

report

Climate Change Adaptation Research for Forest and Rangeland Ecosystems

Resiliency Implications at the Landscape Level

CLIMATE CHANGE ADAPTATION RESEARCH FOR FOREST AND RANGELAND ECOSYSTEMS: RESILIENCY IMPLICATIONS AT THE LANDSCAPE LEVEL

EXECUTIVE SUMMARY

**John L. Innes
Natasha Caverley
Howard W. Harshaw
Walt Klenner**

**Faculty of Forestry
University of British Columbia
Vancouver, British Columbia**

July 2012

For information contact:

**South Selkirks Climate Change Research Team
Forest Resources Management—University of British Columbia**
2nd Floor—Forest Sciences Center #2045–2424 Main Mall
Vancouver, British Columbia V6T 1Z4
Phone: 604.822.6761 | Fax: 604.822.9106
Email: john.innes@ubc.ca | natasha@turtleislandconsulting.ca

The South Selkirks Climate Change Research Study is funded by the Future Forest Ecosystems Scientific Council (FFESC) and BC Hydro

1. INTRODUCTION.

This research was founded on the concepts of vulnerability (the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change, including climate variability and extremes) and resilience (the ability of social or ecological systems to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change). In partial contrast to the IPCC, and consistent with the Millennium Ecosystem Assessment, we view social and ecological systems as being inextricably linked, and began from the premise that if adaptation is to occur at a landscape scale, a holistic approach must be adopted. Fostering resiliency on the land base requires healthy ecosystems, thriving economies, vibrant communities and meaningful connections amongst these dimensions. Fostering adaptation requires that we do not place undue burdens on vulnerable elements of the system. The study area encompassed the South Selkirk region, including the Nature Conservancy of Canada's Darkwoods property, West Arm Provincial Park, Midge Creek Wildlife Management Area, Creston Valley Wildlife Management Area and the West Arm Demonstration Forest. This provided the opportunity to investigate climate change scenarios in a protected area, wildlife management areas and a working forest - areas that are of interest to the local communities of Nelson and Creston and Aboriginal communities of the Lower Kootenay Indian Band, Métis Nation of BC, St. Mary's Indian Band and the Ktunaxa Nation.

As a means of enhancing ecological, economic and socio-cultural values on the land base, our multidisciplinary research project was situated in the South Selkirk Region to serve as a nexus for collaborative-based research amongst Government, Aboriginal People (both First Nations and Métis), industry, academia and the broader community on the topic of climate change adaptation. We examined climate change adaptation in a holistic manner (considering all interconnections between ecological/environmental, economic/financial, socio-cultural/human dimensions of the land and resources) that utilized both Western and Indigenous sciences as complimentary approaches for informing evidence-based policy and planning decision-making for local communities and the Ministries of Forests Lands & Natural Resource Operations, and Environment. The following summary identifies our accomplishments to date.

2. RESEARCH PROCESS.

The goal of the research project was to conduct landscape level, forest management research in the South Selkirk region of BC in order to produce recommendations regarding operational practices that will foster resiliency in adapting to climate change. Resiliency is examined across three dimensions: the *Human Resiliency Dimension*, the *Ecological Resiliency Dimension*, and the *Economic Resiliency Dimension*. Between January 2010 and December 2011, this project examined potential climate change outcomes and implications in the South Selkirks region. In addition to the funding received by FFESC, BC Hydro was a funding partner for this project. This research study utilized a holistic approach to address climate change – an approach that respects social and cultural, ecological and economic interests as a benchmark for forest management practices.

The focus of this research was the resiliency of social and ecological systems in the South Selkirks region (although efforts were made to reconcile the study boundaries of the three resiliency dimensions, some discrepancy does exist between the study areas, see Figure 1). These two areas were the basis for the three resiliency dimensions that framed this research:

1. *Ecological Resiliency Dimension*. The Ecological Resiliency Dimension examined projected climate change scenarios and recommended adaptation practices that encourage resiliency while maintaining ecosystems. The *Ecological Resiliency Dimension* research was focused on a study area bounded on the east by Kootenay Lake and on the south by the Canada-United States border, and includes the Nature Conservancy of Canada's Darkwoods property, provincial parks and protected areas, domestic and community watersheds and the Harrop-Proctor community forest. The leader of this Dimension was Dr. Walt Klenner from the BC Ministry of Forests, Lands and Natural Resource Operations.

2. *Human Resiliency Dimension.* The Human Resiliency Dimension explored which adaptation practices maintained or enhanced existing social and cultural values from both Aboriginal and non-Aboriginal perspectives. The qualitative part of this Dimension focused on 36 predominantly non-Aboriginal communities in the South Selkirks¹, and on Aboriginal residents of the traditional territories on the Ktunaxa Nation St. Mary's Band and the Métis Nation British Columbia. The qualitative part of this Dimension focused on Aboriginal residents of the traditional territories on the Ktunaxa Nation St. Mary's Band and the Métis Nation British Columbia. This Dimension was led by Drs. Natasha Caverley (Turtle Island Consulting Services Inc.) and Howard Harshaw (UBC).
3. *Economic Resiliency Dimension.* The Economic Resiliency Dimension investigated the economic resiliency of lumber firms in the Kootenays Region. The *Economic Resiliency Dimension* was focused on the parts of the Arrow-Boundary and Kootenay Lakes Forest Districts; in particular, the Slocan Valley and three communities with forestry firms that utilized timber drawn from the Slocan Valley (Kaslo, Salmo, and Nelson). This Dimension was led by Drs. Howard Harshaw and Harry Nelson from the University of British Columbia (UBC).

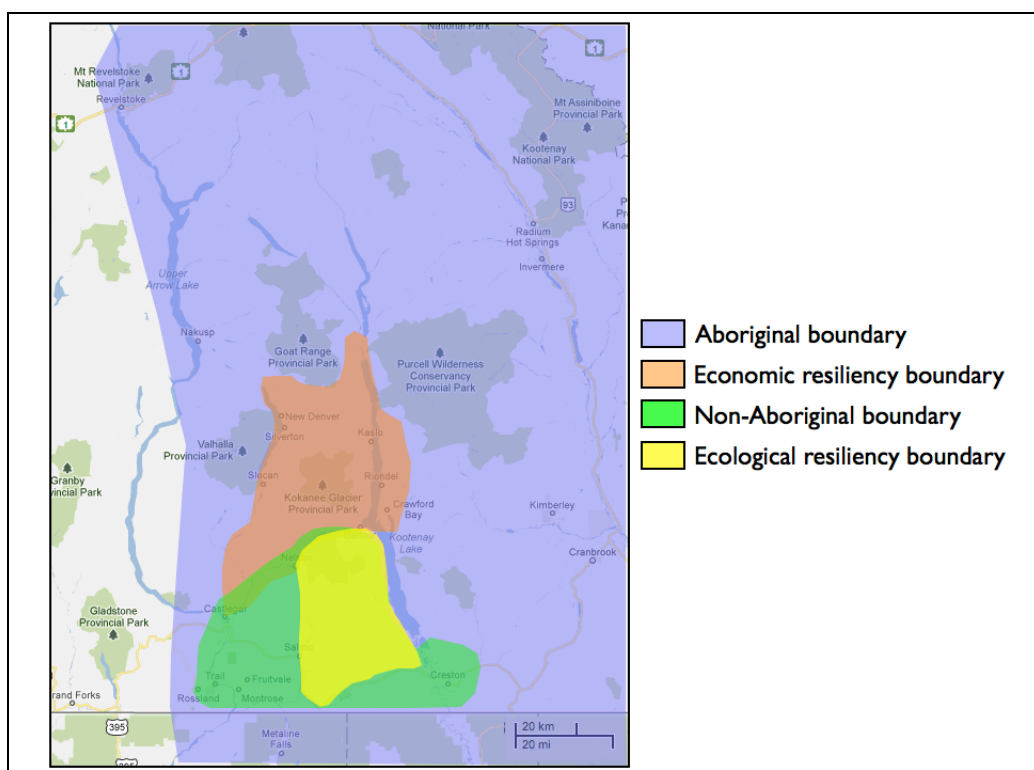


Figure 1. Study area showing the boundaries for the different resiliency dimensions.

