Economic instruments for adaptation to climate change in forestry

Final report

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Executive summary

Climate change will have significant impacts on our forests including negative impacts such as increased frequency and severity of wildfire, pest and disease outbreaks and changes in ecosystem dynamics (tree regeneration, growth and mortality) that lead to maladaptation of tree species. These impacts will have economic, environmental and social consequences. Adaptation involves undertaking activities to better prepare for those impacts such as assessing the risks of those impacts, planning for them and identifying and implementing mitigative or preventive measures.

The nature of forest management in Canada, where many management decisions are delegated to the private sector that also carries out most of the operational activities, means that the private sector will play a significant role in adaptation. Moving forward on adaptation requires understanding how to best engage the private sector. Economic instruments offer an alternative to command and control approaches; where properly designed, previous experience has shown that they can provide more efficient and cost-effective ways of meeting environmental objectives (e.g. OECD 2008; Stavins 2001). However, there has been little work done in this area in regards to adaptation (Bräuninger et al. 2011). The goal of this research was to identify economic instruments that could support adaptation of Canadian forests to climate change by drawing on the experiences and efforts taken to date in BC and elsewhere.

We undertook three case studies oriented around specific climate-change related risks: 1) looking at wildfire risk on the landscape; 2) fire and the wildland-urban interface; and 3) the effect of maladaptation and less resilient future forests (as the trees being planted would not be suited for future climate). In each of these case studies we identified potential instruments that came out of interviews with experts and a review of instruments discussed or applied elsewhere. We found that there was widespread recognition by all stakeholders on the need to reduce risk on the landscape and agreement on what those risks were. However, issues of perceived equity and existing policies impede the ability to work collectively. While some resources are required, it was not seen as the main barrier, and case studies identified ways in which both planning efforts and implementation activities could be financed from those enjoying the benefits of risk reduction. However, barriers to moving forward involved establishing a new risk sharing framework; finding ways to work outside of the forestry sector to realize the broader landscape benefits; and overcoming jurisdictional silos within Provincial governments. These issues of equity and integration are also true for the need to work more effectively between different scales of government; there are actions local governments can take to better mitigate risk in the wildland urban interface, but rather than imposing any such requirements, the role of higher levels of government were seen in supporting local government by disseminating information and promoting awareness, rather than imposing mandates. Changing risks over the longer-term emerged as a consistent theme, and highlighted in particular a clear divergence between the objectives of private parties and the Provincial government emerges, due to the split incentives under the current system. Here the need for a re-evaluation of the current risk sharing framework between the two parties was seen as essential, as well as the need to start reassessing policies to recognize where some risks are now becoming endogenous (i.e. due to existing policies and are not all exogenous).

Clear recommendations emerge for the different levels of government. For the Province, while the need for integrated resource management on the Provincial land base has been acknowledged as necessary to reduce conflict and cumulative effects, there has been little progress in this regard, in large part because of the scale and scope of the policy changes required to achieve that kind of management. However, climate change related impacts (such as wildfire) that cut across sectors and the risks that emphasize the importance of identifying the collective benefits to different parties from collaborating to mitigate those risks (and share costs). So while the province may not necessarily move towards integrated land management in the near future, at the same time these growing risks highlight government's key roles as owner and regulator and the need to provide the institutional and political support and vision within such collaboration can take place. More specifically, the wildfire case study, underpinned by the experience of other jurisdictions dealing with wildfire risk (Western US and Australia), identify fuel management and addressing increasing fuel loads as critical issues that need to be addressed. The Provincial government has to identify these as a priority before action can take place.

Other levels of government can also contribute. The Federal government, and agencies such as the Canadian Forest Service (CFS), have extensive research experience and capacity, which is required to help support science-based activities such as climate based seed transfer (given the strong scientific component that is necessary to support the use of such an instrument), as well as support for knowledge, not only among Provinces but also with other jurisdictions such as the US). A similar role exists for the CFS in supporting research and policy development for fire risk, given its strong history in researching fire and fire management. There is also an important communication and information dissemination role for the Federal government to play in promoting awareness (for example, drawing form the development permits and wildfire case study on providing information to homeowner and local governments on actions they can take to mitigate those risk).

Finally, there are also benefits from the Economics Working Group of Canada's Adaptation Platform on identifying possible synergies between some of the instruments identified in the case studies and risks to forest values that could be translated to other sectors and resource settings, such as the use of development permits and sea-level rise, and where it is important to facilitate more proactive investment by private parties on public lands (e.g. roads, energy infrastructure). In addition, there are also benefits from identifying where further development of analytic techniques, such as Cost-Benefit analysis, can be further adopted to better illustrate the issues involved in facilitating and enhancing adaptation (as is revealed through the Climate-Based Seed transfer case study where the principal agent problem is a potential barrier to planned adaptation activities).

Background

Climate change is expected to have significant impacts on Canada's forests including negative impacts such as increased frequency and severity of wildfire, pest and disease outbreaks and changes in ecosystem dynamics (tree regeneration, growth and mortality) that lead to maladaptation of tree species. These types of impacts can have wide-ranging economic, environmental and social consequences. In the field of risk management, priorities are established by estimating the level of risk as a product of "consequence" (i.e. impact) and probability, as follows (Climate Impacts Group 2007):

$$Risk = Consequence \times Probability$$

Thus, the level of risk is related to both the economic, social, cultural and legal consequences of an impact and the likelihood of that impact. Adaptation involves undertaking activities to better prepare for those impacts such as assessing the risks of those impacts, planning for them and identifying and implementing mitigative or preventive measures.

The nature of forest management in Canada, where many management decisions are delegated to the private sector that also carries out most of the operational activities, means that the private sector will play a significant role in adaptation. Moving forward on adaptation requires understanding how to best engage the private sector. Economic instruments offer an alternative to command and control approaches; where properly designed, previous experience has shown that they can provide more efficient and cost-effective ways of meeting environmental objectives. However, there has been little work done in this area to identify how instruments could be applied in regards to adaptation.

The term "economic instruments" has traditionally referred to the range of tools and approaches that operate on a more decentralized basis by increasing the cost of more environmentally damaging activities while increasing the return from more sustainable activities. More recently, these financial and market-based approaches have expanded through the consideration of behavioural and informational mechanisms that can be used to improve decision-making. The benefits of economic instruments relative to regulatory approaches are that they offer increased flexibility, may require less regulatory expenditure and, in some cases, can raise revenues that can be used to achieve policy objectives. Oftentimes, there may be regulatory changes required to support the instruments.

However, there are challenges in moving from theory to practical application of economic instruments, including identifying the appropriate tools and ways that they can be integrated into existing regulatory structures (UNEP 2004). Other policy constraints, such as political factions, legal gaps and institutional weaknesses, may also affect which types of tools that can be used. Examination of economic instruments and the benefits that they can potentially provide therefore requires consideration of the broader policy and institutional context in which they will be applied. The purpose of this project was to then address this gap and identify where such instruments could be used, looking specifically at the forestry sector and forest resources in BC.

Introduction

The *Economic Instruments to Support Adaptation to Climate Change in Forestry* project explored how different types of economic instruments (e.g. financial, behavioural, and informational) could be adopted to forest management to encourage forest managers, licensees and communities to take a pro-active approach to addressing the risks of climate change to Canada's forests. The goal of this research was to identify economic instruments that could support adaptation of Canadian forests to climate change by drawing on the experiences and efforts taken to date in leading jurisdictions across Canada and around the world. The research was organized around the following three important policy objectives of the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO):

1) Reducing both the risk of forest fire and the negative impacts that follow from forest fire, especially around protecting communities and infrastructure.
2) Ensuring forest health both in the short-term, by protecting against forest pests, and in the longer-term, by minimizing maladaptation.
3) Promoting forest resiliency that will minimize potential vulnerability to the impact of climate change.

We grounded our research in British Columbia because of the emphasis that the province has placed on integrating climate change into forest policy and management. From here, we expanded our geographic scope to compare approaches to adaptation and associated instruments in BC to those in other Canadian provinces (e.g. Alberta, Ontario) and other countries (e.g. USA, Australia).

The remainder of this report describes how the research was carried out and the results of the research. All reports and materials prepared as part of the project and distributed to participants and interested parties are included as appendices to this report.

The research was grounded in an applied perspective through ongoing engagement of government and private sector practitioners from policy and operational backgrounds using meetings, interviews and workshops. Monthly meetings were held for the duration of the project with a project Advisory Team that consisted of six representatives from four Branches of the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and one representative from the Climate Action Secretariat of the BC Ministry of Environment. These meetings were used to obtain feedback on an ongoing basis regarding the research questions, research progress, potential interviewees, relevant literature, draft documents, workshop design and workshop participants. The research was conducted in two main phases between October 2013 and December 2014 (Figure 1), where the outputs form phase 1 were targeted to feed into phase 2.

Phase 1: Interview summary and literature review (Annex 1) (October to December 2013) included a review of the goals of policy makers and forest managers and the most important risks to those goals. Potential instruments (i.e. financial, behavioural, informational and regulatory) were then identified in the context of measures to be considered in mitigating those risks.

Phase 2: Case studies (Annex 2) (January to October 2014) focused on three case studies of economic instruments to support adaptation to climate change in British Columbia's (B.C.'s) forests. Case study 1 explored the use of local government development permits (informational and regulatory instruments) to control the extent, nature and location of new residential development in the wildland-urban interface (WUI), address the risk of loss from wildland fire and ensure that communities are safe places to live, work and play. Case study 2 examined the economic implications to provincial government and private sector actors of using climate-based seed transfer (CBST) to implement assisted migration of commercial tree species by ensuring that seedlings planted following harvest are adequately adapted to the future climate. Case study 3 identified incentives to support collaborative wildfire planning and management (informational, financial and regulatory incentives) between different stakeholders across the landscape including First Nations, provincial and local governments and forest licensees.

Interviews were used to assess the current state and leading edge of instruments to support climate change adaptation within and across jurisdictions during both Phases of the research. The Phase 1 and 2 reports are structured so that they may be read and distributed as stand-alone documents; therefore, some content is re-stated in both reports. The full Phase 1 report can be found in Annex 1; the full Phase 2 report, consisting of all three case studies, can be found in Annex 2.

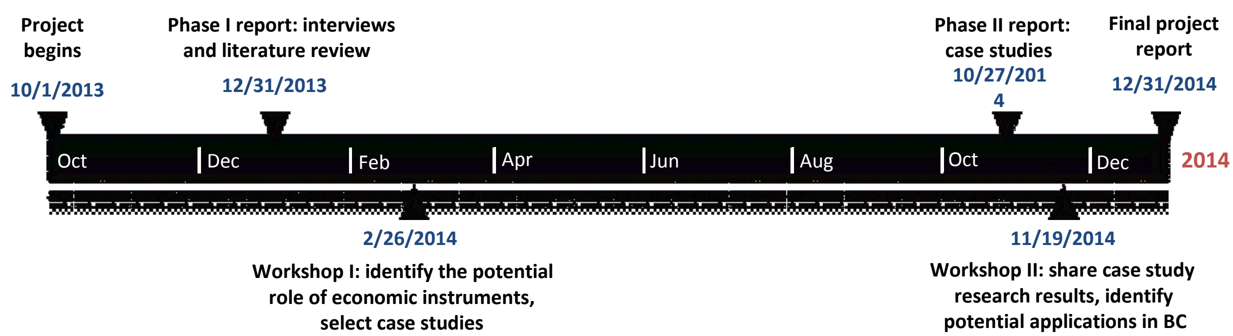

Figure 1. Economic instruments project timeline.

Workshops were used to explore potentially appropriate applications of economic instruments in BC, select case studies of interest, verify the research results from both Phases 1 and 2 and engage policy and operational practitioners in discussions about possible frontiers in climate change adaptation. Summaries from workshop 1 and workshop 2 can be found in Appendix 3.

Interview summary and literature review

The interviews revealed conflicts between the major objectives of private forestry operators, who access timber harvesting opportunities through short- to medium-term licenses; and provincial forest managers, who retain ownership and management authority for forest resources.

Forestry operators reported an interest in maintaining access to timber harvesting opportunities, ensuring a secure fibre supply for business operations and complying with government regulations (e.g. regarding planning, harvesting and reforesting). Climate-related wildfire risks are only considered important where they may have a direct impact on timber harvesting opportunities; risks due to pests and maladaptation are not viewed as a licensee responsibility.

In contrast, provincial policy developers viewed all three risk areas (i.e. fire, pests and maladaptation) as important, but tended to focus on their own specific organizational responsibilities. One consequence of this approach is a focus on individual resource values and a lack of integration across values and among the different actors; there is no process (within government) by which to prioritize these different values or systematically assess trade-offs.

Some government policies were seen as directly influencing licensee decisions including the tenure system, which influences investment certainty; timber pricing system, which influences the economics of timber harvesting and approach to silviculture; and stocking standards, which affect reforestation decisions. Other government processes had lesser influence on decisions; these included the Timber Supply Review (TSR) and Forest and Range Evaluation Program (FREP), which provide information to statutory decision-makers who can then influence policy or administrative decisions.

