilot, in the Cascades Forest District, will move forward in conjunction with the Nicola Tribal Association in the spirit of the provincial government's "new relationship" with First Nations. In addition, with seed money support from the ecosystem restoration program, several other forest districts are now embarking on ecosystem restoration planning and treatment activity.

The practical knowledge and planning expertise gained in the East Kootenays in the last decade supplemented by the ecosystem restoration planning and treatment activities in the Cariboo-Chilcotin and Cascades will help inform other regions with similar ecological concerns. To this end, a Provincial Ecosystem Restoration Strategy (followed by Regional Ecosystem Restoration Strategies) will also be developed over the next year, based largely on the ecosystem restoration concepts, planning, and treatments being employed in the ecosystem restoration pilots. In addition, opportunities to modify current legislation and policy will be investigated to further facilitate large-scale ecosystem restoration treatments.

This is an exciting initiative for British Columbia. In launching the ecosystem restoration program, the province will deepen its expertise in fire-maintained ecosystem restoration, with future application of the concepts of ecosystem restoration to other ecosystems of concern in the province.

Looking forward to the next three years, the future Ministry-led ecosystem restoration targets (in fire-maintained ecosystems) will be the following:

Now…	**Target in 3 years…**
1 forest district actively applying ecosystem restoration treatments on the ground	12 forest districts actively applying ecosystem restoration treatments on the ground
~4000 ha prescribed fire/year	10–12 000 ha prescribed fire/year
~2000 ha moving into maintenance/year	12–15 000 ha moving into maintenance/year
8–12 BC Ministry of Forests and Range Burn Bosses & no certification course	25–30 Certified Burn Bosses
1 Prescribed Fire Council	2 Prescribed Fire Councils

The benefits to the province of undertaking the ecosystem restoration initiative in the fire-maintained ecosystem are numerous and include the following:

- Reduced forest fuels to help decrease the risk of catastrophic wildfire in the dry interior valley corridors
- Increased forage for wildlife and livestock, which contributes to the long-term economic health of the province's ranching, guide-outfitter, and hunting industries
- Increased opportunities for gathering of First Nations traditional-use flora
- Restored historic grasslands, which cover only about 1% of British Columbia, but provide critical habitat to 30% of the province's at-risk species
- Improved forest health and long-term timber values by thinning over-dense, stagnated stands

The proverbial "snowball" is definitely rolling for ecosystem restoration within the BC Ministry of Forests and Range!

8. Ecosystem restoration: the Rocky Mountain Forest District experience

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Since the 1950s the Rocky Mountain Trench of British Columbia has lost 50% of its natural grassland by ingrowth and ingress of ponderosa pine and Douglas-fir into the margins of the grassland. The loss of forage resulted in overgrazing by wildlife and cattle, increased populations of invasive plants, and considerable contention over the allocation of the grassland resource. The increasing fuel load in the forest also raised concerns about interface fires amongst local residents. In 1997, after some 20 years of effort, all stakeholders (ranchers, hunting groups, naturalists, community representatives, the forest licensees, and the BC Ministries of Environment, Agriculture, and Forests and Range) came to a consensus of opinion and action, under the umbrella of the Kootenay Boundary Land Use Plan. The resulting legal direction was the Natural Disturbance Type 4 guidelines, which were further enhanced in 1998 by the planning document "Blue Print for Action," covering ecosystem restoration. The program is overseen by a Steering Committee of local stakeholders, licensees, and agency managers. The Steering Committee reviews the work of an Operations Committee, composed of local resource professionals. The Operations Committee runs the contracts and carries out the work.

Based on the direction of the higher-level plans, the decision was made to manage 118 500 ha of valley bottom, marginal forest land to a mosaic of shrub lands, open range, and open and closed forest. The driest sites, least suited for tree growth were to be managed as open range (< 75 total stems/ha). Slightly better growth sites were to be managed for open forest (76 to 400 total stems/ha), and the moister, north aspect mesic sites as a conventional-managed forest. The choice of management option is ongoing, based on local knowledge, site indices, aspect, crown closure, and biogeoclimatic site series of the existing forest. The Timber Supply Review indicated that these ecosystem restoration activities would have minimal impact on the allowable annual cut.

The normal sequence of treating a site is first to prescribe treatment and arrange for excess sawlog and pulp volumes to be harvested. Ideally, slashing of the undersized stems is carried out, but usually this is a follow-up action. After allowing two years for fuel curing, the site is typically broadcast burned in spring and a follow-up assessment of burn impacts and stand conditions is made. Burning is needed to kill off conifer germinants, reduce fuel, or speed up understorey species change; not all sites need it. With the need to meet good burn indices and a venting window, burning the sites has become a bottleneck to ecosystem restoration. Typically these conditions are only met for three to five days each spring and two to four days each fall. Costs vary, but larger projects usually have better economic values.

Operations follow an adaptive management model. The Rocky Mountain Trench program has a formal monitoring program that measures changes to 12 critical features before and after treatment, and a routine monitoring protocol that measures prescription and contractual compliance. The Operations and Steering committees also determine and support research needs. All monitoring and research reports are reviewed by the Operations Committee each January and changes to operations, procedures, or objectives are recommended to the Steering Committee for approval prior to the spring operational window. To-date the program has generated 48 formal monitoring reports, all of which will be available by March 2008 at the Rocky Mountain Forest District website (www.for.gov.bc.ca/drm).

The degradation of the grasslands is not only caused by forest ingrowth; the ecosystem restoration program must manage the full gamut of threats to the ecosystem by addressing concerns about grazing by cattle and wildlife, and invasive noxious weeds. To gauge the program's effectiveness, all program partners follow monitoring protocols that address the following concerns.

- overstorey tree retention
- understorey vegetation change
- understorey forage increase
- rare plant occurrence
- coarse woody debris
- wildlife tree retention
- wildlife use with an emphasis on ungulates (bighorn sheep and elk), also badger and cavity nesters
- soil erosion and compaction
- insect and disease incidence
- integrity of riparian areas and wetlands
- noxious weeds

The main funding sources for the Ecosystem Restoration Program are the BC Ministry of Forests and Range, the Habitat Conservation Trust Fund, and the Columbia Basin Fish and Wildlife Compensation Program. The BC Ministry of Forests and Range co-ordinates the activities on site, but the program is very much an alliance of partners. The key partners to deliver this program are:

- BC Ministry of Environment
- BC Ministry of Agriculture and Lands
- Columbia Basin Fish and Wildlife Compensation Program
- BC Wildlife Federation
- forest licensees (Tembec, Galloway Forest Products Ltd., and BC Timber Sales),
- District range licensees
- Rocky Mountain Trench Natural Resources Society, which is a coalition of:
    - Cranbrook Archery Club
    - East Kootenay Wildlife Association
    - Kootenay Livestock Association
    - Rocky Mountain Naturalists
    - Southern Guides and Outfitters Association
    - The Land Conservancy of British Columbia
    - Waldo Stockbreeders Association

- Wildsight
- Windermere Farmers Institute

Further information about the Rocky Mountain Forest District's ecosystem restoration program can be found at:
www.for.gov.bc.ca/drm
www.for.gov.bc.ca/drm/erp/Blueprint2006.pdf
www.trenchsociety.com

9. Whitebark pine restoration on the Continental Divide

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Whitebark pine (*Pinus albicaulis*) is a high-elevation tree species that is an important part of subalpine ecosystems in the Pacific Northwest. This tree has been described as a "keystone" species, as its seeds provide an important food source for a number of animals including squirrels, bears, and in particular, the Clark's nutcracker, a high-elevation bird species. Whitebark pine is almost entirely dependent on Clark's nutcracker for successful dispersal and reproduction. Clark's nutcracker is thought to have co-evolved with whitebark pine as its only effective seed disperser (Tomback 1982).Whitebark pine is a long lived species and often attains an age of over 500 years in more open undisturbed sites (Arno and Hoff 1989), and sometimes reaches more than 1000 years (Luckman and Youngblut 1999). The species is also late to reach sexual maturity, generally does not produce cones until 25–30 years of age, and has no sizable cone crops until 60–80 years of age.

Over the past 15 years, managers have come to acknowledge that whitebark pine in the Canadian Rocky Mountain national parks, and other jurisdictions, face several significant conservation problems. These include substantial white pine blister rust infection (Smith *et al.* 2007), increasing mountain pine beetle infection, fire suppression, and climate change (Keane and Kendall 2001).

Wilson and Stuart-Smith (2002) identified seven general goals to help with whitebark pine conservation in the Canadian Rockies. In this paper we focus on outlining the strategies for two of those goals:

1. developing prescribed burning as a tool for enhancing regeneration, and
2. carrying out seed collections from individuals that show some phenotypic resistance to blister rust.

We set up two permanent plot monitoring networks: one to follow blister rust, beetle infection, and other forest health issues in whitebark stands (Smith *et al.* 2007); the other to examine the success of prescribed burning operations in providing more high-elevation early seral habitat for recruitment of new pine seedlings (Wilson, unpublished data).

The data from Smith *et al.* (2007) clearly indicates that white pine blister rust is the most pressing problem for whitebark pine populations in the Canadian Rocky Mountains. The majority of the most heavily impacted stands occur in the southern regions of the study area. Here, infection levels for some stands can approach 100% and mortality (due to all causes) for mature trees exceeds 50%. However, there are other infection hot spots in Kootenay, Banff, and Jasper national parks.

In the Rocky Mountains, whitebark pine populations occur in two distinct elevational distributions: (1) open timberline forests where a more dominate and lasting co-climax of whitebark pine typically experiences relatively continuous regeneration due to a mixed severity, mixed frequency fire regime; and (2) a sparse subdominant early to mid-seral presence in the subalpine closed forests initiated by a higher intensity, longer frequency fire regime. In general, this latter forest type has experienced a dramatic decline in the amount of area burned in the last 100 years (Rogeau and Gilbride 1994). This lack of natural fire through much of the mountain national parks has led to an increase in planned prescribed burning to aid in restoring ecological integrity and to reduce the public safety risk associated with fuel buildup. Presently, we have 14 prescribed burn monitoring sites on the landscape; however, few of the associated planned prescribed burns have been carried out. In most cases, operational constraints related to other factors, such as risk associated with public safety, have led to delays. To date, few planned burns are located in optimal areas for whitebark pine regeneration as other priorities have dictated the location for most sites. However, whitebark pine conservation has recently been included in the mountain parks' fire plan restoration objectives. To aid in identifying the best places to burn from a restoration standpoint, we have developed a spatial model that classifies the landscape into regions of low, medium, and high priority (Figure 1).

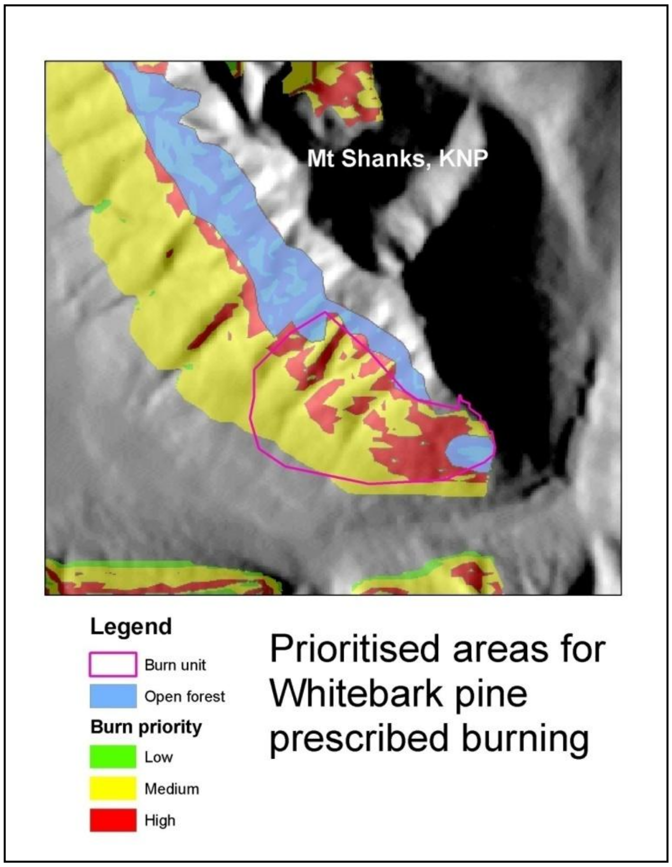

Figure 1: An example of the priority tool, zoomed in on a single planned prescribed burn area.

The model first focuses attention on identifying the location of open climax timberline whitebark stands that could act as seed sources for newly disturbed areas below. Those areas that may be most suitable for regeneration in the closed subalpine forest are prioritized, based on significant landscape level predictors of subalpine whitebark pine. The spatial priority model should be a flexible planning tool for managers working with prescribed fire. It will enable a rapid screening process to assess restoration potential for all fire plans above 1500 m (the lowest recorded elevation for the pine species in the Rockies).

Burn plan unit boundaries can be overlaid on the model to assign a potential level of priority for whitebark pine restoration. Where boundaries overlap with open timberline stands, or medium or high priority polygons in the lower subalpine forest, a site reconnaissance can be conducted to determine the local whitebark population structure.

This feedback will enable planning for possible fuel manipulation prior to burn initiation. The important open timberline seed sources could be protected from stand replacing fire, and mature whitebark individuals within the lower subalpine regions could also have fuels removed to promote their survival as seed trees in the newly disturbed areas. Ideally, efforts to create new ground for regeneration will be focused in regions where there is the greatest incidence of blister rust infection, as this will increase the chances of regeneration from mature individuals that appear to have some natural resistance to the disease.

In the areas of highest blister rust infection and mortality we have established cone collecting sites for seed from trees that appear resistant to blister rust infection. We have also started harvesting cones from a small number of these trees with the aim of stepping up to a long-term propagation program of seedlings for restoration work (Figure 2).

Figure 2. Adrian Leslie examining the cone crop on timberline whitebark pine trees in Jasper National Park.

An obstacle to efficiently collecting cones that have fully matured in autumn is that the Clark's nutcrackers and squirrels may have already removed most of the crop. Leslie's (2007) whitebark pine seed maturity project focused primarily on comparing the timing of seed maturation to the timing of seed harvest by wildlife. The goal of this study was to determine if reasonable germination rates could be achieved from seeds collected from unprotected cones prior to wildlife harvest. Leslie's findings indicate that significant predation of cones occurs before the earliest collection date that provides adequate germination. These results suggest that caging of cones is necessary in order to obtain seeds for conservation purposes.

Further work

A number of tasks need to be addressed for the future conservation of whitebark pine. These are:

- Use, expand, and improve the GIS burn priority model. Managers need to use the tool and provide feed back for further functionality. A better inventory of whitebark pine is needed. The current Alberta Vegetation Inventory and British Columbia's Vegetation Resource Inventory poorly represent the occurrence and abundance of whitebark pine, especially in the lower seral forests.

- Conduct more prescribed fires on the land base, especially in areas where there are high levels of blister rust. Whitebark pine objectives need to feature more highly in planning prescriptions. It is important to also determine how whitebark pine responds to harvesting, as most of the species' distribution in Canada is on provincial Crown land.
- A long-term rust-resistant tree identification and seed collection program needs to be continued in the national parks and initiated on provincial lands. Seeds from individual trees need to be identified using a storage, propagation, and blister rust screening process. Progeny of phenotypically resistant trees that show measurable resistance to induced infection could then be planted out in natural areas where infection and mortality are greatest (Mahalovich and Dickerson 2004). While waiting for this lengthy screening process to be completed, seeds from plus trees should be grown out, planted in priority areas, and monitored for rust resistance.

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Acknowledgements

This project is the result of generous support from a variety of institutions and individuals, including: Parks Canada, Global Forest Science, Selkirk College staff and students, Thompson Rivers University staff, Rob Walker, Jon Stuart-Smith, Daniel Backman, Niki Hiem, Rena Vandenbos, Peter Achuff, and countless others.

10. Fire history of the southern Rocky Mountain Trench: 1540–2005

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Fire Storm 2003 took many people by surprise. The unprecedented fires burned the wildland-urban interface and many homes and businesses at great cost to British Columbians. Many consider these fires a once-in-a-lifetime event. But, evidence from tree rings tells us they are wrong.

We used tree rings to reconstruct fire history and quantify the climate conditions associated with historic fires in the montane forests of the Rocky Mountain Forest District. The 10 study stands were dominated by large diameter western larch, Douglas-fir, and ponderosa pine trees, and were in the Montane Spruce (MS) Biogeoclimatic Zone (Figure 1). Each stand was structurally complex with an upper stratum of veteran trees that established prior to 1870.

Fire scar records from 10 old-growth sites were based on 100 fire scar samples that yielded 296 fire scars and 100 individual fire years between 1540 and 1944 (Figure 2). At the site level, the median fire intervals ranged from 10.3 to 25.6 years, with 2 to 123 years separating successive fires within sites. Our reconstructions indicate historic fires formed a “mixed severity” regime that included both frequent, low-severity fires and infrequent, high-severity fires (Table 1). Although frequent, the impacts of these fires were relatively low. Many large trees survived, although some were damaged and formed fire scars. The greatest negative impacts were to understorey vegetation such as herbs, shrubs, seedlings, and saplings. In essence, these low-severity fires created and maintained old-growth forests and unique wildlife habitats. High-severity fires that initiated a new generation of forest also burned in the East Kootenays, but they burned less frequently, with intervals of 150 years or more between fires.

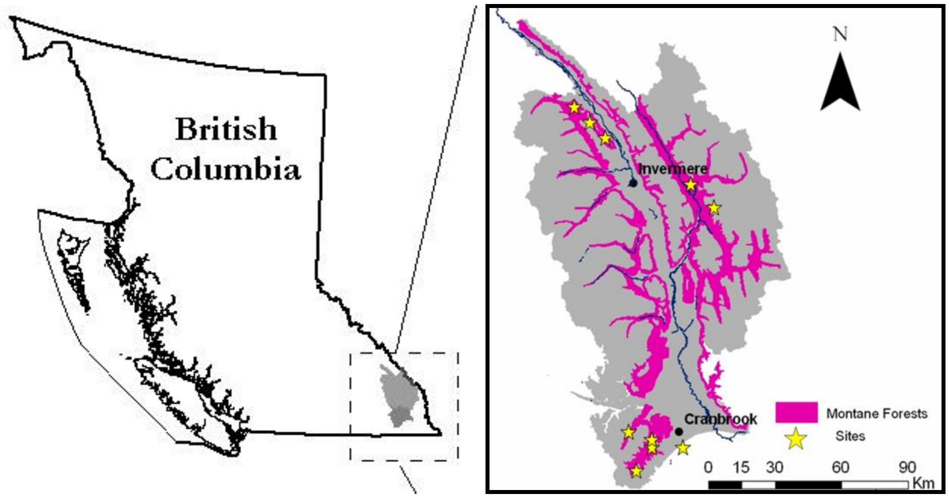

Figure 1. Location of 10 study sites (yellow stars) in montane forests (pink) in the Invermere and Cranbrook Timber Supply Areas (TSAs, grey) which cover 1.4 million ha of the southern Rocky Mountain Trench.