Our approach involved assessing potential climate change impacts on the relationships between people, forests, water, land, air, plants and animals – thereby, honouring the strengths of sharing, acknowledging and utilizing indigenous science and Western science approaches in understanding the changing climate.

¹ The communities sampled were: Beasley, Blewett, Blueberry Creek, Bonnington Falls, Brilliant, Castlegar, Columbia Gardens, Crescent Valley, Erie, Fruitvale, Glade, Glenekle, Granite, Hall, Meadows, Montrose, Mountain Station, Muray Heights, Nelson, Ootischenia, Park Siding, Porto Rico, Raspberry, Riverdale, Rose Spur, Salmo, Shavers Bench, South Slocan, Sunningdale, Taghum, Tarrys, Thrums, Trail, Upper China Creek, Warfield, and Ymir.

The study utilized a mixed methodology approach - utilizing both quantitative and qualitative research methods. Quantitative methods included predictive modeling techniques and public opinion surveys, while the use of qualitative methods (*i.e.*, observation, in-depth interviews) assisted the team in understanding the human behaviour and cultural context to climate change adaptation in the study area – particularly as it related to understanding Aboriginal perspectives about potential climate change outcomes.

3. COLLABORATION.

Our research team included people from Aboriginal communities, academia, the forest industry, non-governmental organizations and consultants, and the Provincial Government:

- Métis Nation BC – Kootenays Region, and the St. Mary's Indian Band/Ktunaxa Nation (Aboriginal);
- University of British Columbia, University of Victoria (Academia);
- Kalesnikoff Lumber Co. Ltd. (Industry).
- Columbia Basin Trust, FORREX, Nature Conservancy of Canada – BC Region, New Direction Resource Management Ltd., and Turtle Island Consulting Services Inc. (Non-Governmental Organizations and Consultants); and
- BC Hydro, Ministry of Environment, Ministry of Forests, Lands and Natural Resource Operations (Provincial Government).

These partners served as either researchers or advisors to the project. Please refer to the Spring 2010 South Selkirks e-newsletter for a summary of the team members comprising each resiliency dimension team. For example, Aboriginal organizations were strategic advisors to the *Human Resiliency Dimension* team led by Drs. Caverley and Harshaw. The Nature Conservancy of Canada (NCC) – BC Region provided forest inventory data from its Darkwoods Property to Dr. Klenner to aid the *Ecological Resiliency Dimension* team in further developing their climate change models for the project.

In addition to these formal partnerships, our team collaborated with Dr. Rachel Holt's *Resiliency and Climate Change in the West Kootenays* project (also funded by FFESC). We liaised with Dr. Holt and her FFESC-funded team by (1) participating in Western Kootenays dialogue sessions/forest manager workshops, and (2) incorporating a sample of community and landscape planners and managers (who were involved with the *Resiliency and Climate Change in the West Kootenays* project) into the South Selkirks Climate Change Public Opinion Survey.

4. COMMUNICATION.

Between January 2010 and December 2011, we engaged in a three communication activities to update our partners, other researchers, and the broader public about our project.

1. *Quarterly E-Newsletters*. Seven e-newsletters were prepared and circulated to our distribution list that included representation from the Government (municipal/provincial/federal/Aboriginal employees and political leaders), industry, academia, and non-governmental organizations.
 - Please refer to the Spring 2010, Summer 2010, Fall 2010, Winter 2010, Spring 2011, Fall 2011 and Winter 2011 editions of our project team's e-newsletters.
2. *Dialogue Sessions*². In August 2011, Drs. Caverley, Harshaw, Klenner, and Innes participated in a dialogue session with representatives from the Great Northern Landscape Conservation Cooperative (GNLCC) in Montana and Idaho, USA. The on-line session provided an opportunity for our team to share our research and to learn more about GNLCC's current activities. In October 2011, Drs. Caverley, Harshaw, Klenner, and Innes engaged in dialogue sessions with

² Please refer to the attached PowerPoint presentation slides (from Drs. Klenner, Harshaw and Caverley) that were presented at these dialogue sessions.

our South Selkirks strategic partners. Held in Vancouver and Cranbrook, BC, the dialogue sessions served as guided conversations to review the research findings and respond to questions about the project:

- Vancouver session with BC Hydro – October 20, 2011
 - Cranbrook Dialogue Sessions – October 24, 2011 (morning session with representatives from the Columbia Basin Trust; Kalesnikoff Lumber Co. Ltd.; Ktunaxa Nation Council; Ministry of Forests, Lands and Natural Resource Operations; NCC – BC Region; St. Mary's Indian Band; afternoon session with representatives from the Métis Nation Kootenays Region).
3. Other. In December 2011, the South Selkirks Climate Change Research Team was featured in the Columbia Basin Trust's Communities Adapting to Climate Change Initiative e-newsletter.

Please refer to *Appendix A* for a further itemization of our communication deliverables for the South Selkirks Climate Change Research Project.

5. DEVIATIONS FROM PROJECT PLAN.

Due to FFESC's request to scale back our initial budget, coupled with the challenge of retaining a forest economics specialist from China, the *Economic Resiliency Dimension* was significantly modified whereby findings from an investigation of lumber firms in the Kootenays completed by Drs. Nelson and Harshaw were utilized to explore the economic impacts of climate change on forest resource-based communities and firms in the study area. Methods involved developing a baseline for economic conditions and reviewing trends in key indicators gathered from the Census, Statistics Canada, and provincial ministries.

In 2010/2011, the NCC – BC Region underwent a series of staff turnovers, which led to four NCC liaisons during the course of our study. Through our strategic communication activities, we were able to keep the NCC informed of our work that provided a relatively seamless exchange of information during its organizational restructuring.

During the course of this project, it came to our attention that the *IPCC 5th Assessment Report* would move away from the scenario approach used in previous reports. We have been unable to determine what the new approach will be, but communication with an IPCC lead author (Andreas Fischlin) suggests that attempts to determine the impacts of climate change will refer more to low, medium and high degrees of change, rather than to specific scenarios. Given the huge uncertainty surrounding the climate implications of specific scenarios, this approach seems to be more realistic.

6. RESEARCH OUTCOMES.

While global economic conditions have recently dominated news headlines, climate change remains a critical issue. British Columbians are well aware of this due to the ravages of the Mountain Pine Beetle, yet interests may already be shifting to other issues. It is not clear that we have learned from the pine beetle infestation, or that people are aware that a range of other pests and diseases could further disrupt our forest sector. Research outcomes from the three resiliency dimensions are summarized below.

6.1. Ecological Resiliency Dimension.

The *Ecological Resiliency Dimension* investigated potential changes to ecosystems, wildlife habitat, landscape susceptibility to wildfire, and the availability of timber under a range of climate change scenarios. This investigation employed the TELSA³ landscape-level computer model that has been used previously by the BC Ministry of Forests, Lands & Natural Resource Operations in the southern interior. The results of the scenarios provided a reference for use in the *Human Resiliency Dimension* survey and

³ Tool for Exploratory Landscape Scenario Analyses

identified possible ecological conditions in the South Selkirk region under different climate change scenarios. The two questions that framed the investigation of the *Ecological Resiliency Dimension* were:

1. What are likely climate scenarios for this region, and how will these affect vegetation succession?
2. What climate change adaptation practices would be required to encourage resiliency while maintaining or enhancing conservation values of ecosystems within the study area?

The modeling group in this project was also tasked with supporting two other FFESC projects (*i.e.*, Holt's *Resiliency and Climate Change in the West Kootenays* project and Nelson's *Kamloops Future Forest Strategy* project) in an effort to understand potential climate change outcomes in British Columbia more generally. The modeling efforts of this Dimension were supported by the development of a thorough review of the climate change modeling literature as well as different modeling approaches. These will be documented in forthcoming publications (see *Appendix A*).