Interviewees suggested several policies and programs to address challenges that exist within the current forest management system and future climate-related risks, including utilizing area-based rather than volume-based tenure agreements; implementing mechanisms for coordinating landscape-level activities; and introducing a program to provide information about selecting enhanced seed. Innovative suggestions included developing a program for Vulnerability Reduction Credits, incorporating adaptation into voluntary forest certification programs and trialling stewardship contracts (as used by the US Forest Service) to create more resilient forests through stand and landscape treatments.

No instruments for consideration emerged out of the literature review, likely reflecting in part the nascent development of these tools and difficulties in adapting them to the policy context, especially given the public land/private actor context; where many of the planning tools had a strong regulatory component. There was some evidence of communication and framing as supporting more adaptive management actions (i.e. prescribing burning as a way to promote forest health) that was seen as more likely to elicit a favourable public response, but few other examples of any such behavioural instruments.

The only instrument reviewed in the literature to receive consideration was the idea of stewardship contracts a used in the US on public lands; as well there was some interest in how insurance rates could be structured to promote adaptation by homeowners, but while it is being trialled in the US, no insurance companies in Canada were willing to consider it and so it was not given further consideration (despite ongoing interest in it).

During the first workshop, participants expressed particular concern about risks of wildfires to communities and impacts of wildfire, pests and maladaptation on future timber values. The area-based tenure concept was re-imagined in terms of a need for broader collaborative planning and management to support achievement of landscape-level objectives. Participants also expressed interest in managing wildfire risks in the wildland-urban interface using fire break tenures or tiered insurance or development charges; managing pest risks through targeted harvesting of priority areas or increased monitoring, supported through a trust fund; and managing maladaptation risks using Climate-Based Seed Transfer and communications tools to provide information about adaptation practices to practitioners. These then formed the basis for the instruments considered in the case studies.

Case studies

The process by which the case study topics and instruments were refined consisted of discussions with both sets of advisory board members, who were each asked as a separate group to rate those risks they saw as most important and within it the sets of instruments in which they had most interest (in many cases a specific instrument tied to a risk had emerged as a potential case study topic coming out of the first workshop). In some of the case studies, it was seen that the potential instrument could have broader application beyond mitigating the more narrowly defined risk (i.e. funding to support actions to reduce wildfire risk on the landscape could in theory be applied to addressing pest and disease risk). This then led to a ranking of each group that the researchers then synthesized and compared across the groups to refine both the topic and instruments. This then led to a summary of the proposed case studies that was presented to the advisory boards that agreed with the approach (see Annex 2, *Introduction to Case Studies*).

Each of case studies addressed a specific risk (i.e. wildfire, maladaptation), selecting instruments that were determined in consultation with both sets of advisory group members as most promising. Given the interest in fire, two of the case studies addressed fire risk but from a different perspective: one from a community perspective, examining efforts to address fire risk within communities as well as at the Wildland Urban Interface (WUI) using development permits and other tools available to local governments; and the second looking at wildfire risk operating on Provincial forestland and taking a Provincial perspective, utilizing collaborative approaches to planning and other mechanisms to coordinate activities. The third case study considered using assisted migration to address the risk of maladaptation, undertaking a cost-benefit analysis of a Climate-Based Seed Transfer program. This topic was influenced in part by the external funding requirements.

Wildfire Risk and Development Permits

Development Permits are planning tools that local governments can use to manage development, protect the environment and address local health and safety issues. The case study identified more than a dozen communities in British Columbia and Alberta that had begun to use Development Permits to control the extent, nature and location of new residential development in the wildland-urban interface (WUI). The case study identified that the use of local government planning tools to address wildfire is likely to spread across Canada. Local government regulations from Nelson, Swan Hills and the District of North Vancouver could provide specific examples of planning regulations for other communities across Canada. During the workshop, participants noted that Development Permits may be cost-prohibitive in rural areas and that implementation of this instrument should remain voluntary for local governments. Instead, the best opportunities here are to promote awareness and help educate both homeowners and local elected officials. Reduced home insurance premiums for private landowners who fireproof their properties was also suggested to encourage adaptation but it was recognized that at the current time the insurance industry does not offer such a program.

Maladaptation and Climate-Based Seed Transfer

Climate-based seed transfer (CBST) is an innovative program to implement assisted migration of replanted commercial tree species in BC by selecting non-local seed sources that are adapted to the range of projected future climates at the planting site. Cost-benefit analysis showed that assisted migration could generate net economic benefits to both the provincial economy and to government revenues due to the potential to reduce the long-term risk of plantation failure. However, as private-sector resource tenants on crown land, forest licensees were found to be highly sensitive to real or perceived increases in short-term regeneration risks, despite these risks being eclipsed by the potential for longer term economic gains. Therefore, accounting for regeneration risk will be a central challenge in engaging licensees as partners in the implementation of CBST. The principal-agent problem was identified as an issue affecting how much adaptation might take place, given the different perspective of private actors versus the provincial government and the incentives they face. Monitoring of the impacts of assisted migration on regeneration success was identified as a fundamental requirement to managing perceptions of risk and also to equitable risk-sharing between licensees and government. Workshop participants re-iterated this concern and identified the need for a formal risk-sharing framework between government and licensees and the guidance necessary to support professional reliance.

Wildfire Risk and Collaborative Planning Approaches

Collaborative approaches to wildfire planning and management are being implemented in BC, Canada; Victoria, Australia; and the USA. Each of these jurisdictions offers insights into ways of addressing the dual challenges of coordinating multiple stakeholders and funding planning and actions to reduce risk across the landscape. Funding mechanisms range from full government support, to preferential government support where funds are matched (e.g. at the State level), to levies on timber harvested by private forestry operators. The case study explored the potential use of additional levy on stumpage in British Columbia as a way to generate funds for adaptation. While several challenges to implementing such a levy were noted during the workshop, there was broad support for new pilot programs for wildfire adaptation in high-risk areas with the intention to expand to broader landscape planning considerations and other climate-related risks (e.g. pests, maladaptation) in the future. The need for broader engagement of beneficiaries beyond the forest sector and government funding to support such pilots was emphasized.

Several of the criteria identified in the first workshop emerged as prominent themes in the discussions around each case study with two as the most important: *effectiveness* (establishing clear causal linkages between the action and intended outcome) and *equity* in terms of distributional impacts. This latter emerged as a more important issue than cost; in other words, it was changes in who might be bearing risks or changes in roles and responsibilities without commensurate recognition rather than the costs of those activities that was seen as the more pressing issue. Beyond those, it was difficult to identify more specific indicators that were common to each case study, especially when they involved different actors (local homeowners and governments versus the Provincial ministry and licensees).

Conclusions

The project took the approach of analyzing potential instruments within the existing governance and policy framework in British Columbia. Instruments considered through the literature review and assessed through the case studies spanned all the different kinds of instruments, including: financial instruments (for example, looking at issues of risk-sharing and rethinking public-private partnerships); behavioural and informational instruments (communicating increasing risks to home-owners or other stakeholders or facilitating action through lowering individual cost of fire-proofing private property to incorporating climate change considerations into planning processes by both licensees and government as well as forest certification bodies); and finally governmental instruments (using cost-benefit analysis to analyze incentives and changing risk profiles of current policies vs. assisted migration policies).

One consequence of examining existing systems was that the instruments that were selected for further investigation were those that could be applied under the current system without considering those that might require more fundamental changes to the system (i.e. changes in rights or introduction of market-based mechanisms, such as creating markets for new types of goods related to achieving adaptation objectives). This approach also revealed common crosscutting institutional elements that influenced both the consideration of a particular tool (or set of tools) to promote certain actions (such as facilitating stand treatments or altering regeneration strategies) and the effectiveness of such actions. While these appeared in the context of the instruments evaluated, they also reflect more systemic issues in making and developing new policies more generally. A fundamental issue is the divergence between the different management objectives of the major actors within the system, principally government and licensees, and the different time frame and planning horizon under which they are making decisions. Compounding these are well-recognized issues under the current forest management system (difficulties in coordinating activities, a lack of long-term incentives within Timber Supply Areas that make up much of the Provincial land base and intra-jurisdictional silos) that have also limited the ability to shift the current system away from its historic timber-centric focus towards management for a broader range of forest values.

The case studies and workshop results revealed ways in which these issues could start to be addressed without necessarily requiring a system-wide change. This was especially clear in that all the case studies highlighted the consensus that a new risk-sharing framework between government and the licensees was needed that also took into account the risks faced by other stakeholders. In doing so, such a framework would allow the incorporation of the wider set of values at risk that could help motivate action by identifying the benefits and who would benefit (and conversely, the costs from not undertaking those actions). This latter point was emphasized in the case study investigating wildfire, where changing climates are already increasing fire-related risks and putting decision-makers in positions of having to trade-off protecting timber against community health and safety and infrastructure. Information already developed through existing modeling efforts can be used to prioritize areas and values at risk; one outcome of this is that it identifies the wider benefits from reducing these risks and thereby supports broader engagement from a wider range of stakeholders, including not only those affected but the potentially the broader public. These shared co-benefits can then support both collaborative planning and the introduction of tools and instruments to carry out risk reduction activities and contribute to funding those activities where necessary. This risk-sharing framework was also seen as essential as it highlighted the changing profile of risks over time, including the costs and benefits from adaptation actions and the distributional consequences of changing existing policies or introducing new tools that would influence acceptance or uptake. For example, the wildfire and assisted migration case studies illustrated that differences in types of risk, time frame and action could have different motivational effects; for example, private sector actors may be more motivated where the benefits (i.e. reduced fire risk) are more immediate and where they may be able to enjoy some of those benefits through reducing the risk around harvesting activities; elsewhere, the longer- time frame associated with adaptation actions where the benefits accrue far in the future (i.e. enhanced forest resilience for future forests) may offer less immediate benefit and government may need to assume greater responsibility.

One other benefit of the development of a risk-sharing framework is that it would provide the basis for a risk communication strategy that would help support further actions, both for policy change but also motivating action whether by government, practitioner, licensee or other stakeholder. This came out strongly in the case study looking at development permits and community wildfire risk, where there were both opportunities to change individual behaviour as well as to change existing development patterns that have historically not taken fire-related risks into account.

Second, this focus on the costs (and benefits) of adaptation activities points towards another key question of whether or not positive incentives are needed to encourage adaptation. The case studies and interviews revealed that the lack of positive incentives was not necessarily a key issue in limiting adaptation action; instead, it was concerns about the disincentives created if these increased costs were not recognized or if they created inequities (whether or not an actor undertaking an activity may be penalized relative to others). Opportunities exist to address these concerns; for example, parties may voluntarily undertake such actions where the opportunity exists to offset those increased costs even if there is no direct immediate benefit (for example, funds raised within a specific areas to support activities designed to reduce longer-term risks that could range from stand treatments to longer-term monitoring efforts), or transition plans to address increasing costs associated with changes in planting regimes (where the system is designed to recognize those costs over the long-term but not in the short-term). Another example is that for the proposed pilot around collaborative planning, where the difficulty was not in the resources required but instead making it a priority (rather than treating it as an additional responsibility).

At a more systematic level the project revealed the importance of working across the jurisdictional boundaries (both within government) and across the different groups to identify promising approaches and tools (where this involved government, licensees, professional foresters and other stakeholders, including community representatives). For example, the second workshop results revealed that while many of the participants recognized the difficulties in introducing these ideas into practice that the resources, expertise and ability to start making some of these changes already exists such as for the proposed pilot around wildfire.

More specific recommendations for individual case studies included sharing information (such as case studies of communities using development permits and providing examples of model bylaws to reduce fire risk), which was seen as highly effective. These observations are consistent with other examples of innovation, where efforts to encourage early adopters can help facilitate longer-term uptake by others of new strategies, ideas and tools. For the Assisted Migration case study, participants identified linkages between the need for monitoring, better information and increased availability of information for both foresters and licensees to make better decisions. Operational trials are important to building this knowledge, as is a robust monitoring scheme that currently has gaps.

We found that there was widespread recognition by all stakeholders on the need to reduce risk on the landscape and agreement on what those risks were. However, issues of perceived equity and existing policies impede the ability to work collectively. While some resources are required, it was not seen as the main barrier, and case studies identified ways in which both planning efforts and implementation activities could be financed from those enjoying the benefits of risk reduction. However, barriers to moving forward involved establishing a new risk sharing framework; finding ways to work outside of the forestry sector to realize the broader landscape benefits; and overcoming jurisdictional silos within Provincial governments. These issues of equity and integration are also true for the need to work more effectively between different scales of government; there are actions local governments can take to better mitigate risk in the wildland urban interface, but rather than imposing any such requirements, the role of higher levels of government were seen in supporting local government by disseminating information and promoting awareness, rather than imposing mandates. Changing risks over the longer-term emerged as a consistent theme, and highlighted in particular a clear divergence between the objectives of private parties and the Provincial government emerges, due to the split incentives under the current system. Here the need for a re-evaluation of the current risk sharing framework between the two parties was seen as essential, as well as the need to start reassessing policies to recognize where some risks are now becoming endogenous (i.e. due to existing policies and are not all exogenous).