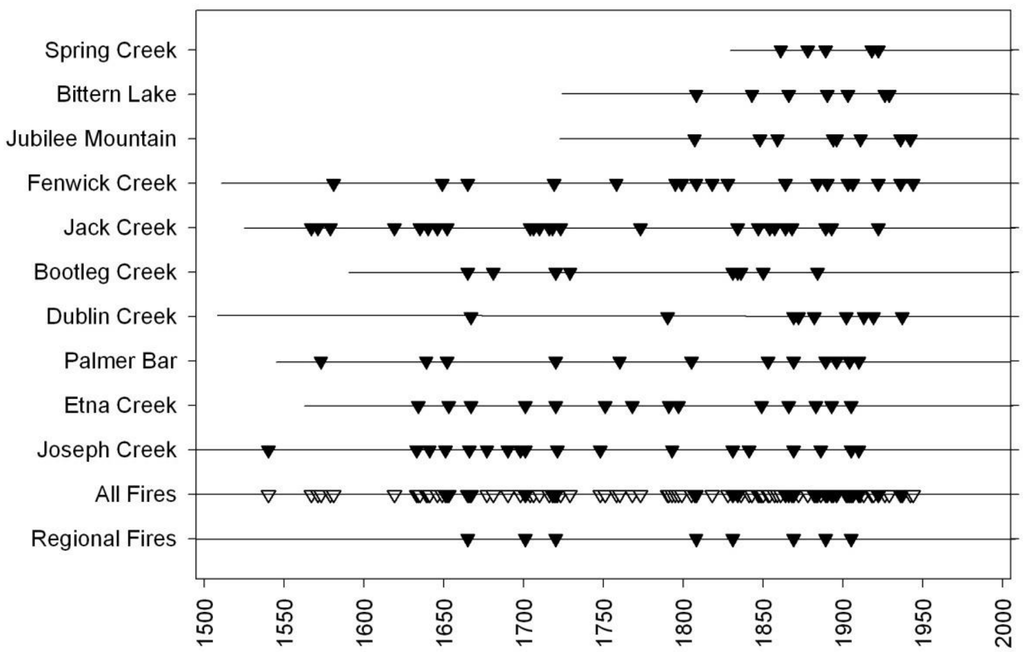

Figure 2. Fire history from 1500 to 2005 for 10 old-growth forests in the East Kootenays. Sites are arranged according to location from north (top) to south (bottom). Horizontal lines represent the fire chronology for each site. Triangles mark the year of fires that scarred ≥ 1 tree. Combined, there were 100 fire years (all fires, open triangles); 28 were major fires that scarred multiple trees (all fires, solid triangles). Regional fires scarred multiple trees at multiple sites.

Table 1. Comparison/contrast of stand-replacing and stand-maintaining fire regimes. Note that these regimes represent opposite ends of a continuum of possible fire regimes. Intermediate, mixed fire regimes include stand-replacing and stand-maintaining fires.

Fire regime	**Stand-replacing fire**	**Stand-maintaining fire**
Magnitude	High-impact, crown fires	Low-impact, surface fires
Frequency	Low frequency	High frequency
Return intervals	> 100 years	2 to 100 years
Size and shape	Variable, generally large with remnant islands	Variable, small to large with very patchy impacts
Impacts on individual trees	Severe–stem and foliage is burned along length of the tree, high mortality of small and large trees	Low severity–scars on stems, low mortality of large trees, high mortality of seedlings and saplings
Impacts on stands of trees and landscapes	Many trees die over large areas, with "islands" of surviving trees; landscapes include many large patches of forests that include trees of similar age having established after fire, boundaries between patches are relatively distinct	Mix of survival and mortality results in open forest stands; within stands, trees are a range of ages and survivors create structural diversity, patches may be identified in the landscape, but boundaries are subtle
Tree adaptations and examples from BC	Serotinous cones are stimulated by heat to release seeds (lodgepole pine); seedlings establish in full sunlight (ponderosa and lodgepole pine)	Thick bark resists fire (Douglas-fir, ponderosa pine, and western larch); regeneration from seed or by root sprouting (aspen)

The fire regime changed abruptly during the twentieth century. For over 400 years between 1540 and 1940, fires burned and scarred trees somewhere in the East Kootenay forests once every three years. Given this historical frequency, we would expect about 20 fire years since the 1940s, but our fire scar records included only six fire years. The low incidence of fires since the 1940s is partly due to variations in climate, but largely explained by cessation of burning by First Nations and very effective fire suppression.

We have discovered that climate is an important driver of the mixed-severity fire regime in the East Kootenays. Historical fires burned during pronounced droughts and decades of warm and dry climate caused by changes in the circulation patterns in the Pacific and Atlantic Oceans. Historically, fires burned under three conditions: (a) the Pacific Ocean was warm and the Atlantic Ocean was cool, (b) during El Niño conditions when both oceans were warm, and (c) during La Niña conditions when both oceans were cool. Fires were least likely to burn when the Pacific was cool and the Atlantic was warm. The latter conditions prevailed from 1946 to 1966, and were not conducive to fire. In contrast, conditions suitable for fires have dominated since 1981 since both the Pacific and Atlantic Oceans have been warm, meaning fires are most likely to burn during El Niño conditions. In fact, El Niño conditions have dominated global climate during the past 30 years. These climate conditions explain the drought and fires of 2003, but they do not explain the low occurrence of fire scars.

In large part, the decrease in fire frequency and increase in intervals between fires are caused by human actions. Fire frequency began to decrease in the early twentieth century due to human land-use change. Agriculture and ranching changed the distribution of forests and fuels, decreasing the spread of fires and the occurrence of fire scars. In the past 60 years, fires were essentially eliminated from many forests due to very effective fire suppression—leading to the "fire-suppression paradox." By trying to protect our forests and communities from fire, we have made many dry forests of the East Kootenays more susceptible to severe fires. In the absence of the low severity fires, tree density and fuels can build up, increasing the chance of a severe, stand-replacing fire that is difficult to control and may threaten human communities.

The changes to the historic fire regime also impact forest habitats and biodiversity. In the absence of low-severity fires, the density of trees, snags, and downed logs increases, adding complexity and a more diverse range of habitats, with potential positive influences on biodiversity. Alternately, negative impacts may include decreased light in the understorey and lower diversity of understorey vegetation, which affects insects, birds, and forage for ungulates. Our ongoing research explores the impacts of historic fires and fire suppression on habitat diversity.

How might we respond to the fire suppression paradox? We propose action where our good intentions have altered natural forest composition, structure, and dynamics. In many forests of the East Kootenays, we need innovative, creative, ecologically-based mitigation and restoration. As individuals, we need to take responsibility for our properties and communities through programs like *Fire Smart*. And, we need to be aware that some fires will burn during summer droughts in spite of our best efforts to control fires, and to restore and mitigate the negative impacts of twentieth-century fire suppression.

For more information about Dr. Daniels's work, and to access reports and project information, visit the website for the University of British Columbia's Tree Ring Laboratory: www.geog.ubc.ca/~ldaniels

11. Ecological restoration as a tool to enhance economic value

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Clean, accessible supplies of fresh water rely on healthy ecosystems, but ecosystems are often challenged by the economics of development and industry. Mining, logging, and recreation occur in most British Columbia drinking water watersheds and development surrounds many streams, lakes, and wetlands. This session presented a series of short case studies that demonstrate the economic benefit of a triple bottom-line approach (Green Value) to development and using this for ecosystem restoration, in the process both saving money and enhancing value for communities, developers, and the ecosystems themselves. This program of Smart Municipal Development is the subject of a new project, titled Nature's Revenue Streams, being developed to assess the effectiveness and value of ecological approaches to water management. Case studies demonstrated how maintaining and restoring the function of aquatic ecosystems can reduce cost and/or increase profit. Case studies included integrated drinking water management in the City of Cranbrook, stream restoration in both agricultural and urban settings, and stormwater management on Vancouver Island and in Kimberley, British Columbia. Patrick also addressed the use of natural corridors in the British Properties in West Vancouver, British Columbia.

12. Genesis of the Rocky Mountain Trench Prescribed Fire Council

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Ecosystem restoration has been aggressively applied in the East Kootenay region of southeastern British Columbia for several decades. In fact, one could argue that this region has been a provincial, and even national, leader in focused ecosystem restoration research, planning, operations, and monitoring. A driving impetus behind this program is the large number of threatened and endangered species and ecosystems found there, while the driving force has been the unusually large number of professionals supportive of the ideology. The Ecosystem Restoration Program is centred on the active management of vegetative structure and composition in dry forest and grassland ecosystems. These ecosystems are considered to be structurally and compositionally the furthest departed from historic reference conditions and they also contain the highest proportion of endangered species habitat. A critical natural disturbance process that these ecosystems have ecologically evolved with is fire. It is largely due to the exclusion of fire over the last 60 to 100 years that has resulted in the significant, and mostly negative, ecosystem changes that fostered the development of the Ecosystem Restoration Program.

The Ecosystem Restoration Program originated in the BC Ministry of Forests and Range and BC Parks, but has recently grown to include the National Park Service, The Nature Trust, The Nature Conservancy of Canada, and a number of municipalities. While there have been numerous successes in the prescribed fire program over the last decade, a number of significant issues have recently endangered the continuation of the program, regardless of jurisdiction. These include: smoke, cost, capacity to carry out the operations, liability, public understanding and acceptance, and the challenge of operating under a modicum of scientific uncertainty. As it turns out, these issues are not unique to the East Kootenay region; they are very similar to issues facing prescribed fire programs throughout North America.

One novel way to deal with the many challenges facing burn programs is through the development of a local Prescribed Fire Council. The first North American Prescribed Fire Council was established in Central Florida in 1992 and was made up of 17 federal, state, local, and private groups that differed in their fire management goals but agreed that the ability to use prescribed fire as a safe and effective land management tool needed to be protected. Since then Prescribed Fire Councils have sprung up in 13 states, Mexico, and in 2007, British Columbia. The Rocky Mountain Prescribed Fire Council (RMPFC) is unique among the Councils in that it is the only international Prescribed Fire Council counting as one of its members the Rexford Ranger District of the Kootenai National Forest in northwest Montana.

The RMPFC encompasses the Rocky Mountain Trench from Montana to north of Radium Hot Springs, and includes prescribed fire practitioners and other resource professionals from the BC Ministry of Forests and Range, BC Parks, BC Ministry of Environment, Parks Canada, The Nature Trust, The Nature Conservancy of Canada, the Regional District of the East Kootenays, the City of Kimberley, and the City of Cranbrook. The council recently approved its terms of reference and has scheduled a fall post-burn practitioners workshop as well as public workshop on prescribed fire effects.

13. Plant community response following dry forest ecosystem restoration

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Dry forest types in the East Kootenay region of British Columbia suffer from excessive forest ingrowth and encroachment. Approximately 250 000 ha of land are contained within the Ponderosa Pine and Interior Douglas-fir biogeoclimatic zones. An estimated 1500 ha of grazing lands are lost annually. This is accompanied by a loss of wood volume and wood quality. This project examined the plant community response following dry forest ecosystem restoration. Grass and grasslike cover is dominated by rough fescue, pinegrass, Richardson's needlegrass, Idaho fescue, northwest sedge, and bluebunch wheatgrass. All of these grasses, except for pinegrass, have been shown to be important components of cattle and wildlife diets and are common in open grassland and open-forest communities. Harvesting and burning treatments reduced forest cover from between 30 and 60%, to 10 and 30%. Increases in forage production of between 25 and 700% have been documented. Significant species change in the herbaceous plant community has not been determined at any treatment. Canopy removal through forest harvest is the most effective treatment for increasing forage production. The release potential of a site depends on the composition of the herbaceous and shrub layer. Failure to remove the regeneration layer will eventually negate any forage-derived benefits. At an operational scale, sites should be prioritized based on the proportion of bunchgrasses and desirable shrubs in the plant community. Further monitoring will be required to accurately assess long-term effects on individual plant species, forage production, fibre volume and quality, and forest ecosystem function.

Evening presentation, October 12, 2007

Eco-cultural approaches to restoration

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I'd like to think that I invented the notion of ecological restoration, but in spite of my overinflated ego, I have to admit, there are a few people who have gone before me on this one. Quite a few, actually.

The first restorationist in this part of the world would have been a Ktunaxa man or, just as likely, a woman, who would have set a grass fire on St Mary's Prairie or Pickering Hills a couple of centuries ago, to bring in more game or perhaps to enhance the Saskatoon crop. That Ktunaxa woman used some of the same tools and knowledge that we use now, but she didn't think of what she was doing as ecological restoration, she thought of it simply as caring for Turtle Island.

Next in the long queue of people who invented ecological restoration before I did was probably a local cattle rancher in the 1920s, who understood the delicate ecological balance between grass and trees, was not scornful of First Nations knowledge, and didn't share the profound fear and hatred of fire that his contemporaries harboured. He didn't think of lighting up that same grassland as ecological restoration, either. He was just looking after business, in the best sense.

Next in the ecological restoration queue would have come an early Forest Service range man, an Edwin Tisdale or perhaps a Jim Milroy. The horrendous spasm that was World War II was over, and he began to turn his thoughts in earnest to the workings of the Rocky Mountain Trench landscape. A lot of observation, and a lot of time on horseback, led him to the conclusion that fire was a part of this landscape, and that fire could actually be applied and controlled, rather than just suppressed when you could, and endured when you couldn't. He probably had to deal with match-happy colleagues who liked to do "recreational burning," but I'd like to think that his methodical approach prevailed.

Then in the 1980s, we moved into the era of the planner, and a series of forces resulted in an almost total loss of fire as a tool.

But now, fortunately, we have the current generation of Trench restorationists, who have worked patiently since the late 1980s to bring fire out of the closet and back into the toolbox. Not only fire, but fire histories, historical stand reconstructions, public outreach about fire, the intelligent application of pre-burn fuel modification, and thinning on its own where necessary, as an analogue of fire.

I happened to come on this scene in about 1990, when I was fresh off the boat from Saskatchewan, and started working as a Range Ecologist for the Forest Service Regional Office in Nelson. One day Ross Tozer, the Regional Manager, called me in and said, “Gayton, there’s a little problem that has developed between the ranchers and the hunters over in the East Kootenays, about access to forage. We want you to go over there and fix it.” So, full of totally unjustifiable self-confidence, and blissfully ignorant of the Byzantine eco-political realities of the Rocky Mountain Trench, I blithely drove over to my first meeting in Cranbrook. All the usual suspects were there—the three Ministries, the various hunter groups, the various rancher groups, and several hangers-on. Both the hunter and the rancher groups were further segmented into affiliated, and non-affiliated. The meeting started, and after about seven and a half minutes of niceties, the knives began to come out. The hunters didn’t trust the ranchers, and vice versa. The affiliateds didn’t trust the non-affiliateds. The sheep guys weren’t sure about the elk guys. The Ministries didn’t trust each other, District staff didn’t trust Victoria staff, Cranbrook didn’t trust Invermere, the Regional District was confused. This fight over forage had actually been going on since about 1949, vicious letters to the editor were a daily occurrence, bodies were buried everywhere, there was absolutely no trustworthy data, the participants seemed to be thoroughly enjoying the verbal violence, and here I was, completely naive, thrown into this ravenous and bloodthirsty den of wolves, saying, “Hi, I’m Ed Broadbent.”

Actually, it turned out to be quite a remarkable story. From that foul and toxic shotgun marriage of hunters, ranchers, and government, came this shining newborn infant known as fire-maintained ecosystem restoration, which has gone forward to become the bright light of ecological restoration in British Columbia, and perhaps in the country. You folks can truly claim to have invented the Trench brand of ecological restoration. The work here is the exception to the general rule that ecological restoration normally occurs only in and around large metropolitan centres. Here, you folks are proceeding apace with broad-scale restoration in a largely rural environment.

But as good as the Trench restoration work is, it is profoundly hobbled by one inescapable fact. Every restoration project in the country is hobbled by the same fact. And this is what I want to talk about. The inescapable and crippling fact is that people don’t care about nature. Our society does not care about nature.

When you are surrounded by people with similar ecological interests and passions, it is easy to lose sight of the fact that to a very large segment of society, nature has no real meaning. It’s not that they dislike it, or are afraid of it. Nature simply isn’t a part of their life.

Nature and ecosystems actually occupy a very low rung in our society’s priorities. A huge plethora of items come first before nature—economics, technology, transportation, real estate, lifestyle, recreation, consumption, and convenience. And all of the good work that you do and I do, in restoration, in education, in conservation, in research, sooner or later runs up against this one brutal fact: nature is not really woven into the fabric of Canadian society. Nature is only honoured in the breach, when some event disrupts the ecosystem services we so casually depend on. Then we pay attention.

I don’t think it’s always been this way. I believe our culture’s relationship to nature, and by extension, our relationship to local place, has been isolated and degraded. And, like Eric

Higgs says, there is a potential attachment for nature incipient in all of us, but it must be cultivated before it becomes active.

Books have been written about why nature has such low status in contemporary society. Science. The influence of technology. The suppression of women. Materialism. The shift from a geocentric, earth-as-mother social perspective to a Baconian perspective of nature as an object to be subjugated, dissected, and controlled. The possible reasons for nature's low status make for interesting debate. But the bottom line is that we tend to classify cultures around the world based on the closeness of their relationship to nature. The ones with close bonds to nature we think of as primitive; cultures with very loose and distant bonds, like our own, we think of as advanced.

Now we all know that ecological restoration is a difficult job. The budgets are small, the payoff is long, and nobody has yet won fame and fortune by being a restorationist. But in spite of all that difficulty, I'm asking us restorationists to take on another task. That incremental task is to come up with ways of elevating the status of nature in society. Preaching to the converted—ourselves that is—is always good, because the converted are under stress, and they need positive reinforcement. But the true battlefield for nature conservation lies not in preaching to the converted, it is a battle for the hearts and minds of average citizens.

In our current cultural context of devalued nature, even the best restoration projects are one-offs, marginal activities, pathetic ecological snowballs in a consumerist July.

If we can get started on this fundamental work, this work of re-inserting nature back into our culture, then all of our restoration projects are going to benefit. I have a few ideas on how to do this.

First, we have to rethink our traditional notions of information transfer about nature and ecosystems. I'm the worst culprit. I've written dozens of extension bulletins, background papers, and interpretive signs over the years, and I persist in thinking that if I could just write the ultimate, truly perfect extension bulletin, the entire world would experience a blinding paradigm shift, and start protecting native grasslands, caring about rivers, abandoning their ATVs, and honouring the spadefoot toad.