Anticipating the effects of climate change on ecosystems has a high level of inherent uncertainty that is complicated by: (1) estimating the magnitude of differences between current and predicted future climate (Figure 2), and most importantly, identifying the timing of precipitation events, (2) interactions between climate, natural disturbances and management, and (3) uncertain succession responses to climate change. For example, warmer conditions may enhance tree growth on cold or wet sites but this may be offset by an extended and more severe wildfire season. To address this uncertainty and develop projections that reflect the uncertainty of current estimates of climate change, three interrelated projects were undertaken: (a) a thorough review of the climate change literature including climate change model predictions and implications of climate change on wildfire, insects and disease pathogens, (b) a review of the ecological consequences of a range of potential climate change scenarios, effects on tree growth rates (site index), likely rates of deforestation, and species composition shifts, and (c) modelling ecological change in relation to climate change, anthropogenic and natural disturbances.

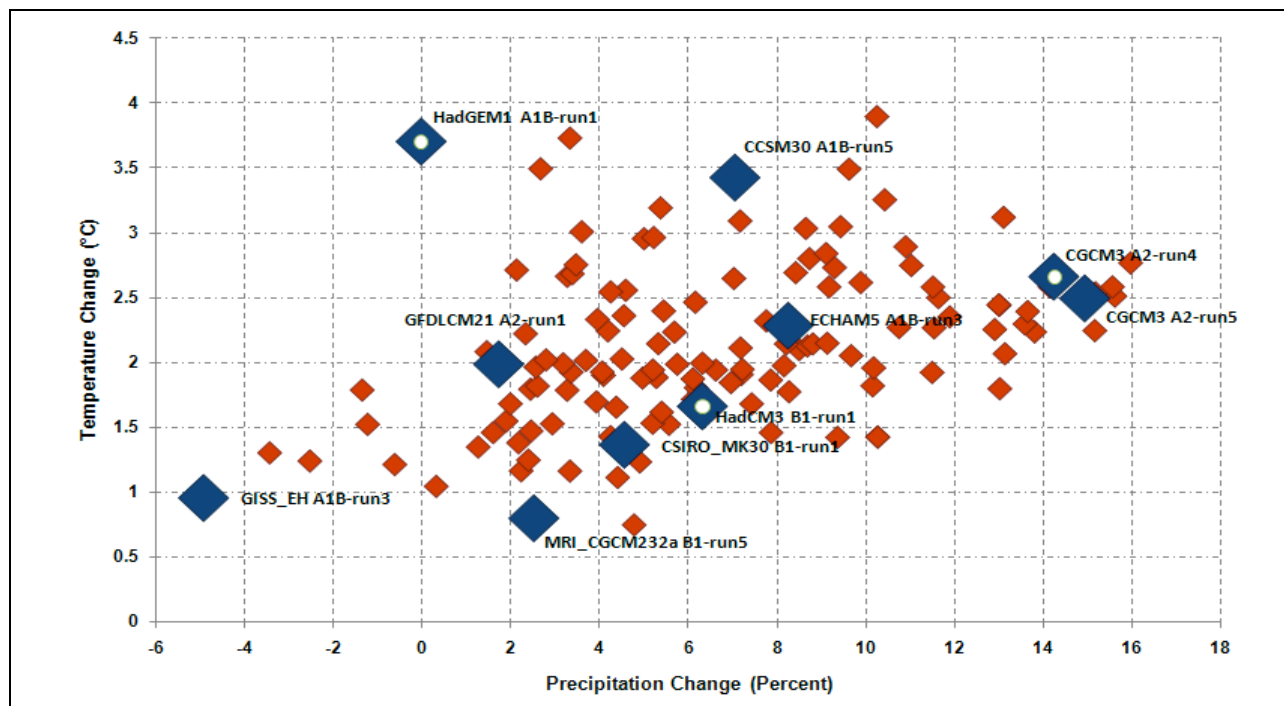


Figure 2. Climate predictions from 130 models for the year 2050, showing high variability in temperature and precipitation predictions. Median estimates of climate change (e.g. by 2050, +2 °C, +6% precipitation) obscure this uncertainty, as does a focus on annual averages vs. growth season conditions (April – July) when vegetation is most strongly affected by temperature and precipitation. (*Adapted from Murdock, T.Q. and D.L. Spittlehouse 2011. Selecting and Using Climate Change Scenarios for British Columbia. Pacific*

Climate Impacts Consortium, University of Victoria, Victoria, BC, 39 pp.

The ecological modelling used the TELSA landscape model, the linked VDDT (Vegetation Dynamics Development Tool) forest succession simulator (ESSA Technologies, Vancouver, BC), and a drainage accumulation model to stratify the landbase into moisture shedding, draining and receiving areas on northerly or southerly aspects. The TAUDM model was used to map dry, mesic and subhygric areas in the landscape using 20x20m DEM grid cells. Dry areas generally followed ridge tops and upper slopes and subhygric areas were most often found in valley bottoms and on lower slopes. Dry and mesic areas were further partitioned into warm (112.5° - 270°) and cool aspect classes ($>270^{\circ}$ - $<112.5^{\circ}$); aspect was not considered important for wetter areas. Each landscape polygon was then classified to moisture and aspect class based on the characteristics of the 20x20m grid cells it contained.

Five climate change scenarios (Table 1) were modelled that span a range of possible future conditions including no change from the last century (the control, CC1), a warmer and wetter scenario (CC2), warmer and drier conditions (CC3), hotter and very dry conditions (CC4) and a warmer and drier scenario characterized by more frequent extreme events including droughts, high precipitation events, summer frosts, windstorms and periodic excessively hot weather (CC5). This latter scenario, referred to as *climate wierding* in the popular media, is likely the most difficult for current ecosystems to adapt to and also to manage for.

Table 1. Predicted summer (June – August) temperature and precipitation characteristics for the five climate change scenarios modelled.

Period	(CC1) No Change From Last Century		(CC2) Warmer & wetter		(CC3) Warmer & drier		(CC4) Hotter & Very Dry		(CC5) Warmer & Drier + More Frequent Extremes	
	Temp	Precip.	Temp	Precip.	Temp	Precip.	Temp	Precip.	Temp	Precip.
2010-2039	0 °C	0%	+1.5 °C	=	+1.5 °C	-10%	+1.5 °C	-12%	+1.5 °C	-10%
2040-2069	0 °C	0%	+2.5 °C	-5%	-2.5 °C	-16%	-3.0 °C	-20%	+2.5 °C	-16%
2070-2100	0 °C	0%	+3.0 °C	-7%	+3.5 °C	-22%	-5.5 °C	-30%	+3.5 °C	-22%

A range of ecological and economic indicators were modelled including the areas affected by natural disturbances, proportion of landscape in different age classes, timber harvested and mature (>80 years) standing volume, productivity (site index) increases and decreases, tree species composition changes, and the conversion of forests to grassland-shrub dominated ecosystems (*i.e.*, savannification).

To project the effects of climate change on the ecological characteristics of an existing landscape, a 283,751 ha study area situated in southeastern British Columbia was chosen, bounded on the east by Kootenay Lake and on the south by the Canada-United States border. Located in the Selkirk Mountains, the average elevation of the study area is 1510 m a.s.l., ranging from 450m-2780m. Approximately 82% of the study area is forested (233,877 ha), with most of the remainder classified as alpine tundra or lakes. The study area encompasses a range of forest conditions from wet-cold ESSFwcw forests to low elevation dry ICHxw forests. Common tree species in the study area include Engelmann spruce, western larch, subalpine fir, lodgepole pine, Douglas-fir and western redcedar. The landbase is composed of multiple planning areas, including the Nature Conservancy of Canada's Darkwoods property, provincial parks and protected areas, domestic and community watersheds and the Harrop-Proctor community forest. Multiple land use designations combined with mountainous terrain restrict the proportion of the study area that can be harvested (Timber Harvesting Land Base - THLB) to approximately 30% (83,969 ha).

