Research final report

Title: **A multi-scale trans-disciplinary vulnerability assessment**

Project Number: B11

Project Leader: Don Morgan c/o Bulkley Valley Research Centre

***Project description*:**

This project identifies climate-induced vulnerabilities in the forest management regime in our study area (i.e., the Nadina Forest District, including the Morice and Lakes Timber Supply Areas) and supports re-evaluation and revision of existing plans and practices (proactive adaptation). It lays the groundwork for structural change (e.g., a move towards adaptive management) by synthesizing current knowledge and uncertainty, and by identifying influential forces working at multiple scales within the forest system. This project also supports development of adaptation strategies by forest-dependent communities.

The project began with four objectives:

1. Management Unit Vulnerability Assessment - assess vulnerability of existing forest management regimes (i.e., objectives and strategies for selected ecosystem services) to climate change in two representative local resource management units;
2. Management Unit Adaptation Policy – use stakeholder workshops to develop local adaptation policy considering a range of climate change scenario narratives (based on vulnerability assessment);
3. Multi-scale Vulnerability Assessment Framework - develop a framework to link multiple disciplines and to link local, regional, provincial and national climate change adaptation policy;
4. Livelihood Assessment - apply livelihood methods to evaluate linkages among people, resources, the environment and the changing climate.

***Collaboration*:**

Clients:

Clients include regional Forest Licensees, Nadina Forest District, Ministry of Environment, and Ministry of Forest, Lands and Natural Resource Operations planners.

Partners:

Jim Burbee – Morice/Lakes IFPA
Agathe Bernard – Nadina Forest District
Carolyn Stevens – Nadina Forest District
Mike Simpson/Gail Hochachka - One Sky: Canadian Institute of Sustainable Living

Research collaboration:

This project collaborated with two FFESC research projects that conducted regional-scale vulnerability assessments and with one FFESC provincial-scale vulnerability assessment:

- FFESC-B8 - Resilience and climate change: adaptation potential for management and ecological systems in the West Kootenays, leader Rachel Holt, Veridian Consultants.
- FFESC-B12 - Validating impacts, exploring vulnerabilities, and developing robust adaptive strategies under the Kamloops Future Forest Strategy, leader Harry Nelson, UBC.
- FFESC-C4 - Interdisciplinary assessment of the implications of climate change on the province's forest and range ecosystems and their stewardship, leader Don Morgan c/o Bulkley Valley Research Centre.

Members of the four collaborating projects discussed and compared vulnerability assessment methodology and results. In particular, cross-scale barriers to adaptation were explored by comparing barriers among regions and by considering the national scale Canadian Council of Forest Ministers (CCFM) vulnerability work led by Mark Johnston.

Our multi-scale project also collaborated on decision frameworks and on barriers to managing for resilience with FFESC project B1-Reducing vulnerabilities and promoting resilience of BC's natural and human systems through adaptation of post-disturbance land management options, leader Alan Wiensczyk, FORREX.

Our project also collaborated with a non-profit organization, One Sky, in delivering a community scenario planning workshop. The One Sky project, Resilience in Times of Change, engaged local community members (near Smithers) to explore the question of what it means to be resilient in times of turbulent change. The project used scenario planning, systems thinking and community conversation to engage people in this discussion. (http://www.onesky.ca/stories/resilience_in_times_of_change/).

***Communication*:**

- Workshops: involving many local forest managers and scientists, and community members.
- Project web page: http://bvcentre.ca/research/project/a_multi-scale_trans-disciplinary_vulnerability_assessment/
- Bulkley Valley Centre newsletter: article describing project in December newsletter (http://bvcentre.ca/files/newsletters/13-BVResearchCentreNewsletterDec10-r.pdf)

***Deviations from project plan*:**

There were no major deviations from the project plan. There was one minor deviation: a conceptual model proposed for the multi-scale assessment was not developed, however ideas about constructing such models were documented.

Research outcomes:

Management Unit Vulnerability and Adaptation:

Several reports were prepared to provide information to support discussions in participatory workshops. They described the existing forest management regime in the Nadina, provided an overview of climate change, and presented descriptive narratives of future conditions (see research reports below). Presentations and background information were also created to support each of two management workshops (background information).