Next steps

Clear recommendations emerge for the different levels of government. For the Province, while the need for integrated resource management on the Provincial land base has been acknowledged as necessary to reduce conflict and cumulative effects, there has been little progress in this regard, in large part because of the scale and scope of the policy changes required to achieve that kind of management. However, climate change related impacts (such as wildfire) that cut across sectors and the risks that emphasize the importance of identifying the collective benefits to different parties from collaborating to mitigate those risks (and share costs). So while the province may not necessarily move towards integrated land management in the near future, at the same time these growing risks highlight government's key roles as owner and regulator and the need to provide the institutional and political support and vision within such collaboration can take place. More specifically, the wildfire case study, underpinned by the experience of other jurisdictions dealing with wildfire risk (Western US and Australia), identify fuel management and addressing increasing fuel loads as critical issues that need to be addressed. The Provincial government has to identify these as a priority before action can take place.

Other levels of government can also contribute. The Federal government, and agencies such as the Canadian Forest Service (CFS), have extensive research experience and capacity, which is required to help support science-based activities such as climate based seed transfer (given the strong scientific component that is necessary to support the use of such an instrument), as well as support for knowledge, not only among Provinces but also with other jurisdictions such as the US). A similar role exists for the CFS in supporting research and policy development for fire risk, given its strong history in researching fire and fire management. There is also an important communication and information dissemination role for the Federal government to play in promoting awareness (for example, drawing form the development permits and wildfire case study on providing information to homeowner and local governments on actions they can take to mitigate those risk).

Finally, there are also benefits from the Economics Working Group of Canada's Adaptation Platform on identifying possible synergies between some of the instruments identified in the case studies and risks to forest values that could be translated to other sectors and resource settings, such as the use of development permits and sea-level rise, and where it is important to facilitate more proactive investment by private parties on public lands (e.g. roads, energy infrastructure). In addition, there are also benefits from identifying where further development of analytic techniques, such as Cost-Benefit analysis, can be further adopted to better illustrate the issues involved in facilitating and enhancing adaptation (as is revealed through the Climate-Based Seed transfer case study where the principal agent problem is a potential barrier to planned adaptation activities).

From an academic perspective, the research revealed the importance of developing tools to better allow the assessment of the benefits of proactive adaptation around risk reduction versus the costs of not taking action. Another example (taken from the landscape wildfire study) would be better identifying the tradeoffs between expenditure son fire suppression versus preventing or reducing fire risk. These tools and methods would strengthen policy analysis and development but will also require closer policy attention to help develop those tools and techniques.

Finally, while these case studies and project focused on specific instruments or tools that could be applied, they also revealed that this collaborative approach to assessment of adaptation needs and policy and management actions is a productive way to promote adaptation actions, through strengthening the adaptive capacity of the actors and system itself, overcoming in part some of the institutional weaknesses currently present where actors are responding to different sets of incentives despite having ultimately a common interest in enhancing the resilience of Canada's forests.

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Annex 1. Phase I: Interview summary and literature review

Economic instruments for adaptation to climate change in forestry

Phase I: Interview summary and literature review

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Executive summary

Climate change poses important risks to the values we derive from our forests due to increasing risks from fire, pests and maladaptation. In order to maintain those values or reduce potential future losses, one important way is to help British Columbia's (BC's) forests adapt to a changing climate, by finding ways to mitigate these risks.

This document provides background information about the existing management context of publicly owned BC forests including the perspectives of the major actors (i.e. policy developers and implementers, industry associations and forestry operators) on current forest management objectives and perceptions of climate-related risks. It includes actors' perspectives on existing decision-making processes, key decision points for adaptation and potential opportunities to apply economic instruments to support adaptation. These ideas are supplemented by an extensive literature review that provides examples economic instruments (some proposed, others in place) that have the potential to address the three major risks (fire, pests and maladaptation) of climate change to forests. We also outline a set of criteria that have been proposed to evaluate different types of economic instruments when considering implementation.

This information is drawn from a series of structured interviews with policy developers and implementers from the provincial government, representatives from industry associations and forestry operators (e.g. consultants, licensees) in British Columbia; conversations with experts in different domains; and a literature review.

The existing forest management system in BC relies on a model in which ownership of land and forest resources remains with the Province (the "Crown") while access to timber harvesting opportunities is granted to private forestry operators through short- to medium-term licenses, many of them renewable. Management activities are delegated to forestry operators who work within a complex framework of regulations set by government (e.g. legislative and administrative) that are designed to maintain environmental and social values. A notable exception are those forestry activities carried out by BC Timber Sales, a business unit within government that develops and prepares timber harvesting opportunities within the timber sale program.

Within this context, the major objectives of forestry operators are to maintain access to timber harvesting opportunities and ensure a secure fiber supply. Climate-related risks are only considered important where they may have a direct impact on timber harvesting opportunities and, of those, fire risk is the most important; risks due to pests and maladaptation are not viewed as a licensee responsibility. Policy developers viewed all three risk areas as important, although those with specific responsibilities in a particular risk area tended to view that risk as most important (i.e. reflecting their organizational priorities). In summary, there are significant differences between industry and policy developers regarding their management objectives, the risks to meeting those objectives and the assignment of responsibility for mitigating those risks.

The important decisions for forestry operators relate to planning, harvesting and reforesting. Again, the emphasis for forestry operators is on identifying timber harvesting opportunities, securing rights to harvest that timber and maintaining timber flows while complying with government regulations. Policy developers focus on their own specific organizational responsibilities or, in the case of information providers, supplying information within that organizational area to the appropriate decision-makers. One consequence of this approach is a focus on individual resource values and a lack of integration across values and among the different actors; there is no process (within government) by which to prioritize these different values or systematically assess trade-offs.

Several important government policies were seen as directly influencing licensee decisions including the tenure system, which influences investment certainty; timber pricing system, which influences the economics of timber harvesting and approach to silviculture; and stocking standards, which affect reforestation decisions. Other government processes had lesser effect; these included the Timber Supply Review (TSR) and Forest and Range Evaluation Program (FREP), which provide information to statutory decision-makers who can then influence policy or administrative decisions.

Several policies and programs were suggested to address challenges that exist within the current forest management system and future climate-related risks, which have the potential to exacerbate existing shortcomings. Suggestions included enhancing or expanding existing approaches or implementing new approaches that have either been utilized in other regions or have not yet been tested elsewhere. Examples of existing programs included utilizing area-based rather than volume-based tenure agreements; implementing mechanisms for coordinating landscape-level activities; and introducing a program to provide information about selecting enhanced seed. Innovative suggestions included developing a program for Vulnerability Reduction Credits and incorporating adaptation into voluntary forest certification programs. The literature review also provides a summary of various economic instruments that have either been proposed or applied to manage risks in forestry, agriculture and land use. These instruments are organized by type and risk area to facilitate comparison.

Together, these ideas, proposals and examples are provided to spur discussion and selection of instruments to explore through case studies within each of the risk areas. Supplementing the discussion of potential instruments is a set of criteria by which to evaluate these instruments, drawn from the interviews and literature review.

Contents

List of acronyms

ABCFP	Association of British Columbia Forestry Professionals
ADM	Assistant Deputy Minister
DFAM	Defined Forest Area Management
FGC	Forest Genetics Council
FPPR	Forest Planning and Practices Regulation
FREP	Forest and Range Evaluation Program
FRPA	Forest and Range Practices Act
FSP	Forest Stewardship Plan
IFPA	Innovative Forest Practice Agreement
MPB	Mountain Pine Beetle
TFL	Tree Farm License
TSA	Timber Supply Area
TSR	Timber Supply Review

Introduction

The future of British Columbia's forests in a changing climate is characterized by increasing risks of fire, pests and maladaptation. Forecasts of climate change indicate increasing average temperatures, changes in precipitation patterns and increasing frequency of extreme-weather events (Day & Pérez 2013). Climate change will create changes in microclimates, local site conditions, disturbances (e.g. fire, insects, disease, drought, extreme storms), phenology (i.e. the timing of biological activity over a year in relation to climate) and the distribution, abundance and ecosystem interactions of invasive species.

Experts anticipate the following priority risks to British Columbia's (BC's) forests in a changing climate:

- Forest fires are expected to be more frequent and more intense in the southern half of BC and in the Taiga Plains, but less important in other areas of the province (Houghian et al. 2012);
- Forest insects and fungal pathogens are expected to more fully occupy the current range of their host tree species and expand ranges northward and to higher elevations along with their hosts. More frequent and more detrimental pest outbreaks are expected in some regions when several years of favourable weather align, which is more likely under current and projected climate trends (Houghian et al. 2012); and
- Maladaptation is expected to occur where the rate and magnitude of changes in the local environment to which species are adapted occurs at a rate exceeding that at which tree species can naturally adjust (i.e. acclimatize, adapt and migrate) to changing conditions (Johnston et al. 2011).

In the field of risk management, priorities are established by estimating the level of risk as a product of "consequence" (i.e. impact) and probability, as follows (Climate Impacts Group 2007):

$$Risk = Consequence \times Probability$$

Thus, the level of risk is related to both the economic, social, cultural and legal consequences of an impact and the likelihood of that impact. However, due to differences in perceptions of responsibility for the consequences of fire, pests and maladaptation between policy developers and forestry operators. within BC, these risks are prioritized and managed differently by various actors in the forest industry. The BC Government, as the owner of 96% of commercial forest land within the Province, has the fiduciary responsibility to be a steward and account for the multiple values of the forest while providing adequate long-term timber supply to sustain forest dependent communities (Bogle and van Kooten 2012). Forestry operators focus on sustaining their commercial operations; their planning horizon may be short- or long-term, depending on the types of timber tenures under which they operate, capital investment and strategic focus. Ultimately, the Province, as the land owner, bears the long-term consequences for impacts under climate change.

Forest policy developers and implementers have the challenge of balancing environmental values with economic ones while developing a framework for forest management to support various forestry activities on the landbase while ensuring that multiple values (many of which are unpriced) continue to be provided over time. Climate change makes the challenge more complex because risks to those values are changing, there is no formal risk evaluation process, relationships between activities and management outcomes may change and objectives are also changing. While there is no simple solution to this challenge, a partnership approach between public and private sectors can be employed to assist in understanding how to best address those risks and identify solutions to help both parties to achieve their objectives.

This research project is organized around the following three important policy objectives of the British Columbia Ministry of Forests, Lands and Natural Resource Operations (FLNRO):

4) Reducing both the risk of forest fire and the negative impacts that follow from forest fire, especially around protecting communities and infrastructure.
5) Ensuring forest health both in the short-term, by protecting against forest pests, and in the longer-term, by minimizing maladaptation.
6) Promoting forest resiliency that will minimize potential vulnerability to the impact of climate change.

The goal of this project is to identify economic instruments with high potential to address climate change adaptation in the forest industry, with a focus on forestry in BC. This includes both identifying existing and potential economic instruments that could be applied and conducting detailed case studies of potential economic instruments with applications to fire, pests and maladaptation.

This document presents preliminary research conducted from October-December 2013 regarding the potential applications of economic instruments to support adaptation to climate change in British Columbia's (B.C.'s) forest industry. Information is presented in two Parts:

Part A: Interview summary synthesizes the results of 20 interviews conducted with policy developers and implementers from the provincial government, representatives from industry associations and forestry operators regarding current forest management objectives, existing decision-making processes and key decision points for adaptation, perceptions of climate-related risks, effective policies and programs and opportunities to apply economic instruments to support adaptation.

Part B: Literature review provides a summary of examples where economic instruments have been implemented to address risks not only in the forest industry, but also in agriculture and land use. The literature included sources and examples recommended by five experts in the field of climate change adaptation and the 20 interviewees.

The intention of this document is to stimulate thinking about how existing or innovative economic instruments could be applied to the three climate-related forest risk areas upon which this project is focused: fire, pests and maladaptation. The contents of this document will provide a foundation for selection and investigation of three detailed case studies of potential economic instruments for analysis during the subsequent phase of this research project, from March-December 2014. This information, as well as information from the case studies, will be made available in a final project report, to be completed by the end of December 2014.

Background

FLNRO has undertaken some initial steps to address the challenge of climate change. First, it has outlined several priority areas where actions could be implemented on the timber harvesting landbase to help BC's forests adapt to climate change in its *Forest Stewardship Action Plan for Climate Change Adaptation 2012-2017.* More specific actions are described in the "Memorandum re: Consideration of Climate Change When Addressing Long-Term Forest Health in Stocking Standards" and the Guidance document "Silvicultural Regimes for Fuel Management in the Wildland Urban Interface or Adjacent to High Landscape Values" as well as other documents available on the FLNRO website.[1] These actions include the following:

- Build fire-resilient landscapes: Conduct landscape wildfire risk assessments, and implement treatments for fire resilient landscapes on priority areas.
- Undertake silvicultural treatments to influence stand structure and, thus, wildfire behaviour and severity.[2]
- Support assisted movement of species into biogeoclimatic zones/subzones where they are not currently considered as preferred or acceptable (i.e. establishment of 'non-conventional' species).
- Encourage increased establishment density to account for the risk of mortality of non-conventional species or specify a reasonable reduction to the free growing stocking density if the reduction is associated with a higher risk of mortality in non-conventional species.
- Encourage conifer mixes when conifer management is the chosen strategy.
- Develop strategies at the TSA level to address climate change considerations at scales broader than the stand. Include landscape level species strategies that consider both the free growing stage and past free growing.
- Devise an approach to free growing that ensures all harvested stands are stocked with healthy crop trees at age 20.
- Incorporate diversity and ecosystem resilience principles into BC forest carbon project opportunities and help leverage investments into public forest lands.
- Develop approaches for incorporating climate change into inputs for timber supply analysis.
- Find ways to ensure adaptation is built into management of other values such as riparian, streams and water quality and practices such as road standards, slope stability, etc.