TELSA model projections of the five climate change scenarios were undertaken to assess the likely future range of forest conditions that may occur. Because of the uncertainty associated with predicting future climate, natural disturbances and forest succession, each scenario is equally likely and should only be

used to identify the range of conditions that may develop in the future. It is also important to note that the scenarios chosen do not represent the most extreme conditions depicted in Figure 1, yet the range of future conditions resulting from our modelling illustrates the uncertainty associated with future conditions of many indicators. For example, projecting climate change scenario 1 (CC1) leads to virtually no shift towards grass-shrub dominated ecosystems, while CC5 leads to almost 40% of forested areas shifting to a grass-shrub dominated system by the year 2100 (Figure 3).

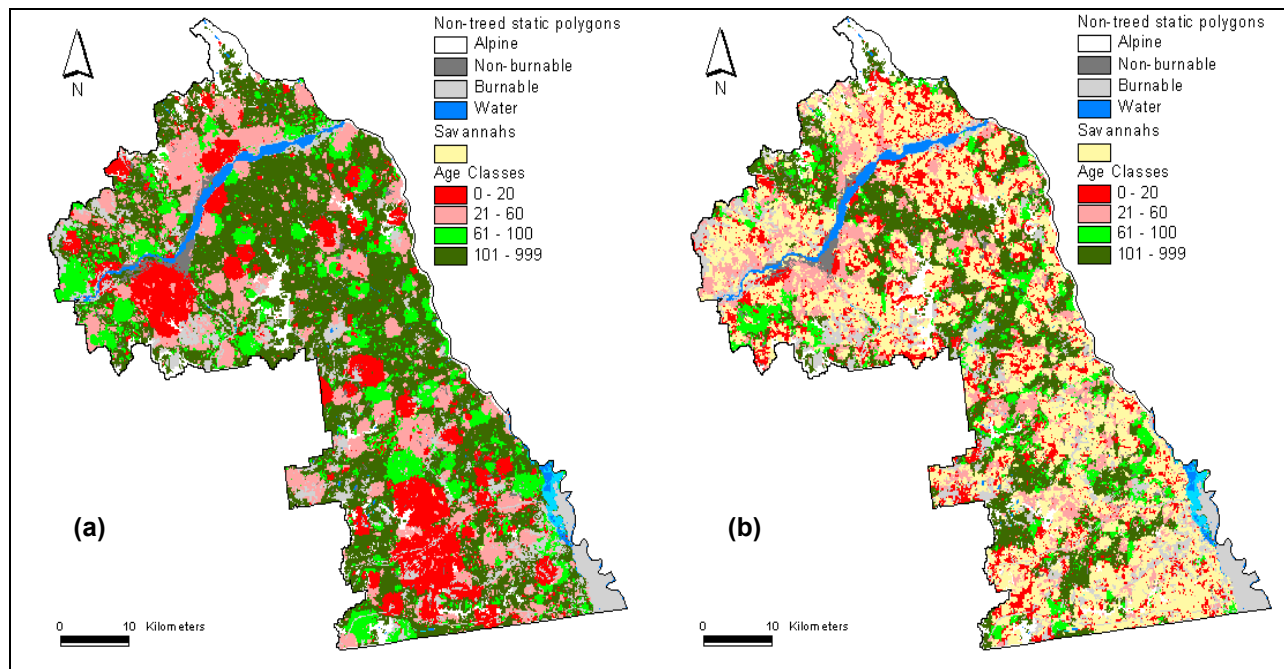


Figure 3. The study area with projected forest age classes and the areas converted to grass-shrub ecosystems (“savannification”) in year 2100 for climate change scenario 1 (a - control or no change from the last century) and climate change scenario 5 (b – warmer and drier with more frequent and severe extremes).

Model results illustrate a broad range of likely future conditions (Figure 4). It is important to note that the effects of climate change on ecological and economic indicators reflect our calibration probabilities. For example, the cumulative area disturbed by wildfire by year 2100 (Figure 4a) varies from 75 – 200% of the forested area (CC1 and CC5, respectively). This range reflects our interpretation of the literature on the likely effects of climate change on the extent and severity of wildfires. It should be noted that we chose relatively conservative estimates from the range reported in the literature which in some cases reported increases of two orders of magnitude or more greater than the estimates we used. For CC4 (hotter and much drier), our estimate was for a doubling of the area disturbed by wildfire and for the climate *wierding* scenario (CC5), a 2.5 fold increase in the area affected by wildfire which was scaled to increase from 2020 to 2100 as the effects of climate change became more severe. Some indicators such as volume harvested (Figure 4b) demonstrated relatively little difference between scenarios, but this result needs to be viewed in the context of the long-term reduction in standing mature volume (Figure 4c). Although harvested volume remained relatively high in CC5 to the year 2100, much of this originated from the salvage of areas affected by natural disturbances and as the supply of mature timber that could potentially be salvaged diminishes, opportunities for mature timber harvest will be reduced. A number of factors contribute to the diminished supply of mature timber for harvest, but wildfire, reduced site index (productivity) and the conversion of forested land to savannah-like conditions (Figure 5) dominated by grass-shrub ecosystems are most important. In our modelling, the conversion of forests to grasslands was most prevalent on south aspects and moisture shedding sites.

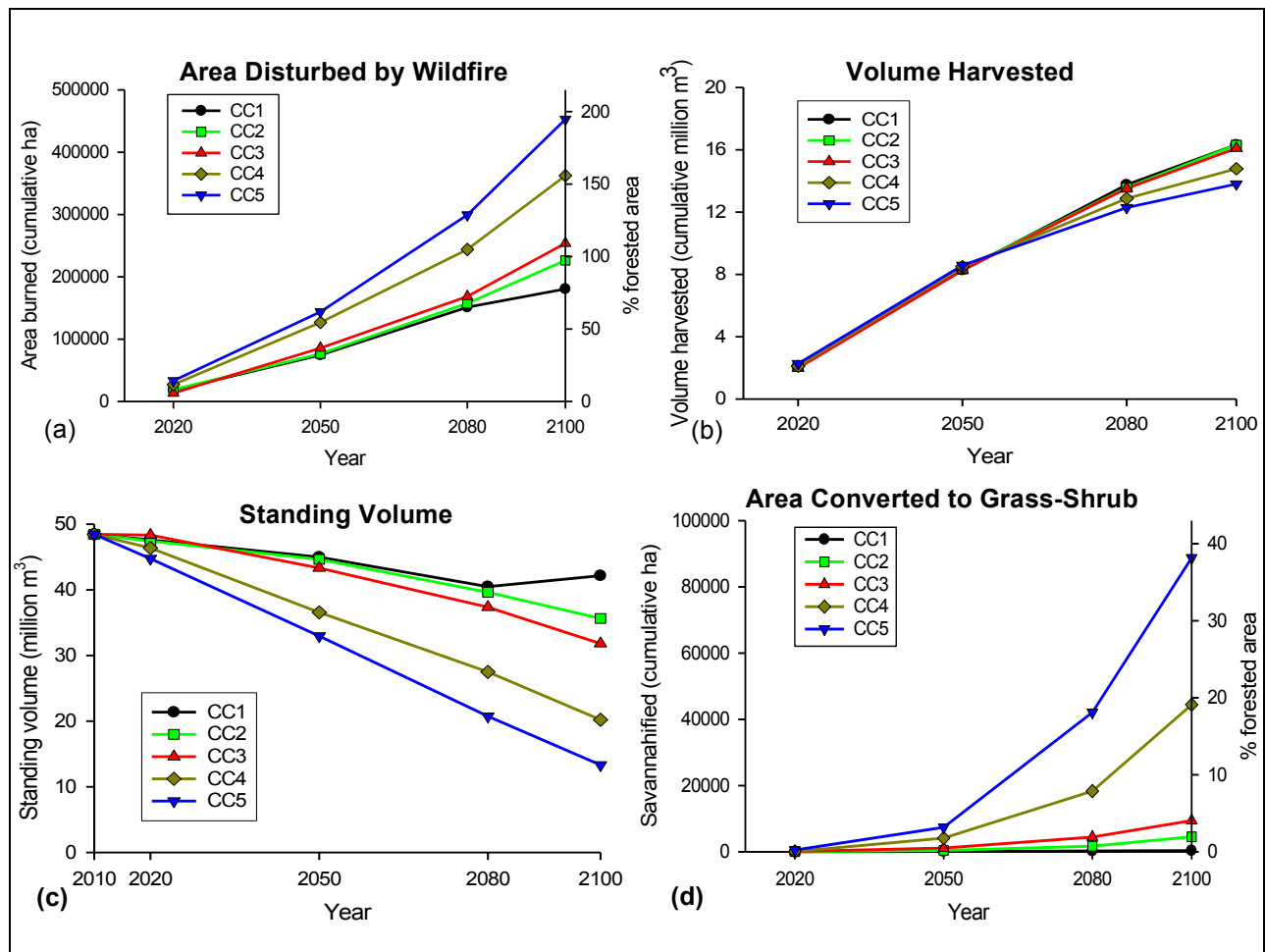


Figure 4. Implications of different climate change scenarios of selected ecological and economic indicators. (a) area disturbed by wildfire, (b) timber volume harvested, (c) standing mature timber volume, and (d) current forested area converted to grass-shrub dominated ecosystems.