Good extension materials will engage, and perhaps even galvanize, about 5% of the population, the ones that are onside already. The other 95% are not likely to even read the materials, much less experience an attitude or behaviour shift as a result.

Like a lot of us, I've been totally co-opted by information. I gather it, I file it, I summarize it, and turn it into an endless stream of extension products, in the naive belief that if I do it just right, that suddenly people would begin to care. What an idiot I am. What idiots we are. Naked information rarely changes hearts and minds.

We live in what I call the era of indifference. In other words, we know, but we don't care. There was a time when ecological ignorance could be claimed as an excuse for the damage we do to nature, but not any longer. Splendid graphs and tables are now instantly available, providing minute detail on how we degrade our atmosphere, max out our energy resources, pollute our rivers, overplow our prairies, overcut our forests, overbuild our cities, and overdrive our roads. Information about nature is not the bottleneck; caring about that information, putting that information into a social, cultural, and ethical framework, and acting on that information—that's the bottleneck.

I think there is really only one way to raise the status of nature in society, and that is to give it cultural and artistic context, or packaging, if you will. Nature needs story. Think of Farley Mowat's *Never Cry Wolf*, or Wallace Stegner's *Wolf Willow*. Nature needs art. Think of Robert Bateman's wildlife paintings or Allen Sapp's evocative prairie landscapes. Nature needs music. Think of Vivaldi's *Four Seasons* or Beethoven's *Symphonie Pastorale*. Nature craves images of itself, such as the photographs of Ansel Adams or the films of Godfrey Reggio. And even closer to home, Chris Harris's wonderful images of the Chilcotin grasslands. Nature needs poetry, pottery, interpretive dance, performance art, fabric arts, and sculpture. These cultural artifices contextualize, editorialize, and memorialize species, ecosystems, and landscapes, and make them important to us. The artistic works persist long after the viewing or reading or listening; they float in our minds, and manifest at odd moments. They refer, and they correlate. They are mnemonics and *aides memoires* for a wealth of biological detail. They link forward and they link backward in time.

This to me is at the core of the genius of Indigenous People's Knowledge: the knowledge is all carried within the enfolding womb of story and ritual and culture.

In the wintertime, I swim at our local recreation centre in Penticton. My idea of a good workout is half an hour in the pool's hot tub, followed by five minutes of swimming laps, so I have a lot of time to look around. On the wall above the hot tub is a big, bright mural that depicts a cute underwater scene with lobsters and treasure chests and sea monsters. Now this is a bit picky, but why couldn't that mural be a fanciful underwater scene drawn from the aquatic ecology of the Okanagan-Similkameen area where I live? Why couldn't we have fierce tiger salamanders and friendly Chinooks and diving ouzels and dancing freshwater clams? Why is it we are so afraid to celebrate the local?

If there is one group more marginal in our society than us biologists, ecologists, and restorationists, it is the artists. We need to join forces with them, show them the wonders of our material, and learn about their needs and desires. The barriers between art and science have been up far too long, and it is time to tear them down.

Ecological restoration is really just getting underway in Canada, but it has the potential for being a long-term, popular movement, that encourages people to commit random acts of kindness to nature, and thus bind them to it. One of the reasons that I keep thinking that I invented ecological restoration is that it is such a compelling idea. There is something for everyone in ecological restoration.

Restoration will not only benefit from nature being more important in our culture, it can also act as one of the mechanisms to make nature more important. William Jordan, one of the leaders of the ecological restoration movement, made what I think is a stunningly brilliant proposal a few years ago, and one that bears on this issue.

Jordan's proposal goes like this. Every human society in history has had ritual as a major part of its culture. In our current culture, the traditional vessel for ritual is organized religion which, for any number of reasons, is no longer a part of mainstream, everyday society. So we are, for the first time in history, a culture that is bereft of ritual. What better material for the re-integration of modern, enlightened ritual into society, Jordan says, than the material of ecological restoration? Restoration touches on all the key elements of ritual. It involves humility, the recognition of past wrongdoing, and it is unselfish. It is an actual and a symbolic gift, a giving back. Restoration pays homage to the earth, to regeneration, to seasons, to water, to fertility, to science, to community.

While I'm touching on the touchy subject of religion, I might as well mention guilt. I thoroughly dislike the way guilt is used in organized religion, but I do recognize that guilt is a powerful motivating, and binding force. What if we took another stab at guilt, but this time not through the religious medium of sin, but through the medium of climate change? Climate change has a lot of guilt potential. It's something we're all equally responsible for, we knew we were doing wrong by the profligate consumption of hydrocarbons, but we went ahead and did it anyway. Now we're slowly confessing our petrochemical sins, and we probably can't completely fix climate change now even if we went full out. So let's take a second look at climate change and our responsibility for it, as a collective, non-religious guilt device to bring us back together as a society, and to re-centre our society in the earth, where it belongs.

I apologize that this all sounds so romantic and airy-fairy. Actually, I take that back. I don't apologize. If I could see a way out of our dilemma through science, I would grab it instantly, but I don't. As wonderful as our vast storehouse of scientific knowledge about nature is, that knowledge has not brought society one iota closer to nature.

What I am proposing sounds atavistic, pantheistic, and primitive, a notion that is truly unsupportable in an age when North American society endlessly generates technological and material progress, almost whether it wants to or not. But maybe, just maybe, we should re-examine that dogma of advanced cultures being distant from nature and primitive ones being close to it. Who exactly, made up that rule? And must we be prisoners of history?

I know that this band of committed individuals and organizations—this five percent—can only go so far with management, with extension, and with one-off restorations. The passionate, art-assisted re-weaving of nature back into the fabric of our everyday Canadian culture is our best, and perhaps our last, hope.

Presentations on October 13, 2007

14. Assessing impacts on Ktunaxa Nation cultural resources from ecological restoration, timber thinning, and prescribed burning in the Rocky Mountain Trench

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This summary is adapted from a poster presentation presented at the 16th Annual International Society for Ecological Restoration Conference, University of Victoria, 2004.

Introduction

The people of the Ktunaxa Nation are culturally and linguistically unique in the world, and have lived in the Rocky Mountain Trench of southeastern British Columbia for centuries (Smith 1984). Archaeological studies have revealed the cultural association of Ktunaxa campsites with kettle lakes in the valley-bottom of the Rocky Mountain Trench north and south of Cranbrook (Choquette 1975). The kettle lake complexes have been assessed in earlier studies as having High Archaeological Potential (HAP) requiring special management attention (Choquette 1999).

Frequent low-intensity fires have historically maintained the dry, low-elevation grasslands and open forests of the Rocky Mountain Trench every 15 to 20 years. These are called Natural Disturbance Type 4 ecosystems due to their fire history (Province of BC 1995). Most of the Trench falls in the Ponderosa Pine (PP) and Interior Douglas-fir (IDF) biogeoclimatic zones (Meidinger and Pojar 1991). Decades of fire suppression have allowed the open forest to become ingrown with dense stands of lodgepole (*Pinus contorta*), and ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*); similarly, conifers are encroaching on the open grasslands.

Ecological restoration projects involving pre-burn timber treatments and prescribed burning are ongoing in the area around the kettle lakes complex. The management of forest lands in the East Kootenays in areas of high density of archaeological sites (or areas of HAP) has been problematic for private and public sector regulatory agencies, the Ktunaxa Nation, and archaeologists. Many of the areas of HAP have been set aside from timber harvest and prescribed burning due to lack of clear management recommendations, leaving them vulnerable to wildfire and fire fighting activities. To avoid further damage of this sort, this research project sought to develop a process of proactive archaeological site management—to achieve the protection of cultural sites, the reduction of fire hazard, and accomplishment of restoration goals.

Study area

The project study areas occur in a section of the Rocky Mountain Trench, south of Skookumchuck and northeast of the City of Cranbrook in the Kootenay region of southeastern British Columbia. The study area falls within the Interior Douglas-fir (IDFdm2) biogeoclimatic zone, characterized by hot, very dry summers, and cool winters with light snowfall (Braumundl and Curran [editors] 1992). Zonal forest vegetation is predominately Douglas-fir, lodgepole pine, and ponderosa pine, with an understorey shrub layer of Rocky Mountain juniper, soopolallie, Saskatoon, and snowberry, and pinegrass in the herb layer (Braumundl and Curran [editors] 1992).

Soils are generally silty, consisting of a relatively poorly developed brunisol layer underlain by deposits of glaciofluvial or glaciolacustrine origin at depths of 5–20 cm (Middleton 2003).

Cultural context

Evidence of human occupation of the Rocky Mountain Trench can be traced to early post-glacial periods of 10 000 to 7000 years ago (Choquette 1999). Artifacts from archaeological sites dating between 5000–2500 years ago are concentrated on the shores of numerous small kettle lakes that dot the floor of the Trench, typical locations of Ktunaxa campsites. Patterns of lithic material found in these sites show a well-developed stone tool technology using microcrystalline stone, quarried tourmalinite, cherty limestone, and Kootenay argyllite (Choquette 1993).

The Upper Ktunaxa group of the Ktunaxa Nation (or Kutenai or Kootenay Indians) followed a nomadic seasonal round, based on abundance and ripening of a broad range of animal and plant resources. Deer and elk were the dominant game animals, supplemented by salmon and other fish from the Columbia River system, bison from the Great Plains over the Rockies, waterfowl, roots and berries, and other plant material (Smith 1984). Ktunaxa traditional use and oral histories recount the occupation of the Rocky Mountain Trench, and numerous Ktunaxa place names have been recorded.

Study methodology

Archaeological inventory
The research inventory and evaluation of five archaeological sites in the Wolf Creek/Premier Ridge area and two archaeological sites in the Reed Lakes area was built on theoretical modelling developed for Archaeological Potential Mapping by Choquette (1999), Ktunaxa Nation traditional use and oral histories, and earlier archaeological information gathered at these sites (Choquette 1975; Choquette and Sauer 1998; Campbell 1999; Brandzin 2000).

One of the defining factors in the rating of HAP is the soil context in which the cultural materials are found. The pre-contact cultural deposits occur in both surface and buried contexts at a range of depths. The location of cultural materials determines their susceptibility to surface and subsurface soil disturbance. The archaeological sites in question are found on sand/silt terraces adjacent to the kettle lakes, making them highly vulnerable to disturbance. Standard operating procedures for timber harvest in these circumstances in the Rocky Mountain Trench require that resource extraction only proceed under winter conditions, with recommended minimum depths of frozen ground (7.5 cm) and snow cover of 30 cm or more (S. Brookes, pers. comm.; Curran 1999).

Conventional feller-buncher equipment for timber harvesting has the potential to cause the most surface disturbance to archaeological sites, and this form of timber removal is the most commonly used in the Trench. This equipment became the focus of the research.

Impacts to artifacts can be measured in several ways: alteration through compositional changes, breakage, vertical and horizontal displacement, and loss or removal from the archaeological record (Hester 1988). In order to determine the horizontal and vertical extent of these sites, field investigations in 2002 consisted of a combination of intensive on-foot visual surface inspections, sub-surface shovel test units, and selected evaluative test excavation units. Field methodologies followed accepted standards for archaeological impact assessments in the province (Province of BC 1998, 2000). Surface and subsurface survey methodology is described in Wood *et al.* (2002).

Harvest and post-harvest field work

During timber harvesting in the winter of 2004, a Ktunaxa Nation field technician was on site, photo-recording the harvest activities on prescribed conditions of frozen ground and snow cover, and monitoring any soil and surface disturbance impacts. Following the winter harvest, post-harvest soil disturbance surveys were completed using methodology from the *Forest Practices Code Guidebook* (Province of BC 2001). Surveys were carried out on timber harvest cutblocks and across forestry access roads, to determine the impact of harvest activities on cultural deposits.

Results

The pre-contact cultural materials, which consist primarily of artifacts from stone tool manufacturing and the stone tools themselves, occur in the archaeological sites in both surface and subsurface (buried) contexts down to depths of almost 60 cm. Materials in the topmost 20 cm are highly vulnerable to surface and subsurface disturbance by resource extraction activities.

Table 1. Summary of the vertical extent of the recovered archaeological material.

Site	DlPw-023	DlPw-024	DlPw-025	DlPw-035	DlPw-036	DkPw-012	DkPw-013
Surface	826	4	170	2	8	11	39
0–10 cm	83	16	406	25	104	7	36
10–20 cm	56	11	322	13	241	6	32
20–30 cm	6	1	208	1	55	0	14
30–40 cm	4	0	80	0	17	0	1
40–50 cm		0	25	0	0	1	1
50–60 cm		0	1	0	0	0	0
Total # of artifacts	**975**	**32**	**1631**	**41**	**425**	**25**	**123**

Table 2. Summary of the disturbance to research sites from timber harvesting activities.

	Timber harvesting activities		
Research site	**Type of impact**	**Extent of impact (% soil disturbance in SDS area)**	**Duration of impact**
DlPw-023	Minor surface disturbance (< 5 cm), compaction	10%	Temporary
DlPw-024	Control site	Control site	Control site
DlPw-025	Minor surface disturbance (> 5 cm), logging slash	23%	Temporary (except for root throw)
DlPw-035	Minor surface disturbance (< 5 cm), compaction	35%	Temporary
DlPw-036	Minor surface disturbance (> 5 cm)	10%	Temporary (except for machine gouge)
DkPw-012	Soil compaction	15%	Temporary
DkPw-013	Soil compaction, logging slash	25%	Temporary

Table 3. Summary of the disturbance from road-related activities at the research sites.

Research site	Type of impact	Average depth of impact	Average width of impact	Range of impact (width)	Length of impact
DlPw-023	Scraping of road surface	0.08 m/8 cm SD 0.03 m/3 cm	3.8 m/38 cm SD 0.48 m/48 cm	2–4 m	200 m
DlPw-025	Interment by equipment and removal	0.23 m/23 cm SD 0.07 m/7 cm	5.02 m/50 cm SD 1.24 m/124 cm	2.65–6.5 m	65 m
DkPw-013	Removal of topsoil, soil displacement	0.57 m/57 cm SD 0.23 m/23 cm	13.86 m/138 cm SD 1.89 m/189 cm	2.5–18.9 m	400 m

The impacts of actual timber harvesting were minor, and rarely exceeded soil disturbance greater than depths of 5 cm. The disturbance associated with road-related activities was much more severe—soil was overturned to depths of 0.8 m in one road upgrading incident, and road surfaces were disturbed to a width of 18.9 m at the same archaeological site. Lack of communication between road contractors and Ktunaxa Nation resource management staff exacerbated the situation in all road-related disturbances.

Recommendations

The following recommendations are presented for the protection of Ktunaxa Nation cultural heritage sites in relation to timber harvesting and prescribed burning activities in the Rocky Mountain Trench:

- Conduct Archaeological Overview Assessments (AOAs) and Archaeological Impact Assessments (AIAs) for all proposed timber thinning, prescribed burning, and road building or upgrading prescriptions and plans
- Flag off identified cultural heritage sites during pre-harvest field work
- Avoid cultural sites completely with feller-buncher harvesting equipment and/or timber skidders, to minimize surface disturbance to sites
- Delegate decision-making authority to the Ktunaxa Nation for determining whether restoration activities take place on or near cultural heritage sites
- Ktunaxa Nation field technicians should monitor all timber harvesting and prescribed burning activities in the vicinity of cultural heritage sites
- Ktunaxa Nation field technicians should conduct post-harvest and post-burn monitoring of impacts to cultural heritage sites
- If impacts do occur, remediation to cultural sites should take place if possible

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15. Mine reclamation strategies in British Columbia

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Reclamation has been an integral part of the mining process in British Columbia since the late 1960s when reclamation legislation was introduced. A variety of reclamation strategies have been applied to lands disturbed by mining. Some reclamation programs have followed traditional forestry practices while other programs have used agricultural systems to develop vegetation cover on the reclamation sites. Poor results have been experienced on sites where high elevations, adverse climatic conditions, and poor substrates limit growth. Ecologically based reclamation systems have had greater success and have been able to return pre-mining productivity to the mining-disturbed sites in some cases. The diversity of ecological and geological conditions in British Columbia requires adaptable reclamation strategies. This paper explores the wide variety of reclamation strategies that have been used in British Columbia over the past 40 years. By looking back at previous successes and failures in light of current knowledge, key features of effective reclamation strategies can be determined. A summary of effective reclamation strategies is provided from this evaluation.

Introduction

Reclamation is an integral part of mining in British Columbia. Reclamation research and work has been undertaken in the province since the 1960s and a significant body of information has been collected (TRCR 2003). Early academic leaders in reclamation provided reclamation strategies based on their background. Forestry (Jack Thirgood), agriculture/soils (Art Bomke and Les Lavkulich), and ecology (Marc Bell) provided the foundations of the approaches to reclamation that have been applied in the province. In addition, reclamation practitioners at the various mines provided their personal stamp on the reclamation strategies that were emerging. Sharing reclamation ideas at conferences held by the Technical and Research Committee on Reclamation and the Canadian Land Reclamation Association has resulted in a blending and modification of strategies. Continued improvements in reclamation performance are part of the progressive mining community in British Columbia.

Mine reclamation in British Columbia is particularly challenging. Steep mountainous terrain and adverse climatic conditions coupled with high wildlife and fisheries values in many minesite areas create conditions that test the skills of reclamation practitioners. The massive size of many British Columbia mines also creates difficulties. Elements such as acid rock drainage, selenium, neutral pH metal leaching, and molybdenum toxicity provide particular challenges at specific mines. Innovative mine and reclamation strategies such as wrap-around dumps (Milligan and Berdusco 1978; Milligan 1988) have been developed to meet these challenges.

Strategies for mine reclamation in British Columbia can be grouped into three major classes: forestry, agriculture and soils, and ecological. Standard tree planting as a revegetation approach would fall into the forestry category while application of a till capping or bio-solids to enhance soil fertility would be assigned to the agriculture and soils category. Successional reclamation (Polster 1989) as well as the use of native species islands (Bittman 1995) belongs in the ecological class of mine reclamation strategies. This paper is organized around these three main classes of reclamation strategies with discussions of the pros and cons of each included with the discussion of the strategy. Conclusions are provided following the section on the strategies.

Forestry-based strategies

Forestry is a dominant player in the economy of British Columbia so it is not surprising that when faced with reclaiming mining disturbances many practitioners turned to forestry and notably silviculture as a model for mine reclamation. Tree planting, including the use of fertilizer tablets to enhance the nutrient content of the substrates the trees were planted in, is a standard approach for revegetation at some mines (Gardiner *et al.* 1992). Tree planting coupled with planting of legumes has also been employed to enhance nutrient characteristics of mine wastes to improve tree growth (Gardiner *et al.* 1992; Polster and DuBois 2007). Other tree establishment approaches fall more appropriately into the ecological category of mine reclamation strategies.