These areas encompass desired outcomes (e.g. fire resilient landscapes) and strategies (e.g. species diversification) that are known to mitigate risks or enhance a forest's ability to adapt to climate change impacts.

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[1] For a complete list, visit the FLNRO Forest Policy and Guidance webpage at http://www.for.gov.bc.ca/het/climate/knowledge/policy.htm

[2] For details of silvicultural practices see: Resource Practices Branch (no date) Silvicultural Regimes for Fuel Management in the Wildland Urban Interface or Adjacent to High Landscape Values – Guidance.

The challenge is to i) articulate desired outcomes (e.g. maintain harvest level, age class distribution) and how they may be assessed; ii) identify risks to those outcomes and/or values; iii) determine how to mitigate risks; and iv) identify a particular strategy and/or action to mitigate risks. Guidance and context-specific information about potential impacts has been identified as a key issue by forestry operators (ABCFP 2013).

Beyond having identified desired outcomes and strategies and the challenge of selecting strategies, FLNRO now faces the challenge of working with forestry operators to implement the desired actions on the timber harvesting landbase. There are two basic types of instruments that FLNRO can use to motivate these actions: regulatory and economic.

Regulatory instruments (or 'command and control approaches') establish legally-enforceable rules by which forestry operators must abide when engaging in forest planning and management and carrying out forest practices. These instruments establish an acceptable level of performance which all forestry operators must achieve. These can either be "technology-based standards" (requiring all forestry operators to carry out actions in a prescribed way) or performance-based (specifying a certain target outcome that typically has to be achieved (Stavins 2001).

The United Nations (1997) describes economic instruments as fiscal and other economic incentives and disincentives designed to incorporate environmental costs and benefits into the budgets of households and enterprises.[3] They aim to encourage environmentally sound and efficient production and consumption through full-cost pricing such as taxes or charges on pollutants and waste, deposit-refund systems and tradable pollution permits. Where properly designed, economic instruments can provide more efficient and cost-effective ways of meeting environmental objectives (Stavins 2001)[4]. A criticism of regulatory approaches is that firms are only encouraged to meet a minimum, regulated level of performance. With economic instruments, firms have the flexibility to improve their performance as long as they determine it to be in their best interest. Such instruments may still require a regulatory intervention; however, the regulation supports the introduction of an economic incentive or disincentive (e.g. a tax on an input or output that creates environmental damages, such as a Carbon Tax) that is expected to achieve a desired objective more efficiently.

[3] United Nations (1997) Glossary of Environment Statistics, Studies in Methods, Series F, No. 67. New York, USA. http://stats.oecd.org/glossary/detail.asp?ID=723

[4] Stavins discusses market-based instruments designed around achieving environmental outcomes, but notes that there are similar instruments that can be applied to managing natural resources (i.e. quota systems for fisheries, tradable development rights). Economic-based instruments include market-based instruments but add behavioral instruments, which do not necessarily involve changing the economic incentives around decision-making but instead influence outcomes instead around how information is presented and choices can be structured.

Economic instruments are intended to promote autonomous adaptation on the part of individual actors (e.g. forestry operators) and share climate related risks (Bräuninger et al. 2011). However, in contrast to mitigation of climate change impacts (e.g. reducing carbon emissions), there has been little work done to explore potential applications of economic instruments to climate change adaptation (Bräuninger et al. 2011). A description of the types of economic instruments that could be applied can be found in Part B of this document, each preceding a description of the instruments currently in place.

Part A: Interview summary

This section summarizes the results of 20 interviews conducted with policy developers and implementers from the provincial government, representatives from industry associations and forestry operators regarding current forest management objectives, existing decision-making processes and key decision points for adaptation, perceptions of climate-related risks, effective policies and programs and opportunities to apply economic instruments to support adaptation. Table 1 lists the affiliations of each of the interviewees; the number of interviewees affiliated is noted in parentheses. A list of interview questions, by type of affiliation, is included in Appendix I.

Table 1. Affiliations of interviewees, by type of affiliation.

FLNRO	*Industry*
Resource Stewardship Division Harvesting and Silviculture Practices, Resource Practices Branch (2) Strategic Initiatives, Forest Analysis and Inventory Branch (1) Tree Improvement Branch (2) *Tenures, Competitiveness and Innovation Division* Competitiveness and Innovation Branch (4) Forest Tenures Branch (1) *Integrated Resource Operations Division* Wildfire Management Headquarters (1) *Timber Operations, Pricing & First Nations Division* Timber Pricing Branch (1)	Forsite Consulting (1) Kalesnikoff Lumber (1) West Fraser Timber (1) Western Forest Products (1) *Associations* Association of BC Forestry Professionals (1) Association of BC Forest Genetics Council (1) Council of Forest Industries (1) Coast Forest Products Association (1)

Information gained during the interviews is synthesized to provide insights related to the following:

- Objectives
- Decision-making processes
- Perceptions of risk
- Examples of effective policies and programs
- Opportunities to support adaptation

Objectives

Forestry operators' main forest management objectives are to ensure a secure supply of timber and to comply with existing regulations and systems. Removal of access to timbered areas for future harvesting and any constraints that may make it infeasible to harvest are of primary concern.

The forest management objectives of policy developers are many and varied among the different Branches. Broadly, the 2012-2013 Ministry Service Plan commits: "This Ministry will continue to ensure that our natural resources are managed in an environmentally sustainable way to grow a sustainable economy."[5] Specific Branch objectives are related to the following:

- Strategic analysis, statutory decision making and policy development (Forest Analysis and Inventory Branch);
- Conservation and sustainable use of forest and range lands (Resource Practices Branch);
- Conservation of forest genetic resources (Tree Improvement Branch);
- Economic prosperity, land and resource stewardship and safety (Forest Tenures Branch);
- Climate change (mitigation and adaptation), non-timber forest products, forest carbon opportunities and the forest-based bioeconomy (Competitiveness and Innovation); and
- Fire hazards and risks, particularly in and around high-value areas (e.g. communities) (Wildfire Management Branch).

Decision-making processes

Forestry operators' decisions are primarily related to harvesting and replanting to achieve free growing stands as quickly as practicable (e.g. within a 10- to 15-year timeframe) as defined by the Forest Planning and Practices Regulation (FPPR) of the *Forest and Range Practices Act* (FRPA), which specifies that free-growing conditions must be achieved within 20 years. Harvesting decisions are typically guided by what stands offer the highest return and which ones are available (i.e. in the Timber Harvesting Landbase). Forest Stewardship Plans (submitted to the government) describe in general terms the strategies that the licensee must meet/adhere to during implementation of harvesting and forest renewal and how strategic objectives will be met but often lack specificity and measurable indicators. In preparation for harvests, licensees prepare site plans (kept on file by licensees but not submitted to government) and obtain approval for cutting permits.

Legislation in BC requires registered forest professionals to prepare those plans, and professional reliance requires them to certify that they meet principles of good forest stewardship. Foresters are bound by codes of conduct and standard of practice, including a Code of Ethics, in accordance with the *Foresters Act* and bylaws of the Association of British Columbia Forestry Professionals (ABCFP). They must not only meet regulations related to forests and forestry, but also other environmental and planning requirements including the federal *Species At Risk Act*, *Migratory Birds Convention Act* and *Fisheries Act*; the provincial *Wildfire Act* and Regulation and *Environmental Management Act* (for smoke from burning of slash); land designations (e.g. Ungulate Winter Range); planning regimes; etc.

[5] See: http://www.bcbudget.gov.bc.ca/Annual_Reports/2012_2013/pdf/ministry/flnr.pdf

Approval of cutting permits rests with the District Manager but must be issued in accordance with Provincial policy. One interviewee stated that short-term cutting permit authorizations and other approvals and appraisals require considerable time and resources to administer and demand a high degree of government resources. But there was divergence in opinions: another interviewee saw these cutting permits as more of a formality once clearance checks and First Nations consultation have been completed and that any additional costs were covered within the appraisal process (under the tenure obligation adjustment).

In TSAs, replanted timber stands remain the licensees' responsibility until such time as they are declared free-growing. Forest professionals determine when free-growing conditions have been achieved and prepare declarations to FLNRO under the Forest Planning and Practices Regulation (FPPR).

Industry representatives and forestry operators expressed frustration about a lack of harmony among the various requirements and the associated regulators (e.g. smoke and fire are regulated under separate regulations and by different government agencies). They also reported working with a broad range of stakeholders including non-government organizations (NGOs), communities and government representatives to achieve multiple objectives related to visual quality, water quality, watershed integrity and Ungulate Winter Range. Forestry operators reported working frequently with First Nations and communities as important stakeholders.

Government direction is defined by legislation (e.g. *FRPA*, *Forest Act*, *Wildfire Act*) and various key policies including the Chief Forester's Standards for Seed Use and Stocking Standards (both referred to in Provincial legislation) and those related to tenure, appraisal, timber pricing, forest licenses, free-growing requirements and wildfire. Interestingly, the Memorandum "Consideration of Climate Change When Addressing Long-Term Forest Health in Stocking Standards" was not referred to explicitly as influencing decisions during the interviews with either forestry operators or policy developers. Of these policies, tenure and appraisal were reported to be the most rigid and the most significant in terms of influencing behaviour. Forest practices policies and Stocking Standards were reported to be more flexible, but they are constrained by tenure and recognition of additional costs in the appraisal system. Decisions that shape policy and standards are typically made at the executive level (e.g. Chief Forester, Assistant Deputy Ministers) using information and recommendations provided by Branch staff. Implementation of executive policies occurs at the Branch level in accordance with Strategic and Annual plans. There were also differences in opinion about the stringency of requirements associated with Stocking Standards, reflecting some confusion.

Several policy developers expressed that their role was focused on data analysis and delivery of information rather than making decisions, while some reported being responsible for program management, budgeting and communications. However, it is important to note that representatives from operational (e.g. regional) government offices were not included in this round of interviews.

Timber Supply Review

A key analytic task undertaken by the Provincial government is the Timber Supply Review (TSR) that provides information to the Chief Forester who then determines sustainable harvest levels for management units (TSA's and TFL's) on a decadal basis. These harvest levels are then apportioned through the Forest Tenures Branch.

Because of the TSR's long-term planning orientation, it appears to have the potential to be an effective tool to extend licensees' planning and decision-making horizon to encompass longer-term projections, both in TSA's (where licensees are outside the process) but also in TFL's where licensees are involved. Forestry operators appear reluctant to support the incorporation of climate change projections into the TSR because of the degree of uncertainty about how long-term timber availability will impact short-term timber availability; however, improved science-based information could alleviate some of their concerns.

Monitoring and Evaluation: Forest and Range Evaluation Program

The Provincial government currently maintains ongoing programs around monitoring and evaluation of forest management outcomes (i.e. the Forest and Range Evaluation Program, FREP), along with compliance and enforcement activities. FREP, while suffering funding challenges, and lacking key feedback loops to decision-making, has been developing mechanisms by which to generate and disseminate information and make it available to forestry operators, government and other decision-makers to inform policies and practices. As an example, FREP can provide evaluation of licensees' performance within a Timber Supply Area and has started doing so on an individual basis (Bradford 2013).

Perceptions of risk

Interviewees were asked how important the three risk areas associated with climate change impacts (fire, pests and maladaptation) were to their decisions. Interviewees described experiencing a great deal of uncertainty about how risk is assessed on the landscape and who holds the responsibility for those risks. Under the current system, government is predominantly responsible for risks related to fire, pests and maladaptation, particularly in volume-based tenures. Forestry operators are concerned about fire and, to a lesser degree, pest-related risks as they relate to short-term timber availability and feel that their responsibility is to meet regulations, including silvicultural requirements. Thus, they do not feel ownership of climate-related risks beyond impacts to their operations. Forestry operators reported that, on Crown Land, the Crown should be making the biggest investment in mitigating forest risks.

Forestry operators also expressed more concern about extreme events than changes in averages (e.g. precipitation) due to climate change and prefer a cautious, science-based approach to adaptation that allows room to integrate new information. They also reported concern about the potential for drastic government action on climate change without adequate compensation mechanisms in place.

Among policy developers, fire, pests and maladaptation are equally important, with variations in relative importance depending on each interviewee's respective Branch. Thus, the importance of these three climate-related risks (e.g. fire, pests, maladaptation) is perceived differently by forestry operators and policy developers. Policy developers are interested in creating incentives to encourage licensees to adopt more long-term planning and decision-making with respect to forest management (e.g. harvesting, reforestation) because of the effects on the long-term timber profile and risks on the landscape.

Examples of effective policies and programs

Area-based tenures

Several interviewees expressed that licensees' forest management decisions are shaped by different tenure types (e.g. volume-based versus area-based tenures). Where volume-based tenures exist, there are multiple licensees and other actors (e.g. agriculture, recreation) engaged in different activities on the landbase and a licensee's connection with a particular area of the tenure may only be temporary. This can also be true for area-based tenures as well, although the problem of coordinating multiple timber licensees' activities is absent (although forestry impacts will still take place form these other activities). In TSA's, without clearly defined operating areas, this can lead to a gold rush mentality and make any type of long term integrated planning tremendously difficult. For this reason, area-based tenures are believed to offer greater opportunities for longer term, integrated planning and monitoring.