Climate change, related natural disturbances and subsequent ecological succession represents a complex and superficially conflicting set of conditions to address in a climate change adaptation strategy. Since the nature and timing of precipitation events remains largely unknown, developing technical solutions that focus on the simplistic and potentially incorrect “climate warming” scenario represents a highly risk-prone strategy. On the other hand, climate change uncertainty, interactions between climate and natural disturbances, and uncertainty regarding the outcome of interactions between climate change, disturbance and succession can present a bewildering array of poorly understood outcomes and conditional responses that make adaptation decisions difficult or impossible. Developing a climate change adaptation strategy for forests and grasslands is neither simple nor impossible but it does require a different approach.



Figure 5. An existing example of the *savannification* of a former forested site that is now dominated by grasses and shrubs with scattered patches of Douglas-fir. The site is located near Falkland, BC and was burned by wildfire in 1967 and again in 2003.

6.2. Human Resiliency Dimension.

The *Human Resiliency Dimension* of the climate change study used a mixed-methods approach to investigate the relationships between human resiliency and adaptation/mitigation as a means of exploring how community members perceive and respond to climate change from socio-cultural, ecological and economic perspectives. The two questions that framed the *Human Resiliency Dimension* were:

1. What climate change adaptation practices would be required to maintain or enhance socio-cultural values within the study area?
2. Which of these practices would be acceptable to local residents (and if divergent, how can these be reconciled)?

The qualitative component of the *Human Resiliency Dimension* contributes to the existing body of work in the positive psychology movement. Positive psychology is concerned with people's strengths and well-being; it focuses on optimizing human performance, behaviours, health and social functioning. This approach is predicated on the idea that there is much to be learned by studying the positive aspects or strengths of individuals within society or in groups (*i.e.*, community settings). A total of 26 interviews were held with Aboriginal people in the study area.

The quantitative component involved a survey of non-Aboriginal (n = 401) and Aboriginal (n = 59) residents, and local land-use managers and planners (n = 60). The survey solicited people's attitudes, beliefs, and perceptions about climate change, and asked about the acceptability of different adaptation

practices that may be required to maintain or enhance socio-cultural values in the study area. The survey: (1) established a baseline of residents' socio-cultural values; (2) examined residents' current and potential adaptation and mitigation behaviours; and (3) explored trade-offs between different socio-cultural, economic, and ecological values to uncover what residents are willing to forego or change in order to adapt to landscape modifications due to climate change.

The majority of survey respondents indicated that they had noticed some effects of climate change in their communities. Many of these anecdotal reports touched on several themes: summer droughts, warmer winters, bird migrations changing, mountain pine beetle, and melting glaciers. Perhaps based on these (and other) observations, most respondents indicated that they knew what to expect in terms of what the effects climate change may have on their community or its surrounding environment.

The majority of respondents reported that they were concerned about the effects of climate change. Respondents from all three sample groups expressed concern about the eight potential local consequences of climate change that were presented to them (Figure 6). It is notable that "severe insect outbreaks" ranked highest in terms of concern and that a reduction in the amount of timber that can be harvested ranked much lower.

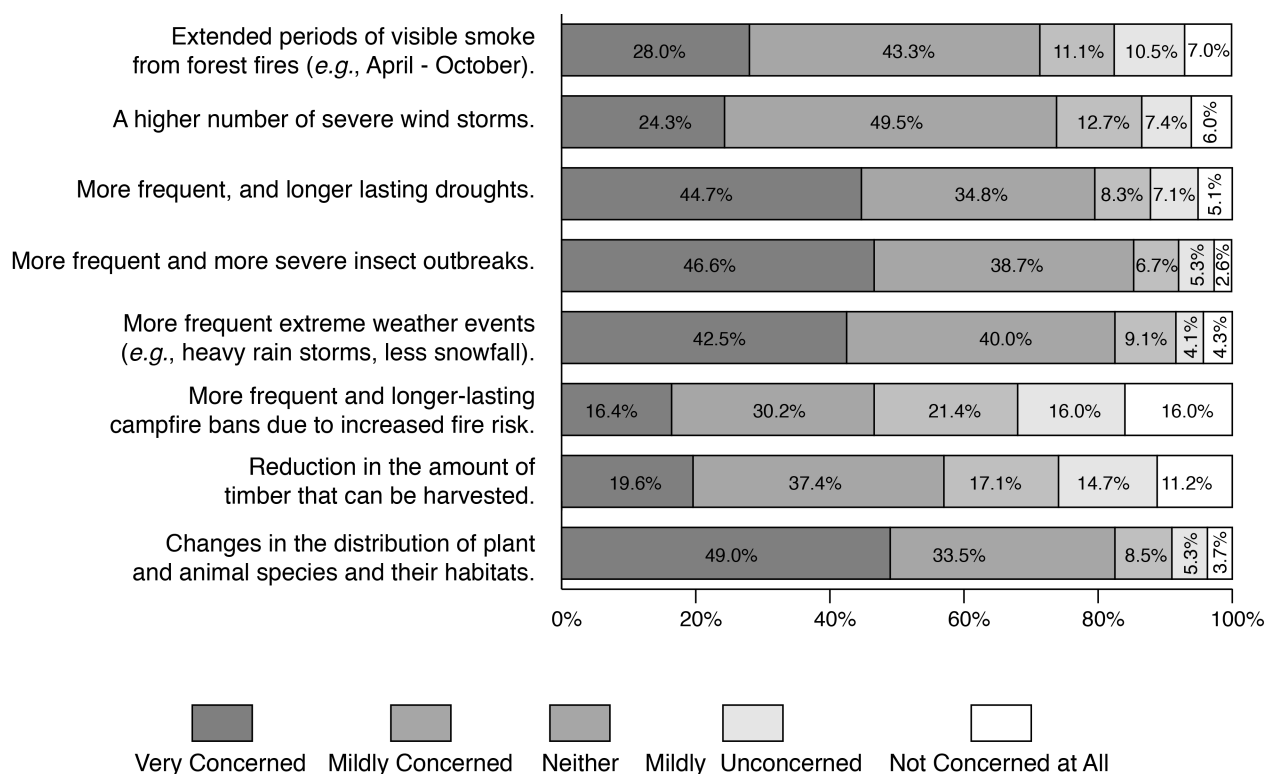


Figure 6. Here are seven different possible consequences of climate change in forested areas like the South Selkirks — please indicate how concerned you are for each possible consequence.

6.3. Economic Resiliency Dimension.

The *Economic Resiliency Dimension* investigated the economic factors that influence the vulnerabilities of different resource users and communities within the South Selkirks region to the impacts of climate change and affect their capacity to adapt. Forestry and wood product economic activities between 1978 - 2006 were reviewed, as this was a period of transition in the area (*i.e.*, the effects of recession and downsizing of the forest industry). During this period, timber harvest volumes decreased (Figure 7), and larger forestry companies moved on; however, it appears that a more resilient local industry emerged,

with local firms being able to respond to new and emerging opportunities relatively quickly. The question that framed the investigation of the *Economic Resiliency Dimension* was:

- What economically-feasible forest management practices would be required to encourage resiliency while adapting to climate change?