Standard silvicultural methods may fail to achieve acceptable growth when applied on mine wastes. The major reason for this is that mine wastes, unlike normal forest soils, lack many of the elements that will ensure the success of tree planting. In most cases, mine wastes lack significant organic components and, thus, elements such as soil micro-organisms that are important in the development of nutrient cycling are lacking. Even when fertilizers are applied at the time of planting, the inability of the freshly planted tree roots to be colonized by appropriate soil organisms limits their growth. Standard silvicultural methods typically fail to achieve satisfactory tree growth on mining wastes.

Compaction can be a significant issue in establishing forest vegetation on mining wastes. Traditional ripping with bulldozers or graders does not loosen the soil sufficiently to allow tree roots to penetrate deeply enough to obtain moisture and nutrients needed for optimal growth. Free dumping, where loose truckloads of waste rock are dumped in a close configuration on the top of dump platforms shows promise in addressing the problems of compaction. However, free dumping is generally only effective where wastes do not need to be covered with some form of suitable growth media. Reactive waste rocks, with the potential to generate acidic drainage, will require an appropriate cover and free dumping will not provide a benefit for tree growth in these cases. Waste dump re-sloping can also serve to loosen compacted dump platforms. Where wrap-around dumps have been built with sufficient regularity to allow re-sloping to reach from one to the next and provide a reasonable slope for vegetation, compaction problems can be avoided and forest growth is a reasonable expectation.

Agricultural strategies

Many of the roots of reclamation in Canada come from agriculture. Standard agricultural treatments such as the establishment of grass and legume forage species, applications of fertilizer and/or bio-solids as well as the use of agricultural equipment, are common practices in reclamation. Early studies of tailings reclamation employed many techniques from agriculture, including liming and fertilization (Gardiner 1977). Drill seeding, another agricultural technique has been used at a number of mines (Jones 1989) while dry broadcast seeding followed by harrowing with a chain link harrow has been used at other mines (Horton and Kempe 2001). Early studies of fertility and the suitability of mining wastes for vegetation drew heavily on standard agricultural tests (Ames 1980). Reclamation practices at the time followed agricultural treatments to address deficiencies.

Many of the agricultural strategies that have been applied to mines throughout the province have been effective in the establishment of agronomic grasses and legumes. Excellent stands of forage species have been established at a number of mines in British Columbia. These are often favoured by wildlife, and large populations of ungulates have established around some mines. Studies of the metals uptake by plants and subsequently by animals have been framed in an agricultural context (Gardner *et al.* 1996).

Establishment of productive grass and legume stands can create problems in establishing woody species (Green 1982). High populations of rodents can girdle woody plant stems while direct competition for moisture and nutrients can result in the death of planted woody stock (Polster 1991). Successional stagnation (Kimmins 1987) can occur where dense stands of agronomic grasses and legumes have been established. Bio-solids, the name applied to treated sewage sludge, may be applied to mine wastes to ameliorate the adverse conditions of the wastes. However, in combination with agronomic grasses and legumes, treating sites with bio-solids may significantly slow the re-establishment of natural successional trajectories while doing little to ameliorate the adverse conditions of the wastes over the long term.

Ecologically based strategies

Ecologically based reclamation strategies are founded on the belief that natural processes of succession and vegetation establishment on adverse sites provide the most effective model for reclamation of mining disturbances. Studies of the colonization by vegetation of talus slopes, natural loose rock slopes that form from the weathering of cliffs, can provide clues to the effective reclamation of waste rock dumps (Polster and Bell 1980). Similarly, knowledge of the dynamics of native vegetation colonization of barren expanses has been applied to the development of native species islands (Bittman 1995). Application of ecological principles to the reclamation of difficult sites promises to provide solutions that have been missing in the use of forestry or agricultural models for reclamation (Walker *et al.* 2007).

Successional reclamation is the term applied to the use of successional models for reclamation of disturbed sites (Polster 1989). The key to successional reclamation is to create the conditions that allow natural successional processes to take over the work of reclaiming the site. This may involve a wide variety of treatments such as re-sloping; amelioration of adverse substrate conditions such as acid rock drainage or dark, heat absorbing colours; and de-compaction of compacted sites. Once the factors limiting vegetation are addressed, establishment of early successional species can provide the start of a successional trajectory that will provide an effective vegetation cover into the future (Polster 1991).

Replacement of critical ecological elements such as large woody debris that initiate nutrient cycling and provide substrate diversity (Lawrence 1983) or planting keystone vegetation species such as alder or early seral willows and poplars (Polster 1991) can be an important part of ecologically based reclamation programs. Seeking natural remedies to elements such as erosion rather than establishing dense stands of seeded agronomic grasses and legumes can result in the re-establishment of natural successional trajectories earlier in the reclamation process. Large woody debris and other organic detritus can help prevent erosion. Similarly, creating a rough and loose substrate can reduce erosion by as much as 50% over smooth compacted soil slopes (Wischmeier and Smith 1965). Determining the vegetation limiting factors associated with the site and ameliorating these conditions allows natural successional forces to re-establish vegetation on most sites.

Ecologically based reclamation programs are often significantly less expensive than other approaches, as the natural processes of vegetation re-establishment are harnessed to provide an appropriate vegetation cover on the disturbed site. Natural seed rain can provide pioneering species on disturbed sites that are appropriately prepared. Similarly, the seed of later successional species such as forest trees can travel large distances and can result in tree establishment where early pioneering species have prepared the site. Application of ecologically based seed harvesting strategies such as the establishment of puddles for willow and poplar establishment can result in the development of an appropriate vegetation cover at a fraction of the cost of traditional tree planting.

Natural ecological processes such as colonization and population expansion in bare areas can be enhanced by planting native legumes (Smyth 1984). Native species islands can serve as colonization centres for the establishment of appropriate vegetation across much larger areas (Bittman 1995). Care must be taken, however, to include enough islands so that the entire disturbed area is suitably vegetated within a reasonable time frame. In addition, the creation of suitable micro-sites for seeds to lodge in and germinate can greatly assist in the spread of native species from the original islands. Similarly, protection from browsing may be needed to allow the vegetation in the islands to reach maturity and start producing seed.

Ecological reclamation strategies can be effective in developing a vegetation cover on mine areas. Establishment of pioneering species can encourage invasion by later successional species. Alder, a keystone species in many ecosystems in British Columbia, often provides this service and can be a valuable species for planting within the context of an ecological reclamation program. Similarly, willows and poplars can be easily established from cuttings and can provide an initial cover for later successional species to invade.

Conclusions

Three major reclamation strategies are found at mines in British Columbia: forestry-based strategies, agricultural/soils-based strategies, and ecologically based strategies. Of these, with the exception of sites that are to be reclaimed to an active agricultural use, ecologically based strategies offer the most effective model for reclaiming lands. Mine sites are rarely covered with good forest soils or good agricultural soils, so approaches that follow forestry or agricultural strategies often fail to perform adequately. However, natural ecosystem processes have been "reclaiming" significant disturbances since the dawn of time. Applying these methods to mine reclamation can provide effective solutions to vexing problems.

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16. Natural colonization of high-elevation mine exploration disturbances in the Elk and Flathead river drainages

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Coal exploration (access roads, drill pads) has been conducted in the Elk River and Flathead River drainages since the 1960s. These activities have affected a number of ecosystems within the Engelmann Spruce–Subalpine Fir, dry cool (ESSFdk1); Engelmann Spruce–Subalpine Fir, dry cool woodland (ESSFdkw); and Engelmann Spruce–Subalpine Fir, dry cool parkland (ESSFdkp) biogeoclimatic subzones. Reclamation practices typically involve re-contouring, seeding with agronomic species, and short-duration maintenance fertilization. However, several areas were not rehabilitated and have been colonized by native species.

A number of sites were visited, and species composition lists and cover abundance estimates were completed. Historical data (i.e., site preparation and revegetation practices) made available by the mines and the government regulators were used to interpret the field observations. Native species colonization is determined strongly by proximity to appropriate donor populations, site preparation techniques, revegetation practices, slope aspect, mesoslope position, and parent materials. Several vascular and non-vascular plants are typical early seral colonists of these disturbances.

Introduction

An extensive network of exploration roads and associated exploration disturbances were created at high elevations in the Elk River, Fording River, and Flathead River drainages since the 1960s. Exploration activities in these areas are typically located on steep slopes and are frequently at high elevations.

Mining companies have a regulatory requirement to reclaim these disturbances (Province of BC 1989). Complete deactivation and reclamation is required for disturbances where potential future exploration activities are not anticipated. Partial reclamation (direct seeding without site preparation) is conducted where seasonal or temporary deactivation of access roads, trails, and pads is necessary to manage stability and drainage concerns from one field season to the next (BC Ministry of Energy, Mines and Petroleum Resources and the BC Ministry of Environment 2006). Maintenance activities (i.e., reseeding and fertilization) are typically not extended beyond 2–3 years.

Within the study area, a range of reclamation practices has been undertaken to rehabilitate exploration disturbances. Some of the disturbances have been decommissioned (site preparation and revegetation), some have been seeded only, while others have not received any treatment.

With the exception of two locations (BC Coal 1981; Smyth and Kovach 2002), the success of natural rehabilitation and abandonment practices on high-elevation disturbances has not been evaluated within the Elk River and Flathead River drainage systems. Since exploration activities affect habitat connectivity for wildlife (Stanlake *et al.* 1976) and also affect ecosystem health through ingress of invasive species, a study was initiated in 2003 to examine the rehabilitation ecology of these disturbances.

Objectives

The objectives of the study were to:

- compare species composition of disturbed and adjacent undisturbed ecosystems;
- identify colonizing species with highest frequency of occurrence and abundance; and
- examine spatial patterns of vegetation recovery.

Study area

The exploration disturbances studied are located within the Engelmann Spruce–Subalpine Fir, dry cool (ESSFdk1); Engelmann Spruce–Subalpine Fir, dry cool woodland (ESSFdkw); Engelmann Spruce–Subalpine Fir, dry cool parkland (ESSFdkp); Engelmann Spruce–Subalpine Fir, warm moist (ESSFwm); and Engelmann Spruce–Subalpine Fir, warm moist woodland (ESSFwmw) biogeoclimatic subzones. The types of disturbances include exploration roads, drill pads, and hand- and machine-dug trenches. Examples of disturbance types are illustrated in Figures 1 and 2. The ages of the sites are difficult to determine with certainty, but, based on a review of annual reclamation reports, the ages of the disturbances range from 20–30+ years. Three levels of rehabilitation were documented: (1) no treatment, (2) direct seeding without site preparation, and (3) site preparation (re-contouring) and seeding.

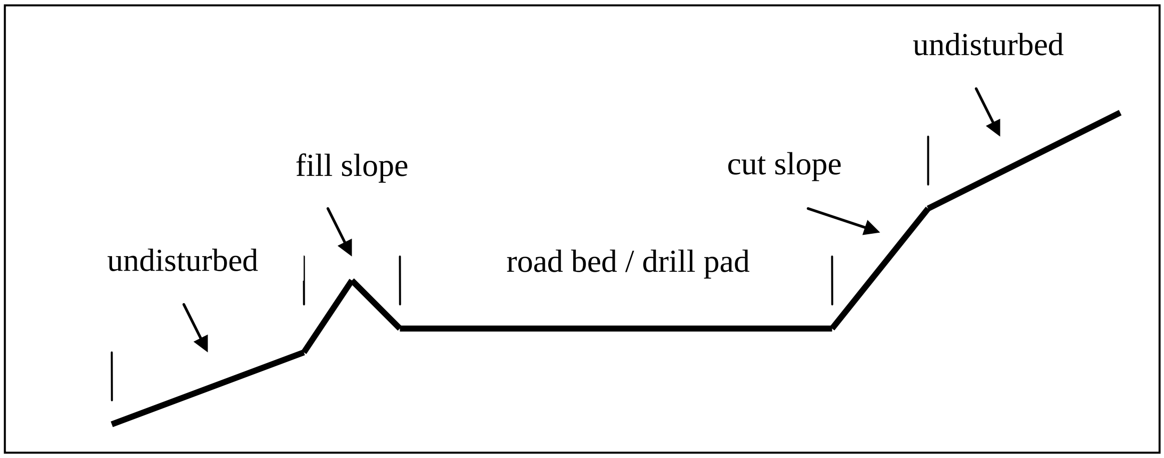

Figure 1. Road and drill pad disturbances.

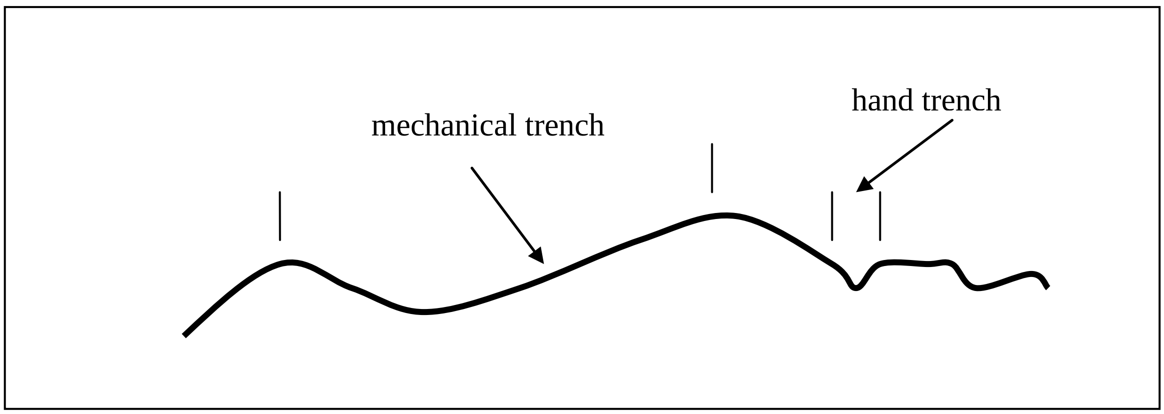

Figure 2. Trench disturbances.

Methods

A total of 65 paired or contiguous sample plots in 11 sites were established throughout the Elk River, Fording River, and Flathead River drainage systems. Representative undisturbed and disturbed (abandoned and/or decommissioned) habitats were selected subjectively within each site. A combination of shrub lands, forests, grasslands, and sparsely vegetated ecosystems were sampled. The herbaceous plot dimensions were 4 m^2. The herb plots were nested within larger (10 m^2) plots where shrubs were present, and within even larger (20 m^2) plots where trees were present. Habitat data collected at each plot included slope, aspect, elevation, mesoslope position, seral status, substrate cover, substrate compaction, soil texture, rooting zone particle size (RZPS), and the presence of surface erosion. The vegetation data collected included species percent cover by layer.

Data analysis included Cluster Analysis (CA) and Multi-response Permutation Procedure (MRPP) to classify/identify seral plant communities based on floristic composition. Indicator

Analysis (IA) was used to identify plant species that indicate disturbance and undisturbed plant communities ecosystems.

Results and discussion

The sample plot breakdown by biogeoclimatic subzone was as follows: 18 in the ESSFdk1, 27 in the ESSFdkw, 9 in the ESSFdkp, 6 in the ESSFwm, and 5 in the ESSFwmw. Ecosystem classification followed Lloyd *et al.* (2006).

Parent materials and soils

The common parent materials encountered were silty rubbly colluvial veneers, although silty rubbly colluvial blankets and sandy gravelly morainal blankets were present occasionally. Mudstones and siltstones were the common rock lithologies. These rocks have high weathering rates and produce friable growth substrates.

The soils of the adjacent undisturbed sites ranged from Orthic Eutric and Orthic Dystric Brunisols to Orthic Regosols. Coarse fragment contents ranged from 25–45% in the undisturbed sites to 40–65% for the disturbed sites. Rooting zone soil textures (< 2 mm) in the undisturbed sites were typically silt loams whereas rooting zone soil textures at the disturbed sites were typically sands or loamy sands. Surface erosion (rill and gully) averaged 76.6% on the cut slopes, 9.2% on the road bed, and 35.2% on undisturbed sites.

Soil compaction measurements within disturbance types, and between disturbed and non-disturbed were highly variable (Table 1). Roadbeds and drill pads with compacted surfaces had reduced seedbed availability.

Table 1. Substrate compaction (penetrometer readings).

Treatment	**Mean (kg/cm^2)**	**Range (kg/cm^2)**
Undisturbed	1.10	0.0–1.5
Disturbed–road bed (non-track)	1.75	1.0–3.25
Disturbed–road bed (track)	3.00	2.5–> 5.0
Disturbed–cut slope	2.00	1.0–3.0
Disturbed–fill slope	1.50	1.0–2.75
Disturbed–drill pad	1.75	1.0–3.0
Disturbed–trench	1.25	1.0–2.25
Asphalt/concrete	> 5.0	–

Vegetation

Historical seed mix information is not available for the revegetated disturbances. However, the species included in the mixes can be inferred from the species list compiled from the sample plot data (Table 2).

Table 2. Seeded agronomic species.

Scientific name	**Common name**
Agrostis gigantea	redtop
Alopecurus pratensis	meadow foxtail
Dactylis glomerata	orchardgrass
Festuca rubra	creeping red fescue
Festuca trachyphylla	hard fescue
Medicago sativa	alfalfa
Phleum pretense	common timothy
Poa compressa	Canada bluegrass
Trifolium hybridum	alsike clover
Trifolium repens	white clover

Remnants of agronomic seeding, i.e., the most common surviving species, were *Festuca rubra* (creeping red fescue), *Phleum pratense* (common timothy), and *Bromus inermis* (smooth brome) (Table 3). Smaller amounts of *Alopecurus pratensis* (meadow foxtail), *Poa compressa* (Canada bluegrass), and *Trifolium hybridum* (alsike clover) were also present. *Taraxacum officinale* (common dandelion) and *Verbascum thapsis* (mullein) are the common weed species (Table 4), and their presence at a location appears to be related to the proximity of the site to agronomic seeded disturbances. Anecdotal observations of the frequency of wildlife signs and all-terrain vehicle tracks in association with weed infestations suggest that animal movements and human recreation activities may be functioning as “vectors” for dispersal of invasive species on exploration disturbances.

Table 3. Relative frequency of agronomic species.

Species	**Percent**
Agrostis gigantea	13.9
Alopecurus pratensis	20.0
Bromus inermis	40.0
Dactylis glomerata	6.2
Festuca rubra	53.9
Festuca trachyphylla	3.1
Phleum pratense	38.5
Poa compressa	20.0
Medicago sativa	3.1
Trifolium hybridum	20.0
Trifolium repens	12.3

Table 4. Relative frequency of weed species.

