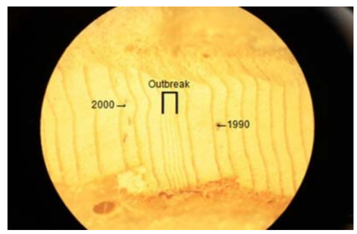
Climate Change Vulnerability of Old-Growth Forests in BC's Inland Temperate Rainforest

Final Report – May 2012

Future Forest Ecosystems Scientific Council of British Columbia



UNIVERSITY OF NORTHERN BRITISH COLUMBIA

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Further information can be found at: http://wetbelt.unbc.ca/
Click on the tab for "Climate Change".

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Executive Summary.

Our research findings suggest that climate change impacts may be particularly severe in B.C.'s inland temperate rainforest (ITR), with large changes predicted in the climate envelope for wet subzones of the Interior Cedar-Hemlock (ICH) biogeoclimatic zone. The combined impacts of warmer temperatures and reduced winter snowpacks may pose a particular threat to the region's western redcedar forests. These stands are typically most productive and support the greatest biodiversity on wet sites, where snowmelt sustains groundwater supply during dry summer periods. Our research found that wet cedar-leading ITR stands are an important regional (even national) carbon store, with undisturbed forests holding more than 450 Mg C ha^{-1} in non-soil stocks, values similar to those of productive wet temperate coastal rainforests in B.C. Our analysis indicated that traditional clearcut harvesting results in a one-time removal of most of this stored carbon, including nearly half of the forest-floor carbon . In contrast, group-selection partial-cut harvesting resulted in retention of nearly 80% of stored carbon. These results have major implications for forest managers if we consider greenhouse gas emissions as a factor in the pricing of forest harvesting. They also suggest that traditional paradigms, which regard young plantations as major greenhouse gas sinks, must take into account prior stand conversions in order to accurately portray net impacts on climate change. The projected changes in winter climate that we have modeled may also place many elements of ITR biodiversity at risk. The ITR is home to rich canopy lichen communities, which have traditionally been regarded as sensitive indicators of environmental change. We have found that these canopy lichen communities are especially vulnerable to increased variability of winter climate. Future land use management decisions should give a high priority to conserving lichen communities in topographic positions where they are potentially buffered from the impacts of climate change, such as in wet toe-slope positions. With a changing profile of available timber supply due to climate change local communities expressed an interest in greater utilization of non-timber forest resources to support economic diversification. Our documentation of these activities for one site, the Ancient Forest trail east of Prince George, shows that economic activity generated from visitor activity at this trail (newly opened in 2006) reached nearly $180,000 in 2011. Projected over the life of traditional harvest rotations in similar sites, these valuations provide additional information for local communities planning economic diversification in the face of climate change. These findings also support community calls for changes in the valuation of provincial tenure systems, which often make it difficult for license holders such as community forests to make long-term land-use planning decisions in response to climate change projections. These research findings paint a valuable portrait of a little-known ecosystem in B.C., where local communities face major challenges adapting to predicted climate change impacts. A high priority for provincial decision makers must be meaningful follow-up to this new and emerging information, both in support of continuing research, and in support of adaptation in local communities.

Section A. Objectives, approach and methods.

Six research teams, four with a physical and/or natural sciences emphasis, and two with socioeconomic emphasis, worked together to address climate change vulnerability and adaptation in old forests stands in B.C.`s inland temperate rainforest (ITR), and the implications for communities.

Our overall objective was to provide information that will assist in the development of higher-level planning processes that can mitigate or adapt to climate change in B.C. `s ITR. We also wanted to work with local communities to determine old-forest related values and help prioritize strategies for maintaining these values in the face of predicted climate change impacts.

Our research team objectives and methods were:

Team 1 – Climate Change Scenarios. This team used global climate model simulations to provide estimates of future ITR climate change. Two models from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change were used: the Coupled General Circulation Model, version 2 (CGCM2) of the Canadian Centre for Climate Modelling and Analysis, and the Hadley Centre Coupled Climate model, version 3 (HadCM3). Particular emphasis was given to the role of snowpack in sustaining forest ecosystems and projected climate change impacts on snowfall deposition patterns.

Team 2 - Climate Change Vulnerability (Dendrochronology). The main objectives of the dendrochronology team were to quantify the response of western redcedar growth to the effects of climate and western hemlock looper, and to quantify the climatic conditions that lead to western hemlock looper outbreaks. Standard methods of tree ring analysis were used. Trees were cored using an increment borer, yielding a cross section from the bark to the center of the tree. Cross sections were sanded and annual increments of radial growth rings were identified visually, then measured. Once all samples had a measurement assigned for each annual growth increment, individual ring-width series were standardized and annual growth indices were averaged across all samples, by site, to produce a chronology, or tree ring history, for that site. Chronologies were then compared to climate records found on the National Climate Data and Information Archive, and records of western hemlock looper outbreaks found in the Federal Insect and Disease Survey records.

Team 3 – Carbon budgets. Team 3 focused on obtaining detailed assessments of carbon stores in old-growth ITR stands and assessing their response to climate change and management actions. This team incorporated previously collected Silvicultural Systems trial data, allowing a comparison of carbon stores in 'group selection', 'group retention' and 'clearcut' silvicultural systems, as well as collecting new data on forest floor carbon on these sites.

Team 4 – Lichen Biomonitoring. Canopy lichen communities of the inland rainforest, especially the globally threatened Lobarian lichen alliance, have become a highly visible symbol of biodiversity and conservation concerns in the ITR. This project component assessed the vulnerability of Lobarion group lichens to projected climate change patterns, and developed protocols for use of branch-dwelling macrolichens as climate change indicators.

Team 5 - Socioeconomic Impacts of Climate Change. The purpose of this socioeconomic study of the impacts of climate change on the ITR stands in the Robson Valley is to assess the (a) perceived values of future non-timber uses of the ITR; (b) perceptions of vulnerability of non-timber uses under different climate change scenarios; and (c) opportunities for adaptation. Primary data were collected using semi-structured interviews with key informants, household surveys of residents in Dome Creek and Crescent Spur, and on-site surveys of people using the Ancient Forest Trail that is located near Dome Creek. The main objectives of primary data collection were to acquire information about the impacts of climate change in relation to held values of the ITR, the perceived vulnerability of these forest values; and, ideas that area residents and other stakeholders have for mitigating and adapting to the effects of climate change in their area.

Team 6 – The Community Forest Model. Adapting to climate change impacts in B.C.'s ITR forest will require forest tenure models that are responsive to community concerns and that incorporate a long-term, place-based vision. The objective of Team 6 was to examine the role of community forests in meeting the challenge of managing old-forest ITR stands in the face of a changing climate. The team used results from surveys and interviews to develop an economic map of the tenure area of the new Dunster Community Forest, and worked with residents and board members in exploring options and finding ways to balance local values as they developed their forest management strategy.

Section B. Collaboration on Project.

Our collaboration included both formal and informal processes. Among formal processes were regular meetings with project partners, culminating in the C4F conference held in Dunster, B.C. in October 2011. We also participated in meetings with the other Prince George based groups (Tracy Summerville, Craig Delong PI's), to insure that our work did not duplicate that of other teams. Collaboration with other teams based at the University of Northern British Columbia (UNBC) included trading field work days and providing sampling site locations to researchers at the Canadian Forest Service, who are currently doing research on stand dynamics following western hemlock looper outbreaks. Community groups such as the Caledonia Ramblers Hiking Club helped us collect socioeconomic data by reading the trail counter at the Ancient Forest trail (Team 5). Many of our project clients were interviewed as part of the key informant data collection process by Team 5.

Section C. Communication with other researchers, clients, partners, stakeholders, and public.

Several forums existed for the communication of project results. These included:

Conference and community presentations. We have provided access to emerging FFESC research through presentations at local, provincial, national, and international workshops and conferences, with 26 presentations recorded to-date (and more planned for this coming year). Significantly, this included 6 presentations at international events. A listing of these presentations is provided in Appendix 1.

Scientific Publications. Numerous publications resulting from the Inland Rainforest FFESC project are in submission or in preparation. These will span audiences ranging from B.C. forest managers and forest professionals (e.g., planned submission to B.C. Journal of Ecosystems by Coxson *et.al.)* to the international scientific community (e.g., planned submission on carbon stocks to the Canadian Journal of Forestry Research). A list of titles in submission or in preparation is provided in Appendix 1.

Project Workshop. Our research group co-hosted the First Annual "Carbon, Climate Change, and Community Forests" (C4F) Conference" held at the Dunster Fine Arts School on October 13th and 14th, 2011. This workshop featured 14 presentations, and was attended by 38 people on the first day and 25 on the second. Presenters came from UNBC, Simon Fraser University (SFU), the Ministry of Forest, Land and Natural Resource Operations, the Simpcw First Nation, the private sector, and both McBride and Dunster Community Forests. The presentations included the outcomes of the UNBC research on wet ICH forests, and examined alternative methods for managing forests in the face of climate change. The Dunster community provided complimentary breakfasts and hosted a dinner social for C4F attendees. There was a clear sense of "ownership" of the conference by the Dunster community. Additional details on the conference can be found on the conference website at http://www.c4f.ca/ (a copy provided in Appendix 2).

Web-based dissemination of results. We have left a major project legacy on the UNBC wetbelt website, describing the project objectives and outlining project results to-date for the FFESC sponsored research. These project links can be accessed from http://wetbelt.unbc.ca/ under the heading "Climate Change". These website postings are written to be accessible to the general public. A copy is provided in Appendix 2.

Contacts with media. Various group members have had contacts with media about the project during the past two years. As part of BC's Year of Science in 2010, the Climate Change Scenarios team was filmed by members of the Vancouver Aquarium performing a snow survey at the Ancient Forest.

Section E. Research Outcomes.

Team 1 – Climate Change Scenarios.

Climate monitoring: In support of this project, the climate change team deployed and maintained three weather stations in a very wet cool variant (ICHvk2) of the Inland Temperate Rainforest (ITR). The stations are located near the Ancient Forest trail (one station deployed in 2009) and at Lunate Creek (two stations installed in 2010/2011), about 100 km east of Prince George, BC. Variables measured include air and soil temperatures, relative humidity, wind speed and direction, precipitation, soil moisture, and snow depth. Data are available at a frequency of 15 minutes.

Snow monitoring: Over the past two winters, full snow surveys were conducted, especially near peak accumulation, to provide us baseline snow information for the ITR. Data collected include information on the spatial variability of snow depth and snow water equivalent as well as snow temperature profiles.

Climate change scenarios: An important first step in our analysis was that of verifying the reliability of Climate B.C. data. Previous concerns have been expressed about the reliability of Climate B.C. data in the ITR, based on the relatively few number of climate stations against which data can be verified, and the complexities of modeling climate in mountainous terrain. This stage of our analysis validated the use of Climate BC for our purposes. Figure 1 shows the close relationship between predicted and observed temperatures at six meteorological stations from across the geographical range of the inland rainforest.

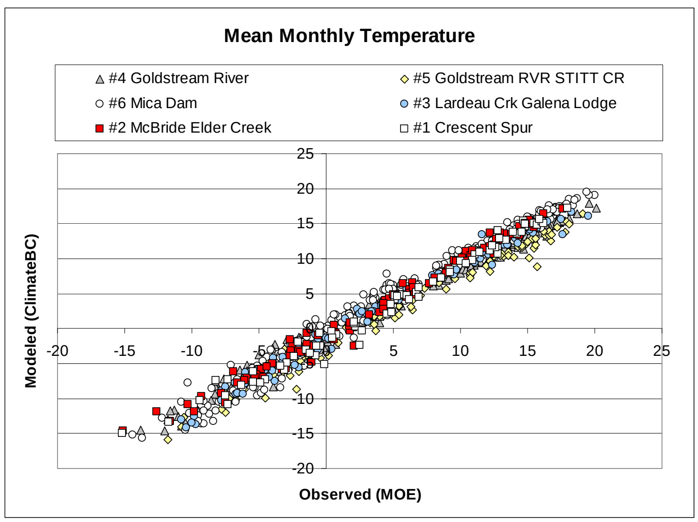

Figure 1 Comparison of mean monthly temperatures for observed values recorded by meteorological stations belonging to the Ministry of Environment and modeled values calculated by Climate BC.

Data from two different global climate models was subsequently used to calculate trends and assess variability of future ITR climate change Two models from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change were used: the Coupled General Circulation Model, version 2 (CGCM2) of the Canadian Centre for Climate Modelling and Analysis, and the

Hadley Centre Coupled Climate model, version 3 (HadCM3). Both models project a warmer, wetter climate in the ITR for the 21st century. While rainfall is expected to increase by 2100, snowfall is expected to decrease.

As an example of the potential interactions between changing temperature and precipitation in the inland rainforest, Figure 2 shows future climate trends in vertical relief for a transect across the upper Fraser River valley near Dome Creek, B.C.. This projection suggests that by 2080 mean annual temperature of valley bottom forests will rise by almost 4°C, while at the same time precipitation as snow will decline by nearly 30%. The combined impact of these changing climate variables may be large. Groundwater supply from melting snowpack is hypothesised to be a key factor in supporting cedar-dominated forests in the inland rainforest. The loss or disruption of this snowmelt could lead to much greater incidence of stand destroying fire and insect mortality in future years.