Following the closure of mills in the 1980s, the traditional industry the forest sector in the South Selkirks region did not collapse. Local forestry firms were able to take advantage of the newly available fiber and adapt to both market situations and resource conditions. The industry diversified and specialized wood products to remain competitive. The forest industry continues to play an important role in the South Selkirks region. Although the forest industry is not as important a source of employment as it once was (*i.e.*, as a share of total employment), it has demonstrated elements of resiliency (*i.e.*, diversification of products, local access to natural resources, and the fostering of local control of natural resource-based businesses).

There has been a decreasing share of forestry as a share of overall employment in the study area, which may be a sign of an industry in decline; although there are declines in some areas and activities, the decreasing share reflects instead the fact that overall employment is growing elsewhere and that the area's economy (at least measured in employment terms) is becoming more diversified. In the study area, the exit of traditional forestry firms may have been a catalyst for change; the forest industry can continue to play an important role in the communities within a region, although it may no longer play a dominant role.

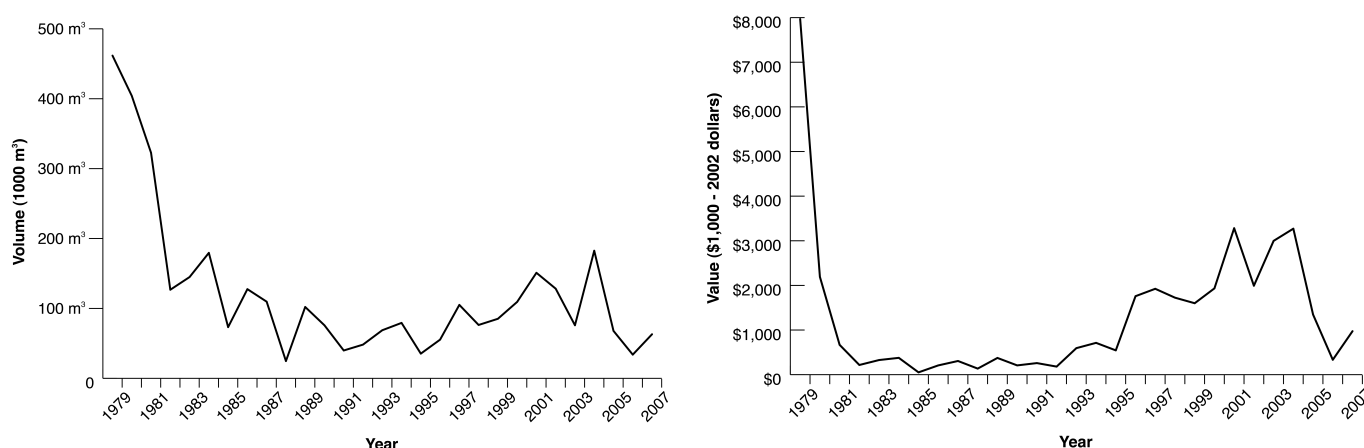


Figure 7. Volume and value of timber harvested in the South Selkirks region, 1978-2006.

6.4. Integration of Resiliency Dimensions.

The *Ecological Resiliency Dimension* employed models to evaluate potential changes to the environment under various climate change scenarios and disturbances (both human induced and natural). This Dimension identified the options for consideration by the *Human Resiliency* and *Economic Resiliency Dimensions*. It is the combination and integration of these three components that will provide the guidance to decision-makers regarding land management and policy development. The *Human Resiliency Dimension* served as the integrating mechanism that brings together socio-cultural, economic and ecological values. This Dimension gives voice to local Aboriginal (First Nations and Métis) and non-Aboriginal residents, land managers, licensees, and knowledge keepers on the topics of climate change resiliency and adaptation/mitigation. Key objectives for the *Human Resiliency Dimension* are the collection of local perceptions of resiliency and adaptive capacity (*i.e.*, strengths and opportunities for coping with climate change from socio-cultural, economic, and ecological perspectives), understanding diverse community perspectives and roles in the South Selkirks region (*i.e.*, Aboriginal, government,

industry and non-governmental organizations), and the examination of the social and environmental changes that participants may have observed and the attributes that they believe make the South Selkirk region resilient in the face of future climate changes.

There are some clear messages from the work that we have done in the South Selkirk region:

- We are not doing enough monitoring and, as a result, we do not have a clear picture of the state of our resources.
- Even if we did have a clear picture of the state of our resources, the trust placed in different information sources is variable: 84% of people trust scientists, whereas 76% distrust politicians as a source of information.
- The future nature of climate change and about the effects that it will have is uncertain. However, this should not be cause for inaction. There are a number of strategies that could be taken.
- We will not be able to maintain the *status quo*. It will be necessary for many residents to find a new balance: Some things will have to be given up, and new initiatives will need to be identified.
- The people of BC are resilient and adaptable; these characteristics need to be supported and maintained.

The future will undoubtedly be challenging, yet this project has shown that while there will be many changes, adaptation is possible given sufficient public will.

7. RECOMMENDATIONS.

In keeping with the holistic approach that framed this research, recommendations are presented based on investigations of the *Ecological, Human, and Economic Resiliency Dimensions*.

7.1. Ecological Dimension Recommendations.

An uncertain future will require emphasis on site-specific prescriptions, the cautious application of technical solutions that are consistent with existing and likely future conditions, a diversity of treatments that reflect the old adage “don’t put all your eggs in one basket”, reduced reliance on one treatment or area to provide required services or commodities (the need for redundancy), and the implementation of spatially explicit treatments specifically designed to maintain desired conditions (*e.g.*, fuel management zones, movement corridors for biota, *etc.*). Several key activities that would facilitate a climate adaptation strategy for forests include:

- Public consultation and dialogue with a broad suite of stakeholders prior to developing or implementing management plans to address climate change.
- A clear strategic vision that identifies the desired characteristics and values that the future landscape is expected to provide. Such a strategic vision is critical if activities are to be evaluated for efficacy and prioritized for implementation.
- Planning, coordination and evaluation to reconcile desired conditions and values with existing and likely future conditions. The need for large-scale coordinated planning cannot receive enough emphasis.
- Because of multiple uncertainties regarding the nature of climate change and how this will influence natural disturbance regimes and succession, implement diverse approaches to forest management.
- Avoid exacerbating the effects of climate change on succession by favoring treatments that retain over-story cover that would help mitigate the effects of exposure (both excessive heat and frost) on regeneration.
- Prioritize the implementation of adaptation strategies. The impacts of warmer, drier and greater temperature variability conditions will be expressed most at the regeneration phase, hence use

landscape topology mapping to identify priority sites (*e.g.*, xeric - moisture shedding, south aspect) for modified harvest (increased retention) or regeneration practices (*e.g.*, “assisted migration” of drought and heat tolerant species or stock types).

- An increase in the severity and area affected by wildfire has the potential to compromise aspects of biodiversity and commodities required by society. The need to address fuel management and forest structure management to help control wildfire behaviour in strategic areas will likely increase.

7.2. Human Resiliency Dimension Recommendations.

The qualitative study on Aboriginal perspectives about climate change in the South Selkirks region highlighted the interconnectedness of land, resources and people, and reinforced the idea that climate change adaptation strategies have to extend beyond ecological interests to also include social, cultural and economic needs. Aboriginal Knowledge Keepers were forthcoming in sharing their perspectives on human resiliency, coping and climate change adaptation. They indicated that climate change policies, strategies, and initiatives require that cultural paradigms to be respectfully integrated into climate change decision-making to promote the sustainability of Aboriginal communities in the region over time. Failing to do so could perpetuate conflicts, disputes and related cross-cultural misunderstandings in collectively addressing the complex issue of climate change and its effects on natural and human systems in the region. Seven recommendations that are a result of the Aboriginal component of the *Human Resiliency Dimension* studies are identified below.