This project used participatory workshops to define project scope and identify potential vulnerabilities to climate change (Management Workshop #1), to develop conceptual models of ecosystem function used to assess vulnerability (Technical Workshops), and to identify management and adaptive management responses to climate change (Management workshop #2). Different workshops focused on different resource values and included different mixes of ecological and management expertise. Follow-up discussions and report reviews were used to clarify workshop discussion and fill knowledge gaps. Information to develop conceptual models also came from existing models, developed to support past land-use planning processes, and from appropriate literature. The final report (Management strategies

for climate change in the Nadina Forest District) summarizes vulnerabilities and management responses, but omits the details presented in the workshop summaries.

Conceptual models (see Technical workshops) provided the logical constructs for organizing ideas about how climate change will influence selected resource values. They provided a means to focus discussion on the most relevant ecological and management variables. Individual conceptual models were developed for timber, biodiversity and hydrology; models can be linked together to examine interactions. The models relate resource values (e.g., timber supply) to ecological (e.g., fire disturbance) and management (e.g., harvest level, fire control) processes and ecosystem structures (e.g., riparian habitat). Climate change influences ecosystem structures and processes.

Management Unit Vulnerability and Adaptation Documents:

Background Information for Workshop #1 - Nadina Climate Change Vulnerability - April 20, 2010

- Introduction, Dave Daust
- Vulnerability Assessment Context, Don Morgan
- Overview of the Kamloops Future Forest Strategy, Ken Zielke
- Complexity & Uncertainty, Don Morgan
- Nadina Forest District, Forest Management Objectives and Strategies Overview, Agathe Bernard
- Climate Variability & Climate Change, Jim Pojar

Background Information for Workshop #2 - Nadina Climate Change Adaptation - April 12, 2011

- Agenda
- Climate change narratives, Don Morgan
- Climate change impacts and management tools, Dave Daust
- Resilience management backgrounder, Dave Daust

Management Workshop #1 - Nadina Climate Change Vulnerability - April 20, 2010

- Vulnerability Summary

Technical Workshop Summaries:

- #1 –Impacts on Biodiversity, November 8, 2010
- #2 - Impacts on Trees and Timber, November 22, 2010
- #3 - Impacts on Hydrology, November 25, 2010

Management Workshop #2 - Nadina Climate Change Adaptation - April 12, 2011

- Adaptation Summary

Management Unit Vulnerability and Adaptation Research Reports:

- Projections of climate-induced shifts in ecological zones of the Skeena Watershed
- Projected Climate Change Impacts in the Nadina Forest District
- Nadina forest management regime: summary of land management objectives and strategies
- Future Histories: BC Climate Change Narratives for the Nadina Forest District
- Management strategies for climate-change adaptation in the Nadina Forest District

Multi-scale Vulnerability Assessment Framework:

We evaluated a multi-scale vulnerability assessment framework that enables understanding and evaluation of interactions across social (e.g., local management objectives, market pressures) and ecological domains. The framework addressed questions such as, how do the vulnerabilities between two regions compare, what is the source of the differences, which ecosystem services are most vulnerable, and how do decisions at different scales interact synergistically and antagonistically? It identified jurisdictional challenges and expertise required. We applied the framework in a workshop involving members of three regional vulnerability assessments. Although vulnerability assessment methodology varied among the projects, we found that different regions face the same types of climate impacts and barriers to adaptation (Multi-scale Vulnerability Assessment Research Report).

Multi-scale Vulnerability Assessment Research Report:

- Removing multi-scale barriers to climate-change adaptation in managed forests of BC

Livelihood Assessment:

People exist within a context of complex multi-scale social, economic and ecological systems. To help communities adapt to change, it is critical to describe these socio-ecological systems—to clarify different scales of decision making, where communities fit in, how people will be impacted, what they have control over, who can respond to climate change and how. To explore these concepts we used a sustainable livelihood methodology modified to incorporate integral theory concepts. Sustainable livelihood thinking considers the coping and adapting mechanisms that people use in response to the dynamic nature of the system in which they live. These mechanisms are not typically captured in traditional assessments that focus on employment, production, markets, and forestry systems. A livelihood approach asks questions such as "what institutional arrangements enable some people to achieve sustainable, secure livelihoods, while others fail?" Participation by interest groups helps build adaptive capacity.