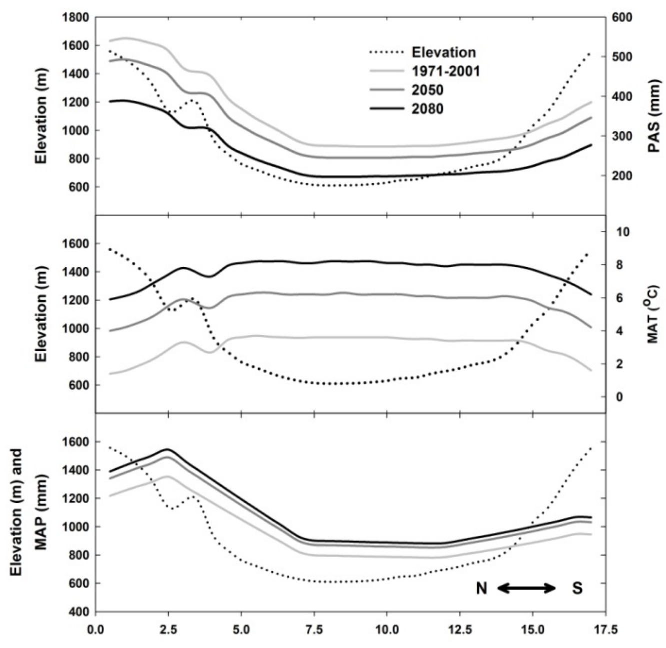

Figure 2 Current (1971-2001) and predicted (2050 and 2080) precipitation as snow (PAS), mean annual temperature (MAT) and mean annual precipitation (MAP) across a 17.5 km upper Fraser Valley climate transect. An exaggerated vertical relief of elevation is shown by the dotted line in each plot. Climate modelling from the CGCM2 A1F1 scenario.

Role of snow in replenishing soil moisture in the Ancient Forest: Heidi Knudsvig began a Master's degree at UNBC in August 2010. Her research project explores snow distribution in the ITR with a focus on the lateral transfer of soil moisture in the area. Three sites were selected to perform complete snow surveys during the winter 2011/2012. These were located near our weather stations at Lunate Creek and Ancient Forest. Piezometers and weirs were installed to quantify water productivity from springs. This data will provide future snow and groundwater information at toe slopes of the Cariboo Mountains where old growth cedars and hemlocks thrive.

Team 2 - Climate Change Vulnerability (Dendrochronology).

Expected results of the dendrochronology component were suppressed radial growth in years of low snowpack, released radial growth in years of elevated snowpack, suppressed radial growth during western hemlock looper outbreaks (see Fig. 3 below for example), and variability in the above results based on slope position, elevation, and aspect. Preliminary results have been determined based on four site level chronologies. Correlation analysis was used based on the tree ring chronologies and three variables: total precipitation as snow, total precipitation as rain, and mean annual temperature. The only significant correlation was between the variable total precipitation as snow and the Site 1 chronology (-0.4250, P = 0.0050). Snowpack decreased radial growth in this instance, which may be explained by the location of Site 1 at the upper elevational limits of western redcedar in an area that may be snow-bound late into the growing season. Other site/variable comparisons did not yield significant correlations, however determining the importance of seasonality may uncover more significant relationships. Some more preliminary correlation analysis using monthly Pacific Decadal Oscillation (PDO) values was also completed. PDO values were run against the Site 1 chronology, indicating importance in January and February ocean temperatures. Our hypothesis, that the previous winter's snowpack (or lack thereof) may have a large influence on tree growth in wet toe-slope cedar stands, through linkages with ground water supply, were not verified in the initial data analysis. However, relationships between past climate and hemlock looper outbreaks (which were clearly evident in the data set) remain the subject of ongoing data analysis.

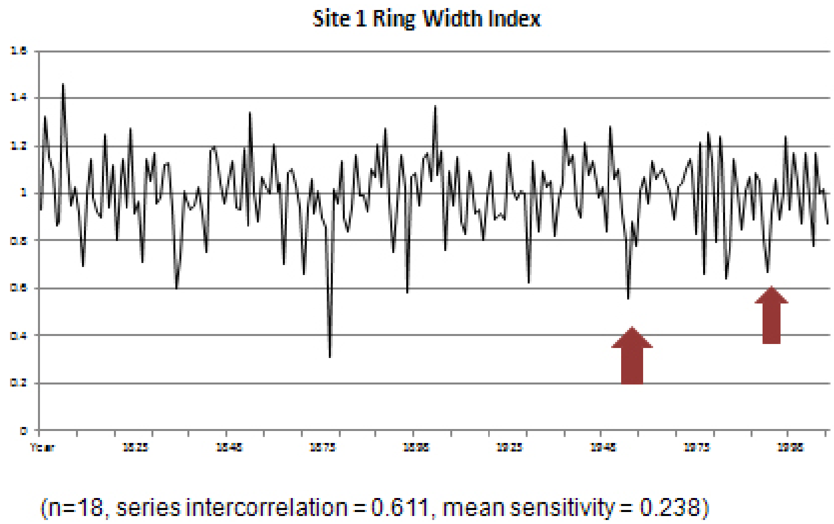

Figure 3. Standardized ring width indices for one of the sample sites. The red arrows indicate suppression events which line up temporally with known western hemlock looper outbreaks

Team 3 – Carbon budgets.

Forest carbon (C) stocks were assessed across three pre-existing Northern Wetbelt Silvicultural Systems Project (NWSSP) study sites (East Twin Creek, Lunate Creek, and Minnow Creek) established between 2000 and 2001, to compare alternative silvicultural systems in BC wetbelt forests. The study sites are located between the communities of Prince George and McBride in the wet cool (ICHwk3) and very wet cool (ICHvk2) subzones of the ICH. The experimental design at each site involved four harvesting treatments; 'clearcut' (CC) with 0% post-harvest retention, 'group retention' (GR) with 30% post-harvest retention, 'group selection' (GS) with 70% post-harvest retention, and 'uncut' (UN) with 100% retention. Existing data from these trials were used to estimate live-tree, CWD, and snag C stocks. New measurements were made of forest-floor C stocks at all three sites. In addition, we measured and modeled the impact of internal decay and hollowness in cedar and hemlock of the live-tree and snag component C stocks.

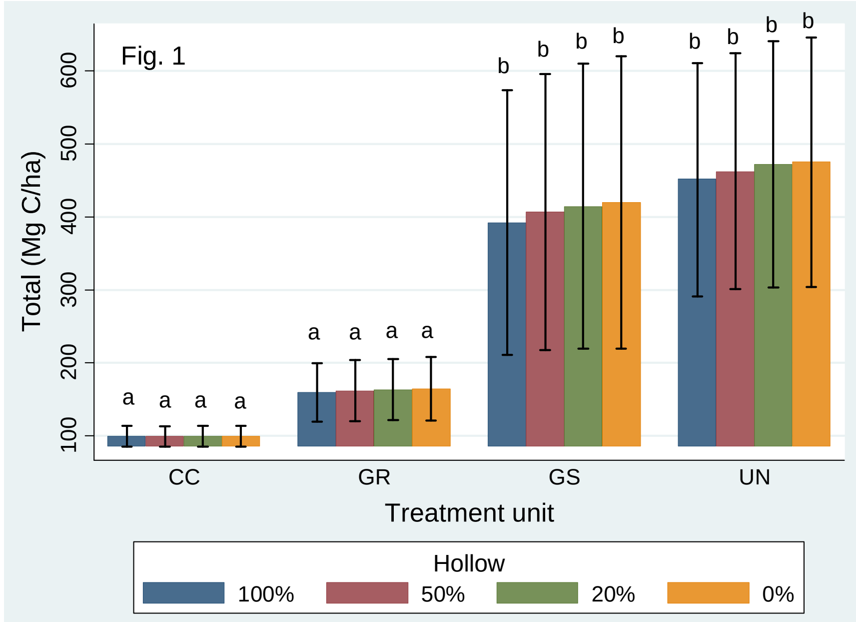

Figure 4. Total carbon stocks (Mg C/ha) by stem status (% hollow) in clearcut (CC), group-retention (GR), group-selection (GS), and uncut control (UN) silvicultural systems trials from interior cedar-hemlock forests in the upper Fraser River valley.

Across the three sites, total non-soil forest C stocks in old-growth (UN) cedar-hemlock stands were 455 ±156 Mg C ha^{-1} (± 95% confidence interval) (Fig. 4). These estimates are similar to regional averages for old-growth forests of the US Pacific Northwest and coastal BC. Despite the high incidence of heart-rot in interior western redcedar, old inland temperate rainforests have large reservoirs of C with live-tree C stocks amounting to 76% of the total non-soil C in uncut old stands. Our results demonstrate that hollowness does not significantly reduce total non-soil forest C stocks. Average dead-organic-matter C stocks (including snags, coarse woody debris, and forest floor) were 107 ±19 Mg C ha^{-1} or 24% of total non-soil C stocks. The dead-organic-matter C estimates were also similar to those found in other cool, temperate and wetter, sub-boreal BC forests. After evaluating the relative contribution of error components of live tree C stocks to their total uncertainty, we found tree biomass allometric equations were the largest contributor to the total uncertainty in live-tree C stocks. We found significant effects of silvicultural systems on forest C stocks, with CC < GR < GS < UN in total non-soil forest C stocks. This indicates that high-intensity harvesting approaches such as CC and GR may reduce long-term (non-soil) forest C stocks through loss of C stocks and capacity to store C in live trees. In contrast, low intensity harvesting such as GS showed potential to provide both wood products and maintenance of forest C stocks.

These research findings will provide important feedback to forest managers, as greater emphasis is given to determining the effect of forestry practices on greenhouse gas emissions. In the wet ITR, the data will also assist in the evaluation of the life-cycle impact of various biofuel harvesting proposals. The adoption of partial-cut harvesting systems, in particular, the group-selection silvicultural system, with 70% post-harvest retention, would on a given site greatly reduce the impact of forest harvesting on greenhouse gas emissions. However, if a management decision to adopt partial-cut harvesting in one site means that more site elsewhere must also be logged (to achieve the same timber supply), then there would be no net gains in greenhouse emissions, and indeed cumulative impacts on biodiversity and other ecosystem values could even be higher. This raises important social questions about the level of timber supply that is regarded as a sustainable practice by local communities.

Team 4 – Lichen Biomonitoring.

Current climate models suggest that climate change may affect winter more than any other season in the inland rainforest, with warmer temperatures and more periods of rain instead of snow. Climate scenarios calculated for the upper Fraser River valley (Fig. 1 above) suggest that mean annual temperatures in valley-bottom locations may increase by up to 4°C by the year 2080, equivalent to that of present day climate differences between valley bottom and mountain peak locations. At the same time predicted future winter snow packs may decline by over 30% (Fig. 1). Lichen communities will thus likely spend less time under protective snow cover in winter. Further they will likely experience more winter rainfall events and will generally face more variable winter climate conditions.

For lichen communities these changes may have important consequences. In a traditional wetbelt winter lichen communities are largely dormant, typically frozen for long periods, sometimes desiccated on branches if the onset of very cold conditions precedes snowfall, other times frozen under a thin crust of ice or snow, when snowfall accompanies the onset of subzero temperatures. If lichen communities in the future remain wet under low light winter conditions they may essentially starve, using up valuable carbon reserves to support vital metabolism.

We have now conducted a series of experiments examining how wetbelt lichens respond to different winter climate conditions. This work examined the physiological responses of two species of cyanolichens (lichens that contain cyanobacteria). Photosynthetic and respiratory responses were measured after lichens had been exposed to a range of simulated climate change conditions, including alternating periods of freezing and thawing, and prolonged low-light exposure to wet conditions.

These experiments showed that *Lobaria pulmonaria* was fairly resilient to increased hydration exposure under low-light winter conditions. The increased winter wetting resulted in increased photosynthetic activity compared to the start of the experimental period. However, one critical exception was lichens that were exposed to daily freeze-thaw conditions, where rates of photosynthesis were severely reduced. Unfortunately, this is a very likely future climate change scenario, where greater temperature fluctuations are seen during the winter period, with lichen communities insulated by snow less often.

The second component of this project was the development of protocols to monitor the response of inland rainforest lichen communities to climate change. Based on these new lichen monitoring protocols, we have now established over 60 permanent biomonitoring plots in the upper Fraser River valley near Slim Creek. Assessments of these plots in future years will provide an important index of ecosystem response to climate change.

Team 5 - Socioeconomic Impacts of Climate Change.