- Develop a consistent set of human resiliency measures or indicators (*e.g.*, measures on language, laws, governance, lands, community health and well-being and economic diversification) for climate change adaptation to effectively monitor human systems and sustainability as the climate changes in the region.
- Integrate cultural values into clearly defined climate change adaptation objectives – including resources (human and financial) for Elder and Youth engagement, language preservation and cultural revitalization.
- Work with Aboriginal communities to engage Knowledge Keepers as local observers for climate change and related ecological monitoring initiatives and aid in prioritizing monitoring needs in the region.
- Broaden the understanding and research on climate change to include localized knowledge (*i.e.*, traditional knowledge) and indigenous science alongside and equal to western science to expand the depth and breadth of adaptive capacity; and localized decision-making and adaptation strategies to maximize community engagement and access to traditional knowledge to ensure that cultural values and practices inform decision-making in the region.
- Expand the climate change knowledge base and distribution of information through proactive and full engagement of Aboriginal people in climate change adaptation decision-making from research analysis to the design and implementation of adaptation strategies.
- Utilize existing communication methods in Aboriginal communities in the South Selkirks region to grow capacity, knowledge and understanding about climate change, which includes framing information and customizing messages, concepts and diagrams based on Aboriginal communities in the region.
- Develop equitable partnerships and collaborations within Aboriginal communities in the South Selkirks region and with strategic partners (*e.g.*, municipal/provincial/federal governments, industry and academia) as a lever to share resources (financial and human resources and infrastructure) in collectively addressing climate change effects in the region.

Many of the recommendations identified in the Aboriginal component of the *Human Resiliency Dimension* studies are relevant to non-Aboriginal people as well. There is recognition in the area that human

activities have played a role in climate change. There is strong support to start acting now on climate change with what we know, instead of continuing to monitor for climate change so we can learn more. This pragmatic approach to addressing climate change may be a result of the majority of respondents indicating that they thought that their lives were being affected by climate change – climate change is not an abstract notion, it is something that has been experienced by many of the respondents in a variety of ways. It is important to engage local people in deliberations about the management and planning of natural resources and local landscapes. The following recommendations support the resiliency of communities in transition.

- Provide opportunities and support the development and maintenance of skills, knowledge, and creativity for community members.
- Continue to involve local citizens in community and landscape planning.
- Support the building of relationships between community members to foster trust and productivity.
- Diversify sources of local income.
- Provide local access to natural resources.
- Promote local control of natural resource-based businesses.

7.3. Economic Resiliency Dimension Recommendations.

Traditionally, economic resiliency in BC has focused on mitigating change while maintaining economic activity – a “business as usual” approach. However, climate change has created ecological and social stresses that have, in turn, affected the economy of the South Selkirk region. Based on the resiliency demonstrated by the forest industry in the South Selkirk region during the 1980s, three recommendations can be made.

- Diversify product lines and support product specialization.
- Continue to support local access to natural resources.
- Promote local control of natural resource-based businesses. Smaller local firms may be more agile in responding to changing ecological conditions and constraints.

7.4. Synthesis/Strategic Alignment and Implementation of Recommendations.

Although the above recommendations stem from the results of three different aspects of our resiliency research, there are some commonalities that suggest four broader sets of recommendations. These are described below.

7.4.1. Formalize the adoption of Adaptive Management to guide forest management in light of climate change.

- Prioritize the implementation of adaptation strategies. The impacts of warmer, drier and greater temperature variability conditions will be expressed most at the regeneration phase, hence use landscape topology mapping to identify priority sites (*e.g.*, xeric - moisture shedding, south aspect) for modified harvest (increased retention) or regeneration practices (*e.g.*, assisted migration of drought and heat tolerant species or stock types). (*Ecological Resiliency Dimension*)

7.4.2. Involvement of local Aboriginal and non-Aboriginal people in land-use planning

- Public consultation and dialogue with a broad suite of stakeholders prior to developing or implementing management plans to address climate change. (*Ecological Resiliency Dimension*)
- Planning, coordination and evaluation to reconcile desired conditions and values with existing and likely future conditions. The need for large-scale coordinated planning cannot receive enough emphasis. (*Ecological Resiliency Dimension*)
- Broaden the understanding and research on climate change to include localized knowledge (*i.e.*, traditional knowledge) and indigenous science alongside and equal to western science to expand

the depth and breadth of adaptive capacity; and localized decision-making and adaptation strategies to maximize community engagement and access to traditional knowledge to ensure that cultural values and practices inform decision-making in the region. *(Human Resiliency Dimension)*

- Continue to involve local citizens in community and landscape planning. *(Human Resiliency Dimension)*

7.4.3. *Refinement of local sustainable forest management criteria and indicators to incorporate and address socio-cultural aspects of climate change.*

- Develop a consistent set of human resiliency measures or indicators (e.g., measures on language, laws, governance, lands, community health and well-being and economic diversification) for climate change adaptation to effectively monitor human systems and sustainability as the climate changes in the region. *(Human Resiliency Dimension)*

7.4.4. *Support and foster diversification of forest products.*

- Diversify sources of local income. *(Human Resiliency Dimension)*
- Promote local control of natural resource-based businesses. *(Human Resiliency Dimension)*
- Diversify product lines and support product specialization. *(Economic Resiliency Dimension)*
- Promote local control of natural resource-based businesses. Smaller local firms may be more agile in responding to changing ecological conditions and constraints. *(Economic Resiliency Dimension)*

8. EXTENSION OF RESEARCH OUTCOMES.

Our clients have shared with us how they are utilizing our research findings to inform decision-making:

- *Métis Nation BC – Kootenays Region:* Engaging in future climate change adaptation planning at the Chartered Community and regional levels; integrating our research findings to advance future studies on the implications of climate change on mountain caribou in the Kootenays and Métis traditional harvesting.
- *St. Mary's Indian Band/Ktunaxa Nation:* Integrating our research findings into the implementation of the community's strategic plan, economic development strategy and land use plan; integrating our research findings into their applications and planning related to bioenergy opportunities in their community (e.g., biomass district heating system).
- *Kalesnikoff Lumber Co. Ltd.:* Engaging in further dialogue with Aboriginal communities – includes building new relationships with the Métis Nation Kootenays Region in relation to sustainable forest management.
- *Columbia Basin Trust:* Engaging in opportunities to extend their climate change adaptation tools to Aboriginal (First Nations and Métis) communities in the Kootenays.
- *FORREX:* Utilizing the South Selkirks Climate Change Research Project as a case study for inclusion in the Social Science and Natural Resource Management (SSNRM) Curriculum. The SSNRM curriculum is utilized by natural resource management professionals to aid them in their understanding of socio-economic topics such as public involvement and participatory research; use of social, economic and cultural indicators; and traditional ecological knowledge.
- *Nature Conservancy of Canada BC Region/BC Hydro/Ministry of Environment/Ministry of Forests, Lands and Natural Resource Operations:* Integrating the research findings into their climate change adaptation plans at the regional (e.g., Kootenays), organizational (BC Hydro, Darkwoods Property) and community levels (Aboriginal and non-Aboriginal).

Please refer to *Appendix A* for a further itemization of our deliverables for this research project.

9. UTILITY OF THE FFESC RESEARCH PROGRAM.

Successes: The multidisciplinary approach of bringing together individuals from the natural sciences, social sciences and indigenous sciences to work together on common climate change issues and adaptation solutions – by having partners as advisors to the project team added to the richness and direct impact of the research questions being posed and reported on for our three resiliency dimension teams.

Opportunities for improvement: There is interest from neighbouring jurisdictions (*i.e.*, USA, Alberta) and non-governmental organizations to participate in climate change adaptation initiatives with BC research teams.

APPENDIX A: RESEARCH PRODUCTS & DOCUMENTATION

Technical Reports

- Caverley, N. (2011). *Honouring the voices of Aboriginal Knowledge Keepers in the South Selkirks Region: Perspectives on climate change*. Vancouver, BC: University of British Columbia.
- Harshaw, H.W. (2012). *South Selkirks Forest Management & Climate Change Public Opinion Survey, 2012*. Vancouver, BC: University of British Columbia Faculty of Forestry.