Collaborative planning

Innovative Forest Practice Agreements (IFPAs) were introduced to facilitate enhanced forest management by licensees in TSAs, while Forest Practices Code pilot projects were introduced as ways of testing alternative approaches to meeting forest management outcomes rather than the prescriptive, Code-based system in place at the time. Both programs used several different types of tools (e.g. agreements and pilots) and were introduced with mixed results; not all have been sustained. However, two ongoing examples of forest management stemming from those programs (i.e. an IFPA in Merritt and a pilot project in Fort St. John) introduced new approaches that some interviewees suggested warranted further investigation, as both were based on collaborative planning.

The Provincial government also introduced Defined Forest Area Management (DFAM), which was intended to offer more general tool for licensees a way to move forward on collaborative planning. However, DFAM encountered resistance, in part because of concerns that licensees would be taking on additional obligations without a clear description of what those obligations could entail and how these additional obligations would be funded.

Professional reliance

Both forestry operators and policy developers noted that the professional reliance model under *FRPA* has demonstrated successes. Professional reliance is believed to offer the flexibility necessary to keep up with changing conditions because changes to legislation occur slowly; interviewees also reported high rates of compliance with existing standards and regulations (e.g. Standards for Seed Use, Stocking Standards).

However, other interviewees also noted that a goal of *FRPA* had been to facilitate innovation in forest practices but that these types of practices or ideas have failed to materialize, suggesting that pressures exist on professionals, as employees, to minimize silviculture and reforestation costs to licensees.

Responsibility for regeneration

Several people commented that the shift toward licensee obligation for regeneration has been largely successful (e.g. increased licensee investment in seed orchards) but that there have been unintended outcomes (e.g. over-reliance on pine as a reforestation species). Interviewees reported that, over time, ratcheting down of allowed costs through the appraisal system has reinforced a focus on minimizing costs. Therefore, identifying ways in which these types of policies can be adjusted to account for unintended outcomes could increase their effectiveness.

Climate-Based Seed Transfer

Several interviewees reported the success of the Climate-Based Seed Transfer (CBST) program. Success is believed to be due, in part, to the partnership approach used to develop and refine the program. The Tree Improvement Branch works closely with the Forest Genetics Council (FGC) of B.C., which provides oversight to the CBST program through strategic and business planning processes. The FGC includes technical advisory committees from the Coast and Interior regions for certain program areas (e.g. seed transfer and genecology, communication, genetic conservation) and offers a strong community of practice. The Tree Improvement Branch also has strong ties to the Chief Forester because the Chief Forester's Standards for Seed Use are legally-enforceable.

Thus, the Tree Improvement Branch receives direction from the ADM and Chief Forester but also has a parallel process that helps with strategic planning and investment. Both forestry operators and policy developers have been supportive of this process, to the degree that government is having difficulty keeping up with the demand for information. Forestry operators report altering their planting decisions based on information delivered through the CBST program; however, the degree to which decisions are changing is not currently being monitored by government. A need for tracking in order to evaluate program success was identified.

Opportunities to support adaptation

Integrated resource management

Several interviewees were strongly in favour of a collaborative, landscape-level planning process that includes multiple actors and operations on the landbase. Some policy developers did report that they are currently working with other Branches to develop landscape-level objectives and targets because existing targets identify stand-level standards that tie to provincial objectives and do not address other scales (e.g. genetic diversity at the landscape level or management unit). Policy developers expressed optimism that a new policy framework will focus more on the landscape level and will provide flexibility as needed.

A shift toward integrated management was proposed help to share and mitigate risks among actors on the landbase. It was noted that incidence mapping (e.g. where fire has occurred) can help to identify where problems occur but does not mitigate risk; however, these types of maps could be used to identify what species could be planted where and at what density to mitigate risks.

Type 4 Silviculture Strategies were noted as an example of a mechanism to bring all actors together to develop spatially-explicit forest management plans; however, these were reported to be happening only on a portion of the landbase (e.g. areas affected by Mountain Pine Beetle) and include a weak climate change focus.

Interviewees noted the need for policy developers to develop and implement a tool to identify how short-term actions on the landbase can and are changing the risk profile; otherwise, forestry operators will continue to operate within the existing system.

There is clearly interest on the part of forestry operators and policy developers in developing planning processes to manage for multiple forest-related objectives and risks, such as managing buffers for fire risk. These processes could identify ways to share reforestation or silviculture costs with municipalities and other organizations. The West Arm Interface Steering Team (WIST), which is made up of the City of Nelson, Regional District of Central Kootenay, local fire departments, forest companies, Ministry of Forests Lands and Natural Resources Operations, Wildfire Management Branch, Ministry of Environment and BC Parks and other local organizations, was offered as an example of a collaborative approach to risk (i.e. fire) management. This type of project can help to manage wildfire fuel sources on the landscape while reducing carbon emissions associated with burning slash.

Another example of an innovative project in integrated management of multiple values, including timber, was reported to be ongoing at Stella Lake. Here, forestry operators have begun to explore and model possibilities for managing multiple values (e.g. wildlife, water) effectively at the landscape if regulated set-asides are relaxed. This work is ongoing; however, one interviewee felt that preliminary results are encouraging.

Two interviewees noted the use of this type of an outcome-based approach (i.e. regulating for desired forest management outcomes, rather than practices) in Alberta and Saskatchewan. Further investigation of this type of approach may yield specific ideas for future analysis.

Potential applications: Fire, pests and maladaptation

Public-Private Partnerships

One interviewee described a forest carbon partnership program with private sector actors that was launched in March 2013. The Provincial government is responsible for approximately 17 million hectares of forests that were damaged by Mountain Pine Beetle (MPB). The program is focused on re-establishing and restoring these damaged forests by targeting stands that are either at high risk of wildfire or in urgent need of silviculture. It focuses on managing net carbon over the landscape; not carbon sequestered in trees. Private partnership with the Carbon Offset Aggregator Corporation helps the government to achieve replanting and silviculture by providing connections with businesses looking to invest in Corporate Social Responsibility. In essence, the Crown benefits from having trees planted while retaining ownership of the land, but the company retains the carbon benefit. This type of partnership can help to fill the funding gap that currently exists within government for managing forests with respect to climate-related risks (e.g. fire risk or pest and disease treatment).

One interviewee described a proposed land-based silvicultural organization. This concept is modelled after the Stewardship Contract approach in use in the National Forests of the western US[6]. In this model, government would provide a multi-year contract to a company that would confer rights to timber and an obligation to restore the forest to a specified condition. The contract bidding process could result in either a positive sale balance or a negative contract cost for a defined contract area in the range of hundreds to thousands of hectares. This approach was noted to be particularly useful for forests affected by Mountain Pine Beetle, low-value species assortments or high-density stands of low quality and poor growth. The contractor and the industry were reported to benefit from the sale of low-volume or low-value fibre that is recovered through the restoration work, while government benefits by the restoration of degraded or low-quality stands.

Potential applications: Fire, pests and maladaptation

[6] See http://www.fs.fed.us/restoration/Stewardship_Contracting/

Vulnerability Reduction Credits

One interviewee described this relatively new type of instrument. Vulnerability Reduction Credits offer another type of financing mechanism for forest management by considering how different actions reduce risk on the landscape (e.g. replanting with a few different tree species to reduce vulnerability to a particular disease agent). While concept is in a nascent stage, the interviewee was interested in how to integrate this type of thinking into other programs; for example, by using vulnerability assessment to examine risks to social and ecosystem components and potential impacts of climate change. It was felt that a precursor would be to establish high, medium and low risk ratings and then figure out what is required to move from a higher risk rating to a lower rating.

Potential applications: Maladaptation

Forest Health-National Forest Pest Strategy

One interviewee noted the need for a coordinated, inter-provincial and territorial strategy for managing pest issues as a high priority because pest issues "don't respect borders". They noted that a protocol is required to establish cost sharing agreements to manage pests occurring in one jurisdiction that may be threatening several jurisdictions. The Mountain Pine Beetle outbreak in Alberta was offered as an example: it is driven by climate change and threatens all provinces to the North and East. The interviewee also noted that non-native invasive species are becoming established in one province and spreading to others.

From a national perspective, it was noted that there no longer exists a nation-wide pest survey or monitoring program that can detect changes in pest behaviour related to climate change. Provinces like Quebec, Ontario and New Brunswick, which have a monitoring plot network and budget for an annual ground based survey (designed primarily to monitor for eastern spruce budworm), are able to capture changes in various types of pest damage over time. B.C.'s diversity presents an added challenge for monitoring and the province has no funding for such an intensive plot network. It was suggested that such a pest monitoring program could make use of the permanent sample plots operated by the Forest Analysis and Inventory Branch, which already collects forest health information. The Forest and Range Evaluation Program (FREP) includes a program on Stand Development Monitoring that is similar to a silviculture survey and may be able to detect gross changes over time.

The National Forest Pest Strategy (NFPS) was initiated in 2008 by the Canadian Council of Forest Ministers (CCFM). To date, it has produced a national risk response framework, an inventory of monitoring efforts and methods across Canada, case studies for national-level pests (i.e. MPB , spruce budworm, brown spruce longhorned beetle, emerald ash borer, sudden oak death) and identified science and technology investment priorities to deal with national level issues. Future projects look to improve the linkages between the NFPS initiative and the CCFM climate change task force.

Potential applications: Pests

Climate-Based Seed Transfer

Interviewees felt that the policy components that deal with tree species and migration have the potential to facilitate adaptation. It was noted that forestry operators are pushing for more information and direction related to CBST and that policy developers are having difficulty managing expectations because redesigning the existing system involves significant business transformation; policy developers stressed the need to approach this in a stepwise way. It was suggested that implementation may occur incrementally, in a phased pilot approach (e.g. with early adopters), but that the information and approach is transformative.

It was noted that the original seed trading policy used when interior spruce orchards were coming online to encourage forestry operators to trade in natural stand seed for orchard improved seed was successful. Less improved (e.g. natural, not collected from a seed orchard) seed was traded for A-Class inventory, which created a shift toward improved seed and reduced investments necessary for forestry operators to collect natural seed. Recently, it was noted that interest in seed sharing cooperatives has been growing. At present, all actors own seed individually (e.g. buy seed or own orchards) and manage their own seed profiles. Sometimes government must purchase seed from licensee orchards when demand for certain seed is high. The impacts of future CBST program expansion on government seed inventories is not known, but government may need to revisit the issue of developing a climate-based seed cooperative because inventories originally developed for specific areas may be more appropriate for other areas. This was noted as a possible option to explore.

One interviewee reported that the Standards for Seed Use can be inflexible and add costs. Also, there was concern that the government both makes the rules regarding seed use and sells the seed, which could present a conflict of interest. Some interviewees suggested that stumpage and appraisals could provide avenues to promote adaptation by offering cost relief to licensees since some of the barriers to adaptation are related to costs (e.g. of planting new species or finding new seed). Another interviewee suggested that government could pay for additional silviculture costs incurred for adaptation by describing specified actions (e.g. planting species to increase diversity within an area). By counteracting perceptions or recognizing costs through appraisal, it may be possible to create incentives for adaptation.

Potential applications: Maladaptation

Operational and risk information

Forestry operators identified a need for more specific information regarding management guidance and operational decision-making related to reforestation and harvesting, including how to address potential future climate change impacts through current management practices. For example, shifting the range of current planting can have negative consequences (e.g. snow or frost damage), even though climate projections suggest that planting may be appropriate in the future. Forestry operators are eager for better information to reduce uncertainty regarding the impacts of management decisions. One interviewee noted that they are working to develop a Species Selection Tool, which would provide information on species with multiple objectives and help foresters to make decisions that address other objectives.

Information could also be made available to forestry operators to encourage them to identify and prioritize more vulnerable stands. This information could be provided in the form of a forest risk rating, which would enable forestry operators to determine what actions they can take now to reduce future risks.

Further, interviewees suggested that there is a need for a risk framework that outlines obligations of forestry operators and government and provides a failsafe. At present, there is no overall assessment of risk or process for managing and mitigating risks to forests. One interviewee suggested either placing greater responsibility on the current owner (i.e. the public and government) or transferring more responsibility and security to the tenant (i.e. licensees) by clearly assigning responsibility for risk. What this type of risk-sharing or risk framework would look like remains to be identified; however, one interviewee proposed that framework development should be undertaken jointly by licensees, government and other actors as partners rather than using a legislative approach. The Forest Stewardship Planning (FSP) process was provided as an example: FSP initially focused on innovation and adaptation, but when changes were presented, impacts on the landbase and unknown outcomes became barriers to cooperation due to potential impacts on timber supply.

As mentioned earlier, FREP has started providing some licensees with customized reports on aspects of their performance. This kind of reporting can be useful in changing behaviour first by alerting licensees to how they are performing (where they may lack that information) and also for more public disclosure.

Potential applications: Fire, pests and maladaptation

Legislative changes

Interviewees recommended amendments to promote fire prevention at the wildland-urban interface through the *Local Government Act*. Funding from the Provincial government to local governments to conduct fire preparedness has already been increased to 95% of the total cost.

It was noted that a section of the *Forest Act* may be reviewed to include landscape fire management planning as a requirement under FRPA. This change would require all forest companies to consider a fire management objective when undertaking land management activities.