Team 5 interviewed 35 of the 51 households in Dome Creek and Crescent Spur. Of the 51 households, only 42 households were deemed approachable; those that were accessible only by boat or might be unsafe to approach were not surveyed. Results from the household survey show that the inland rainforest plays a central role in the lives of the residents in Dome Creek and Crescent Spur, with participants indicating that the forest is either ‘highly important’ (83%) or ‘important’ (16%) to them. We found that residents’ held forest values were most vulnerable to human disturbances, such as logging. Their levels of concern about climate change were less than their concerns about human disturbances but more than natural disturbances. With regard to actions that would help preserve their forest values, and reduce the vulnerability of those values to future changes, area residents emphasized the need for education, working together, contacting local politicians, maintaining a balance between preservation and economic growth, increasing tourism and research, and reducing human impacts, consumption, and waste.

Thirteen key informant interviews were completed, including stakeholders representing tourism, provincial government, economic development agencies, community forest corporations, and private businesses. Responses indicated that ecotourism could play a larger role in the future regional economy. Thirty percent rated ecotourism as ‘highly important’ and 30% answered ‘important.’ Other factors seen as positively affecting the regional economy included new trade markets in Asia, continued improvements in local infrastructure, promotion of the valley as a single unit, utilizing the resource-rich environment in a sustainable way, the entrepreneurial spirit of local people, the advent of new technologies, and increases in forest related manufacturing. Some potential issues relating to ecotourism development were identified, such as land-use conflicts, lack of investment, and changing climate. The results suggest that climate change is expected to have a significant impact on timber harvest and winter ecotourism and less impact on industrial development and timber manufacturing, but only a moderate impact overall.

In 2010 we completed 410 surveys with people using the Ancient Forest Trail, an area that has been the focus of trail development by local communities since 2006. An additional 42 surveys were completed in 2011. We found that among trail users, about 50 percent were at the trail for a day-trip and about 40 percent were tourists. For the 2011 hiking season (May to October) we estimate that between 8,500 and 9,300 people hiked the trail, continuing the trend of increasing use since the trail opened in 2006 (Fig. 5). The number of tourists was then considered alongside average daily expenditures of tourists in the region. Preliminary results suggest an annual economic impact of just under $180,000 for visiting tourists at the Ancient Forest Trail.

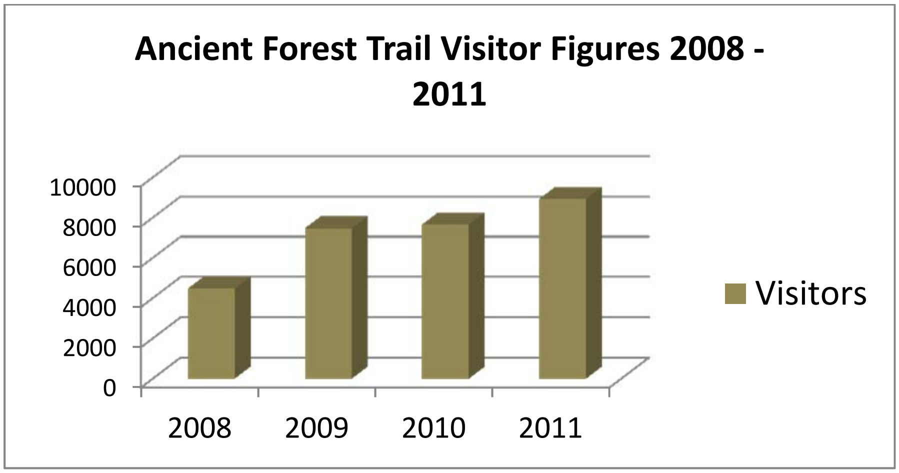

Figure 5. Non-timber socioeconomic usage of forests as an adaptive response to climate change; case study of visitor usage of the Ancient Forest Trail site from 2008 to 2011.

Team 6 – The Community Forest Model.

During residency in McBride in July and August 2010, project graduate student Tim Kelly (supervisor Dr. Evelyn Pinkerton, SFU) interviewed over 25 individuals in McBride, including McBride Community Forest (MCF) Board members, the General Manager of MCF, loggers, local mill owners and residents. Tim used this information to develop indicators of sustainable management of the community forest. During the winter of 2010-2011, Tim reviewed data collected the previous summer and developed a method to map the economy of McBride. This would allow the calculation of the localized multiplier effect of community-management of natural resources by measuring how often currency circulated in the economy. .

In winter 2011 the community forest team shifted their primary continued emphasis to working with the Dunster Community Forest Society (DCFS). Dunster is an unincorporated area 30 kilometers east of McBride, with approximately 180 residents. DCFS is a new community forest, having received their tenure agreement 18 months earlier, and they had not yet begun logging. DCFS is already having to respond to the effects of climate change, as the majority of its tenure area is being decimated by Mountain Pine Beetle. Rather than start over with very little time remaining, the community forest team elected to continue with the economic mapping project as an indicator of sustainable management in the face of climate change within ICH areas. DCFS immediately expressed an interest and embraced the economic mapping project. Over several weeks in June, July and August, 2011, Tim distributed surveys and interviewed business owners in Dunster, participated in several volunteer events important to the community, and along with the DCFS Board Chair, hiked through some of the DCFS forest tenure area to help DCFS learn more about the forest inventory within their tenure.

As a result of this exploration, DCFS learned of three old growth cedar-leading ICH patches within their tenure area. Dunster has many challenges as a small community forest with limited resources. The high economic-value Old Growth patches are in near-pristine areas that include wildlife corridors and recreational activities, and the community would prefer to leave these areas unlogged. Following the discovery of these patches, DCFS re-evaluated its management strategy and decided to focus on research and education efforts.

The first step in this process was the creation of the first annual “Carbon, Climate Change and Community Forests (C4F)" conference (C4F 2011). The Dunster community provided two complimentary breakfasts and one large dinner social for all C4F attendees. There was a clear sense of "ownership" of the conference by the Dunster community. At the C4F conference, Tim Kelly presented the results of the economic mapping, which highlighted a lack of business capacity within the community. Without a capacity to add additional value to the harvested log, Dunster is faced with an inability to capture the maximum possible value from the log. If the forest is then managed for maximizing economic return, the inevitable outcome is that harvesting will be maximized.

The issue of long term planning as an adaptation to climate change was a commonly heard concern by the community forest team. Under the current tenure system variations of up to 10% in the Annual Allowable Cut (AAC) are allowed within a five year period for a community forest. However, this does not allow the community forest to determine for itself the optimal rotation period based on local knowledge and values. Local control over harvesting levels is a known essential component of sustainable management of natural resources. Absent control over harvesting levels the community forests do not achieve a level beyond basic forest consumer and cannot fully meet their mandate for managing for multiple values, including watershed and wildlife habitat protection, recreation, and social and cultural enhancement.

Section F. Recommendations.

Teams 1& 2 - Climate Change Scenarios and Climate Change Vulnerability.

Our refinement of climate models for the inland rainforest in B.C. will be of special interest to climate scientists and others who model expected changes to species distributions due to climate change, forest managers responsible for developing and implementing mitigation strategies for climate change, and forest health managers and scientists. Our results provide information on the climatic variables that are most influential on cedar growth, and ultimately their vigour and adaptability. This information can be incorporated into predictions assessing the vulnerability of western redcedar to climate change. Our analysis of the impact of western hemlock looper outbreaks on western redcedar and associated impacts of climatic variables that are conducive to outbreak development has potential as an important input variable to models that estimate the change in frequency and severity of future looper outbreaks. This information is critical to the development of adaptation and forest health management strategies.

Team 3 – Carbon budgets. Potential end-users of our research outcomes are industries working in the wetter SBS and ICH forests of BC and the BC Forest Service. Given continued greenhouse-gas accumulation in the atmosphere and attendant climate change, our society will need to continue to find ways to retain existing C stocks, conserve or increase CO_2 sequestration and reduce emissions of CO_2. Forests are increasingly being affected by climate change, and therefore their C stocks are now increasingly in jeopardy from both natural and anthropogenic activities. As a result, we envision a shift in the present social, economic, and ecological values that have been currently attached to existing old-growth forests. Given a land base that is >90% forested, BC will need to ensure that it conserves forests with large legacies of C (e.g., wetter, old-growth forests) where possible, and uses silvicultural and harvesting practices that minimize losses of these C stocks where conservation is not possible. Our research shows that high-retention (70%) harvesting (GS) in inland temperate rainforests can result in similar landscape-level C stocks to those of uncut old growth. Therefore, partial-cut harvesting approaches need to be considered where possible to mitigate the losses of C stocks and sequestration potential of live trees in our forests, and particularly in the ITR.

Team 4 – Lichen Biomonitoring. The results of our lichen research will be useful to land use planners engaged in the selection of conservation areas at various scales. Areas of the ITR that are buffered from climate change, especially variability in winter climate, should be given high priority as conservation refugia, especially for organisms such as canopy lichens that are highly responsive to ambient climate. In the ITR, protected wet toe-slope positions may be particularly important as refugia for old forest dependant organisms. Ongoing monitoring of these sites will be critical to determining the developing impacts of climate change.

Team 5 - Socioeconomic Impacts of Climate Change. In the face of a declining forestry sector, economic diversification is a critical issue for the local economy. The documentation of held forest values and corresponding assessment of the role of ecotourism in the valley's economic development fill a significant gap in the knowledge of non-timber uses of the inland rainforest. The research results will inform future decisions about the uses of the forest, including .timber supply reviews and the development of protected areas. We expect the information will be valuable to a range of knowledge users including tourism associations, local economic development agencies, .provincial ministries, and local governments. The information will also assist private companies involved with tourism in the area, such as outdoor adventure and touring businesses. During our interviews, several clients explicitly asked if they could use the results of the research to complete their economic assessments and tourism strategies. Finally, we anticipate that the information will be used by local groups, such as the Dome Creek Community Forest Committee, to promote local interests in land use planning.

Team 6 – The Community Forest Model.

Interestingly, the issue of economic diversification in face of climate change impacts on local tenure holders has also emerged as a key issue for community forest partners. The Dunster Community Forest is exploring options that would provide more revenue from educational and tourism opportunities, providing a valuable synergy between our Team 5 and Team 6 objectives. Our team's research has further indicated the value of fostering local transactions, providing maximal economic return for income as it circulates within the community.

The community forest team recommends that the determination of the least amount to be harvested should be a responsibility of the community forest, while the province remains responsible for determining the maximum harvest level as the annual allowable cut. Depending on market conditions and long term planning, community forests would be allowed to not harvest. In keeping with the understanding that the community forests are capturing some non-timber value from their tenure even in the absence of harvesting, we recommend that the land tenure rent payment be due the Crown even in the absence of harvesting.

Section G. Extension of research outcomes.

The extension of our research outcomes has followed our project plan, using the community workshop in Dunster as a major launching pad for presentation of project findings to a range of stakeholders and policy advocates. Similarly we have discussed our emerging research findings in a variety of scientific and policy venues (see presentation list below).

For some facets of our research, it may be premature to discuss the implementation of policy changes based on emerging science. Although our data on carbon stores in wet ITR forests, for instance, has large implications for policy discussions on issues such as the pricing of carbon credits, until these results are published in the peer-review literature, their consideration by policy makers will remain limited.

Our communication strategies with local communities and stakeholders have led to discussions (e.g,. with DCFS) on the need for changes in tenure pricing models for community forests, with current pricing models creating an expectation for timber harvesting streams that may not be sustainable in face of climate change.

Appendix 1. Publications and Presentations.