Species	Percent
Cirsium arvense	6.2
Leucanthemum vulgare	6.2
Medicago lupulina	4.6
Taraxacum officinale	41.5
Tragopogon dubius	3.1
Verbascum thapsus	15.4

The suitability of adjacent donor populations with appropriate life history or functional traits (Grime 2001) often limits natural colonization and this was certainly the case in this study. As well, a lack of site preparation (e.g., recontouring and ripping) prevented vegetative colonization by suitable adjacent colonizers. The steep cut slopes and shallow unstable substrates prevented all but *Populus tremuloides* (trembling aspen) and *Arctostaphylos uva ursi* (bearberry) from establishing. Common colonizing native species are listed in Table 5. Several of the native colonists have been reported by BC Coal (1981), Moritsch and Muir (1993), Smyth and Kovach (2002), and Zabinski *et al.* (2002) as early colonizing species at high elevations. The absence of native graminoids in the disturbance plots reflects the low cover of grasses and sedges in the adjacent undisturbed plots.

Cluster analysis separated undisturbed and disturbed ecosystems, and between subzones. The greatest separation was between forested/woodland and parkland subzones.

Indicator species analysis indicated that early native seral dominants species such as *Achillea millefolium* (common yarrow) and *Anaphalis margaritacea* (pearly everlasting), and introduced species *Festuca rubra* (creeping red fescue) are indicators of disturbed ecosystems while species such as *Peltigera canina* (dog lichen) and *Vaccinium scoparium* (grouseberry) are indicators of undisturbed ecosystems.

Seral plant communities are forb-dominated in dry south-facing aspects in all subzones. Shrub-dominated seral plant communities are common in the ESSFwm and ESSFwmw subzones and on cool aspects and moist sites.

Lower elevation sites that have been seeded with agronomic species impede or prevent ingress of native species as has been observed elsewhere (Younkin and Martens 1987; Smyth and Kovach 2002). At higher elevations in the ESSFdk1 and ESSFwm and in the woodland and parklands, growth and vigour of agronomics are more restricted and there is more “biological space” (Urbanska and Chambers 2002) for native species. Site preparation affords more uniform establishment by plants while the absence of site modification results in patchy establishment. Sloughing of non-recontoured cut slopes contributed little to native establishment except if the species present possess appropriate colonizing attributes. Re-contouring facilitates re-colonization, but success is strongly influenced by the functional traits of the adjacent native species donor populations.

Table 5. Common native species colonists.

ESSFdk1, ESSFdkw, ESSFdkp	**ESSFwm, ESSFwmw**
Bryophytes and Lichens *Brachythecium albicans* *Leptobryum pyriforme* *Polytrichum juniperinum*	Bryophytes and Lichens *Ptilidium ciliare* *Polytrichum juniperinum*
Forbs and Grasses *Achillea millefolium* *Anaphalis margaritacea* *Phacelia hastata*	Forbs and Grasses *Achillea millefolium* *Anaphalis margaritacea*
Shrubs *Rosa acicularis* *Rubus idaeus* *Spirea betulifolia*	Shrubs *Alnus viridus* *Rosa acicularis* *Rubus idaeus*
Trees *Abies lasiocarpa* *Picea engelmannii*	Trees *Abies lasiocarpa* *Picea engelmannii*

Species richness is greatest for the undisturbed sites, with values greatest in the ESSFdkp and ESSFdkw subzones (Figure 3). Herbaceous cover was higher in the undisturbed sites as compared to the disturbed sites with the exception of the ESSFwm subzone (Figure 4). The reversal in cover between the undisturbed and disturbed sites within the ESSFwm subzone is due to the skewing of the results because of the abundance of sample sites with high agronomic seed cover.

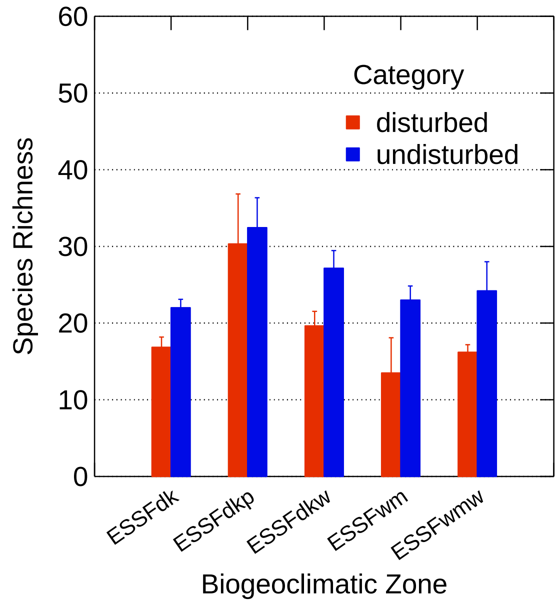

Figure 3. Species richness.

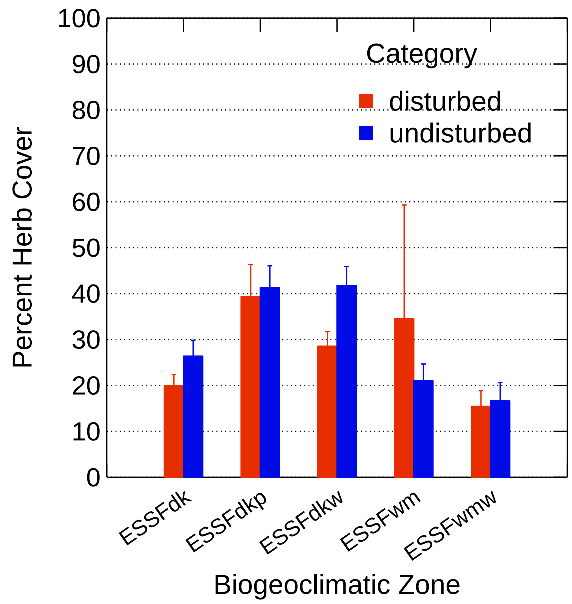

Figure 4. Percent herb cover.

Shrub cover (Figure 5) and tree cover (Figure 6), as expected, were greater in the undisturbed plots. Shrub and tree cover is greatest in the lower elevation ESSFdk1, and the wetter ESSFwm and ESSFwmw subzones.

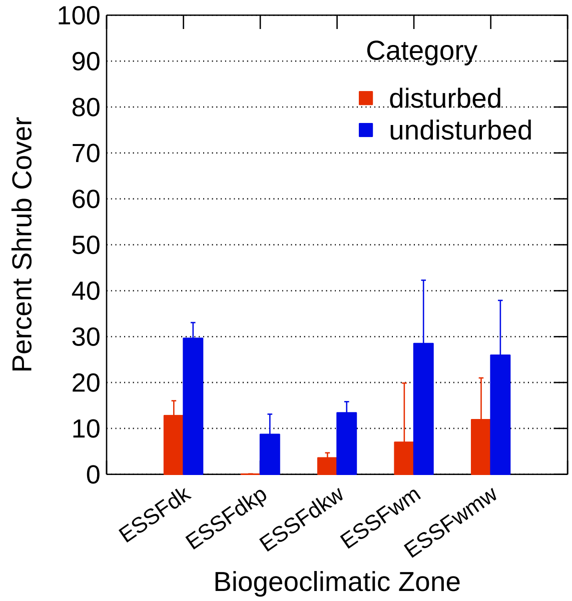

Figure 5. Percent shrub cover.

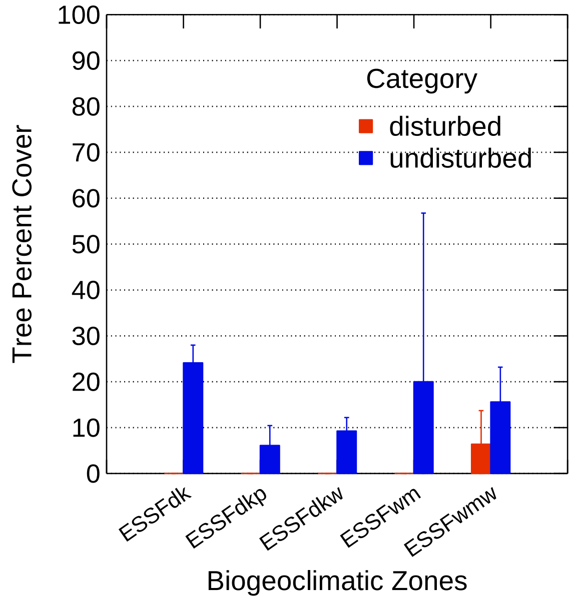

Figure 6. Percent tree cover.

Four mechanisms of vegetation establishment were identified:

1. Seed dispersal (wind, animal, and erosion and deposition) followed by germination was common throughout the study area.
2. Vegetative suckers or rhizomes/stolons from adjacent vegetation was limited in extent due to barriers such as unstable or shallow substrates.
3. Cut slope failure/sloughing and sodding were limited in extent by the root/soil binding properties of the upslope vegetation.
4. Artificial or direct seeding intervention was common in more active exploration areas.

Finally, exploration roads provide movement corridors for animals, particularly ungulates.

Recommendations

Several recommendations are proposed.

Management practices

- Conduct pre-disturbance assessments to (1) determine appropriate site preparation techniques, (2) evaluate "natural" colonization potential, i.e., proximity to appropriate donor populations, (3) assess potential for invasive species establishment, and (4) evaluate impacts on wildlife habitat.
- Site preparation (ripping) of road beds and drill pads should be undertaken to decrease soil compaction and increase the seedbed surface area.
- Exploration disturbances should be revegetated with native species seed mixes.

Monitoring

- Monitoring of performance should be expanded within the existing sites as well as at additional sites, particularly those north of the Elk Valley Coal Corporation's Fording River mine. More sites should be sampled in the Flathead River basin.
- Monitoring and reporting of weed infestations of exploration disturbances and adjacent undisturbed areas should be undertaken.

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17. Reclamation at Elk Valley Coal's British Columbia operations

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Abstract

The Elk Valley Coal Corporation operates five open-pit metallurgical coal mines in the Elk Valley of British Columbia: Fording River, Greenhills, Line Creek, Elkview, and Coal Mountain Operations. Reclamation plays a critical role in mining operations, returning previously mined land to productive and functional ecosystems even as new sites are opened for mining. At the end of mine life, over 15 000 ha of land at the five operations will have been successfully reclaimed to a variety of end land uses. To ensure that this happens, the Elk Valley mines conduct extensive yearly reclamation programs, which include research to develop techniques to meet new challenges, implementation of operational seeding and planting programs, and monitoring to assess success and to allow modification of programs as required. To date, over 10% of the total disturbed area has been reclaimed, with stands of young forest over 20 years old on some reclaimed sites. In addition to the establishment of forest stands on the site, the Elk Valley mines are dedicated to reclaiming valuable wildlife habitat, including critical high-elevation habitat for elk and bighorn sheep. This paper will discuss all aspects of the reclamation programs at Elk Valley Coal's British Columbia mines, from planning and pre-disturbance research, to post-closure reclamation and monitoring.

Introduction and background

History and development

Mining at the Elkview and Coal Mountain sites started as early as the turn of the last century, with modern large scale operations generally commencing in the late 1960s to early 1980s, and an outlook to continued mining well into the future. Elk Valley Coal is one of the largest landholders in British Columbia, with almost 40 000 ha of privately held land, and crown licences on approximately 67 000 ha. Together, these mining operations are the largest scale, open-pit metallurgical coal mines in the northern hemisphere, and are the second largest supplier in the world, delivering products to customers in 28 countries on five continents, and employing almost 3000 people.

The Elk Valley coal mines were some of the first coal mines to be permitted under the *Mines Act* when it was first enacted in 1969, with Elkview and Fording River Operations holding permits C-2 and C-3, respectively. Reclamation research began at Fording River Operations in 1969, prior to the commencement of mining operations in 1972. Many reclamation programs at Elkview Operations began in the early 1970s, and included reclaiming historic mining disturbance in Michel Creek dating back to the beginning of coal mining operations on the site in 1898. Coal Mountain Operations began underground mining in the early 1900s, and began open pit mining on a “modern” scale in the 1960s. Reclamation on Coal Mountain has been limited compared to the larger Elk Valley Mines due to most areas of the mine remaining active; however, reclamation of the exploration disturbance at the McGillivray Mine owned by Coal Mountain was completed in 2002, and reclamation bonds were released in 2007 (Coal Mountain Operations 2007).

Ecology

The footprints of all five of the British Columbia Elk Valley Coal operations fall within the Engelmann Spruce–Subalpine Fir (ESSF) Biogeoclimatic Zone, although at upper elevations they are transitional to Alpine Tundra (AT). Elevations on the mine sites range from approximately 1100–1200 m above sea level at the Line Creek and Elkview valley-bottom plant sites to approximately 2300 m. Due to the large disturbance area and range in elevations, reclamation at these sites must aim to re-establish a variety of ecosystems, from the coniferous forests that dominate the area to grasslands and other non-forested or sparsely forested sites (e.g., subalpine parkland).

The mine reclamation process

The fundamental goal of the mine reclamation process is to re-establish both ecosystem function and form. Function refers to the capacity of ecosystems to support fundamental processes of nutrient and moisture cycling and energy flow, while form refers to the structural and species composition attributes of an ecosystem. Because of the severity of disturbance associated with mine development, mine reclamation generally begins on substrates with little to no functional capacity. Thus, although ecosystem function and form are fundamentally interrelated, re-establishing ecosystem function is the primary task of mine reclamation. It can be said that “function begets form;” that is, if ecosystem function can be successfully re-established, appropriate ecosystem form can follow, whereas there can be no ecosystem form without function. It is this perspective of the primacy of ecosystem function that has shaped the reclamation approach of the Elk Valley coal mines.

If mine reclamation is to be successful and cost effective, it is critical that reclamation programs be clearly linked to identified objectives, and conducted in an organized fashion to achieve these objectives. The examples provided in the remainder of this paper represent the outcome of an organized approach to mine reclamation conducted on the five Elk Valley Coal operations over a span of up to 40 years.

The mine reclamation process, although potentially complex in its detail, can be simplified to three primary steps:

1. Identify post-closure end land-use objectives.
2. Identify appropriate techniques (for materials handling, species selection, and establishment) to achieve objectives—this has conventionally taken the form of trial-based reclamation research to test a variety of techniques, at least early in the reclamation process.

3. Implement, assess, and adapt—this step in the process is based on what was learned in the development step above, and is the mechanism by which operational (large-scale) reclamation is accomplished, and through which the adaptive management feedback loop is established.

These steps are discussed in more detail, below.

Identifying post-closure objectives

This step is based on an evaluation of pre-disturbance land uses, and on identifying the range of potential post-closure land uses. Although in reality most reclaimed lands will simultaneously provide for multiple uses (e.g., wildlife habitat, recreation, and potential for future commercial forestry), identification of post-closure land uses aids in the reclamation planning process by indicating an emphasis or primary direction for reclamation activities, as well as criteria against which the success of reclamation can be evaluated. Identification of end land uses is a component of mine reclamation required by the Health, Safety, and Reclamation Code for Mines in British Columbia (BC Ministry of Energy and Mines 2003), which states: "The land surface shall be reclaimed to an end land use approved by the chief inspector, that considers previous and potential uses."

Previous end land uses are identified through reference to pre-disturbance conditions. Often information supporting this identification is found in baseline biophysical studies, typically conducted in the current regulatory regime as part of the Environmental Assessment and permit application process. These studies identify critical values or attributes of the pre-disturbance landscape, which may be important to replace, or attempt to replace, through reclamation. Potential post-closure land uses that differ from previous uses may be identified through understanding of future desired services. Examples of such uses would be to meet societal demand (recreation) or to support recovery of previously rare species or ecosystems (reclamation of wetlands in areas where, previously, wetlands were absent).

Two primary end land uses that have been identified for the post-closure landscape at Elk Valley Coal's operations are:

1. low- to moderate-yield commercial forestry; and
2. wildlife habitat.

While this is not an exhaustive list of identified end land uses for the five British Columbia Elk Valley Coal operations, it identifies the land uses on which the bulk of reclamation effort has been focused to date, and they are illustrative of the reclamation approach employed by Elk Valley Coal. These end land uses are used as the basis for the remainder of the discussion on development of techniques, implementation, and evaluation of success.

The end land use of low- to moderate-yield commercial forestry has been adopted at a number of the Elk Valley Coal mines due to the dominance of forested ecosystems in the pre-disturbance landscape, and the importance of forest harvesting on this landscape. However, identification of commercial forestry as an end land use creates potential difficulties, as at the time that this objective was adopted, there was no established history of successful reforestation of coal mines in western Canada, and techniques to accomplish this objective were not clear. An end land use of commercial forestry introduces additional risks to the reclamation program, as provincial standards for forest licensees are well established, and thus criteria by which success of this land use objective can be judged are clearly defined, unlike the majority of potential uses.

Development of techniques—Materials handling

The earliest reclamation research in the Elk Valley (and at many other mines in British Columbia) centred on characterizing mine waste materials as growth media. These studies, initially conducted in greenhouses, later evolved into field-scale trials. The evaluation of mine waste materials was performed periodically between 1972 and 1995, focusing on chemical and physical properties of the material that could be limiting to plant growth such as pH, salinity, coarse fragment content, and fines content. These studies suggested that most mine waste rock material was comparable to the local overburden available for capping as a growth medium. Based on these results, the mines began developing techniques for establishing vegetation directly on mine waste, rather than capping prior to revegetation (Straker *et al.* 2005). More recent studies now focus on assessing the reclamation suitability and nutrient capital of mine waste materials through a bioassay or vegetation sampling approach, along with direct sampling of reclamation substrates, to allow evaluation of the relationship between material properties and plant responses.

Development of techniques—Species selection and establishment

The results of early reforestation research where conifer seedlings were planted into a cover of agronomic grasses and legumes showed high seedling mortality, attributable to competition with the agronomic cover for moisture and nutrients. Although a primary goal of the reforestation program had to be successful establishment of conifer species (achievement of desired ecosystem form), it was not possible to respond to observed high mortality rates simply by removing ground cover treatments, as these ground covers contribute to a number of functional processes that are critical to successful reclamation (e.g., nitrogen fixation, organic matter additions through litter deposition and root turnover, support of above and below ground biota, and protection from surface erosion). In order to simultaneously achieve these objectives, reclamation specialists on the mine sites began investigations into techniques to co-establish conifer seedlings and nitrogen-fixing agronomic ground covers. Nitrogen was seen to be a critical nutrient for enhancing soil processes and site productivity, as it is the primary nutritional limitation to forest production in British Columbia (Ballard and Carter 1985) both in natural forest stands and on disturbed sites such as cutblocks and mine sites. The hypothesis was that unacceptable seedling mortality rates might be avoided through initial establishment of container seedlings, followed by a delayed interseeding of a legume ground cover. In order to test this hypothesis, a series of trials was installed on re-sloped coal spoil on the Fording River mine site. These trials were replicated to allow statistical inference and formation of sound conclusions. Although previous research had shown substantial nitrogen fixation by legumes in forest plantations, at the time of Fording

River’s trial initiation very little information was available on the specific effects of a legume ground cover on conifer plantation survival and growth performance (Trowbridge 1992).