Published Articles

- Caverley, N. (2011). Indigenous perspectives on climate change adaptation in the South Selkirks Region. *Branchlines*, 22(4). 18-19.
- Caverley, N. and Beevis Trickett, C. (2011). NCC collaborates in climate change research study. *The Ark*. 8.
- Caverley, N., Harshaw, H.W., Carlson, M., and Legare, G. (2011). Examining climate change in the South Selkirks Region. *Identifying*. 42 – 45.
- Harshaw, H. (2011). Fostering climate change adaptation. *Branchlines*, 22(1). 14-15.

Article in Press

- Caverley, N. (in press). The guardians of Mother Earth: A qualitative study of Aboriginal Knowledge Keepers and their views on climate change adaptation in the South Selkirks Region. *Native Studies Review*, 21(1).

Article in Review

- Caverley, N. (in review). Reflections on climate change in the South Selkirks Region: Indigenous perspectives. *Native Journal*.

Articles in Preparation

- Harshaw, H.W. and Nelson, H. (in prep.). *Understanding economic resiliency options for climate change outcomes: Lessons from the South Selkirks region of British Columbia*. To be submitted to the Canadian Journal of Forest Research or Society and Natural Resources.
- Harshaw, H.W. and Spetic, W. (in prep). *Prioritizing factors for community resiliency: Identifying strategies for adapting to climate change outcomes*. To be submitted to the Canadian Journal of Forest Research or Society and Natural Resources.
- Innes, J.L. and Harshaw, H.W. (in prep). *Understanding the ecological, human, and economic dimensions of community resiliency: Climate change in the South Selkirks region of British Columbia*. To be submitted to the Forestry Chronicle.

Presentations

- Caverley, N. (2011). *Experiences on Climate Change and Forest Management in the South Selkirks Region*. University of British Columbia and Environment Canada – Proactive Adaptation: Challenges and Opportunities for Incorporating Climate Change Response Within Sustainable Forest Management Workshop, Vancouver, BC, February 14, 2011.

- Caverley, N. (2011). *Examining the human dimensions of climate change in the South Selkirks*. Presentation made to the FORREX Human Dimensions of Natural Resource Management Webinar series, Vancouver, BC, November 10, 2011.
- Caverley, N. (2011). *Qualitative Interviews – Aboriginal Perspectives Research Findings*. Presentation made to the St. Mary's Indian Band/Ktunaxa Nation, Cranbrook, BC, October 24, 2011.
- Caverley, N. (2011). *Qualitative Interviews – Aboriginal Perspectives Research Findings*. Presentation made to the Métis Nation BC – Kootenays Region, Cranbrook, BC, October 24, 2011.
- Caverley, N. (2011). *Qualitative Interviews – Aboriginal Perspectives Research Findings*. Presentation made to BC Hydro (representatives from the Corporate Environment, Aboriginal Relations, Transmission/Distribution, and Fish/Wildlife Compensation Teams), Vancouver, BC, October 20, 2011.
- Harshaw, H.W. (2012). *Climate Change in the South Selkirks: The human dimension*. Paper presented at the Southern Interior Silviculture Committee (SISCO) Winter Workshop, Salmon Arm, BC, April 3, 2012.
- Harshaw, H.W. (2012). *Examining Community Resiliency to Climate Change: Insights from Aboriginal and Non-Aboriginal communities the South Selkirks, British Columbia*. Invited presentation made to the American Indian Studies Program, University of Arizona, Tucson, AZ, March 21, 2012.
- Harshaw, H.W. (2012). *Healthy Forestry, Healthy Indigenous Communities: Examining Perceptions of Climate Change in the South Selkirks Region of BC*. Paper presented at the 8th International Conference on Environmental, Cultural, Economic, and Social Sustainability, Vancouver, BC, January 10-12, 2012.
- Harshaw, H.W. (2011). *Reconciling the human dimensions of climate change in the South Selkirk region of British Columbia: Understanding the values of local residents, aboriginal people, and land-use managers*. Invited Internet seminar made to the Great Northern Landscape Conservation Cooperative (coordinated by the United States Geological Survey), Vancouver, BC, January 25, 2012.
- Harshaw, H.W. (2011). *Examining the human dimensions of climate change in the South Selkirks*. Presentation made to the FORREX Human Dimensions of Natural Resource Management Webinar series, Vancouver, BC, November 10, 2011.
- Harshaw, H.W. (2011). *Economic Dimension: Forest Sector Transformation*. Presentation made to the St. Mary's Indian Band/Ktunaxa Nation, Cranbrook, BC, October 24, 2011.
- Harshaw, H.W. (2011). *Economic Dimension: Forest Sector Transformation*. Presentation made to the Métis Nation BC – Kootenays Region, Cranbrook, BC, October 24, 2011.
- Harshaw, H.W. (2011). *Economic Dimension: Forest Sector Transformation*. Presentation made to BC Hydro (representatives from the Corporate Environment, Aboriginal Relations, Transmission/Distribution, and Fish/Wildlife Compensation Teams), Vancouver, BC, October 20, 2011.
- Harshaw, H.W. (2011). *South Selkirks FFESC Project: Initial Survey Results*. Presentation made to BC Hydro (representatives from the Corporate Environment, Aboriginal Relations, Transmission/Distribution, and Fish/Wildlife Compensation Teams), Vancouver, BC, October 20, 2011.
- Innes, J.L. (2011). *Overview of the South Selkirks Project*. Presentation made to the St. Mary's Indian Band/Ktunaxa Nation, Cranbrook, BC, October 24, 2011.
- Innes, J.L. (2011). *Overview of the South Selkirks Project*. Presentation made to the Métis Nation BC – Kootenays Region, Cranbrook, BC, October 24, 2011.

- Innes, J.L. (2011). *Overview of the South Selkirks Project*. Presentation made to BC Hydro (representatives from the Corporate Environment, Aboriginal Relations, Transmission/Distribution, and Fish/Wildlife Compensation Teams), Vancouver, BC, October 20, 2011.
- Klenner, W. (2011). *Conserving working landscapes – the future of agriculture in the East Kootenay*. East Kootenay Conservation Program, Cranbrook, BC, May, 2011.
- Klenner, W. (2011). *Ecological Resiliency Dimension Findings*. Presentation made to the St. Mary's Indian Band/Ktunaxa Nation, Cranbrook, BC, October 24, 2011.
- Klenner, W. (2011). *Ecological Resiliency Dimension Findings*. Presentation made to the Métis Nation BC – Kootenays Region, Cranbrook, BC, October 24, 2011.
- Klenner, W. (2011). *Ecological Resiliency Dimension Findings*. Presentation made to BC Hydro (representatives from the Corporate Environment, Aboriginal Relations, Transmission/Distribution, and Fish/Wildlife Compensation Teams), Vancouver, BC, October 20, 2011.

Brochure

- Kremsater, L. and Klenner, W. (2012). *Managing Dry Forests in the Southern Interior of BC for Diverse Values in an Era of Climate Change*. British Columbia Ministry of Forests, Lands and Natural Resource Operations.

Posters

- Innes, J.L., H.W. Harshaw, H.W., Nelson, H., Caverley, N., Klenner, W., and Krishnaswamy, A. (2012). *Climate Change Adaptation Research for Forest and Rangeland Ecosystems: Resiliency implications at the landscape level*. Poster presented at the Southern Interior Silviculture Committee (SISCO) Winter Workshop, Salmon Arm, BC, April 2 - 4, 2012.
- Klenner, W. and Kremsater, L. (2012). *Stewardship Practices to Facilitate Forest and Range Management in an Era of Uncertain Climate*. Poster presented at the Southern Interior Silviculture Committee (SISCO) Winter Workshop, Salmon Arm, BC, April 2 - 4, 2012.
- Walton, R. and Klenner, K. (2012). *Climate Change & Implications for Forest and Grassland Management in BC*. Poster presented at the Southern Interior Silviculture Committee (SISCO) Winter Workshop, Salmon Arm, BC, April 2 - 4, 2012.

Training

- Caverley, N., and Krishnaswamy, A. (2012). South Selkirks Climate Change Research Project – Case Study. FORREX Social Science and Natural Resource Management (SSNRM) Curriculum.