Presentations:

1) Connell, D.J. 2010. *Socio-economic Benefits of Non-timber Uses of BC's Inland Rainforest: Research Bulletin, January 2010*. Prince George, BC: School of Environmental Planning, University of Northern British Columbia. Connell, David J. and Laura Gareau 2008. *Inland Rainforest of the Upper Fraser River Valley: Socio-economic Benefits of Non-timber Uses: Research Bulletin, November 2008*. School of Environmental Planning, University of Northern British Columbia. Prince George, British Columbia.
2) Connell, D.J., Hall, J., and Shapiro, J. 2011. *Socio-economic impacts of climate change in the Robson Valley* First Annual Carbon, Climate Change, and Community Forests (C4F) Conference" held at the Dunster Fine Arts School on October 13th and 14th, 2011.
3) Connell, D.J., Shapiro, J., and Hall, J. 2011. *Socio-economic Benefits of Non-timber Uses of BC's Inland Rainforest: Research Bulletin, May 2011*. Prince George, BC: School of Environmental Planning, University of Northern British Columbia.
4) Connell, D.J. 2010. Council of Tourism Associations of British Columbia [COTABC] (2006). *Economic Opportunities Study for Tourism in North & Central British Columbia*. Available on-line from http://www.cotabc.com/documents/publications/NorthernBC_EconomicImpact_Final.pdf. Accessed November 22, 2011.
5) Coxson, D. 2010. *Impacts of Climate Change on Inland Temperate Rainforests in western North America: Snow Forests No More?* Jan 29, 2010. NRESi Colloqium Presentation. University of Northern British Columbia
6) Coxson, D. 2010. *Inland Temperate Rainforest Ecosystem at Risk? – Interactions between Climate Change and Forestry Practices in Northern British Columbia.* Invited Seminar Speaker Department of Ecological Botany, Umea University. 14th May, 2010.
7) Coxson, D. 2010. *Inland Temperate Rainforests – Snow Forests No More?* Invited Seminar Speaker Friday 30th April, 2010. Norwegian University of Life Science, As, Norway.
8) Coxson, D., Dery, S. 2010. *Impacts of Climate Change on B.C.'s Inland Temperate Rainforest: Snow Forests No More*? Primeval Forests Conference. Sundsvall, Sweden. Oral Presentation, Wednesday 11 August 2010.
9) Déry, S. J., 2011: *Recent climate and environmental changes in the upper Fraser Basin*, Climate Research Division, Environment Canada, Downsview, Ontario (invited talk).
10) Déry, S. J., 2011: Climate, *water and snow: An overview of recent changes in the Upper Fraser Basin*, International Centre for Climate Change (IC3), University of Waterloo, Waterloo, Ontario (invited talk).
11) Hall, J. 2012. *Assessing the Economic Benefits of Ancient Forest Trail Ecotourism in the Upper Fraser Valley of Northern British Columbia*. CONFOR West 2012, Canmore, AB, February 2-5th.
12) Hall, J. 2011. *Tourism: An Economically Beneficial Non-Timber Use of the Inland Temperate Rainforest.* CONFOR West 2011, Banff, AB, February 3-5.
13) Hall, J. and Connell, D.J. 2011. *Ecotourism: an economically beneficial non-timber use of the Inland Temperate Rainforest in British Columbia*. [poster] UNBC Graduate Conference, Prince George, BC, March 13-16.
14) Knudsvig, H., Mlynowski, T. J., Déry, S. J., and Coxson, D., 2011: *Climate change and the Great Snowforest of Canada*, IUGG conference, Melbourne, Australia.
15) Konchalski, C., and Lewis, K. 2012. *Sensitivity of Western Redcedar growth to Climate and Western Hemlock Looper in British Columbia's Inland Temperate Rainforest*. The First International Cedar Symposium, hosted by the University of Victoria, May 2010 (Poster presentation).

16) Konchalski, C., and Lewis, K. 2012. *Sensitivity of Western Redcedar growth to Climate and Western Hemlock Looper in British Columbia's Inland Temperate Rainforest*. The 58th Annual Western Insect and Forest Disease Workshop Conference (WIFDWC), held in Valemount, BC, October 2010.
17) Konchalski, C., and Lewis, K. 2012. "Sensitivity of Western Redcedar growth to Climate and Western Hemlock Looper in British Columbia's Inland Temperate Rainforest". The American Association of Geographers (AAG) annual general meeting, held in Seattle, April 2011 (Oral presentation).
18) Konchalski, C., and Lewis, K. 2012. "Sensitivity of Western Redcedar growth to Climate and Western Hemlock Looper in British Columbia's Inland Temperate Rainforest". First Annual "Carbon, Climate Change, and Community Forests" (C4F) Conference" held at the Dunster Fine Arts School on October 13th and 14th, 2011.
19) Knudsvig, H., Mlynowski, T. J., Déry, S. J., and Coxson, D., 2011: *Climate change and the Great Snowforest of Canada*, IUGG conference, Melbourne, Australia.
20) Matsuzaki, E., Fredeen, A., and Sanborn. P. 2011. "Carbon Stores in B.C.'s Inland Temperate Rainforests. First Annual "Carbon, Climate Change, and Community Forests" (C4F) Conference" held at the Dunster Fine Arts School on October 13th and 14th, 2011.
21) Matsuzaki, E., Fredeen, A., and Sanborn. P. 2011. *Carbon Stocks of Western Redcedar and Western Hemlock Stands in Canada's Inland Temperate Rainforests.* Carbon Management in British Columbia's Ecosystem, June 15-16, 2011, Nelson, British Columbia.
22) Mlynowski, T. J., Knudsvig, H., and Déry, S. J., 2011: *Future climate of the Inland Temperate Rainforest: Demise of the Snowforest?* First Annual "Carbon, Climate Change, and Community Forests" (C4F) Conference" held at the Dunster Fine Arts School on October 13th and 14th, 2011.
23) Shapiro, J. 2012. *A Study of Forest Values Surrounding Ancient Cedar Stands in the Inland Temperate Rainforest.* CONFOR West 2012, Canmore, AB, February 2-5.
24) Shapiro, J. 2011. . A Study of Environmental Values Surrounding the Inland Temperate Rainforest. CONFOR West 2011, Banff, AB, February 3-5.
25) Shapiro, Jessica and David J. Connell 2011. *A Study of Environmental Values Surrounding the Inland Temperate Rainforest.* [poster] UNBC Graduate Student Conference, Prince George, BC, March 13-16

<u>Publications/Theses in preparation or submitted:</u>

1) Connell, D. J., Shapiro, J. and Hall, J. 2012. *Socio-economic Benefits of Non-timber Uses of BC's Inland Rainforest: Research Bulletin, January, 2012*. Prince George, BC: School of Environmental Planning, University of Northern British Columbia. (4 pages)
2) Connell, D.J., Shapiro, J. and Hall, J. 2011. *Socio-economic Benefits of Non-timber Uses of BC's Inland Rainforest: Research Bulletin*, May 2011. Prince George, BC: School of Environmental Planning, University of Northern British Columbia. (4 pages)
3) Coxson, D. and Goward, T. 2012. *Climate change and the inland rainforest in British Columbia – The vulnerability of Ancient Forest Dependant Lichen Communities.* In preparation.
4) Coxson, D. and Campbell, J. 2012. *The impact of climate change on canopy lichen communities in B.C.'s inland rainforest – The role of winter respiratory responses.* In preparation.
5) Hall, J. 2012 *Assessing the Economic Benefits of Ancient Forest Trail Ecotourism in the Upper Fraser Valley of Northern British Columbia*. M.A. Thesis. . MA, Natural Resources and Environmental Studies, UNBC. In preparation.
6) Kelly, T., and Pinkerton, E. 2012. *Quantitative analytical methods for distributing benefits in natural resource dependent communities*. In preparation.

7) Shapiro, J. *A Study of Forest Values of British Columbia's Inland Temperate Rainforest.* M.A. Thesis. . MA, Natural Resources and Environmental Studies, UNBC. In preparation.
8) Konchalski, C., and Lewis, K. 2012. *The Climatic Response of Western Redcedar in the Inland Temperate Rainforest of British Columbia*". In preparation.
9) Konchalski, C., and Lewis, K. 2012. *The Response of Western Redcedar to Western Hemlock Looper in the Inland Temperate Rainforest of British Columbia*". In preparation.
10) Konchalski, C. 2012. *Sensitivity of Western Redcedar growth to Climate and Western Hemlock Looper in British Columbia's Inland Temperate Rainforest,* M.Sc. Thesis in preparation, UNBC.
11) Matsuzaki, E. 2011. *Carbon Stocks of Western Redcedar and Western Hemlock Stands in Canada's Inland Temperate Rainforests.* M.Sc. thesis. Accepted Dec 7, 2011.
12) Matsuzaki, E. , Fredeen, A., and Sanborn. P. Carbon Stocks of Western Redcedar and Western Hemlock Stands in Canada's Inland Temperate Rainforests. Manuscript in preparation.
13) Mlynowski, T. J. and Déry, S. J. 2010: *Future climate of the Inland Temperate Rainforest*, technical report, 43 pp.
14) Mlynowski, T. J., Knudsvig, H., Déry, S. J., and Coxson, D., 2012. *Climate change in Canada's Great Snowforest*. In preparation.
15) Knudsvig, H. 2012: *Characterization of subsurface flow from snowmelt runoff, Ancient Forest,* British Columbia. M.Sc. Thesis, in preparation, UNBC.

Appendix 2. Web page postings.

Section 1. Postings from UNBC Northern Wetbelt Website http://wetbelt.unbc.ca/
Section 2. Postings from CF4 Conference Website http://www.c4f.ca/
Section 3. Posting from *The Rocky Mountain Goat* http://www.therockymountaingoat.com/

Northern Wetbelt Forests of British Columbia

HOME

British Columbia's northern interior mountain ranges are home to unique inland wet-temperate rainforests.

These forests are now the focus of interdisciplinary research at the University of Northern British Columbia.

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Climate Change and the Inland Rainforest

Overview

The unique character of the northern interior wetbelt depends, in part, on its unique climate. As air masses moving east from the Pacific Ocean approach the Rocky Mountains and begin to rise, they drop precipitation on the western flanks of the mountains. This maritime influence creates a climate that is wetter than that of other ecosystems of the British Columbia interior. At the same time, the high latitude of the northern wetbelt and its distance from the ocean create a continental climate – one with a warmer summer and a colder winter than a coastal climate at the same latitude. As a result of these two influences, maritime and continental, a substantial portion of the precipitation in the interior wetbelt comes as snow. As the snow gradually melts each spring, it feeds the streams, rivers, and lakes of the interior wetbelt. It also seeps downslope through the soil, helping to keep water-receiving sites at low elevations moist throughout the growing season.

How will this unique regional climate, the ecosystems that depend on it, and the people that depend on the ecosystems, be affected by global climate change? That is the topic of a current multidisciplinary research program, being conducted under the auspices of the **Future Forest Ecosystems Scientific Council of British Columbia** at the University of Northern B.C.

Left: Changes to winter snowpack are a key climate variable that could have large influences on the future composition of B.C.'s inland rainforests. Project student Asha MacDonald, here at the Ancient Forest trail, is developing lichen biomonitoring protocols to assess climate change.

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Darwyn Coxson

Devils club and western redcedar, two iconic species of the inland rainforest. How will their future be affected by climate change?

British Columbia's northern interior mountain ranges are home to unique inland wet-temperate rainforests.

These forests are now the focus of interdisciplinary research at the University of Northern British Columbia.

Projecting Future Climates

Global climate models that project future climate regimes already exist, but before they can be applied to the inland rainforest, we must be sure we have the best possible understanding of its contemporary climate. This project has three components:

- defining the contemporary climate,
- projecting future climate, and
- examining the special role of snow in the climate and ecology of the inland rainforest.

To define the contemporary climate of the inland rainforest, we used independent meteorological records to validate the data generated by Climate BC, a program that calculates climate variables for specific locations based on latitude, longitude, and elevation. We have also established and maintained three weather stations in the Slim Creek Very Wet, Cool Variant of the Interior Cedar-Hemlock Zone (ICHvk2) in the upper Fraser River valley. Air and soil temperatures, relative humidity, wind speed and direction, precipitation, soil moisture, and snow depth are available at 15-minute intervals.

To provide estimates of the future climate in the inland rainforest, we applied two different global climate models and two different sets of assumptions about carbon emissions to climate data extracted from Climate BC, giving us four different future climate scenarios. The global climate models we used were the Coupled General Circulation Model, version 2 (CGCM2) of the Canadian Centre for Climate Modelling and Analysis, and the Hadley Centre Coupled Climate model, version 3 (HadCM3). The carbon scenarios (A2 and B2 of the Intergovernmental Panel on Climate Change) were chosen because other scenarios have results that can be interpolated between these two scenarios.

Over the past two winters we have conducted full snow surveys, especially near peak accumulation, to provide baseline snow information for parts of the inland rainforest. Information has been collected on the spatial variability of snow depth and snow water equivalent, as well as snow temperature profiles. Three sites have been selected near the weather stations to perform complete snow surveys during winter 2011/2012. Piezometers (instruments that measure water pressure) and weirs will be installed nearby to quantify water productivity from springs.

Preliminary results

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Master's student Heidi Knudsvig verifying the status of a meteorological station deployed in the inland rainforest, 27th July 2010.

Our results validated the use of Climate BC for our purposes. Figure 1 shows the close relationship between predicted and observed temperatures at six meteorological stations from across the geographical range of the inland rainforest.

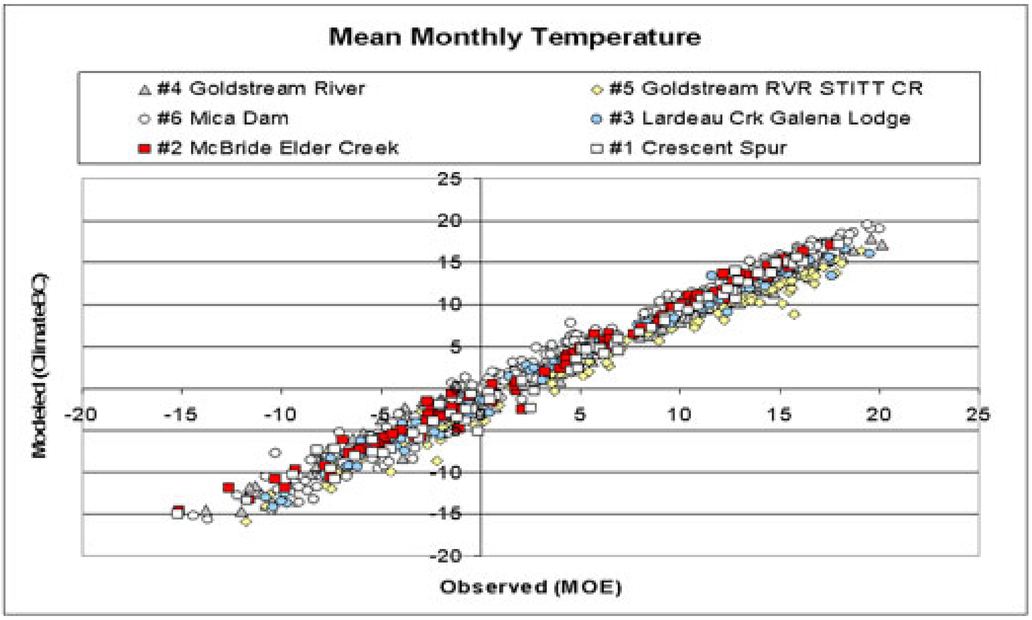

Figure 1 Comparison of mean monthly temperatures for observed values recorded by Ministry of Environment meteorological stations and modeled values calculated by Climate BC.