Workshops:

- Bulkley Valley Livelihood Assessment—building scenarios for a community adaptation workshop, September 8, 9, 2011 - Resilience in Times of Change
- Climate Change and Community Adaptation Workshop, November 30, 2011 (workshop summary is included in the Livelihood Assessment research report)

Livelihood Assessment Research Report:

- Applying Livelihood Methods for Climate Change Adaptation

Recommendations:

This section describes how we expect different audiences to use our research results.

Forest managers (Forest District and Licensee forestry staff):

Our research filled an information gap. Forest managers that participated in our project have observed the effects of climate change in the Nadina District (e.g., mountain pine beetle mortality and plantation failure) and were very interested in learning more about projected changes in climate for the region and about ecological consequences. Forest managers have a responsibility to base management on sound knowledge. Our project highlighted issues that should be considered when planning in the context of climate change.

We believe this project has contributed three levels of information to forest managers:

- describing climate change and general ecological impacts—to increase awareness;
- developing conceptual models that highlighting vulnerabilities—to inform forest managers and to serve as a basis for adaptive management;
- developing adaptation strategies—providing a clear set of recommendations that merit further consideration for implementation.

Regional staff with Ministry of Forest Lands and Natural Resource Operations:
We believe the demand for regionally-relevant climate-change information will increase. We expect our reports and maps describing climate change may have broad interest and that the conceptual models may be useful to environment staff addressing specific topics.

Outside the region:
Relatively few vulnerability assessments have been conducted in BC, although the number is growing. Our report provides an example of an approach to vulnerability assessment.

Community:
Our research was directly linked with a broad cross section of the local community, not only natural and social scientists. We intentionally included people representing different cultural backgrounds, genders, age groups, disciplines, and socio-economic sectors—to include as many perspectives as possible. Attention to the diversity of participants was somewhat unusual for what is often considered a 'scientific' or 'technical' workshop topic, and provided a more representative cross-section of the communities in the region. Without losing a connection to the important insights of climate science, the workshop was framed around dialogical engagement. This approach, in our opinion, helped build community adaptive capacity and will help trigger future community based climate change discussions.

Lessons Learned:
Vulnerability Assessment
The lessons learned for the vulnerability assessment and adaptation component of the project are summarised in table 1. Presented are the adaptation strategies designed to address the main climate-induced ecological changes expected to affect three types of ecosystem services in the Nadina District: trees and timber; biodiversity; hydrology and aquatic systems. Most strategies presented are not novel; however, they will need to be implemented more widely and thoroughly, with the underlying goal of learning more about their effectiveness.

Table 1. Climate-induced effects (bold) and adaptation strategies (bulleted) for trees and timber, biodiversity, and hydrology and aquatic resources.

Trees and Timber
Increased tree growth potential on sites with sufficient moisture
• Plant climatically-suited species and genetic stock
• Fertilize appropriate sites
• Partially-cut stands on dry sites
Increased tree disease virulence (mainly younger stands)
• Plant climatically-suited species and genetic stock
• Increase stand-scale species diversity
• Remove stumps with root disease
Increased bark beetle virulence (mainly older stands)
• Plant climatically-suited species and genetic stock
• Increase stand-scale species diversity
• Shorten rotations of susceptible stands
• Monitor and control beetle populations
Increased fire hazard (all stands)
• Control human access during high hazard times
• Reduce post-harvest fuels
• Leave fire-breaks
• Provide more and better fire-suppression equipment on site
• Improve access for fire suppression
Biodiversity
Loss of old forest habitat and connectivity due to increased tree mortality
• Create a network of reserves, corridors and wildlife tree patches; limit salvage in network
• Reduce disturbance from insects, disease and fire across the landscape
Loss of suitable microclimate and soil conditions following harvest (e.g., dry sites, brushy sites)
• Avoid harvesting sensitive sites
• Partially-cut stands on dry sites