Results from these trials, conducted in the mid 1980s at Fording River, indicated that unacceptable mortality could be reduced, and indeed excellent survival rates could be achieved, through the delayed interseeding treatment. Thus, reforestation on the mine site moved from the “technique development” stage to the operational implementation and assessment stage.

Implementation and assessment

The successful reforestation techniques developed through trial-based reclamation research were transitioned into standard practice across the Fording River mine site, and subsequently adapted at the Greenhills and Line Creek Operations. With growing confidence in the success of this technique, the focus of the reforestation program moved to assessment monitoring, both to allow adjustments to standard operational practice where necessary, and to provide further insight into the development and maintenance of ecological function and long-term productivity on the reclaimed mine site. This assessment monitoring phase has been accomplished through two primary programs:

1. Standard regeneration and performance monitoring on all operationally planted stands on the mine site
2. Continued periodic re-assessment of the original reforestation trials

Standard reforestation monitoring

This monitoring program is conducted on all sites reforested to a commercial end land use on the reclaimed mine sites. Surveys are performed to track performance of all plantations, using the same survey methods and standards applied to local forest licensees. Circular plots are installed at a density of 1–1.5 plots/ha, prior to and again within the applicable Free-to-Grow window (generally for the ESSFdk1 subzone). BC Ministry of Forests and Range standards for acceptable species, acceptable spacing, target and minimum stocking levels, minimum tree heights by species, and absence of competition are applied, and stands are assessed as either Free Growing or Not Sufficiently Restocked. This assessment allows adjustment of reclamation reforestation programs to ensure that future plantations meet provincial standards, and also provides a hectare-by-hectare accounting of reclamation success for this end land use objective.

Periodic re-assessment of reforestation trials

Although the intent of the initial reforestation trials was primarily focused on the development of novel reclamation techniques, these trial sites now represent the best long term information available on productivity and functional attributes of forest stands on reclaimed coal waste in the Elk Valley. For this region, these trials are assessed on a 5-year interval for properties such as site index (growth performance) and foliar nutrient status. The last monitoring of these trial sites was conducted in 2006. Examples of results and interpretation of this monitoring are provided below.

Site Index

Site index is an age-adjusted measure of tree height/growth performance, based on current measurement of total height and age at breast height (of undamaged and unsuppressed dominant or co-dominant trees) projected to a predicted total height at breast-height age 50 years. This measure is a standard used in forest productivity work as it is thought to be relatively independent of stand density, and is thus more reflective of inherent site properties than other productivity measures (e.g., stem diameter, which is significantly influenced by stand density, and thus establishment history). Site index for Engelmann spruce is presented over time by ground cover treatment (interseeded or not; in this case with birdsfoot trefoil) in Figure 1.

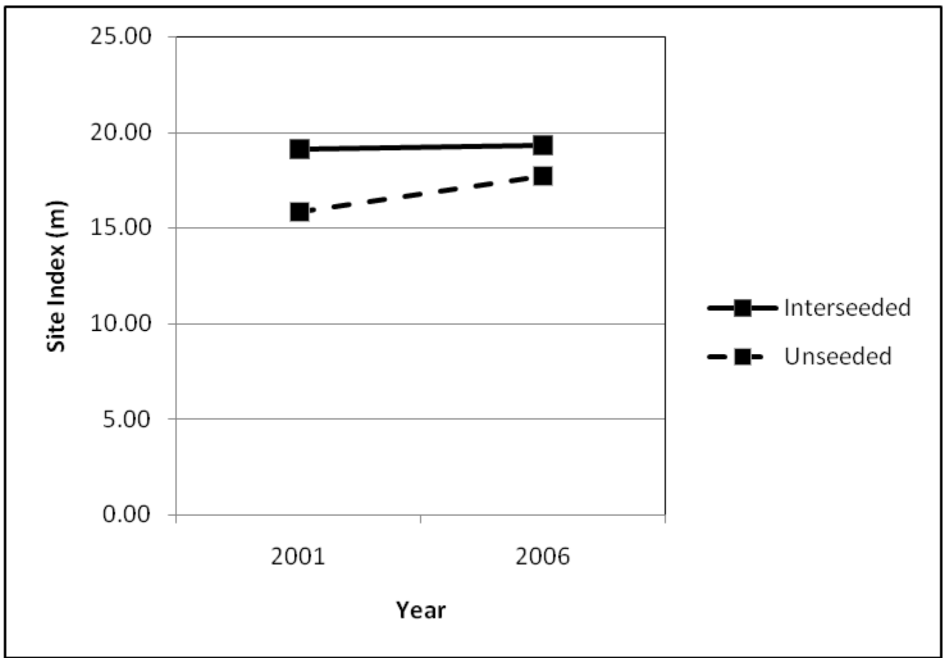

Figure 1. Site index by understorey treatment for Engelmann spruce.

This figure shows relatively stable performance of both treatments over the 5-year assessment interval. This information is a critical sign of the sustainable productivity of these stands, as reclaimed forest stands that are deviating from observed behaviour of standard post-harvest regeneration and showing declining productivity would show changes in estimated site index over the assessed period. The figure also demonstrates a maintained advantage in productivity on interseeded treatments, although that advantage appears to be dissipating with time. Although the information is not reported on the graph, comparison of these site index values to measured values on equivalent offsite stands show that reclaimed forest stands are achieving growth performance equivalent to that measured off site.

Foliar Nutrition

Sampling of conifer foliar tissue and analysis for nutrient element concentrations has been shown to be the most reliable method for diagnosing stand nutrient status (for example, in comparison to soil sampling and analysis). Figure 2 presents information on foliar nitrogen concentrations by interseeding treatment over time. Nitrogen is selected for presentation as it is the most limiting nutrient on reclaimed and other forest stands in the region (as discussed above).

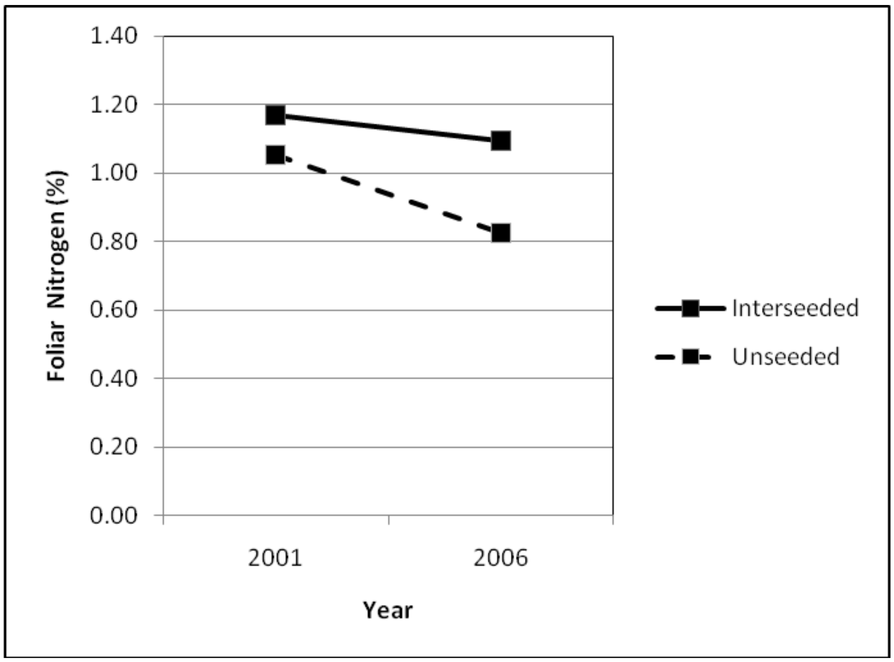

Figure 2. Foliar nitrogen concentrations by understorey treatment for Engelmann spruce.

Information presented in Figure 2 demonstrates a continued substantial nutritional advantage provided by interseeding treatment, and that this advantage is maintained even 20 years after the treatment is applied. Stability in the nutritional status of the interseeded treatment is also a positive sign, indicating that even though this stand is reaching crown closure (where inter-tree competition for nutrients intensifies), foliar nitrogen levels are relatively stable.

By linking the foliar nitrogen and site index information, we can begin to demonstrate the mechanisms behind the increased productivity observed on interseeded treatments, as these treatments clearly show a sustained improvement in nitrogen status in comparison to the unseeded treatments. This observation in turn provides evidence of the successful establishment of the functional ecosystem process of nutrient cycling and the subsequent capture of energy (resulting in greater growth rates) that it allows.

Soil nutrient status

A last piece of evidence linking treatment and performance is provided by information presented in Figure 3, which shows soil nitrogen concentrations by interseeding treatment.

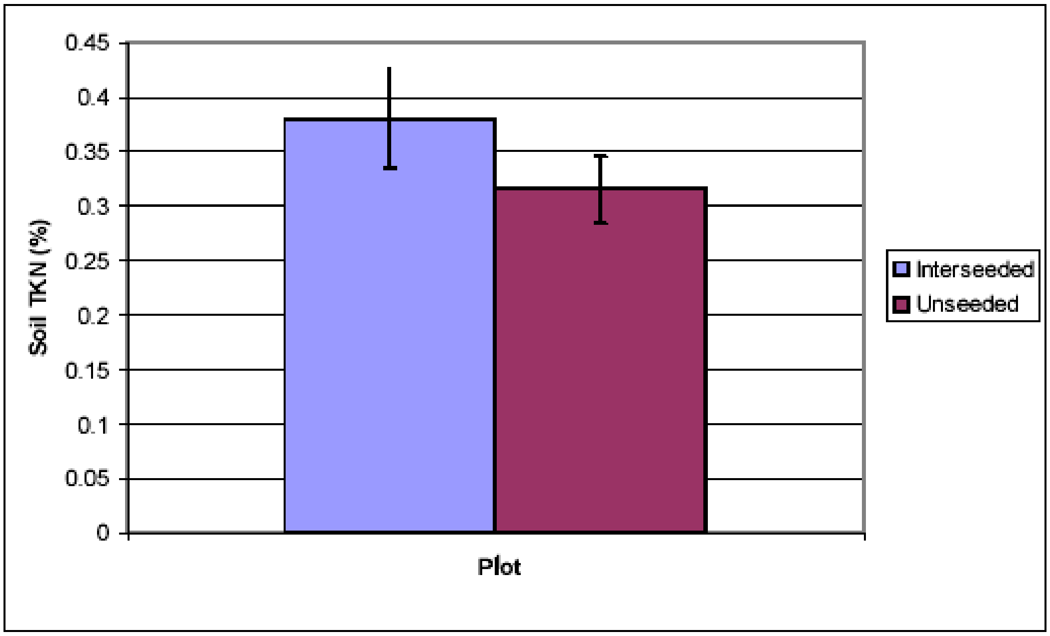

Figure 3. Soil nitrogen concentrations by interseeding treatment.

This information demonstrates higher nitrogen concentrations on interseeded treatments (consistent with the foliar nitrogen data) and closes the circle between the bioassay evidence of increased nutrient status and growth performance, with a below-ground measure of total nutrient capital. This is further evidence of successful establishment of ecosystem function in which nitrogen-fixing legumes have increased soil nitrogen capital, plants have taken advantage of nutrient uptake and cycling processes to improve their own nutrient status, and this improvement has in turn resulted in a measurable increase in photosynthesis as measured by above-ground growth performance. The expectation is that this pattern of increased function and improvement, once initially established, can be self-sustaining, as larger trees with more above-ground biomass deposit more litter, which is in turn decomposed and cycled back through the soil/plant system, and as older trees become more efficient at internally cycling nutrients and thus maintain the nutritional advantage initially realized through application of an external interseeding treatment.

The above example of reclamation of coal waste to a commercial forest stand illustrates, for a specific site and objectives, the steps of the reclamation process used by the Elk Valley Coal mines to link stated objectives to practice. This process is both continuous and adaptive: continuous, in that research into refinement of techniques and evaluation monitoring is conducted on an annual cycle, so that reclamation practices are not static; and adaptive, in that the refinement and monitoring cycle allows improvements to reclamation techniques to be brought into standard practice as they are recognized.

These elements of continuous use of what we have learned and adaptation of practice allow reclamation at the Elk Valley Coal mines to be a dynamic process, in which refinement is based not only on accounting of success or failure by hectare, but also on research into the underlying mechanisms responsible for these results.

Re-creating wildlife habitat

By far the most common end land use for the Elk Valley Coal mines is wildlife habitat. Indeed, the wildlife habitat end land use is the most common on all mined lands in British Columbia. One of the elements that sets selection of this end land use apart in the Elk Valley Coal mines is the recognition that reclamation of wildlife habitat includes re-creation of some valued and potentially limiting habitat elements. Elk are abundant in the Fording and Elk River valleys, with bighorn sheep and goats present at higher elevations. Mining operations have and will disturb habitat for these and other species, including some valuable winter range habitat. Early studies conducted to characterize the elk habitat of Eagle and Turnbull Mountains (at Fording River Operations) resulted in development of an elk winter range reclamation plan that includes high-elevation grasslands and deciduous shrubs, with conifer stands as a lesser component to provide thermal and hiding cover. Having identified this reclamation as an objective, however, is the beginning of the challenge for reclamation work, as winter range habitat in particular is located on challenging (high-elevation, exposed) sites. In addition, the current abundance of wildlife using the active and reclaimed mine site poses significant challenges to reclamation, as use, and thus pressure on young reclaimed areas can be intense.

Development of techniques–Materials handling, species selection, and establishment

Materials handling issues are largely generic to all revegetation activities on coal waste; thus, what we have learned (as described above) is equally applicable to reclamation of wildlife habitat.

Early attempts to revegetate southwest-facing coal spoil with preferred elk browse shrub and tree species resulted in little success, due to harsh conditions (low soil and atmospheric moisture content) and to overbrowsing by wildlife prior to successful plant establishment. In an effort to address these issues, trials were initiated to test the use of both chemical browse deterrents and physical plant protectors on survival of shrub seedlings. This work has yielded a number of findings, including optimal species selection for survival and growth on coal spoil, optimum planting windows for different species, and protection treatments (presence and duration of protection) to enhance success. These findings are being applied to operational reclamation of wildlife habitat areas for establishment of both shrub and tree species in exposed conditions. Translating research trial results into practice in this case is somewhat more complex than in the commercial forestry example, as although physical plant protectors are effective at increasing survival, their installation and maintenance costs preclude their site-wide use on a large scale. Thus, some of the challenges in reclamation of wildlife habitat involve adaptation of research findings to the scale of operational design.

Documentation of bighorn sheep winter range use began in 1982 on Ewin Ridge, Todhunter, Mt. Banner, and Imperial Ridge (at Line Creek Operations), and appropriate species for reclamation were determined. Current reclamation goals at Line Creek Operations also include the creation of appropriate spring, summer, and fall sheep habitat. Results from the elk winter range reclamation trials at Fording River are being used to design year-round habitat for both elk and bighorn sheep at Line Creek.

A smaller scale, but significant component of wildlife habitat reclamation involves re-creation of riparian areas on the mine sites. Riparian (stream edge) areas provide the opportunity to increase species diversity on reclaimed mine sites and increase wildlife habitat and fisheries values. Fording River Operations has considerable experience in the re-establishment of creeks and rivers. Early in the mining process, a portion of the Fording River was successfully moved to a new channel on the opposite side of the valley. More recently, Henretta Creek was diverted to allow a dragline mining project and once the mining was completed, Henretta Creek was re-established entirely on coal spoil materials. A component of this creek re-establishment project necessitated the creation of riparian areas that included wetlands.

While mining was occurring in the Henretta drainage, a research project was designed and installed in an adjacent drainage area to identify how selected plant species would respond to fluctuating water levels in coal spoil materials. Three soil moisture regimes were evaluated, a poorly drained area subject to seasonal flooding, and imperfectly drained slope and bench areas affected by a fluctuating water table. A range of species including sedges, bog birch, willow, alder, balsam poplar, trembling aspen, and Engelmann spruce were included in this trial. Survival and the sensitivity of the species to the inundation of water during periods of flooding were documented (Fording Coal Ltd. 1998). These results indicated that various species of sedges, willows, balsam poplar, and bog birch had good survival on the lower, seasonally flooded area and that a different group of the tested species had good survival on the upper areas which experienced only a seasonally fluctuating water table. Additionally, these riparian areas were colonized by various native and non-native species that provide valuable cover and diversity to the developing habitat.

Implementation and assessment

Results of both the winter range and riparian reclamation research program have been employed in subsequent operational reclamation initiatives. In the Henretta Creek re-establishment project, seeds of sedges and various woody shrubs and trees were collected in the local area and seedlings were grown in nurseries for planting into the riparian areas created adjacent to the re-established creek. The plantings have been successful and have resulted in the establishment of a range of native plants on the various soil moisture conditions typically occurring in riparian habitats. On upland habitat areas, findings on preferred species for re-creation of wildlife habitat and methods for successful establishment of these species have been adopted into the operational reclamation programs at all Elk Valley Coal mines.

Evaluation of the success of operational reclamation of wildlife habitat has generally focused on the productivity and sustainability of reclaimed forage stands, as measured by three principle components:

1. above ground biomass production;
2. forage/stand species composition; and
3. forage quality.

As with the assessment of commercial forest stands, the purpose behind these measurements is both to provide assessment data for each reclaimed area on the successful achievement of reclamation objectives, and also to provide more insight into the initiation and maintenance/change of functional processes on reclaimed sites. These components are discussed in more detail below.

Forage productivity

Measurement of above-ground forage biomass production provides information on the ability of reclaimed forage stands to support wildlife use (e.g., support a certain number of animal units), and also uses a bioassay approach to an overall assessment of supply and cycling of moisture and nutrients in the reclaimed ecosystem. If reclaimed forage stands can be comparably productive to similar undisturbed areas, and maintain that productivity over time, this is evidence of the establishment and persistence of a functional ecosystem. An example of data interpretation in this bioassay approach is provided in Figure 4.