Ph.D. candidate Ian Picketts in a snow pit (about 2 metres deep) dug to measure the snow temperature profile in the inland rainforest, 28th April 2011.

All the scenarios showed increases in mean annual temperature and precipitation in the ICH vk2 for the 21st century. The amount of precipitation falling as snow, however, is projected to decrease (Figure 2).

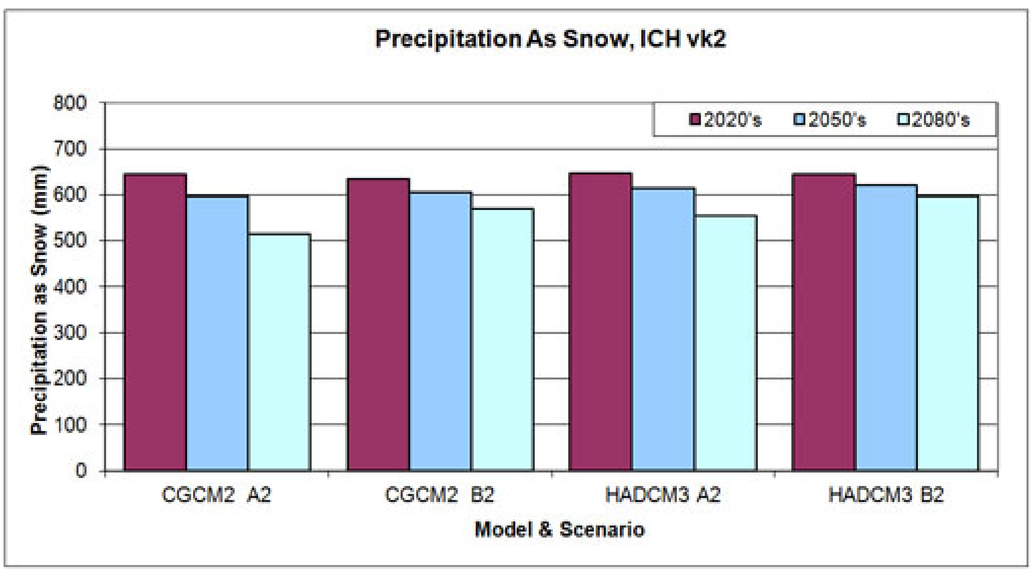

Figure 2. Future projection of precipitation as snow in the ICHvk2 Biogeoclimatic Ecological Classification variant. Projections are shown for the CGCM2 and HADCM3 models and the A2 and B2 carbon emission scenarios for the 2020's, 2050's, 2080's.

Stephen Déry extracting a snow core with a Federal Sampler in the inland rainforest, 5th March 2010.

With decreasing precipitation as snow, there is the potential for decreased snowmelt infiltration into the groundwater. Decreased infiltration could lead to depleted soil moisture, making the stands more susceptible to fire during summer. Our ongoing research on snow distribution in the inland rainforest, with a focus on the lateral transfer of soil moisture, will provide information about snow and groundwater along toe slopes that currently support old-growth stands of cedar and hemlock.

Research team: Stephen Déry (Environmental Science, UNBC), Theo Mlynowski, Heidi Knudsvig

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Sensitivity of Western Redcedar Growth to Climate and Western Hemlock Looper

Growth rates of trees respond to variations in climate, tree health, and other environmental factors that affect growing conditions. Analysis of patterns in growth rings can help us understand how tree growth is affected by changes in growing conditions over time, or by differences in growing conditions among sites. If we know more about how growth of western redcedar has been affected in the past by changes in climate and by insect outbreaks, we will be better able to predict how western redcedar will respond to future conditions.

The western hemlock looper (Lambdina fiscellaria lugubrosa) is a defoliating insect that is normally present in the inland rainforest, and occasionally reaches outbreak levels. During outbreaks, the looper causes suppressed growth or mortality in affected trees. As the level of mortality resulting from such outbreaks is variable, the western hemlock looper has important but complex effects on stand structure. The climate drivers and periodicity of outbreaks have not yet been described in the scientific literature. Outbreaks are known to have occurred in the upper Fraser River valley in 1954-55 and 1992-94.

In this project, we are using dendrochronology (tree ring dating) to examine the following questions:

- Does radial growth of western redcedar vary with climate?
- Does sensitivity of western redcedar to climate vary with slope position, elevation, and aspect?
- Can we identify the occurrence of past outbreaks of western hemlock looper in the growth rings of western redcedar?
- What has been the frequency and severity of western hemlock looper outbreaks, as indicated by the growth rings of western redcedar?
- Are outbreaks of the western hemlock looper related to climate conditions?

Tree ring samples from western redcedar have been collected along elevational transects on the north-facing and south-facing sites of the upper Fraser River valley. Samples were also collected from a level, well-drained site, and from a moisture-limited site, to provide data for the analysis of the role of groundwater. The samples are either narrow cores, extracted with an increment borer at a height chosen to minimize the extent of heartrot, or discs cut from fallen trees or stumps. The 560 samples have been processed at the UNBC tree ring laboratory, and data analysis is in progress.

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M.Sc. student Chris Konchalski at his study site at Lunate. Many of the western redcedars this size are

Two obstacles have made data analysis especially challenging. First, internal decay is prevalent in western redcedar in the study area, and the series of tree rings that can be obtained from a given tree is relatively short. Second, because all the inland rainforest tree species can be affected by the looper, we cannot compare tree rings in host and non-host species. That has made it more difficult to isolate western hemlock looper outbreaks from other variables that affect growth rates.

Nevertheless, our preliminary results show a clear pattern of growth suppression during western hemlock looper outbreaks. The thin rings illustrated in Figure 1 were produced during outbreak years. We were able to determine through cross-dating that one annual ring was missing, suggesting that defoliation was so severe during that year that no detectable growth occurred. Figure 2 shows reduced ring width indices coinciding with the two known western hemlock looper outbreaks in the study area, based on 18 samples at one of our sites.

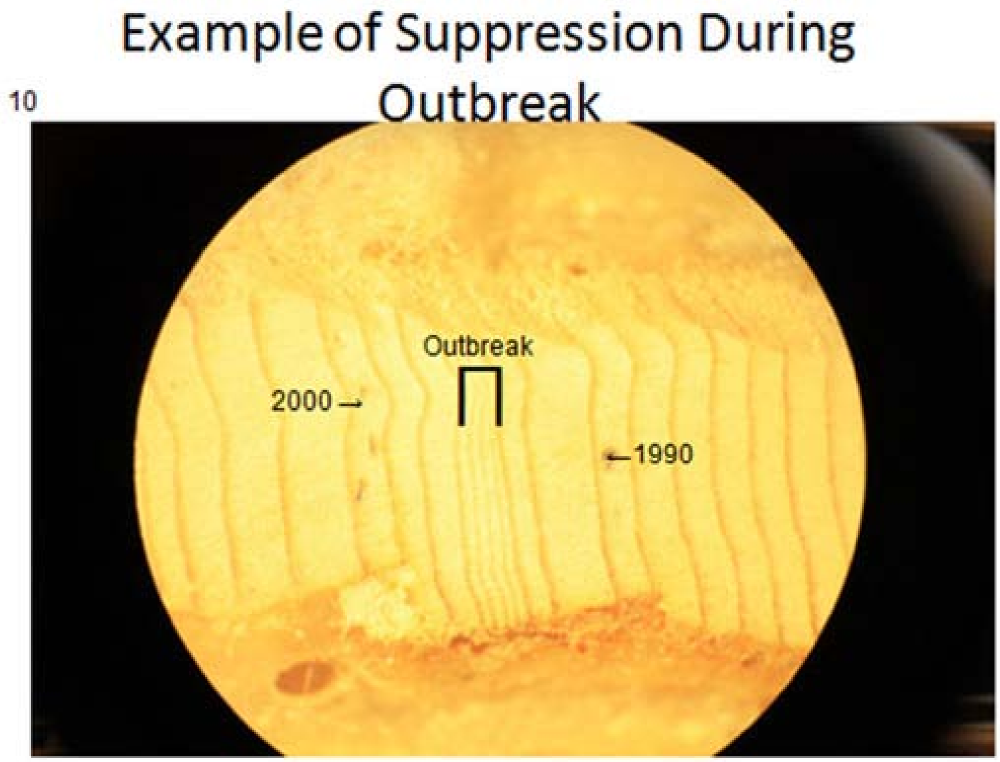

Figure 1. A series of narrow growth rings in the mid-1990s is attributed to defoliation by the western hemlock looper.

hollow, making dendrochronology studies challenging.

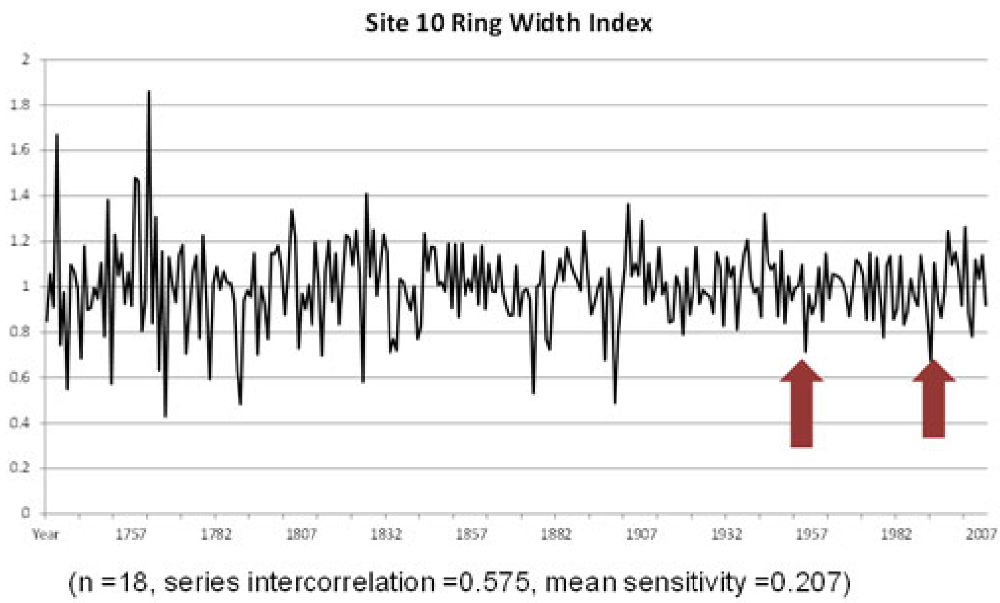

Figure 2. Standardized ring width indices for one of the sample sites. The red arrows indicate suppression events which line up temporally with known western hemlock looper outbreaks

Ongoing work includes developing criteria for distinguishing suppression due to looper attack from suppression for other reasons, and analyzing the climate data that are needed to address our climate-related objectives.

Team members: Kathy Lewis (Ecosystem Science and Management, UNBC), Chris Konchalski

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British Columbia's northern interior mountain ranges are home to unique inland wet-temperate rainforests.

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Carbon Budget

Old-growth stands in the inland rainforest support a great deal of biomass in the form of standing and fallen trees, and probably have a disproportionately large role in carbon storage, compared to other interior BC forest types. However, carbon stocks in the inland rainforest have not been quantified. The objectives of this project are:

- to quantify carbon stocks in old-growth and managed cedar-hemlock stands (including live trees, snags, coarse woody debris, and forest floor, but not mineral soil),
- to evaluate impacts of various retention-harvest methods on the C stocks,
- to incorporate the effects of hollowness and internal heart rot of western redcedar and western hemlock into the assessment of tree C stocks, and
- to develop a model capable of simulating the impacts of forest harvesting on carbon sequestration and carbon storage in the inland rainforest.

To quantify carbon stocks, we have drawn on data already collected at the Lunate, Minnow, and East Twin Creek sites as part of the Northern Wetbelt Silvicultural Systems project. Data on standing trees from permanent sample plots and data on coarse woody debris from permanent transects in harvested and unharvested portions of the three study sites were assembled. The three study areas have three or four treatment units based on % tree retention: clear-cut (CC, 0% tree retention), group retention (GR, 30%), group selection (GS, 70%), and control (UN, 100%). These data, together with literature-based allometric equations (equations that relate the size of a portion of an organism to the size of the whole organism), are being used to calculate carbon stocks. However, we had no data on one important reservoir of carbon that is likely to be influenced by forest management and by climate change – the forest floor. For that reason, forest floor samples were collected at all three study sites. The 640 samples were oven-dried, weighed, and ground, and have been analyzed for carbon concentration.