• Retain down wood
• Rapidly reforest sites
Loss of young forest vigour and diversity due to species maladaptation to changing climate
• Retain naturally-occurring and regenerating species and plant a diverse species mix
• Use stand tending to influence successional pathways
• Plant climatically-suited species and genotypes
Increased spread of invasive species
• Minimize roads
• Minimize road use
• Minimize grazing
• Minimize site disturbance
Hydrology and aquatic ecosystems
Increased stream temperature
• Retain riparian cover
• Properly maintain ditches and properly deactivate roads
• Avoid harvesting sites with high water tables
Increased risk of landslides and surface erosion
• Avoid locating roads and cutblocks on unstable terrain
• Design roads and drainage structures to accommodate increased peak flow and bedload transport in areas likely to become wetter
Increased peak flows (western mountains)
• Limit ECA[1] to 30 to 50% of THLB

Livelihood Assessment

The project was structured to transcend traditional approaches to vulnerability assessment through its final objective "Livelihood Assessment - apply livelihood methods to evaluate linkages among people, resources, the environment and the changing climate". However, the integration of more socially oriented considerations of climate change adaptation was present in other aspects of the project. For

[1] Equivalent Clearcut Area: percent of basin that functions hydrologically as though it were clearcut (calculation assumes hydrological recovery of disturbed sites is a function of tree height).

example, the project used participatory workshops to not only capture knowledge about forests, hydrology and biodiversity, but also to document assumptions, about the behaviour of natural systems, which reflect people's cultural, organizational or discipline bias. Additionally, the project used scenario narratives as a technique to describe possible futures under different climate scenarios to stimulate dialogue. We learned that these were very effective at engaging non-scientists in understanding the social and ecological drivers that lead to different possible futures. As well, the scenario planning workshop allowed scientists and non-scientists to develop climate story lines that reflected shared understanding of how science, government policy, technology and politics could combine and produce different futures. We found these exercises were very effective at engaging non-scientists in discussions of the social meaning of climate change. With the livelihood assessment the specific human, social, financial, infrastructure and natural community assets were identified that would constitute human and natural adaptive capacity to climate change. This exercise was very effective at bringing further connection of how climate change impacts people's lives and what capacities exist and that can be used to help adapt.

Recommendations for Government:

Vulnerability Assessment

In our vulnerability assessments, we identified lack of mandate and resources as the largest barrier to adaptation at the regional scale (Table 2), followed by restrictive legislation and policy and then by planning capacity. Although knowledge about future conditions under climate change is limited, we did not find it to be a substantial barrier, at least in the short-term.

Table 2. Observed importance (0 to 3 Xs show nil, low, medium and high) of different types of surmountable barriers (based on CSSP 2008 and Glick et al. 2009)

Barrier	Importance rating
1. Lack of concern	—
2. Lack of knowledge expertise	X
3. Lack of planning capacity	XX
4. Lack of mandate/resources*	XXX
5. Restrictive legislation and policy**	X to XXX
6. Lack of political will	Assume causes lack of mandate/resources

*we assume that resources should accompany mandate.

**moves from a X to XXX when publicly-defined management objectives are included.

Adaptive capacity can be improved in several ways: by increasing the awareness of provincial leaders, by improving regional knowledge, by updating resource management policy (goals), by improving and land and resource planning, by motivating private enterprise and by removing restrictive legislation

1. Increase awareness of provincial-scale forest managers of the need to support climate change adaptation

This step is similar to one recommended for the US Forest Service—providing appropriate climate change information to the multiple actors that influence forestry decision-making - but focuses on

provincial decision-makers. This first step is critical because the remaining recommendations require a mandate and resources from provincial leaders. Forest managers and researchers that are already aware of risks posed by climate change are ultimately responsible for spreading information. Ideally, the Association of BC Forest Professionals should develop a stance and guidance on climate change adaptation. Professional associations can influence members to pay greater attention to climate change and can raise the awareness of provincial leaders.