Amendments to the *Land Act* may also be considered to designate a special management zone around communities to specify that two-kilometer buffer must be managed specifically for fire-related objectives. This would prioritize fire management over timber supply or other aspects within those areas.

Potential applications: Fire

Financial incentives: Insurance

It was reported insurers may consider raising insurance rates for high fire risk areas to create private incentives for individuals to reduce risks through FireSmart activities or public incentives for local governments to bring individuals' rates down by proving that risks have been reduced.

Potential applications: Fire

Stocking Standards

Approval of Stocking Standards and the release of free growing liability are important decision points for forestry operators. Stocking Standards also have a direct impact on silviculture costs; consequently, they can have a strong influence on forestry operators' decisions. However, the existing appraisal system offers one uniform rate for each given area (e.g. ecological classification, management unit) for replanting for a given set of conditions based on a historic average cost generated from industry cost surveys. One interviewee suggested the possibility of offering a tiered rate to reduce the disincentive for doing something different.

Forestry operators also expressed that the existing regulatory framework sometimes stifles the opportunity to be creative. For example, if forestry operators decided not to follow Stocking Standards in order to adapt to expected, localized changes in future conditions, their Forest Stewardship Plans would not be approved. Forestry operators did express that the existing, results-based system offers more opportunities to be flexible than the previous Forest Practices Code; however, objectives are fixed. Insufficient flexibility exists to experiment with various potential outcomes under climate change (e.g. using growth and yield plots, fertilization) under the current rules. Forestry operators felt that different approaches to stocking standards, harvesting regimes and other practices should be encouraged through a more incentive-based approach rather than a regulatory framework.

Another interviewee described a need for independent, professionally-designed, regional-scale Stocking Standards that are based on local factors and local experience. The interviewee felt that the current Standards are fettered by too many individual biases and agendas to truly achieve effective outcomes.

Several interviewees noted the impact of prevailing economic conditions on forestry operators' willingness to incur costs associated with adaptation (e.g. seed, silviculture). These interviewees acknowledged that existing approval processes offer some flexibility, but that because financial resources are limited, forestry operators are seeking ways to minimize costs; these lowered costs are then reflected in lower silviculture appraisal cost estimates in subsequent years, which reinforces disincentives to incur additional costs. One interviewee reported that the current timber appraisal system effectively ratchets down silviculture costs, but that there is no mechanism to allow costs to increase other than through a general agreement among licensees to increase costs, thereby having these reflected in future industry cost surveys. They noted that licensees would be willing to spend more money on replanting and silviculture, but only if the benefits will be returned to them in the long term or if short-term monetary incentives are provided.

Potential applications: Pests and maladaptation

Timber Supply Review

The TSR, which is designed to project future timber availability, utilizes existing and historical knowledge of productivity, practices, disturbances/risks and management decisions (i.e. current practice). Alternative future management projections or changes to growth and disturbance rates over time are typically not addressed. Adapting TSR to incorporate exploration of alternative future conditions and management practices could highlight vulnerabilities and make a strong case for adaptation strategies in the short term.

Potential applications: Fire, pests and maladaptation

Timber pricing

The current stumpage system was reported to incentivize harvesting in configurations that maximize cost recognition and log values/volume; not necessarily where forest management intervention is most needed. It was recommended that changes to the appraisal system could create incentives for harvesting for other objectives, such as forest health, possibly by linking stumpage to the aforementioned forest risk rating. Tiered silvicultural costs were also proposed as a way to reduce the disincentive for licensees to invest in additional or more costly silvicultural treatments.

Potential applications: Fire, pests and maladaptation

Long-Term Forest Health Test

One interviewee noted that this test could be used to ensure that forestry operators consider climate change; however, forestry operators did not report that this test was applied for this purpose. The test was reported to suggest that forestry operators should consider forest health beyond the first 20 years after reforestation. The Long-Term Forest Health Test could be reviewed through a climate change lens to present opportunities for adaptation.

Potential applications: Pests

Forest Resilience: Forest certification

Both forestry operators and policy developers expressed a keen interest in addressing maladaptation by incorporating targeted considerations into existing forest certification protocols. Interviewees felt that certification could create markets for desired outcomes and appropriate baselines and measures.

Potential applications: Maladaptation

Support existing policy and guidance

Interviewees reported that FLNRO is entering a new policy cycle. FRPA has been in force for 10 years, which means that the provincial government is due to re-engage on the policy front. It was noted that all policies are being examined in terms of professional reliance and ability to address uncertainty. Changes in policy offer new opportunities to address adaptation and mitigate unintended outcomes of original policies.

FLNRO has developed the following policy and guidance documents to support adaptation:

- Climate-based Seed Transfer Interim Policy Measures
- Mixed Species Options for Forests for Tomorrow
- FFT Assisted Species Migration Guidance
- Consideration of Climate Change When Addressing Long-Term Forest Health in Stocking Standards
- Silvicultural Regimes for Fuel Management in the Wildland Urban Interface or Adjacent to High Landscape Values - Guidance
- Tree Species Selection Tool
- Guidance for assessing FSP stocking standards
- Flexibility options in FSP results or strategies
- Guidance for the implementation of western larch into FSP and WLP stocking standards in areas of assisted range and population expansion
- FRPA General Bulletin (Number 22) – An Overview of FSP Extensions
- Guidance to Tree Species Composition at the Stand and Landscape Level

These represent the best information currently available to FLNRO regarding adaptation and may provide a starting point for developing economic instruments.

Potential applications: Fire, pests and maladaptation

Key characteristics of economic instruments

Interviewees were asked to identify important characteristics of potential economic instruments for adaptation. Their responses were supplemented with a review of existing literature (see Stavins 1997, Bräuninger et al. 2011, UNFCCC 2011) on economic instruments to develop the following list of criteria for economic instruments for adaptation to climate change.

Economic instruments must be:

Adaptive	Incorporate planned and periodic evaluation and changes
Equitable	Consider and mitigate distributional impacts
Effective	Be able to meet objectives
Efficient	Achieve outputs optimally relative to resources allocated
Flexible	Address both incremental and transformative changes
Gradual	Include a transition period
Harmonized	Be consistent with other legislation, standards, policies and reporting requirements
Legitimate	Be politically, culturally and socially acceptable
Practical	Be plausible given technological, social and economic constraints and relevant timescales
Robust	Be applicable under a range of future climate projections
Risk-based	Be able to address uncertainty
Results-based	Have measurable outcomes, based on professional reliance
Science-based	Be based on high-quality scientific knowledge
Synergistic	Offer co-benefits, considers and addresses unintended consequences
Scalable	Operate at local, regional or provincial scales
Transformative	Forward looking, anticipates changes and scenarios
Transparent	Offer a clear set of rules and processes

There are several different types of economic instruments:

- Financial (e.g. price signals, tax credits/allowances, bonds, risk sharing, public-private partnerships, R&D incentives);
- Behavioral (e.g. nudging through default rules, or communications techniques);
- Informational (e.g. reporting requirements, disclosure initiatives); and
- Regulatory (e.g. instruments used in the development and appraisal of policies).

These four types of instruments are neither necessarily independent nor exclusive; indeed, a particular instrument may be part of a broader policy designed to promote a particular activity or outcome or to reduce risk or the negative consequences of different events (i.e. floods, fire, drought).

It is important to note that financial instruments encompass a wide range of instruments. These can be sub-divided into two very different kinds of instruments when examining their application in terms of mitigating risk: market based instruments (MBI), which are organized around the financing and financial incentives around decisions (e.g. taxes, subsidies), and risk financing instruments (RFI), which are organized around sharing and transferring risks and losses prior to catastrophes.

These MBI are similar to those discussed in Stavins (2001), who examines them from an environmental focus and groups them into four categories: pollution charges; tradable permits; market friction reductions; and government subsidy reductions. Finally, one other important area is that involving changes in rights, which can encompass the creation of rights and markets (i.e. around tradable permits, or the development of rights to manage natural resources) but can also involve changes in liability rules.

Part B: Literature review

This section provides a summary of examples (see Table 3) where economic instruments have been implemented to address risks from natural hazards. While many of these examples were not developed or implemented explicitly for the purpose of climate change adaptation, they either target a climate-related risk (e.g. flooding, wildfire) or have potential applications to such risks. These examples are drawn not only from applications to forestry, but also from the areas of agriculture and land use. While many examples have been drawn from Canada and the USA, examples from other global jurisdictions are also included. Existing instruments provide valuable information about goals, stakeholders, design characteristics, implementation, successes, challenges, impacts and outcomes and can help to identify what types of instruments are more likely to produce successful results.

This literature review encompassed published peer-reviewed and grey literature as well as articles and examples that were provided during interviews with Canadian climate change adaptation experts as well as policy developers and implementers from the provincial government, representatives from industry associations and forestry operators with extensive knowledge of forestry practices and management. Additional examples will be incorporated into this document as they are discovered throughout the course of this project.

Existing instruments

Table 2. Summary of existing economic tools with potential applications to adaptation in forestry

Risk	*Type of tool*	*Tool (specific)*	*Examples*
Fire	Financial	MBI (Tax incentive)	Mitigation Tax Credits, Colorado (proposed fall 2013)
		Risk-financing (insurance)	Insurance Premiums recommended after 2003 Okanagan Fires Homeowner's Insurance Reform Act (Colorado, 2013-2014)
		PPPs	Canadian Interagency Mutual Aid and Resource Sharing (MARS) Agreement, 1982 LiDAR Information Sharing (Alberta, 2005)
		MPP	Community Forest Management Plan – 2013 proposal (Cranbrook, East Kootenays, etc.)
	Behavioural	?	?
	Informational	Educational	FireSmart Program, started in 1990
		Awareness campaign	Wildfire Ready (Colorado, 2012-2013)
		Cost-Benefit Analysis	Investment in fuel reductions and benefits of avoiding fires (Washington/Oregon Case 2003 Study, Summary by Patrick Daigle)
	Regulatory	Building code	NFPA wildfire building codes California Building Code Chapter 7A: Wildland-Urban Interface Code
Pests	Financial	MBI (Tax incentive)	Tree Maintenance Incentive City of Toronto (Clean Air Partnership research paper 2007) and Ontario Ministry of Natural Resources (2012 update to Ontario Managed Forest Tax Incentive)
	Behavioural	?	?
	Informational	Training/ extension	Provincial Forest Health Strategy 2013-2016 (MFLNRO Workshops for Forest Health Specialists/ other methods of training/education)
	Regulatory	?	?

Table 2. Summary of existing economic tools with potential applications to adaptation in forestry (continued)

Risk	*Type of tool*	*Tool (specific)*	*Examples*
Maladaptation	Financial	PPPs	Forest Carbon Offsets Investment Program, MNFLRO and COAC, 2010
		Bonds	Forestry-backed bonds (e.g. “EcoSecuritization”) – proof of concept study completed by Forum for the Future and EnviroMarket Ltd.
	Behavioural	Nudging	Behaviour Insights Team – potentially wide ranging applications (British Government 2010-present)
	Informational	Performance rating	The US Forest Service Climate Change Performance Scorecard, 2011
		Awareness campaign	Neighbourhood Awareness Programs (Various locations, projects, and years)
	Regulatory	Legislation	The Act on the Financing of Sustainable Forestry (1996) and the Act on energy support for low-grade timber (2011)
		Subsidy reform	Rural Development Regulation (EU) re-allocates 10% of direct-aid into Fund for Adaptation Measures in Agriculture and Forestry (2009 Amendment)
		Regulatory incentives	Innovative Forest Practices Agreements BC, 1996
		R&D incentives	Climate-Based Seed Transfer Program BC, started in 2008
		Voluntary certification	Adaptation in Voluntary Certification Standards (e.g. FSC or SFI) 2010 and 2012 Proposals/ Recommendations

Financial instruments

Market-Based Instruments (MBIs): promote proactive adaptation through monetary incentives and by altering price signals (Bräuninger et al. 2011, Stavins 1997). This is a broad category that includes subsidies (e.g. grants, tax reductions, price supports), taxes and fees (e.g. carbon, land use), licenses and permits (e.g. project-based offsets) and other measures (e.g. payments for ecosystem services) (Bräuninger et al. 2011).

Loans: offer increased accessibility of loans for adaptation activities in the private and public sectors, including the use of green bonds (Bräuninger et al. 2011).

Risk-Financing Instruments (RFIs) (e.g. insurance): compensate losses through pre-arranged risk sharing and pooling mechanisms, may help with coping with the additional burdens imposed by climate change and may incentivise proactive adaptation (Bräuninger et al. 2011).

Public-Private Partnerships (PPPs): cover contracts between public and private entities to finance adaptive activities or cover losses (Bräuninger et al. 2011).

Municipal-Provincial Partnerships (MPPs): similar to public-private partnerships, these streamline government processes and utilize government resources more efficiently.