Calculation of carbon stocks in old inland rainforest stands should take into consideration the high incidence of internal decay and hollowness, especially in large western redcedars, but we had no data on which to base a correction factor. To remedy this problem, cross-sections of the stems of western redcedars were measured, and samples of decayed wood were collected for bulk density determinations. This information, in combination with information from the Ministry of Forests and Range on volume reductions due to stem defects, will be used to develop a correction for internal decay and

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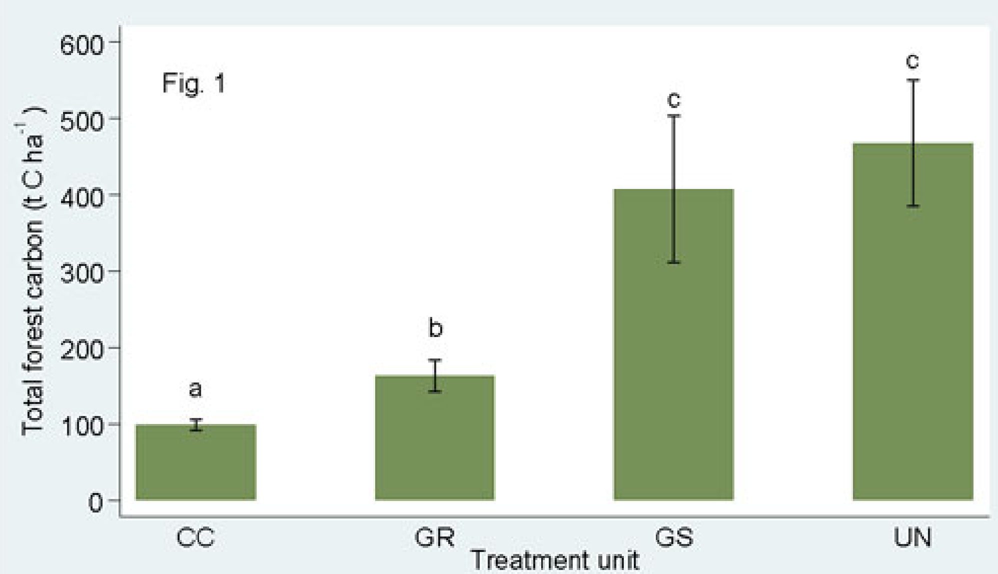
Graduate student Eiji Matsuzaki takes a core sample of the forest floor hollowness.

Preliminary results

Total forest C (excluding mineral soil) in uncut old-growth stands was 468 ± 161 tonnes of carbon per hectare (± 95% confidence interval; Fig. 1), similar to the regional average of the Pacific Northwestern USA (540 t C ha-1) and coastal cedar-hemlock stands in BC (357 – 710 t C ha-1). Despite the presence of extensive heart rot, old inland temperate rainforests have high total biomass C with live-tree C constituting 76% of total C. Nonetheless, analysis of the contribution of different components to uncertainty identified allometric equations for tree biomass to be the largest contributor to total uncertainty in live-tree C, indicating the need to develop allometric equations that specifically target old inland temperate rainforests for more accurate assessment of the C stocks. High-intensity harvesting (GR and CC) was significantly different from low-intensity harvesting (Fig. 1), indicating the reduction of long-term total forest C stocks by decreasing live-tree C. In contrast, low-intensity harvesting (GS) has the potential of maintaining long-term total C (Fig. 1).



Error bars indicate standard error. Means sharing the same letter are not significantly different.

Note: to reflect the extent and characteristics of heart-rot in old-growth redcedar and hemlock stems, these estimates assume that 50% of the volume of this internal decay is actually hollow.

Dead-organic-matter C (snag + coarse woody debris + forest floor) in uncut (UN) old-growth stands accounted for 23% of total C, demonstrating the importance of this C stock. Decaying wood in forest floor C accounted for 25 to 44% of forest floor C, suggesting key roles of coarse woody debris in dead-organic-matter C in old inland temperate rainforests. Dead-organic-matter C pools were relatively resilient to harvest intensity in the short-term. These results suggest the need to recognize the dynamic relationship between aboveground and belowground pools in old inland temperate rainforests.

Like other old-growth temperate forests, old inland temperate rainforests are important C reservoirs. Managing these forests for C sequestration will require strategies to maintain the complex structural attributes and biological diversity often observed in old-growth forests. Carbon in inland temperate rainforests is vulnerable to intensive harvesting, through reduction in C stocks and reduction of the capacity of the live trees to take in C from the atmosphere. In contrast, low-intensity harvesting provides a good compromise between forest harvesting and maintenance of forest C stocks. The maintenance or sequestration of forest C may call for a precautionary approach that conserves both structural and biological diversity in the remaining old-growth inland temperate rainforests.

Together, data on these components – standing trees with corrections for internal decay, coarse woody debris, and the forest floor – will provide a comprehensive snapshot of carbon stocks in old-growth and recently-harvested stands. However, to predict how carbon stocks respond over time to influences such as forest harvesting or climate change, a model is needed.

We used the SORTIE-BC model , a spatially-explicit, multi-species model that was originally developed to simulate stand dynamics in the Interior Cedar-Hemlock zone in northwestern BC. Some modifications were needed to make the model more applicable to the inland rainforest, and more suitable for our purposes. Specific starting conditions, based on stand data from the Northern Wetbelt Silvicultural Systems project, were incorporated. The model was also modified to allow for the extraordinary longevity and large biomass attained by western redcedars in the inland rainforest. Other improvements included updating allometric equations, accounting for the effect of snags on light availability, and modelling the influence of neighboring trees on tree growth and mortality. Further development of the model is in progress.

Team members: Art Fredeen (Ecosystem Science and Management, UNBC), Paul Sanborn, Dave Coates, Eiji Matsuzaki, Jocelyn Campbell, Susan Stevenson

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British Columbia's northern interior mountain ranges are home to unique inland wet-temperate rainforests.

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The Response of Lichen Communities to Climate Change.

Lichen communities have long been used as biological monitors, providing an inexpensive and effective means of assessing environmental change. They have been used to monitor air quality, forest health, and more recently, climate change. The inland rainforest is known for its rich lichen communities, which include a number of rare species, and which are sensitive to regional gradients in temperature and precipitation (See Stand Structural Attributes and Canopy Lichen Diversity). This has raised concerns that future climate changes may have a disproportionate impact on the health of lichen communities in B.C.'s inland rainforest.

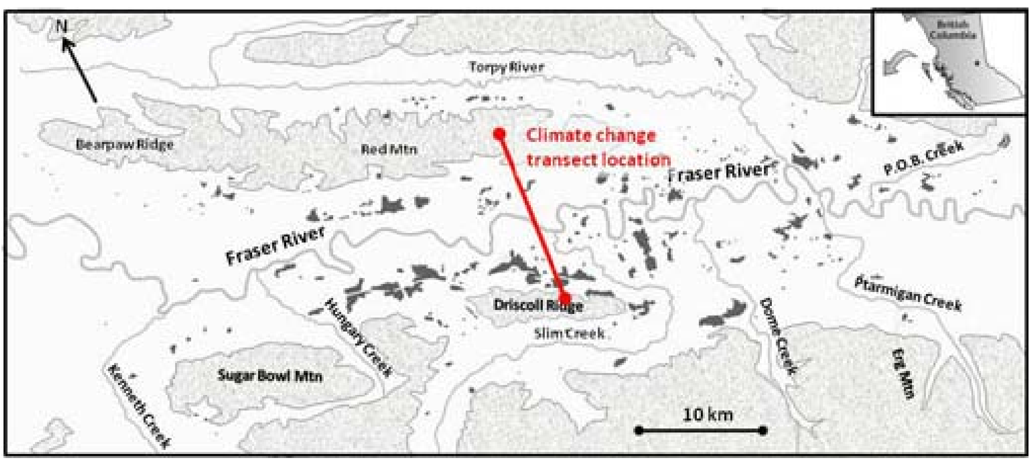

Figure 1. The location of the climate transect (red line) between Driscoll Ridge and Red Mtn. across the upper Fraser River valley.

We have now examined this topic in a program of research at UNBC. Our project has two components. One examines changes in lichen viability after exposure to different simulated winter climate conditions. The second project component establishes lichen biodiversity assessment plots in the upper Fraser River valley. These plots will provide baseline data against which future climate change impacts can be assessed.

Current climate models suggest that climate change may affect winter more than any other season in the inland rainforest, with warmer temperatures and more periods of rain instead of snow. Climate scenarios calculated for the upper Fraser River valley (Fig. 2) suggest that mean annual temperatures in valley-bottom locations may increase by up to 4°C by the year 2080, equivalent to that of present day climate differences between valley bottom and mountain peak locations. At the same time predicted future winter snow

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The canopy cyanolichens Lobaria pulmonaria (bright green) and Nephroma bellum (center of image) resume growth during spring snowmelt in wetbelt forests. The response of wetbelt lichens to changes in winter snowmelt conditions will play a key role in the ability of canopy lichens to survive future climate change.

packs may decline by over 40% (Fig. 3). Lichen communities will thus likely spend less time under protective snow cover in winter. Further they will likely experience more winter rainfall events and will generally face more variable winter climate conditions.

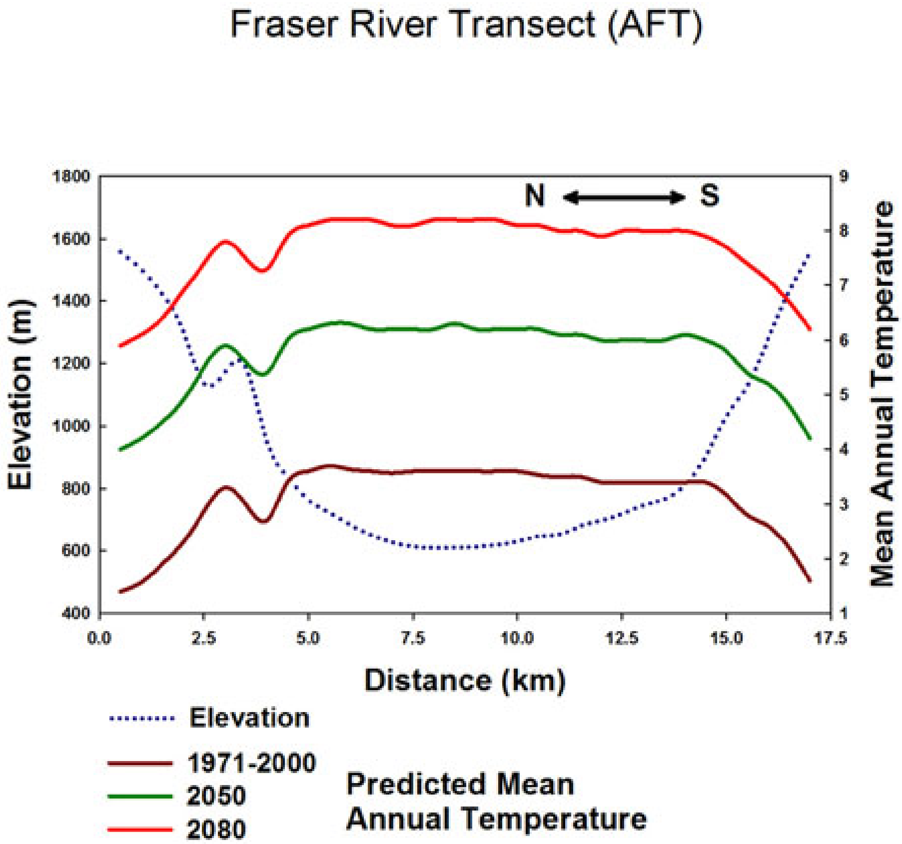

Figure 2 Predicted temperature changes in the Upper Fraser (see Fig. 1 for transect location). Based on CGCM2A1F1 scenario (continued high rate of greenhouse gas emissions).

UNBC M.Sc. student Asha MacDonald conducts assessments of canopy lichens for lichen biodiversity monitoring plots.