2. Develop regional learning programs to improve knowledge and support decision-making

A substantial number of papers addressing climate change call for adaptive management as a means of dealing with the uncertainty created by climate change. Here we use the term "regional learning program" to avoid pre-conceived notions of adaptive management. Learning is intended to be broad in scope and methodology and can take a variety of forms:

- synthesize the latest knowledge (e.g., tree species responses to climate change, hydrological models);
- improve inventories needed for climate-change planning (e.g., soils maps);
- monitor climate trends (e.g., is the region becoming wetter or drier in the summer?);
- monitor ecological response (e.g., is tree disease increasing?);
- conduct research to understand ecological responses (e.g., how does provenance influence susceptibility to disease?);
- monitor responses to management (e.g., has disease incidence decreased in plantations?);
- test management alternatives (e.g., which provenance reduces disease and grows fastest?).

Steps to create a learning program include:

- build on existing regional strengths (i.e., mainly government research staff);
- create a regional climate-change adaptation research/extension position;
- create a framework for recording and disseminating knowledge and for identifying knowledge gaps that can survive staff turnover and institutional restructuring (e.g., Babine Watershed Monitoring Trust[2]);
- create formal and informal channels for sharing information among external researchers, regional researchers, regional and provincial forest managers and interested community members (e.g., articles, conferences, collaborative projects).

3) Review and revise forest management objectives (policy)

Broad direction for land and resource management (e.g., Land and Resource Management Plans) was developed largely without consideration of climate change; it should be updated. For example, the role of forests in climate change mitigation and in supporting autonomous ecological adaptation should be considered.

4. Review and revise forest management plans

[2] www.babinetrust.ca

Implementing new objectives for mitigation and resilience will require a provincial-scale land management strategy. Existing planning approaches should be improved to better address climate change.

5. Create incentives for companies to adapt.

The benefits and costs of adaptation to climate change depend on perspective. Companies representing shareholders have different goals and time-frames than governments representing the public. Private enterprise can be encouraged to undertake adaptation that benefits the broader public with incentives (e.g., taxes, subsidies, regulations) and extension (e.g., technology transfer, education), depending on the situation (Figure 1). In the early stages of adaptation, collaborative projects, involving forest managers and researchers from various organizations, may be useful for developing and testing climate-savvy management strategies.

6. Remove legislative and policy barriers

Removal of legislative and policy barriers requires careful consideration. Legislation and policy can constrain adaptation, but also protects forest values by providing minimum performance standards. The costs and benefits of each change need to be weighed. Increasing flexibility in legislation for the purposes of research trials provides one means of advancing climate change adaptation without substantially increasing risk.

Livelihood Assessment

With the inherently interdisciplinary nature of the questions posed, an integral framework was used that could not only foster dialogue between the disciplines but also coordinate and integrate meaning among them. Integral theory provides a basis for developing this type of transdisciplinary methodology to foster greater understanding of communities and climate change adaptation that meshes well with the concept of livelihoods. Integral frameworks map out the individual and collective into subjective and objective domains. By forming questions that help to inform each domain of the framework a richer understanding of community adaptive capacity was gained through the project. Through the integral and livelihood methods employed the project was able to identify some of the barriers to building adaptive capacity, namely the lack of recognition of the interior quadrants of the Integral Theory framework. This helps to explain why scientists, who tend to focus primarily on the objective, are often challenged with low public acceptance and lukewarm political response to the emerging climate science. The integration of these methods also demonstrates how other scientists and communities might seek a more comprehensive way forward with both further research and community engagement on climate change. Specifically, government should focus on not only the objective technical-scientific aspects of climate change adaptation, but also include the subjective human-cultural components. Dialogue between scientists and policy makers should consider scenario exercises to help engage a broader understanding of the social context.