Market-Based Instruments

Tax incentives

Mitigation Tax Credits	
Colorado	
Goal:	Encourage homeowners to protect their own property from forest fire through mitigation activities
Date implemented:	Proposed fall 2013
Implementer(s):	Colorado government
Key stakeholders:	Colorado property owners
Description:	Colorado municipalities have been working on mitigation activities to protect their homes and properties, and are hesitant about a change to building code. Instead, the Colorado Legislative Committee proposed an income based mitigation tax to cover half of mitigation costs, up to $2,500.
Impacts:	Protect private property from fire damage.
Outcomes:	Encourage homeowners to conduct mitigation activities: • Creating and maintaining a defensible space around structures; • Establishing fuel breaks; • Thinning of woody vegetation for the primary purpose of reducing risk to structures from wildland fire; • Secondary treatment of woody fuels by lopping and scattering, piling, chipping, removing from the site or prescribed burning.
Challenges:	Half of mitigation costs covered, but will homeowners cover the rest?
Lessons learned:	n/a
Unknowns:	
References:	CO Lawmakers won't pursue building code for fires by Ivan Moreno Colorado Department of Revenue FYI: http://www.colorado.gov/cms/forms/dor-tax/Income65.pdf

Tree Maintenance Tax Incentive	
Ontario and Toronto	
Goal:	Encourage adaptation options in Toronto's Urban Forest. For example, heat and drought already stress Toronto trees and under climate change these conditions are expected to get worse. Planting trees more tolerant of heat and drought conditions, watering programs, planting methods that reduce soil compaction and public incentives to encourage tree planting and maintenance are various ways in which the City can and has begun to adapt.
Date implemented:	Clean Air Partnership Research paper 2007, Ontario's Tax Incentives for Managed Forest Plan Guide was updated in 2012
Implementer(s):	Clean Air Partnership Researchers (Toronto Research Paper 2007), Ontario Ministry of Natural Resources
Key stakeholders:	Urban forest managers in Toronto, private forest owners in Ontario
Description:	Because tree maintenance can be a financial burden for private landowners, a tax incentive for property owners to maintain the urban forest could encourage more participation from community members. For example, there is a tax incentive to rural land owners with four hectares or more of forest, and who agree to follow a Managed Forest Plan for their property. Participating landowners pay only 25% of the municipal tax rate for residential proper ties.
Impacts:	
Outcomes:	
Challenges:	
Lessons learned:	Similar incentives: • A similar incentive for the management of urban trees could be a very effective way to engage private property owners in the City. This may be best suited for home owners on ravine lots, or large institutions such as universities. • In San Francisco, the City grants sidewalk (boulevard) landscaping permits to property owners, which allows them to convert a portion of sidewalk in front of their property into a landscaped area (City and County of San Francisco 2006). Trees, plants with low-water needs and those appropriate to the climate are encouraged. Granting ownership over the area creates a greater likelihood that the property owners will also maintain the landscaping. This option may be most viable in neighbourhoods that have a strip of land between the sidewalk and the street (Climate Change Options for Toronto's Urban Forest 2007).
Unknowns:	
References:	Clean Air Partnership. Climate Change Options for Toronto's Urban Forest. 2007. Researchers and authors: Ireen Wieditz, MES, Researcher, Clean Air Partnership Jennifer Penney, ScD, Director of Research, Clean Air Partnership. Ontario Ministry of Natural Resources (2007) Ontario Managed Forest Tax Incentive Program Guide. City and County of San Francisco (2006) Department of Public Works

Public-Private Partnerships

Canadian Interagency Mutual Aid and Resource Sharing (MARS) Agreement	
Canada, based in Winnipeg	
Goal:	Mandate of CIFFC is to provide operational forest fire management services to Member Agencies that will, by agreement, gather, analyse and disseminate fire management information to ensure a cost effective sharing of resources; and actively promote, develop, refine, standardise and provide services to Member Agencies that will improve forest fire management in Canada.
Date implemented:	CIFFC started in 1982
Implementer(s):	Canadian Interagency Forest Fire Centre Inc. (CIFFC)
Key stakeholders:	• The Board of Trustees: Assistant Deputy-Ministers responsible for forestry representing each of the Provinces, Territories and Federal Government. • The Council of Directors: Directors responsible for forest fire management for each of the Provinces, Territories and a representative of the Federal government. • Fire Centre Staff
Description:	Resources in Canada are shared on a formal basis under the Canadian Interagency Mutual Aid Resources Sharing (MARS) Agreement which outlines three categories of resources: equipment, personnel and aircraft. In addition to this intra-Canadian co-operative agreement, a Diplomatic Note signed with the United States authorises the sharing of resources for fire suppression across the international boundary.
Impacts:	Equipment, personnel and aircraft sharing between Provinces and the USA in times of need.
Outcomes:	CIFFC has attracted international attention and delegations from various developing nations regularly visit the Centre to review its operations. Through Canada's Department of External Affairs, CIFFC has coordinated Canadian response to international requests for assistance. Such requests for international assistance will continue and the Fire Centre, along with member agencies and Canadian corporations will be organized to address these requests.
Challenges:	
Lessons learned:	
Unknowns:	
References:	Canadian Wildfire Strategy 2006

LiDAR Information Sharing	
Alberta	
Goal:	Seek excellence in information: Government of Alberta efficiency, industry competiveness, stewardship and planning, innovation, enterprise risk
Date implemented:	2005?
Implementer(s):	Alberta Government
Key stakeholders:	Research partners (2005-2013): Sustainable Forest Management Network, Alberta Parks, Alberta ESRD, Forest Resource Improvement Association, Millar Western, DMI, JD Irving Ltd., Statoil, Devon, New Brunswick, University of New Brunswick, NSERC CRSNG
Description:	LiDAR uses optical remote sensing to measure properties of scattered light to determine range of and other information about a distant target. • Current Government of Albert a Inventory: 28 million hectares • Investment: > $20 million • Site license restrictions in place • Accuracy: 30cm horizontal, 45cm vertical (medium to high quality data) • Primary innovation activity has been around moisture and water mapping and forest fibre inventories.
Impacts:	
Outcomes:	
Challenges:	• Policy linkages • Buy-in to “Big Data” • All LiDAR not created the same • Standards for data acquisition • Innovation capacity • Staff capabilities and workload • Software and infrastructure challenges • Inter-departmental or cross-organization support • Ownership versus site license • Cost is no longer an issue
Lessons learned:	
Unknowns:	
References:	March 2013 Government of Alberta ESRD Presentation by Barry White

Community Forest Management Plans	
BC forest municipalities	
Goal:	Local governments generate money to pay for wildfire hazard reduction with the products of thinning in local buffer zones.
Date implemented:	Proposed summer 2013 by forest fire ecologist Robert Gray
Implementer(s):	?
Key stakeholders:	BC forest municipalities
Description:	There are 1.7 million hectares of forest close to communities in B.C. that need to be thinned for wildfire protection, Gray said. In 2005, a UBCM program set aside $85 million for that treatment. Since then, just three per cent of those hectares have been treated, using up $80 million. "We are running out of money, and we've got very little done," said Gray. The cost is so massive that treatment is happening very slowly – slow enough that trees are growing back in on property treated last decade. The proposed solution: Community Forest Management Plans. The policies boil down to a simple concept: municipalities should be able to decide how wide an area around each community should be kept as a fire buffer. Then, Crown land inside that buffer should be under the control of the local government. The community could then thin out the forest in the buffer, and sell the forest products for bio-energy. "If we take all the revenues from within that zone and keep it in a local account, we'll have program dollars versus project dollars. Right now, we go from year to year and we apply for single postage-stamp size treatments. We need program dollars where we can set a five-year development plan to treat hazardous fuels."
Impacts:	"If we do local heating projects, Cranbrook has looked at converting 10 of the largest heat producers to wood waste. That's about 2,000 tonnes a year – about 50 hectares. There are about 50,000 hectares that need treatment," said Gray. What's more, a collaboration of the Cities of Cranbrook and Kimberley, ?aq'am (St. Mary's Band), the Ktunaxa Nation and the Rocky Mountain Trench Natural Resources Society has signed a memorandum of understanding with U.S. Fortune 500 company SAIC to explore establishing a bio-energy industry in the East Kootenay. "Local consumption is not going to be able to deal with the significant amount of volume that would be available with this type of approach," said Kevin Weaver, the City of Cranbrook's economic development officer. "The bulk of the volume is going to have to be dealt with essentially as an export product."
Outcomes:	Gray's concept has been presented to the B.C. Minister of Forests, Lands and Natural Resource Operations. "Minister (Steve) Thomson reviewed it. He requested clarification and direction from the director of the Wildfire Management Branch, he got it, so the minister is in favour of what we're trying to do here," said Gray. Cranbrook has already voted in support of the concept; on Friday, August 2, the Regional District of East Kootenay board did the same.
Challenges:	
Lessons learned:	
Unknowns:	
References:	http://www.dailytownsman.com/breaking_news/218996151.html?mobile=true http://www.columbiavalleypioneer.com/?p=10687

Forest Carbon Offset Investment Program, MFLNRO Public Private Partnership	
British Columbia	
Goal:	The goal is to return forests to their natural role of net carbon sinks (recent wildfire and mountain pine beetle devastation have damaged millions of hectares of our forests).
Date implemented:	2010 (In 2010 the Pacific Carbon Trust purchased 730,000 tonnes of CO2e offsets on behalf of the provincial government, which, by law, must achieve annual carbon neutrality.)
Implementer(s):	MFLNRO initiated, but Carbon Offset Aggregation Cooperative (COAC), an independent organization was selected to manage both the investments and subsequent carbon credits. The co-operative, which will use the carbon offset credits for long-term replanting and forest management activities, was selected through a competitive bid process, posted in fall 2012.
Key stakeholders:	Public-private partnership – COAC, investors and MFLRO
Description:	The BC Forest Carbon Offset Investment Program offers investment in reforestation, rehabilitation, and better forest management to increase carbon storage in BC's forests. Investors can have the opportunity to profit from the sale of carbon offset credits, but also "takes action against climate change, improves your corporate carbon footprint, provides significant additional environmental benefits and can provide long-term financial returns". The Pacific Carbon Trust, a crown corporation, purchased carbon credits to meet carbon-neutral government goals in the initial offering of this program.
Impacts:	See above – investment benefits, but also a number of environmental benefits including carbon storage
Outcomes:	In partnership with the Province of British Columbia, Carbon Offset Aggregation Cooperative has signed an agreement to reforest crown land that has been affected by Mt. Pine Beetle and Wildfires by the end of 2018. Organizations can participate in the TreeGen Project by investing $5 for every tree they want to plant. The trees planted will be labelled, and as they grow they will sequester carbon dioxide from the atmosphere. This carbon dioxide removed from the atmosphere can be sold as Carbon Offsets to organizations who want to reduce their own carbon footprint. In June 2013 news release, it stated more than 20,000 trees had been planted with this program.
Challenges:	Carbon offset project investments are protected by legislation that guarantees organized enforcement, regular monitoring, and public reporting. Investment is heavily protected from illegal logging.
Lessons learned:	
Unknowns:	
References:	BC Forest Carbon Offsets Investment Opportunities, MFLNRO COAC website. Forest carbon program means more trees for B.C. - News release, Province of BC

EcoSecuritization	
Tropical forests	
Goal:	Apply conventional structured finance methods to natural tropical forests to give forest managers greater ability to access long-term finance for Sustainable Forest Management (SFM)
Date implemented:	2006 - Chile 2008 - Guyana
Implementer(s):	Government, private sector
Key stakeholders:	Bonds have been purchased by institutional investors (e.g. pension funds, banks, insurance agencies)
Description:	"The proposed mechanism utilises portfolio diversification; recent developments in forestry insurance and risk mitigation techniques; and the emergence of markets for ecosystem services in order to attract a diverse range of capital market investors." The Lignum Investment Fund "was launched in 2006 and is a $39.4 million Chilean fund and the first Latin American forestry investment fund." It is "backed by a guarantee from the CORFO (Corporación de Fomento) and private-sector. These bonds have been purchased by institutional investors such as pension funds, banks and insurance agencies. The funds raised from the bond sale have been used to purchase immature planted forests (15 - 20 years old) and pay for forest management and reforestation costs. In return, bond holders and forest owners will share the profits from harvesting operations in these forests." "In 2008, Canopy Capital announced a partnership with the International Centre in Guyana that involves guaranteed payments over a five-year period in return for rights to market the ecosystem services produced by a rainforest reserve. These services are defined as rainfall, cooling of the atmosphere, carbon and biodiversity storage, and weather moderation. The funds are expected to provide livelihoods to 7,000 indigenous people who depend on the reserve and to support conservation of the rainforest. The rights will in turn be packaged and sold to investors as forest-backed bonds that are expected to acquire value over time. Up to 90% of the profits will be shared with the Iwokrama community in the long-term."
Impacts:	"Guyana is still struggling to get the projects off the ground. It has yet to receive any substantial financing from a climate fund created by Norway because Guyana has largely been unable to win approval for its proposals to spend the money. A separate agreement meant to preserve forests while providing returns to private investors never took off."
Outcomes:	The Guyana program has "completely failed to address the structural problems underlying the forest sector in Guyana."
Challenges:	• Underlying cash flows necessary to repay bond holders. Need to consider a broad range of revenue streams from which to pay back bond holders. • Establishing a price for the value of forest assets • Lack of large scale funds for demand that can commit for the long term. Also needed to develop absorptive capacity.
Lessons learned:	

Unknowns:	
References:	Ellsworth, B. (2011) Guyana forest carbon plan struggle to get off paper FAO (no date) Forestry Policy Brief – Financing Sustainable Forest Management Forum for the Future and EnviroMarket Ltd. (2007) Forest-Backed Bonds Proof of Concept Study Henderson, I. (2012) From Forest Bonds to the Forest Finance Facility (WWF) Lang, C. (2012) Protest at appointment of ex-President Bharrat Jagdeo of Guyana as IUCN high level envoy for sustainable development in forest countries WWF (2009) Guide to Conservation Finance.