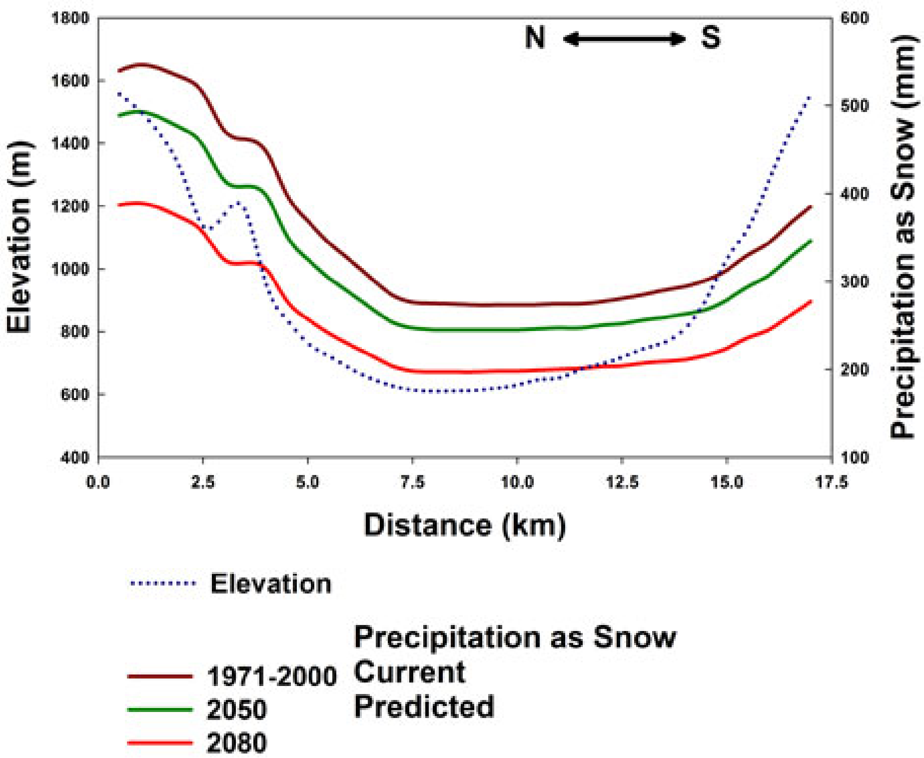

Figure 3. Predicted changes in precipitation as snow in the Upper Fraser (see Fig. 1 for transect location). Based on CGCM2A1F1 scenario.

For lichen communities these changes may have important consequences. In a traditional wetbelt winter lichen communities are largely dormant, typically frozen for long periods, sometimes desiccated on branches if the onset of very cold conditions precedes snowfall, other times frozen under a thin crust of ice or snow, when snowfall accompanies the onset of subzero temperatures. If lichen communities in the future remain wet under low light winter conditions they may essentially starve, using up valuable carbon reserves to support vital metabolism.

We have now conducted a series of experiments examining how wetbelt lichens respond to different winter climate conditions. This work, based in the Aleza Lake Research Forest, examined the physiological responses of two species of cyanolichens (lichens that contain cyanobacteria). Photosynthetic and respiratory responses were measured after lichens had been exposed to a range of simulated climate change conditions, including alternating periods of freezing and thawing, and prolonged low-light exposure to wet conditions.

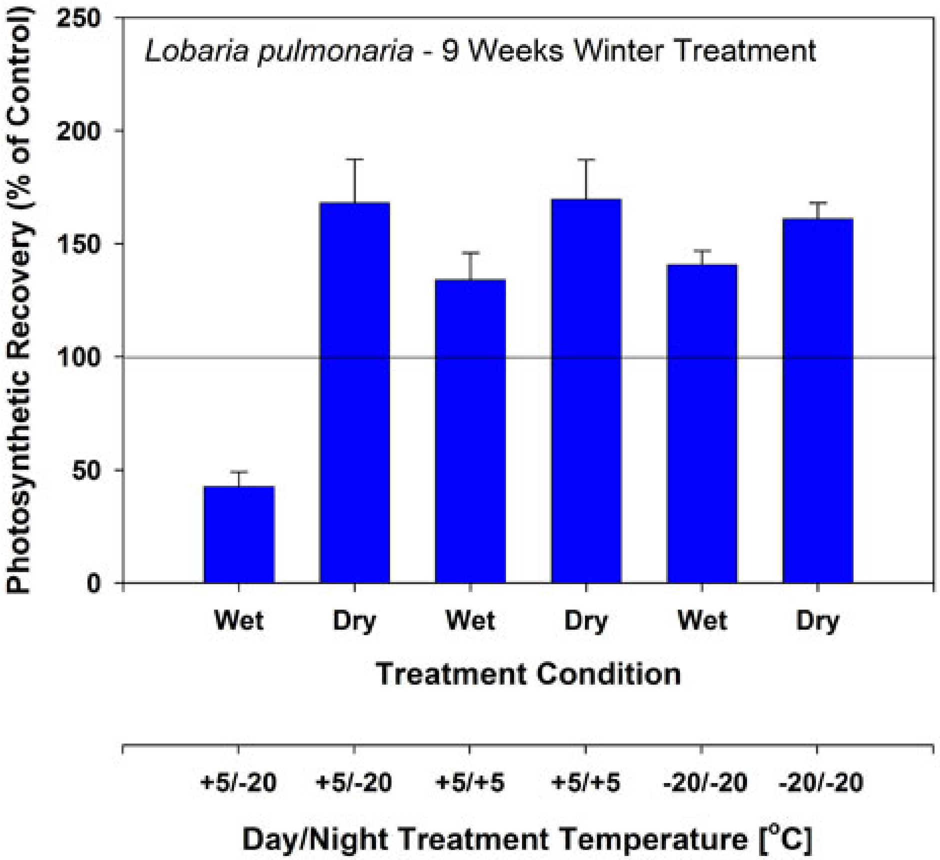

Figure 4. Photosynthetic response in the cyanolichen Lobaria pulmonaria to simulated climate change scenarios. Control response was the rates of photosynthesis in field collected lichens at the end of October, 2010.

These experiments showed that Lobaria pulmonaria was amazingly resilient to increased hydration exposure under low-light winter conditions. The increased winter wetting resulted in increased photosynthetic activity compared to the start of the experimental period. However, one critical exception was lichens that were exposed to daily freeze-thaw conditions, where rates of photosynthesis were severely reduced. Unfortunately, this is a likely very future climate change scenario, where greater temperatures fluctuations are seen during the winter period, with lichen communities insulated by snow less often.

The second component of this project was the development of protocols to monitor the response of inland rainforest lichen communities to climate change. Based on new lichen monitoring protocols that have subsequently been developed we have now established over 60 permanent biomonitoring plots in the upper Fraser River valley near Slim Creek. Lichen species being assessed are listed in Table 1. Assessments of these plots in future years will provide an important index of climate change responses.

Table 1. Lichens being assessed in upper Fraser River valley climate change biomonitoring plots.		
Alectoria sarmentosa	*Nephroma occultum*	*Sticta sylvatica*
Bryoria fuscescens	*Nephroma parile*	*Leptogium burnetiae*
Cladonia sp.	*Parmelia hygrophila*	*Green Sticta A*
Dendriscocaulon sp.	*Parmelia sulcata*	*Green Sticta B*
Hypogymnia enteromorpha	*Parmeliopsis ambigua*	*Ramalina dilacerata*
Hypogymnia physodes	*Parmeliopsis hyperopta*	*Ramalina pollinaria*
Hypogymnia tubulosa	*Peltigera collina*	*U. chaetophora*
Hypogymnia vittata	*Platismatia glauca*	*N. resupinatum*
Lobaria pulmonaria	*Pseudocyphellaria anomala*	*U. glabrata*
Lobaria retigera	*Ramalina thrausta*	*Polychidium* spp.
Lobaria scrobiculata	*Sticta fuliginosa*	*Physcia alnophila*
Melanelixia subaurifera	*Tuckermannopsis chlorophylla*	*S. limbata*
Nephroma bellum	*Usnea* sp. *(filipendula* or *scabrata)*	*Hypogymnia wilfiana*
Nephroma helveticum	*Vulpicida pinastri*	
Nephroma isidiosum	*Polychidium dendriscum*	

Team members: Darwyn Coxson (Ecosystem Science and Management, UNBC), Curtis Bjork, Trevor Goward, Asha MacDonald

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Northern Wetbelt Forests of British Columbia

HOME

British Columbia's northern interior mountain ranges are home to unique inland wet-temperate rainforests.

These forests are now the focus of interdisciplinary research at the University of Northern British Columbia.

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Climate and Communities – Non-timber Values

Changes to ecosystems brought about by climate change are likely to have a cascading effect on the people who use and value those ecosystems. This project focuses on non-timber values and uses in the inland rainforest. How do local residents, recreational users, and tourists perceive future non-timber uses of the inland rainforest? How do they perceive the vulnerability of these uses to climate change? What opportunities do they perceive to mitigate or adapt to the effects of climate change?

In the summer of 2011 we conducted surveys with residents of Dome Creek and Crescent Spur, which are hamlets located among the forests of the upper Fraser River valley. Semi-structured interviews focused on three major areas: held forest values; vulnerability of those values under possible sources of change to the valley's forests, including natural disturbances, climate change, and human disturbances; and visions community members have for adapting to these changes.

Results from the survey show that, in general, the ecological features that are important to community residents include the health of the air, water, and soil. Residents feel connected with the rivers, as well as with the health of the forest, and many speak highly about the view of the mountains. Several participants noted that these ecological features are the prime reason they moved into the valley, others say that they are part and parcel of the experience, and some feel that the environment makes them who they are. Overall, the results suggest that the inland rainforest, including the ancient cedars, plays an important role in the lives of the residents of Dome Creek and Crescent Spur.

We also asked about the vulnerability of these values. We found that residents' held values about the forest were most vulnerable to human disturbances, such as logging. Their concerns about climate change were less than human disturbances but more than natural disturbances.

Research conducted as part of this project also contributes to on-going efforts to examine the economic potential of ecotourism in the valley, which is an important non-timber use of the forest. Since 2008 data have been collected about the number of trail users. For the 2011 hiking season we estimate that between 8,500 and 9,300 people hiked the trail, continuing the trend of increasing use (Figure 1). We have also been conducting on-site surveys of users of the Ancient Forest Trail at the trailhead. We found that among these hikers, about 50 percent were people at the trail for a day trip and about 40 percent were tourists. Data analysis and fieldwork will continue into the fall. We are completing interviews with key informants about the

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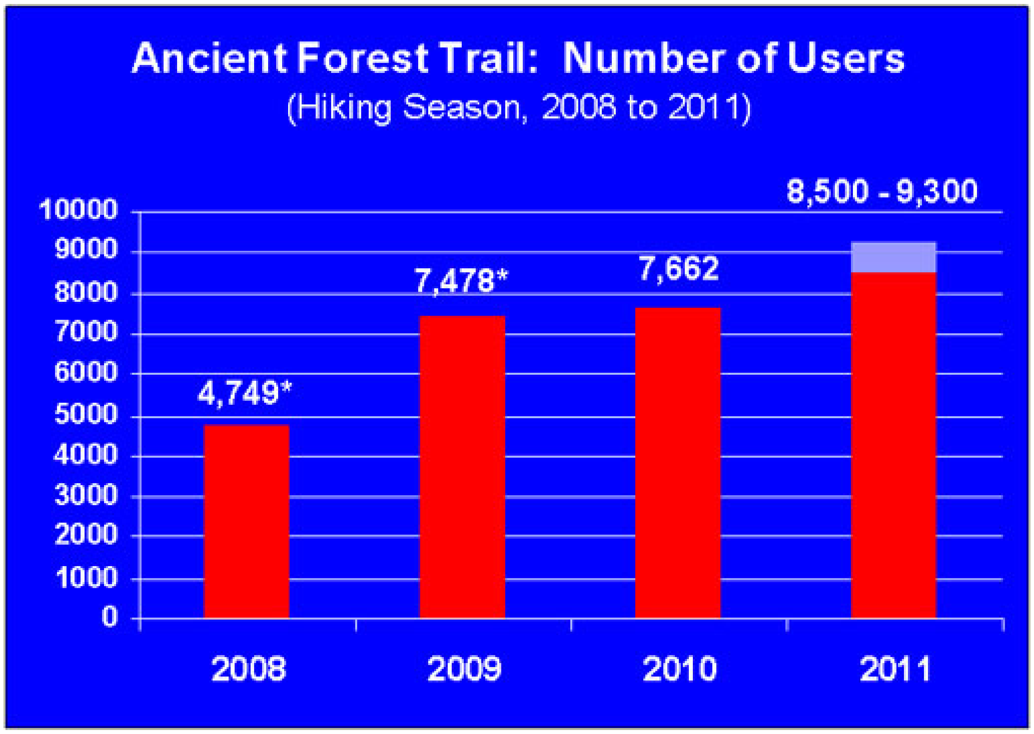
UNBC M.A. student Jonathan Hall set up to conduct interviews with trail users at the Ancient Forest trail.

vulnerability of ecotourism and other non-timber economic values of the forest in the context of a changing climate. Through these interviews we will also explore opportunities for adaptation.



*Revised

Figure 1. Number of Ancient Forest Trail users, 2008-2011. Team members: Dave Connell (Environmental Planning, UNBC), Jessica Shapiro, Jonathan Hall

Hikers on the Ancient Forest Trail walk under a large fallen cedar on their way to see the Big Tree. (photo by Harold Armleder)

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UNBC

British Columbia's northern interior mountain ranges are home to unique inland wet-temperate rainforests.

These forests are now the focus of interdisciplinary research at the University of Northern British Columbia.