***Extension of research outcomes*:**

We used two complementary approaches to transfer project findings to practice, facilitating adaptation. First, our project used a participatory workshop approach. This approach provides participants with an

in-depth understanding of the issues and complexities related to climate change. Because adaptation can be costly and increase risk, adaptation requires a substantial familiarity with climate change issues (i.e., provided in the workshops and related materials). This approach benefited technical professionals, but also was key in engaging the broader non-technical community. A more technically informed community will positively contribute to climate change adaptation policy discussions. Also, workshops provided an opportunity for managers to develop or improve relationships with the regional topic experts that can assist their adaptation efforts. One Licensee forest manager is aiming to incorporate climate-savvy management strategies into Sustainable Forest Management planning.

Second, we created a web site with region-specific, climate-change information and with reports addressing vulnerability and adaptation. This information source serves managers in the region and nearby regions, and technically minded community members, even if they did not participate in the project. We know of one forest manager and one fish manager, who were not involved in the project, that have used information from the web site. Our final project report has also been added to the Canadian Climate Change Adaptation Community of Practice web site, for wider distribution to forest managers.

Our project also identified several barriers to adaption. Implementation of adaptation strategies will be limited until some of the direct costs and monetary risks related to adaptation are reduced. In brief, collaboration and support from provincial-scale forest managers and policy-makers is needed to create an environment that enables adaptation.

***Utility of FFESC research program*:**
This project successfully provided forest managers with a good understanding of management issues and options related to climate change and improved collaboration among researchers and managers. It advanced vulnerability assessment methodology by constructing explicit models linking climate change and management actions to ecological functions and services. The models can be used as a platform for adaptive management. In some cases, the models were able to provide rough estimates of the projected magnitude of ecological change and rough estimates of uncertainty. Such estimates are not usually made in vulnerability assessments, but are essential for adaptation decisions.

This project could have been improved by formally evaluating the costs and risks of different adaptation strategies. It could have been improved by taking steps to better integrate results with existing management plans. It could have been improved by incorporating better estimates of hydrological responses to climate change (e.g., hydrological models). These steps would have required a moderate amount of additional funding. For a more substantial investment, this project could have been extended into a multi-year project that established operation trials to test adaptation strategies.

Our project addressed forest management regimes and forest-dependent communities separately. Initially, we felt this was a weakness in our approach, however the expertise and methodology needed to address forest management differ greatly from those needed to address forest-dependent communities. In retrospect, we may have been less successful if we had tried for a broader, more

integrated approach. It may be best to address these two types of adaptation separately, being aware of potential interactions.

We were fortunate to have a diverse team addressing forest management that included knowledge and expertise related to

- risk assessment and mathematical modelling;
- workshop facilitation (including expert workshop facilitation);
- narrative development (scenarios describing climate change);
- local forest management practices and issues;
- driving forces affecting industry;
- hydrology, geomorphology, aquatic ecosystems and fish;
- natural disturbance regimes, insects and disease, silviculture and timber supply;
- plant communities, wildlife and coarse filter biodiversity;
- local ecosystem function.

In short, we had regionally-relevant ecological and management knowledge coupled with knowledge about assessment. Ironically, our weakest subject may have been climate change, however, we were able to obtain climate projections from the web and climate envelope projections from T. Wang, UBC. Also several good reports about the effects of climate change on Canadian forests have been produced recently.

The main goal of the Livelihood Assessment component of the project was to test methods to support adaptation of communities to climate change using the concept of sustainable livelihoods, augmented with integral theory. The methods tested included: presentations of climate change impacts and local forest resource system vulnerability; community based scenario planning; sustainable livelihoods assessment; application of Integral Theory to the Livelihood Assessment; and summary of livelihoods and impacts. By testing these methods in a transdisciplinary approach, this project was able to identify some of the barriers to building adaptive capacity, namely the lack of recognition of the interior quadrants of the Integral Theory framework (subjective perspectives, for example personal beliefs and culture). This helps to explain why scientists, who tend to focus primarily on the objective (physical world), are often challenged with low public acceptance and lukewarm political response to the emerging climate science. The integration of these methods also demonstrates how other scientists and communities might seek a more comprehensive way forward with both further research and community engagement on climate change.