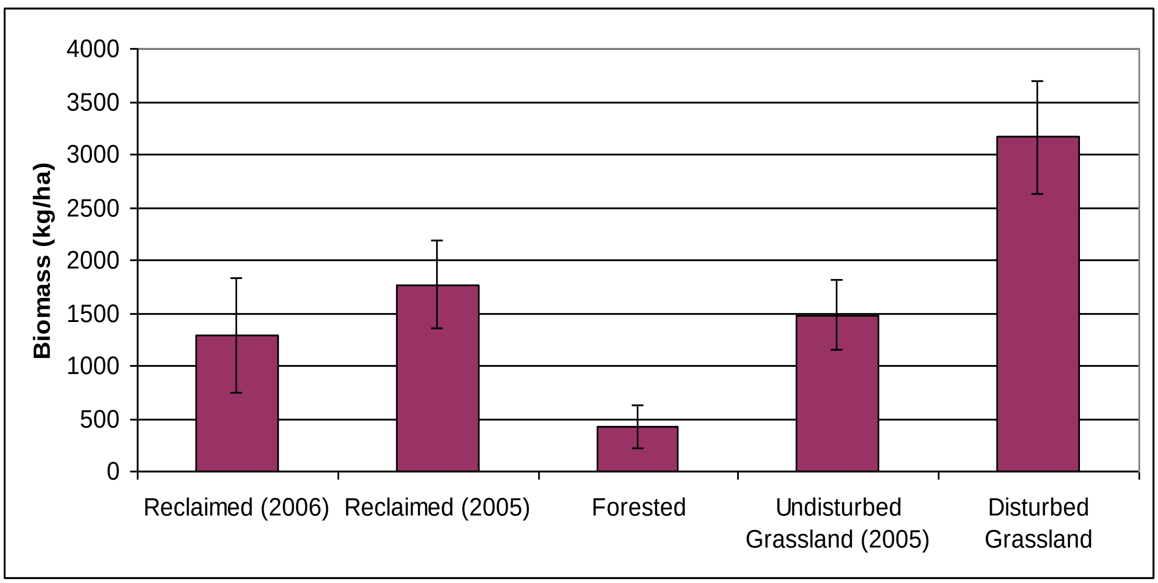

Figure 4. Biomass by site category.

The above figure presents above ground forage biomass information from reclaimed sites (the two left-most bars) to three categories of comparable offsite areas. This comparison shows the following:

- Forage production is substantially higher on reclaimed areas than in undisturbed forest ecosystems. This is because vegetation in these latter ecosystems is dominated by trees, and to a lesser extent shrubs, leaving little resources for development of a forb/graminoid understorey. This simply illustrates that there is more forage per unit area available on reclaimed sites than in the forest ecosystems that dominate the adjacent landscapes.
- Forage production on reclaimed sites is comparable to that observed on undisturbed grasslands, although the species present in these ecosystems are different. This illustrates the equivalency of reclaimed sites to comparable pre-disturbance ecosystems. However, it is important to note that in the pre-disturbance setting, grasslands make up only a small component of the overall landscape.
- Forage production on disturbed (but not mined) grasslands is substantially higher than on reclaimed sites. These former sites are generally associated with reclaimed exploration roads and drill pads that have been reclaimed with agronomic seed mixes similar to those used in mine reclamation. Because the species present on both sites are similar, this comparison is informative about differences in production due to substrate. The comparison suggests that largely undisturbed soils are more productive than coal wastes, as they have a greater degree of development and intact biotic processes.

Taken in synthesis, the data in Figure 4 show equivalence (or better) in forage production on reclaimed sites in comparison to the pre-disturbance landscape. Although the comparison with other disturbed grasslands is not directly informative with respect to equivalency, it does provide insight into how differing substrates affect production.

One aspect of forage productivity measurements that is not illustrated in Figure 4, but is critical to the assessment process, is the temporal component. All assessed sites are measured at multiple points in time (typically at 5-year intervals). These observations provide information on the stability (sustainability), and thus functional attributes of assessed sites, and also provide a context for evaluation in terms of variation in production that should be expected due to inter-annual climatic variation. This allows one to distinguish between changes in values that are truly indicative of changing site conditions, versus apparent changes that are really simply an aspect of inherent year-to-year variation.

Forage stand species composition

Species composition data, generally collected by repeat observations of all vegetation species along set transects, are useful both as measures of ecosystem form (are the species present desirable? diverse?) and function (is stand diversity maintained over time?). As agronomic species are a key element of wildlife forage reclamation, they are expected to dominate sites in initial post-reclamation stages. Species composition assessments are used to evaluate whether there is a transition towards increased occupation of sites by native species, which would provide evidence that reclaimed stands were on converging trajectories with original native ecosystems.

Forage quality

Sampling and analysis of foliar quality is used both to directly assess nutrient cycling in reclaimed forage stands (in much the same way as discussed for conifer foliage, above), and for assessment of the quality and value of forage for wildlife consumption. Analysis of macronutrients in forage (primarily nitrogen) over time provides an evaluation of the continued presence and cycling of these nutrients as management inputs (e.g., fertilization) are withdrawn. These observations can be directly linked to conclusions on site sustainability. Comparison of analytical data to nutritional requirements for wildlife provides information on the utility of forage for local species. Evaluations of the quality of reclaimed site forage and browse species have been conducted at all mines, and suggest that reclaimed vegetation will be as nutritionally valuable as that found on undisturbed sites. In addition to vegetation analysis, Elkview Operations has also monitored the crude protein content of elk fecal pellets collected each winter since 1994 to determine whether winter forage on the mine site is adequate to sustain the elk.

In conjunction with nutritional evaluation, seeded forages have been monitored at most of the mine sites to determine the concentrations of metals and trace elements. These data are interpreted with respect to dietary tolerances for wildlife. These assessments have generally shown acceptable levels of analyzed elements. Particular concern has been paid to selenium, as it is an element known to be associated with coal bearing strata, and is the subject of aquatic investigation in the Elk Valley. Selenium analyses have shown occasional mild elevations in selenium in reclaimed forage in comparison to offsite data, but that all levels are still within published safe dietary limits for domestic and wild ungulates, which have been shown to be relatively conservative. Elemental assessment has also included monthly sampling campaigns, to determine whether the standard sampling windows used in routine evaluations are representative of overall conditions. An example of data from such an evaluation is shown in Figure 5.

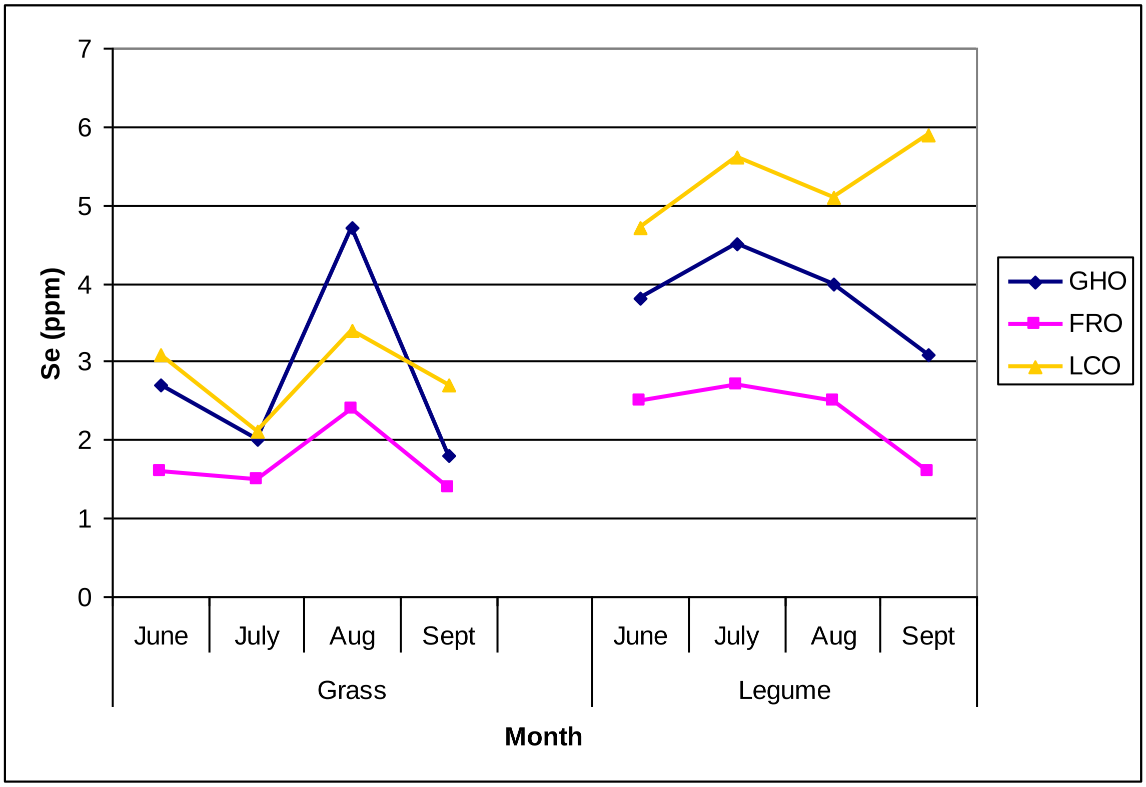

Figure 5. Selenium concentrations by month for three Elk Valley Coal operations.

Conclusion

Elk Valley Coal mines have been conducting successful operational reclamation based on detailed research for nearly 40 years, which has led directly to the reclamation programs in place at the five British Columbia operations today. These programs are based on a foundation of identifying end land uses based on ecological and societal need, and then developing techniques and operational practices to ensure that these end land use objectives can be successfully replaced on the reclaimed landscape. All of the five Elk Valley Coal operations have individually carried out valuable work in advancing understanding of reclamation principles and processes. With the creation of the Elk Valley Coal group in 2004, the mines now have the advantage of being able to synthesize these individual programs to result in a strong body of knowledge that will guide both future reclamation practice on the mine sites and also future inquiry into further refinements and improvements of this practice.

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18. Reflections on the conference and the future of ecological restoration in British Columbia

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The single word that comes to mind upon reflection about this conference is "abundance." We are a large group (more than 180) pursuing elusive ecological challenges and managing complicated projects with extraordinary hard work, generosity, persistence, and patience. I am especially impressed by the bold work underway in the East Kootenays, where rapid development is throwing up obstacles and opportunities for creative restoration. Nowhere is this more evident than in the prescriptions for returning historical fire patterns to the landscape.

We were brought to the brink last evening by a great question: Why do we restore? Don Gayton urged us to acknowledge and support the full range of human inspiration for restoration—stories , art, and spirit matter alongside ecological inspirations. In his banquet presentation Don drew a thick line between ecological and cultural realities, and it helped me to realize that we can answer the question by appealing to either ecocentric or anthropocentric values. However, what we really want is an infusion of the two, ecological restoration that is motivated by a simultaneous concern for ecology and culture.

This point was made clear for me during a project that Jeff Ralph, a graduate student in the UVic School of Environmental Studies, organized last year as part of his teaching assistant role in our introductory ecological restoration course. Jeff had worked with a community group and city staff for several years to restore the Southwest Woods, a remnant coastal Douglas-fir forest in Victoria's Beacon Hill Park. A work party was organized for what turned out to be a spectacular Saturday in October. Sixty students from UVic showed up and cycled through three work stations: ripping English ivy from an area previously untreated, ripping ivy from a former site of removal, and planting thousands of plants and bulbs. More remarkable than the sheer amount of work accomplished in a few hours was the connection that the students made with the place. There was a remarkable energy throughout the day, and several students made a point of mentioning that they had no idea that so much could be accomplished and at the same time how much work remained. The ecological messages were clear enough. Another theme emerged: the students felt they achieved a connection to the Southwest Woods that would remain in their memories for a long time, and for some it began a longer term connection to the place. Many wrote about their experience in a later reflection assignment and I was struck by the diversity of their inspiration. More than simply benefiting Beacon Hill Park, this awareness of the ecological and cultural values of restoration resonates in other parts of their lives. This I call "focal restoration."

Richard Louv realizes this connection in his influential book, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*. The loss of intimate experience in childhood with nature and natural processes does more than alienate us from responsibility to ecosystems and places; it deracinates our social relationships and cultural understanding.

What Louv does well as a journalist, and what Don Gayton urges us to consider, is telling cogent and compelling stories about our work as restorationists. These stories connect us to the dual benefits of restoration and help remind us that we are doing more than simply restoring the landscape; we are re-storying it and recovering our capacity for sustainable living.

This theme is picked up in an important new document that Parks Canada has developed, titled *Principles and Guidelines for Ecological Restoration*. Drier reading, of course, but as the world's first national-level guide for restoration, the document urges us to think of good restoration as consisting of three components: effectiveness, efficiency, and engagement. Engaging restoration means drawing people into projects to receive their contributions and support, but also to help connect them more deeply to nature and in the case of Parks Canada, nationally significant protected areas. We are witnessing an infusion of a broader approach to restoration in all levels of practice.

I had expected to make a desperate plea at this meeting for greater attention to historical knowledge. At the recent joint conference of the Society for Ecological Restoration International and the Ecological Society of America (San José, CA in early August) I was stunned to hear presentation after presentation that, in one way or another, rejected historical information in the rush to cope with rapid climate change. After all, the implicit argument went, why bother with detailed chronologies if everything will shift outside the recent historical range of variation? It occurred to me that history becomes more important, not less so, as a way of providing guidance and clues for future restoration and management, and not the least as an anchor that tethers our restless ambitions. We do not want to proceed with climate change mitigation that acts as a gigantic experiment just because we have the capacity to conduct such experiments. We want to proceed with care and clarity, and this will come through the discipline of history. It was reassuring to hear talks at this conference such as the elegant summary of denchronology by Lori Daniels, and Greg Anderson's plans for forest ecosystem restoration in British Columbia. Fortunately, history seems alive and well at SER-BC.

A question came to mind when listening to the presentations on forest history and restoration: Will ecological restoration treatments improve adaptive capacity of ecosystems in the wake of rapid climate change? In other words, does it make sense to proceed with intensive restoration treatments when we have a sense that the basic conditions for that system's flourishing will be compromised? My intuition is that it will, and if anything restoration treatments will become more urgent in coming years. We learn from close work with ecosystems that there is more complexity than we can know, and the best approach is to assist resilience and adaptive capacity. We will make profound mistakes if we believe that we can fully design and engineer ecosystems for climate change.

At a recent meeting on ecological restoration sponsored by Parks Canada in Waterton, Alberta, there was energy in the room that I had not seen since the very successful 1998 conference in Victoria, "Helping the Land Heal." I come to Cranbrook and find the registration capped at 180, by far the largest SER-BC group since the international conference we hosted in 2004. Could it be that we are experiencing viral growth? Has something clicked in the last year or so that is causing restoration to rise in popularity?

Skeptics will point immediately to a boom/bust cycle, but there is evidence around us to support unprecedented (viral?) growth: there are many young people at this conference, many of them students; the private sector is here in stronger numbers; provincial programs are heating up; and national and international support grows stronger.
What will ecological restoration look like in 10 years? The strength of the movement will depend on how much bottom-up efforts are matched by top-down policies and funding.

In 10 years, SER-BC will be looking at close to 20 years of continuous operation. The sparse years will be behind us, and we will have a membership numbering more than 500. The participants will be diverse, representing the small and large scale private sector, government officials, non-governmental organizations, students, and teachers, who have found ecological restoration a powerful organizing concept and practice. SER-BC will be complemented by strong chapters in other parts of Canada, notably SER-Ontario, but will also be irrigated by a national network of restorationists.

A national network will begin to form in 2008 following the interest generated by Parks Canada in the creation of the national Principles and Guidelines. Indeed, it is this document that begins to mobilize increased top-down support for on-the-ground restoration. For the first time, agencies and organizations will have a set of consistent and clear guidelines that will enable new programs and funding. As doors are open, the growing cadre of trained and motivated restorationists will be ready to work.

Learning opportunities will be a key in this growth. I am deeply biased, of course, but the provision of training is essential. The Restoration of Natural Systems program at UVic is the longest standing program of its type in Canada (and in the world), but initiatives at BCIT and Selkirk College as well as one at Lakeland College in Alberta have joined it recently. The new Restoration Institute based at the University of Victoria will provide annual intensive and collaborative learning opportunities.

As we develop it is important that we remember who we are and what we have accomplished. What seems a commonplace effort to us now will end up being the material upon which people build the history of the movement. We do it because we care deeply about restoration, but the founders of SER-BC and those attending meetings such as this will look back in 10, 20, and 30 years on the significance of the early days. Hoard our history!

I return to the importance of stories, of re-storying the landscape. We are moved to act by the compelling accounts of restoration that are told through stories, photographs, art, performance, and music. The numbers matter, yes, but they seldom move a wider public. Concentrate on how you can tell a good story, literally and figuratively, about the work you do, and match this to your audience. Get out to the public schools and community-based organizations. Use PowerPoint sparingly, and if you do use it at all focus on the images and not the words. Most of all, speak from your heart about the things that matter deeply to you: inspiring children to learn, connecting communities, experiencing natural processes, bringing big creatures back to the landscape, allowing fire to burn the way it did, and fostering cultural and ecological relationships.

Posters and Displays

The following is a list of posters and displays at the conference. Abstracts appear where they were provided.

1. Stewardship program for high school and community groups at the Creston Valley Wildlife Management Area

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The Creston Valley Wildlife Management Area is a 17 000 acre wetland habitat that forms a valuable link in a chain of wetlands extending from the Arctic Ocean to California. It is designated as a wetland of international significance (Ramsar site), an Important Bird Area, and an Important Amphibian and Reptile Area.

Starting in the spring of 2007, the Wildlife Area began a stewardship program for high school and community groups that involves active habitat restoration and enhancement activities. The program aims to improve environmental quality and achieve sustainable outcomes within the wetland.

We have hosted a variety of groups to date including: Prince Charles Secondary School Forestry 11/12 class, Creston Air Cadets, Conservation Corps, and Katimavik. We concentrated our efforts on the removal on an invasive plant species called yellow flag iris.

The iris is a garden escapee that grows in water saturated soils and it has spread its seeds into the channels around the Wildlife Centre. It grows so thick in some spots that it has become an impenetrable wall for those water loving creatures that move around from pond to pond. The iris also out-competes native vegetation, such as cattails, that many species rely on for food and shelter.

Groups physically dug out the plants and root system and clipped seed pods. The work is hard and labour intensive but satisfaction levels were high as groups learned of the importance of eradicating this invasive plant. We hope to continue to offer such restoration projects to interested high school and community groups.

2. Understorey succession following ecosystem restoration treatments in ingrown dry forests

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Restoration of ingrown stands of ponderosa pine (PPdh2) (*Pinus ponderosa*) and interior Douglas-fir (IDFdm2) (*Pseudotsuga menziesii* var. *glauca*) was carried out using a prescription of partial cutting and slashing in 1999 and 2000. Partial cutting consisted of thinning the forest canopy and removing intermediate layer trees. Slashing consisted of cutting pre-commercial, intermediate layers to reduce the risk of crown fire during prescribed understorey burns. The PPdh2 stand was subjected to a prescribed fire in April 2004. Total forage production was doubled at the PPdh2 site on areas partially cut to allow a 44% increase of understorey light compared to areas partially cut to allow 17% more understorey light (454 kg/ha versus 190 kg/ha, respectively).

Most of the increase was due to production of all grasses combined, including pinegrass (*Calamagrostis rubescens*) and bunchgrass. Bunchgrass production alone did not respond to the harvesting treatments. Six years after treatment, understorey light levels explained 64% of the variation in the production of all grasses combined at the PPdh2 site. The relationship had an exponential nature, with relatively greater forage responses to increasing understorey light levels in more open canopies. Over the six year period, and after accounting for growing season precipitation effects, annual forage production of all grasses combined was predicted to be 148 kg/ha greater on areas with 80% canopy openness compared to areas with 40% canopy openness at the PPdh2 site.