Climate and Communities – Community Forests

The way in which knowledge about the potential impacts of climate change is incorporated into timber management is likely to vary with different kinds of forest tenure. Community Forests are especially well positioned to be responsive to community concerns and to incorporate a long-term, place-based vision. In 2011, the Dunster Community Forest Society (DCFS) became our partner, and we worked extensively with them to evaluate their options in managing their 20,000-ha tenure area with a 15,000m3 Annual Allowable Cut.

Archie McLean, Chairman of Dunster Community Forest Society, in a wet cedar-leading old-growth ICH patch in the Raush River Valley part of DCFS's tenure.

Our aim is to encourage awareness and consensus on economic, social and ecological practices that require adaptation in the face of climate change. We are doing this by engaging community members and the DCFS Board in exploring options and finding ways to balance local values. During three months of on-site research in Dunster, the Community Forest team spoke with many residents representing many different interests. The diverse needs of the community members show how essential collaborative planning is for sustainable management of a natural resource such as a community forest.

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The community of Dunster faces many challenges as a result of climate change and past logging practices. While much of the DCFS Robson Valley tenure area has been hit by Mountain Pine Beetle, their tenure area in the Raush River Valley still contains a substantial amount of merchantable timber. However, the Raush River tenure areas are not readily accessible, perhaps explaining why this timber is still there. The Raush River Valley is nearly pristine, and many Dunster community members are working to keep it untouched. Within the DCFS' tenure area in Raush River Valley are three wet and dry cedar-leading old-growth cedar-hemlock patches. These stands were unknown to the DCFS before the summer of 2011, and their identification resulted directly from our efforts to explore and assess the tenure area with DCFS. The decisions facing DCFS include choosing between the extensive clearing of low value beetle-attacked pine in direct sight of the Dunster community, or logging in high value cedar, fir and spruce areas in the Raush River Valley, on the opposite side of a mountain range from the community.

After discussing the conditions and challenges facing Dunster, the Community Forest team and DCFS embarked on two strategies. The first was to map the local economy and attempt to quantify how much derived economic value is kept in the community in the absence of any logging in the tenure area (Dunster is a new Community Forest and as of Oct. 1, 2011, had not received its single tenure-area cutting permit). Through a combination of mathematical techniques and social network analysis, DCFS has been given a definitive starting point on which to base decisions regarding the distribution of benefits, including logging opportunities, in order to optimize equitable distribution and capture of value. The data collection was completed by the end of August, 2011. The analysis has also been completed and the results, along with a modeling run, were presented to the Dunster community on Oct. 14, 2011.

Even without the guidance of the economic mapping, DCFS members are aware that they have limited opportunities to capture economic value from the timber beyond simply cutting it down and selling it out of town. The second strategy DCFS has embarked on is to redirect management focus away from a purely logging strategy and instead position the Dunster Community Forest as a destination for researchers and graduate students. The first step in this strategy is the extension of the originally planned workshops into an extensive two day conference, "Carbon, Climate Change, and Community Forests." The original grant called for six presentations to community members by the grant team, with one day in Prince George and one day in Dunster. Through the efforts of DCFS, the C4F conference was held in Dunster on Oct. 13 and 14, 2011, and had 14 presentations from 13 individuals, including people from Ministry of Forests, Lands and Natural Resources, academia and the private sector. Additionally, local community members spoke about how important the community forest was to them, and how important the community was to their lives. Dunster community members opened their doors to visiting graduate students, and arrangements were made for low cost and free meals during their stay. There was a community-sponsored dinner and social on the evening of the first day. The conference was well attended, with 38 participants on the first day and 25 on the second day. DCFS hopes to turn this into an annual conference, with a recurring emphasis on learning about the impacts of carbon management and climate change on community forestry. Further details can be found at http://www.c4f.ca.

Team members: Evelyn Pinkerton, Tim Kelly

First Annual "Carbon, Climate Change, and Community Forests" (C4F) Conference

Theme: "Managing the ICH/Wetbelt of Interior B.C."

Oct. 13th and 14th, 2011
Dunster Fine Arts School, Dunster, B.C.

View Larger Map

This conference is open and free, but you must register in advance.

The C4F conference brings together researchers and community members to discuss the impacts of carbon stores and emissions in forests on climate change and the steps community forests can take to enhance management of the forests within their tenure areas. The conference has a high emphasis on audience inquiry after presentations, and an open invitation to students and researchers to explore additional areas of research available in community forests. This year's conference is the result of a partnership with the Future Forest Ecosystem Scientific Council, the University of Northern British Columbia, and Simon Fraser University, as part of the research project **"Climate Change Vulnerability of Old-Growth Forests in British Columbia's Inland Temperate Rainforest."** The conference is hosted by the Dunster Community Forest Society.

This year's theme centers around managing the wet and very wet Interior Cedar-Hemlock (ICHwk3 and ICHvk2) zones of interior British Columbia. These zones are most present in the northern Robson Valley areas between McBride and Prince George, B.C., surrounding the communities of Dome Creek and Crescent Spur, but Dunster also has wet and dry moist and mild cedar-leading (ICHmm) patches within its tenure area on the Raush River Valley. These areas comprise the world's only known Interior Temperate Rainforest (ITR). The local topography in these areas creates frequent moisture events throughout the year, which leads to a low frequency of stand-destroying fires. As a result, stands may have not seen stand-destroying disturbance event in hundreds of years, perhaps even thousands. These areas have very high ecological values, as the undisturbed environment has allowed for an immense development of biodiversity.

Additionally, with the lack of fire, the forests accumulate large amounts of carbon in both the trees and the forest floor. Disturbance events of any kind are likely to lead to the release of some or all of that carbon, contributing to the carbon dioxide levels in the atmosphere. Carbon dioxide is widely cited as a major contribution to climate change. While climate change is largely projected to lead to hotter and drier conditions globally, local geologic conditions may lead to variations from this projection. As such, further study is necessary to attempt to project the impacts of climate change in the Robson and Raush River Valleys and the ITR. Without the natural impacts of fire, the greatest threat to these areas may be humans, through logging and climate change. There is a financial value in the forest wood fiber, and as a forestry-dependent area, the Robson Valley communities face many economic challenges. It may well be that long before climate change impacts the ICH zones, humans have had a direct role in creating major disturbance events.

Please join us as researchers and community members discuss carbon, climate change and community forests within the Inland Temperate Rainforest as we seek to balance the needs of the present and the needs of the future.

This conference is open and free, but you must register in advance.

Confirmed Presentation Groups as of Oct. 7, 2011:

1) Heidi Knudsvig* and Stephen Dery (UNBC)
Predicting Climate change in the Robson Valley

2) Chris Konchalski* and Kathy Lewis (UNBC)
Sensitivity of Western Redcedar to Climate and Western Hemlock Looper in British Columbia's Inland Temperate Rainforest

3) Eiji Matsuzaki*, Art Fredeen, Paul Sanborn, Susan Stevenson (UNBC)
Carbon Stores in B.C.'s Inland Temperate Rainforests

4) David Connell*, Jessica Shapiro, Jonathan Hall (UNBC)
Socio-economic impacts of climate change

5) Darwyn Coxson,* Jocelyn Campbell, Asha MacDonald (UNBC)
Lichen Communities in the Inland Rainforest - Canaries in the Coalmine for Climate Change?

6) Vanessa Foord (BC MoFLNRO)
Climate change and natural disturbance research

7) Simcpw First Nations
TBD

8) Ray Travers
Extended Rotations Capture More Carbon and Produce More Ecological, Economic and Social Benefits in Well Managed Forests

9) Marc von der Gonna, General Manager of McBride Community Forest
TBD

10) Debbie Ladouceur, Director of Dunster Community Forest Society
Research opportunities with the Dunster Community Forest

11) Evelyn Pinkerton (SFU)
Community Forest Governance Models

12) Tim Kelly (SFU)
Analytical methods for distributing benefits in natural resource dependent communities

13) Ashley Smith (SFU)
People, Place and Landscape Values: Aesthetic Management in British Columbia’s Community Forests

14) Darwyn Coxson (UNBC)
Preserving biodiversity in wet cedar stands: A park proposal for the Ancient Forest trail.

Presentations from research universities (UNBC, SFU) will be 20 minutes with a 10 minute Q&A session. The 20 minute time limit will be enforced in order to give the full 10 minutes of time to audience questions. Overage will be recovered during the five minute changeovers and during the ten minute breaks after every two presentations.

Presentations from the community forests and other speakers will be 10 minutes with a 5 minute Q&A session. The 10 minute time limit will be enforced in order to give the full 5 minutes of time to audience questions.

Schedule for October 13th:

7:30am - Complimentary Continental "Plus Protein" breakfast
8:00am - Keith Berg and Jane Houlden of Dunster's Berg Horns play Keith's hand-made French Horns
8:15am - Opening ceremony (Introductions, background information)
8:25am - Simpcw
9:00am - Heidi Knudsvig
9:45am - 10 minute break
10:00am - Chris Konchalski, Eiji Matsuzaki
11:30am - Lunch (concession lunch with locally grown food, under $10, carnivore, omnivore and herbivore options)
12:00pm - local craftspeople and musicians present their crafts on display
12:45pm - Darwyn Coxson (Lichens), Dave Connell
2:20pm - 10 minute break
2:30pm - Vanessa Foord, Marc von der Gonna, Debbie Ladouceur
4:00pm - afternoon wrap-up
5:00pm - free potluck social for C4F attendees, locally grown foods provided by the Dunster community, meet and greet Dunster community members

Schedule for Oct. 14th:

8:00am - Morning discussion
8:15am - Ashley Smith, Tim Kelly
9:45am - break
10:00am - Ray Travers, Evelyn Pinkerton, Darwyn Coxson (Park Proposal)
12:00pm - Lunch (concession lunch with locally grown food, under $10, carnivore, omnivore and herbivore options)
12:45pm - Official closing ceremony
1:00pm - Informal discussion about community forests and what was learned at the conference, open to the public

This conference is open and free, but you must register in advance.

Dunster hosts climate change conference

– SEPTEMBER 18, 2011

How can we manage our forests in a way that takes into account climate change?

That is one of the questions that will be addressed at the first annual Carbon, Climate change & Community Forests (C4F) conference to be held in Dunster Oct. 13-14.

The Dunster Community Forest Society is sponsoring the conference and hopes it will help spur locals to think more broadly and long-term about forest management, says Debbie Ladouceur, community forest secretary. Stakeholders are especially welcome.

“The Dunster Community Forest stakeholders are any people who have an interest in what’s going on in their own backyards.”

The C4F conference will bring together researchers and community members to discuss the impacts of forest carbon stores and emissions on climate change, as well as the steps community forests can take to enhance management tenure areas.

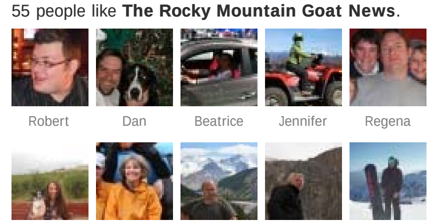
The conference is the result of a partnership with the Future Forest Ecosystem Scientific Council, the University of Northern British Columbia, and Simon Fraser University, as part of the research project “Climate Change Vulnerability of Old-Growth Forests in British Columbia’s Inland Temperate Rainforest.”

A dozen speakers are already lined up for the two-day event which is free and open to anyone – though participants must sign up in advance. People can register online at http://www.c4f.ca/C4F_registration.php

Organizer and SFU grad student Tim Kelly has been doing research in Dunster in conjunction with the community forest this summer. He says community forests are still a young concept and it’s important to continue the conversation about how they can and should be managed. His research looks at the socioeconomic benefits of natural resources such as timber, and how the spinoffs can be maximized in a community.

“The purpose of this is to convey knowledge to the Dunster community,” he says. “This is an early stage of developing their management strategy.”

“In terms of climate change, we have to think about what the area is going to look like in 70 years, because we can



adapt our logging practices now."

He adds that predicting the effect of climate change is very hard.

This year's theme is managing the wet and very wet Interior Cedar-Hemlock zones of interior British Columbia. These zones are most present in the northern Robson Valley areas between McBride and Prince George, B.C., surrounding the communities of Dome Creek and Crescent Spur, but Dunster also has wet and dry moist and mild cedar-leading patches within its tenure area on the Raush River Valley. These areas comprise the world's only known Interior Temperate Rainforest.

With the lack of fire, the forests accumulate large amounts of carbon in both the trees and the forest floor. Disturbance events of any kind are likely to lead to the release of some or all of that carbon, contributing to the carbon dioxide levels in the atmosphere. Carbon dioxide is widely cited as a major contribution to climate change. While climate change is largely projected to lead to hotter and drier conditions globally, local geologic conditions may lead to variations from this projection. Further study is necessary to project the impacts of climate change in the Robson and Raush River Valleys and the ITR. Without the natural impacts of fire, the greatest threat to these areas may be humans, through logging and climate change, Kelly says. There is a financial value in the forest wood fiber, and as a forestry-dependent area, the Robson Valley communities face many economic challenges.

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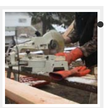

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