Total forage production was almost doubled at the IDFdm2 site on areas partially cut to allow a 32% increase of understorey light compared to areas partially cut to allow 9% more understorey light (421 kg/ha versus 248 kg/ha, respectively). Unlike at the PPdh2 site, most of the increase was due to production of forbs, not grasses. It is notable that bunchgrass production did not increase in response to the heavy partial cut treatment. Over the seven year period, and after accounting for growing season precipitation effects, annual total forage production was shown to be 220 kg/ha greater on areas with 70% canopy openness compared to areas with 20% canopy openness at the IDFdm2 site.

The ratio of rough fescue (*Festuca campestris*) frequency to pinegrass frequency has decreased slightly over time at both sites, an indication that pinegrass is “winning the race” relative to rough fescue. The frequency of rough fescue, and most other co-dominant species, has decreased over time at both sites, although this was not linked to the harvest treatments. The prescribed fire at the PPdh2 site increased the frequency of exposed mineral soil by 40%. Greater bark char height as a result of the fire was positively correlated with more frequent mineral soil exposure. It is evident that desirable plant species such as rough fescue have not yet been able to reproduce substantially with the treatments employed, and under the environmental conditions experienced over the study period. Rough fescue may eventually dominate at the two sites provided that conditions conducive to its reproduction are maintained for sufficient time; however, it is likely that intermediate plant communities formed by species with greater reproductive potential than rough fescue will occur first.

3. Managing ingrown Douglas-fir stands for biodiversity, forage, and timber: The Farwell Canyon project

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The Farwell Canyon Project was initiated by the BC Ministry of Forests in 2001 to explore options for managing densely ingrown Douglas-fir stands in the IDFxm to achieve biodiversity, forage production, and timber objectives. Returning some of the densely ingrown stands to a more open condition, through commercial timber harvesting and controlled ground fires or mechanical means, would likely increase ecological, wildlife, and multiple use values of these stands. However, the level of canopy removal required to stimulate the return of a grassy undergrowth and increase forage production and merchantable tree stem growth while not substantially decreasing stand level growth is unknown.

The Farwell Canyon study was initiated as a pilot trial to begin exploration of alternative stand management options for these densely ingrown stands (Steen 2005). It was designed to evaluate and demonstrate:

- A modified operational silviculture system, including mechanical thinning and prescribed underburning, that substantially reduces densities of small stems in ingrown stands
- The effects of these density reductions on vegetation composition, forage production, tree seedling establishment, and tree growth

The study is being conducted on two sites near Farwell Canyon southwest of Williams Lake in the Chilcotin plateau in central British Columbia. The treatments included:

- No treatment areas established to serve as untreated controls for demonstration and comparison purposes.
- Logging only treatment (applied in late summer 2001) using a feller-buncher and grapple-skidders to apply a "BDq" approach leaving a residual stand basal area ("B") of about 15 m^2/ha. The merchantable size was reduced to 12.5 cm dbh for Douglas-fir.
- Logging treatment plus manual thinning of juvenile stems (< 12.5 cm dbh).
- Logging and thinning treatment plus underburning to remove accumulated slash.

Results to date indicate that the modified harvest treatment (harvesting of smaller stems and cutting of many juvenile stems), with or without additional treatments, appears to set stands on a trend towards meeting biodiversity and forage production objectives. Increased biodiversity is indicated by increased number of vascular plant species per plot; increased ground cover of shrubs, graminoids, and forbs; and increased occurrence and mean cover of grassland grasses. These changes are all creating an undergrowth with greater structural complexity and, therefore, greater wildlife habitat value. In addition, the treatment is restoring a habitat type (fire-maintained savannah-like Douglas-fir stands with grassy undergrowth) that was more common when wildfires were frequent.

This project was initiated by Ordell Steen and is currently funded by the Habitat Conservation Trust Fund and the BC Ministry of Forests and Range.

4. Ecosystem resilience: Swan Lake watershed as a case study for urban aquatic restoration

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Swan Lake is a nine hectare lake, surrounded by 15 hectares of wetland, located in an urban area of Saanich (within Greater Victoria), British Columbia. The lake and its main inflow/outflow streams are part of a tributary to Colquitz Creek, one of the last remaining urban salmon-bearing streams in the region, which is in turn connected with a unique marine estuary system. This Master's research project aims to assess the health, in terms of ecosystem resilience, of the Swan Lake watershed, as a case study for urban aquatic restoration. Resilience theory, also called Panarchy, provides a theoretical framework for addressing disturbances and links with social systems, in order to better understand the behaviour of complex systems. This poster presents a "story" of Swan Lake and its key attributes and processes as a series of snapshots from the 1850s to the present, and depicts several possible trajectories into the future, including possible restoration options.
This project is sponsored by the University of Victoria, Municipality of Saanich, Aqua-Tex Scientific Consulting Ltd., and Swan Lake Christmas Hill Nature Sanctuary.

5. Road access management–US Forest Service approach

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No abstract provided.

6. Post-wildfire hydrologic risk mitigation: Considering the effects of hillslope stabilization treatments

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In undisturbed forest soils, the hydrologic response is dominated by subsurface flow. However, wildfire can cause changes to the soil, such as increased water repellency and loss of forest floor. These changes can generate significant overland flow and lead to exceptionally high peak runoff on a watershed scale.

The severe 2003 fire season resulted in major erosion and mass movement incidents on several fires, a phenomenon that had not previously been documented in British Columbia. Treatments to reduce post-wildfire erosion have been conducted in the US for many years, and after the 2003 fire season in British Columbia, the BC Ministry of Forests and Range began to develop similar procedures to assess and reduce the risks to life and property.

The 2007 fire season was intense in the west Kootenays and risk assessments have helped identify several areas that are at high risk of erosion events that could potentially damage residences and highways. Large-scale treatment operations on severely burned hillslopes are currently underway on two of the fire sites. These treatments, which consist of broadcast seeding and straw mulching from helicopters, are being monitored for effectiveness. Other treatment options, including WoodStraw™ and pulp wood chips, are being tested on small plots. The use of reforestation is also a consideration in areas where there is a high risk of avalanche hazard.

Although the purpose of the treatments is a rapid post-fire response to stabilize hillslopes that pose a high risk of flooding and debris flow hazards affecting life and property, it is also important to consider the ecological impacts inherent in applying certain treatments, such as reforestation, straw mulching, and non-native seeding, in these ecosystems.

7. Bristly Locust: Distribution of a new weed in the West Kootenays

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Juliet Craig, Central Kootenay Invasive Plant Committee

Bristly locust (*Robinia hispida*) is a leguminous shrub introduced to the West Kootenay as a garden ornamental. A 2006 inventory conducted by the Central Kootenay Invasive Plant

Committee found 42 separate populations in a variety of habitats, including several large colonies on roadsides, dry slopes, grasslands, and open forests. Two distinct forms were identified:

1. 67% of all occurrences were smooth-stemmed, with rose-purple flowers that were did not set seed, and,
2. 33% were bristly-stemmed with pale pink to rose-purple flowers and hispid seed pods containing 3–5 seeds.

Bristly locust has clearly overcome a number of the natural barriers and is invading natural habitats. It forms dense clones over large areas, potentially altering ecosystem structure, function, and process. Virtually no native vegetation grows with it. We were unable to determine if bristly locust is able to disperse over long distances, which would define it as an invasive plant that can threaten broader areas. Further research into its ecological invasiveness should include seed viability testing and ongoing inventory. As a precaution, people should be discouraged from planting bristly locust in their gardens and ongoing public education should focus on the dangers of introducing new, potentially invasive plants.

8. About the Central Kootenay Invasive Plant Committee

Juliet Craig, Central Kootenay Invasive Plant Committee, Nelson, British Columbia
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The Central Kootenay Invasive Plant Committee is a group of concerned local citizens, land managers, government, and non-government agencies who share a common concern about the increase of non-native invasive plants in the Central Kootenays and British Columbia.

The Central Kootenay Invasive Plant Committee was formed to:

- Raise awareness and educate the public about invasive plants and their impacts
- Prevent the further introduction and spread of these species
- Promote co-ordinated and collaborative management between agencies and land occupiers
- Work towards the control of highly invasive non-native species
- Provide a conduit for information and a source of expertise
- Develop and maintain an inventory of invasive plants in the region

To learn more about the Central Kootenay Invasive Plant Committee, visit: http://www.kootenayweeds.com

9. About the Society for Ecological Restoration–British Columbia Chapter

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SER-BC is a chapter of the international Society for Ecological Restoration (SER), which is headquartered in Tucson, Arizona. SER has more than 2500 members in 24 countries. The inaugural meeting for the British Columbia chapter was held in April, 2000.

SER-BC is a diverse group of ecologists, researchers, and restorationists from all over British Columbia and western Canada. They come from the ranks of consulting, business, government, universities, interest groups, and the general public. The common bond is the concern for the health of British Columbia ecosystems, and direct involvement in projects to restore those systems.

For more information, visit: www.ser.org/serbc

10. About the Osoyoos Desert Society

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The pocket desert of the South Okanagan is one of the most threatened natural areas of Canada. This arid shrub-steppe is found only in the very hot, dry subzone of the Bunchgrass ecosystem of British Columbia and is largely confined to the valleys of the Okanagan and Similkameen below 700 m. This habitat has British Columbia’s greatest concentration of rare and endangered plant and animal species.

So far, 68% of the original desert habitat has been destroyed. Much has been converted to farm or residential use. Only 9% of the original arid shrub-steppe remains undisturbed. There is an immediate need to begin a process that will ultimately reverse the elimination of habitat and the endangerment and extirpation of species. The key to this reversal is knowledge.

The Osoyoos Desert Society is dedicated to saving Canada’s only true desert. The Society works to promote and demonstrate native plant landscaping, ecological restoration and research, and habitat conservation. Volunteers help make this possible by participating in weed pulls and plant salvages, writing, consulting, guiding tours, monitoring, organizing events, and many other tasks.

For more information contact: www.desert.org

Conference Field Trips

Four conference field trips were offered; 110 people participated in field trips. Field trips left just after noon on October 13.

Aquatic and riparian restoration

Field trip leader: Michael Keefer, Keefer Ecological Services

- Upper Joseph Creek, with Cori Barraclough and Gerry Oliver.
- Upper reaches of Joseph Creek in reference condition and the stream bypass at the Cranbrook Reservoir.
- Kinsmen Park, with Gerry Oliver, Michael Keefer, and Stewart Wilson. View instream structures, riparian plantings, hear about the environmental education of school age children, view the soil bioengineering course site, and learn about the efforts of moving the city of Cranbrook to being riparian friendly.
- Tamarack Mall with Cori Barraclough. View the new channel of Joseph Creek.

Flammulated Owl habitat, restoring wildlife winter range habitat, mine reclamation

Field tip leader: Don Eastman

Route: Cranbrook, Fort Steele, south to to Mause Creek Forestry Road, then on to Bull River winter range, and the mine site near Aberfeldie dam, returning via main highway back to Cranbrook.

- Mause Creek: Visit to nest site and discussion of options for protecting nesting habitat of Flammulated Owl.
- Bull River winter range: Restoration on a big game winter range—a historical perspective.
- Gallowai Bul River mine site with Clint Smyth: Tour of various reclamation activities on the mine site, including acid rock drainage and earlier range restoration.

Fire regimes and wildfire restoration

Field Trip Leader: Jed Cochrane, UBC

Route: Drive from Cranbrook northwest to Marysville, travel the Perry Creek and St Mary Forest Service roads to a dry transitional site into the MSdk subzone. Tour will discuss fire history methods and results for the plot and landscape scale. The major stop will be the fire history research plot on the St Mary Forest Service Road.

Dry forest restoration, impacts on First Nations cultural resources, wetland restoration

Field trip Leader: Randy Harris, BC Ministry of Forests and Range

- TaTa Creek/Miller Road: Randy Harris, Rob Neill, and Tim Ross: Dry forest restoration: Comparing pre-and post-treatments for dealing with forest ingrowth. Range management concerns; swing pastures, logging and slashing treatments;

responses of range vegetation to forest ecosystem restoration; and the East Kootenay Conservation Program and role of The Nature Trust.

- Reed Lake: Reducing impacts of logging on First Nations cultural resources, with Thomas Munson and Robert Williams; and mud bogging and ATV use of grass lands.

Summary of Conference Evaluation Forms

Conference evaluation forms were distributed on the second morning of the conference. Out of 180 forms distributed, only 35 were returned. Not all forms had comments for each question.

1. How well did the conference meet your expectations?

22 Fully met   12 Met most   0 Met only a few   0 Did not meet any

2. How do you rate the quality of the presentations?

16 Excellent   18 Good   1 Average   0 Poor

Do you have comments about any of the presentations?

- Wanted presentation from Ktunaxa Nation.
- Lots of slides with too much text or graphs you couldn't read (2 comments).
- Wanted shorter presentations with more time for questions.
- Found some overlap in topics.
- Wanted a wider range of ER topics covered.
- Screen hard to see from back of room (2 comments).
- Wide variety of presentation topics. Could have been better grouping of topics.
- Some topics were eye-openers for new people like me.
- Too many presentations on prescribed burning. Are there other techniques that could have been highlighted?
- Great local representation, but few talks from outside of the region.
- Wanted more variety of topics.
- More visuals, less graphs, keep on time.
- Several presenters (Bob Gray, Thomas Munson) provided inaccurate and misleading information. These inaccuracies could have easily been rectified with improved communication with Protection Branch staff and other MOFR experts. Presenters should stick to their area of expertise to avoid misleading the group with opinions and assumptions vs. using the facts.
- Cori and Patrick's talk provided an interesting and necessary solution to inevitable problems.
- Length of presentations was just right.

Generally positive comments such as "great": 8

3. How do you rate the quality of the field trips?

___ Excellent   ___ Good   ___Average   ___Poor

Do you have comments about any of the field trips?

(Most forms were turned in before the field trips)

- Too much blustery talk from one couple leading the trip. Overall not too bad but thin on actually seeing stuff. Turtle guy did not show. Riparian area in park was good. Upper watershed discussion was slanted to irrelevant issues.
- Fire regimes field trip provided good discussion as well as a good visual on what was done in the field.
- Good that we are now studying fire history at mid-elevation Montane Spruce sites.
- It repeated the talk a bit. Great for getting into conversations. Great for getting out.
- I found the descriptions hard to "get." The trips didn't seem to be each on a theme, but rather were cobbled together series of stops. A theme would have been preferred.
- Good variety, hard to choose.
- Field trips had many last minute changes, confusion on rides, MOFR had to step in.
- FT 1 was an excellent way to wrap up the conference.
- Interesting stops and good discussion.

4. Do you have any other comments about the conference? Any comments on the venue, food, or service?

Not summarized. Most comments favourable.

5. We are considering holding a sequel to this conference in a few years. What topics would you like more information on? What topics did we not present here that you would like to hear about in the future?

- Propagation of native species for use in restoration projects—where, how, studies, seed sources.
- How to encourage changes to law to encourage ER and prevention of habitat degradation (re: ATV and snowmobile use).
- Prescribed fire.
- Outcomes and results of past ER efforts.
- The big picture. How do we decide on regional and provincial priorities for ER?
- What about the impacts of recreation and tourism?
- Invasive aliens, especially plants, after fires.
- Progress on a few burning projects, to hear about who well projects went, lessons learned, costs, results.
- Ways that community groups can apply restoration techniques and research at the community level.
- Hands-on stuff.
- ER as a business process.
- With increased development in the Trench how do we maintain the ecosystems, i.e., as opposed to fixing them afterward.
- Some presentations on restoration/wildlife/species at risk would have been nice.

- Alternate stable states of ecosystems—once the weeds invade, ecosystems may be irreversibly changed. Sometimes controlled burns eliminate native plants and disturb the area for thick invasive stands to establish…discuss.
- More on wetland restoration.
- More on education programs related to restoration, what works.
- Mine reclamation techniques, continue to address.
- Nurse crops.
- Restoration and climate change.
- Grazing as a tool/factor in rehabilitation and restoration.
- How to work closely with leaseholders (pipelines), partnerships, other large agencies.
- How to get the public involved?
- Capacity building—who is training the future ER practitioners?
- Results monitoring.
- Policy and legislation support for ER.

6. CMI is considering hosting a regional science conference on "Invasive Flora and Fauna" with a focus on southeastern British Columbia. Would you find this conference useful? What topics would you like to see covered?

Would find it useful: 18

- Hard data on disturbance effects on invasive plant generation.
- How ordinary people can deal with them on their own properties.
- Innovative methods for monitoring invasive weeds using remote sensing.
- Research on both terrestrial and aquatic ecosystems.
- Use of invasive species in revegetation and reclamation.
- State of biocontrol for each invasive species.
- Multijurisdictional programs—when weeds cross borders.
- As applied to mining reclamation.
- How would regional strategies work rather than property-by-property.
- Removal techniques specific to certain species, when to use them (3 comments).
- More on education programs, who is doing what.
- How to get community involvement and education of public and industry (4 comments).
- When to control invasives and when to let them go.
- Invasives in the Okanagan.
- How can we reduce weed transport and how to do this between jurisdictions.
- What legislation is currently available.
- Seed dispersal from logging trucks.
- Include insects.
- About Integrated Pest Management.
- Work with CKIPC and RDEK to identify knowledge gaps and where conference would be held.
- What happens after wildfire or prescribed fire.

- How do you prevent them from spreading.
- How do invasives and SAR interact.

7. What suggestions do you have for future topics and locations of SER-BC meetings?

- I enjoyed the talk on ER in combination with development and incorporating natives into new development to increase economic values. Want more on this. Are people getting connected with nature?
- Grasslands ER, Chilcotin, and Williams Lake.
- Wants greater integration of art and culture into all technical meetings to compliment the science, or to be an explicit part of the conference. Science on its own is not what I want to see.
- ATVs and snowmobiles: effects.
- Suggest future conferences to include presentations from MOFR's fire management program and other MOFR experts on training certification requirements, archaeological legislation.
- Is it actually possible to restore certain ecosystems, e.g., grasslands? Should we admit that once disturbed these ecosystems never, within human lifespan, return to original species composition? Restoration should not be seen as a license to disturb more.
- Northern restoration.
- Access control.
- Go north for next meeting to Prince George or Fort St John.
- Have it during week days.

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

- Monitoring and evaluation techniques and tools. There was a lot of talk about photo point monitoring, but no discussion on how to use this tool.
- How to give a good presentation.
- Fire science.
- Project management, contract management.
- Ecology and mine reclamation as it relates to end land use strategies.
- Invasives.
- More introduction to stats courses.
- R software courses.