Risk-Financing Instruments

Insurance

Insurance Premiums & Pre-Conditions	
Okanagan/British Columbia	
Goal:	The 2003 Okanagan Mountain Park Fire, which spread to the outskirts of the City of Kelowna, resulted in payouts from private insurers totalling more than $200 million. In the future, insurers may use preconditions for insurance as a way to direct homeowners to address certain risk factors in order to minimize their losses.
Date implemented:	Recommendations made after 2003 Okanagan fires
Implementer(s):	
Key stakeholders:	
Description:	Within Canada, insurance companies have not yet placed conditions on the construction or reconstruction of buildings to obtain insurance in fire-prone areas. State Farm Insurance, the largest insurance company in the United States, is starting to address this situation.
Impacts:	
Outcomes:	
Challenges:	• The most important role for private insurers is to develop premiums that reflect the true level of risk for the insured property. If premiums do not reflect the true risk, inefficient decisions about fire protection may result (Hesseln 2001). • A moral hazard exists when the act of insuring creates an incentive for the insured party to use less than optimal inputs for safeguarding the insured property or to underemploy levels of a precautionary activity (Turvey et al. 2002).
Lessons learned:	
Unknowns:	
References:	• Canadian Wildland Fire Strategy 2006. • Hesseln, H. 2001. Refinancing and restructuring federal fire management. J. For. 99:4–8. • Turvey, C.G.; Hoy, M.; Islam, Z. 2002. The role of ex-ante regulations in addressing problems of moral hazard in agricultural insurance. Agric. Finance Review 62:103–116. • Firestorm 2003 Provincial Review.

Homeowner's Insurance Reform Act	
Colorado	
Goal:	The Act delineates new rights, duties, and obligations of insurers, insurance producers, and consumers with regard to the purchase of homeowner's insurance.
Date implemented:	May 2013 brought into law, most provisions go into effect January 1, 2014
Implementer(s):	Colorado Government
Key stakeholders:	Colorado Homeowners, Insurers, Colorado Law-makers
Description:	This law stems from property insurance issues raised by some homeowners and state legislators following the Four mile Canyon, High Park and Waldo Canyon Wildfires.
Impacts:	The key statutory changes for all homeowners insurance policies include: mandatory replacement coverage offers, provisions regarding policy deadline extensions, requirements for simplified policy language and for increased agent/company education and policyholder communication, and provisions clarifying the terms for documenting contents in the event of total loss. In addition, the new law requires that at least 3 of the 24 hours of continuing education for producers authorized to sell property or personal lines must be for courses in homeowner's insurance coverage. Most of these provisions will go into effect on January 1, 2014.
Outcomes:	See above.
Challenges:	Too early to determine.
Lessons learned:	Too early to determine.
Unknowns:	
References:	Homeowner's Insurance Reform Act: http://www.rmiia.org/downloads/CO_HB-1225_Fact_Sheet.pdf

Behavioral instruments

Arising from the field of behavioural economics, these instruments use subtle shifts in the way information is presented to create changes in behaviour. Richard Thaler and Cass Sunstein, in their recent book Nudge (2012), describe the practice of "choice architecture", whereby the framing, design and presentation of choices, and the default options behind these choices, can be altered to encourage individuals to choose the optimal choice, regardless of individual biases and bounded rationality. These types of "light touch" policies can offer the advantage of being cheap to implement (DEFRA 2010).

Nudging

Behaviour Insights Team	
Britain	
Goal:	Engineer small tweaks in the environment which will "nudge" but not "shove" or "legally require" people to make better decisions (2008 Book 'Nudge: Improving Decisions about Health, Wealth and Happiness' by Richard Thaler and Cass Sunstein)
Date implemented:	2010, David Cameron Britain's then-Opposition Leader set up "behaviour insights team" (BIT or Nudge Unit)
Implementer(s):	
Key stakeholders:	
Description:	"The guiding tenet of nudging is that people often act against their best interests or intentions – but that can be ever so gently steered in the right direction by skilled 'choice architects'." (Engelhart). It is part of a broader theory of "libertarian paternalism" and takes cues from behavioural economics. For example, text message reminders to pay a fine, or a letter to late tax payers informing them that most people in their town had already paid (repayment rates rose by 15 percent).
Impacts:	The 14 person BIT team claims to have saved Britain hundreds of millions, perhaps with billions more to come.
Outcomes:	
Challenges:	Cameron's BIT has critics. E.g. "Libertarian paternalism" is seen as "nanny statism". Other worry about 'choice architects' themselves- incompetent, or malevolent? Also, resistance from the inside: 2011 National Audit Office report noted many Westminster departments 'less than eager' to adopt BIT recommendations. Also, need to ensure "paradoxical substitution effects" don't occur (labelling food as healthy can lead to over-consumption).
Lessons learned:	
Unknowns:	
References:	Nudge Economics by Katie Engelhart. 2008 Book 'Nudge: Improving Decisions about Health, Wealth and Happiness' by Richard Thaler and Cass Sunstein

Informational instruments

Informational instruments can be applied where actors fail to adapt due to uncertainty, short-term thinking or a lack of information about the physical and economic risks of climate change impacts or a poor understanding of adaptation options. In these situations, providing information can help individuals or businesses to make more informed decisions.

We identified the following five types of informational instruments during the literature review:

Cost-Benefit Analysis: presents information about the costs (e.g. planning, preparing for, facilitating, and implementing adaptation measures, including transition costs) compared to the benefits (e.g. avoided damages or accrued benefits) of adopting and implementing adaptation measures (UNFCCC 2011).

Awareness campaigns: focus the attention of a wider group of people and increase knowledge or understanding of a subject, issue or situation.

Education: provides targeted educational materials to groups or individuals in appropriate language and using relevant media.

Training/extension: applies scientific research and new knowledge to skill development for groups or individuals to influence specific practices and decisions.

Performance ratings: report accomplishments and plans for improvement to measure performance over time (internal), enable comparison (external) and provide accountability.

Cost-Benefit Analysis

Cost-Benefit Analysis in Forest Fuel Reductions	
Okanogan National Forest in Oregon and Washington (similar to south-central BC)	
Goal:	Cost-benefit analysis of forest fuel reductions
Date implemented:	2003 Study. Several papers published (Mason, L. et al. 2003, 2004, 2006; Lippke et al. 2007).
Implementer(s):	Mason et al.
Key stakeholders:	Local employment for forest thinning crews, public and private infrastructure/property owners (at risk of fire damage), and general public
Description:	• Six management treatments were examined: four included fuel-reduction treatments, whereas no action resulted in increased high risk status stands. • Using 2002 log markets, the economic analysis examined costs for logging, pre-commercial thinning, regeneration, and post-fire rehabilitation
Impacts:	Local employment for forest thinning crews, firefighting costs, timber losses, facility losses, rehabilitation and regeneration costs, regional economic benefits, smoke and forest and atmospheric carbon, energy, water quality and quantity, erosion, community value of fire risk reduction
Outcomes:	• Failure to remove small logs (cost of thinning, low value) may result in retention of ladder fuels for crown fires with destructive impacts • "The negative impacts of crown fires are underestimated and that the benefits of government investments in fuel reductions are substantial."
Challenges:	Mason notes that for some non-market benefits, it's difficult to ascribe a dollar value, such as habitat value (timber value used as surrogate).
Lessons learned:	The study provides a credible analysis framework and figures that are reasonable low-bound estimates (e.g., logging or regeneration costs and time until fire consumes a high-risk stand).
Unknowns:	
References:	Mason, L. et al. 2003. Investigation of alternative strategies for design, layout and administration of fuel removal projects. University of Washington, College of Forest Resources, Rural Technology Initiative. 78 pages plus 115 pages of Appendices.

Awareness campaigns

Wildfire Ready Campaign	
Colorado	
Goal:	With the Waldo Canyon and High Park fires fresh in Coloradoans' memories, the 2013 strategy has been to leverage the three main Wildfire Ready action messages: 1. Creating a home inventory 2. Taking steps to protect property 3. Reviewing insurance coverage
Date implemented:	2012-2013 Campaign
Implementer(s):	Rocky Mountain Insurance Information Association (RMIIA) and insurance partners
Key stakeholders:	Public
Description:	The Rocky Mountain Insurance Information Association (RMIIA) and insurance partners developed a public awareness campaign in the spring of 2012 to promote property and insurance preparedness. The campaign continued in 2013 with insurer partners contributing over $78,000 and media partners contributing $165,000 in advertising value and video/ad/digital production.
Impacts:	
Outcomes:	The centerpiece of the Wildfire Ready campaign is the CBS4 Denver "Are You Wildfire Ready?" website and resource center with all other campaign elements driving traffic to the site. The campaign kicked off the 2013 year on May 5 with a primetime 30-second education spot on 60 Minutes featuring Governor Hickenlooper. When the massive Black Forest Fire erupted in early June, Wildfire Ready was already positioned with high-profile outreach, especially in southern Colorado and El Paso County.
Challenges:	
Lessons learned:	
Unknowns:	
References:	Wildfire Insurance and Forest Health Task Force Report, by Kapplan Kirsch Rockewell

Neighbourhood Awareness Programs: Watering and Tree Maintenances	
Winnipeg, Toronto, Chicago	
Goal:	Neighbourhood watering awareness programs can lessen the watering burden on the City and increase the survival rate of trees.
Date implemented:	GreenHere Campaign started 2005, Winnipeg Adopt-a-Tree 2006, Chicago
Implementer(s):	City of Winnipeg, Green Streets Canada, GreenHere, Nichols Park Advisory Council
Key stakeholders:	Public
Description:	• In Winnipeg, the Adopt-a-Tree program funded by Green Streets Canada, aims to reverse the decline of elm trees along a major road way. Activities include tree inventories, education, and maintenance. Community members can adopt a tree and help pay for these activities by pledging $1,000 per year for five years (City of Winnipeg). • In Toronto, both the Harbord Village Residents' Association (HVRA) and GreenHere have undertaken initiatives to involve the community in tree stewardship, tree pruning and watering (GreenHere). • In Chicago, a community organization called the Nichols Park Advisory Council runs a publicity campaign to recruit volunteers during periods of drought to water trees in parks and neighbourhoods • In Chicago, community members are being engaged in tree maintenance through a certification process. An organization called Open Lands trains and certifies community volunteers to be TreeKeepers. A course is held twice per year to teach skills such as planting, pruning and mulching. After completing seven classes, the students must pass a final exam and hands-on skills tests. The students then become part of a volunteer corps that convenes for regular work bees to care for city trees in public parks, on city streets, and at other public spaces (Open Lands 2007).
Impacts:	
Outcomes:	
Challenges:	
Lessons learned:	
Unknowns:	
References:	• Green Here Campaign. 2013. http://www.greenhere.ca/ • Clean Air Partnership. Climate Change Options for Toronto's Urban Forest. 2007. Researchers and authors: Ireen Wieditz, MES, Researcher, Clean Air Partnership Jennifer Penney, ScD, Director of Research, Clean Air Partnership. • Nichols Park Advisory Council. http://www.hydepark.org/parks/nichols.htm • City ofWinnipeg Adopt-a-Tree. http://winnipeg.ca/publicworks/Forestry/adoptatree.asp • Open Lands. http://www.openlands.org/

Education

FireSmart Program	
Across Canada, based in Alberta	
Goal:	"To facilitate interagency cooperation in the promotion of awareness and education aimed at reducing risk of loss of life and property from fire in the wildland/urban interface"
Date implemented:	Partners in Protection started in 1990, FireSmart label and technical manual 1999
Implementer(s):	Partners in Protection (PiP) is an Alberta based multidisciplinary non-profit association, made up of members representing national, provincial and municipal associations, government departments responsible for emergency services, forest and parks management, land use planning and private business and industry
Key stakeholders:	Various
Description:	FireSmart Communities Recognition program based on the model developed by Firewise Communities/ USA®. The program provides the criteria, training and education necessary for a community to become certified as Firewise. In 1999 published the comprehensive technical manual titled "FireSmart Protecting your Community from Wildfire", with the second edition published in 2003.
Impacts:	This program has nearly 700 recognized communities in 41 states throughout the United States.
Outcomes:	The program encourages homeowners to assess risks to their own property, local planners to consider FireSmart design principles for communities, and land managers to consider mitigating strategies in landscapes surrounding interface communities.
Challenges:	Voluntary basis, so lack of regulatory tools or capacity
Lessons learned:	
Unknowns:	
References:	https://www.firesmartcanada.ca/about Canadian Wildland Fire Strategy 2006, Hirsch and Fuglem (page 17)

Training/extension

Provincial Forest Health Strategy 2013-2016	
British Columbia	
Goal:	Mission: Provide science-based, economically rationalized best management practices and implement treatment programs that prevent or mitigate the impacts of forest health agents.
Date implemented:	March 2013
Implementer(s):	Forest Health Program, BC Government Resource Practices Branch
Key stakeholders:	Forest health specialists (who recommend adaptations to management practice that account for pest responses to a changing climate)
Description:	• Improve the knowledge and skills of field staff in pest identification and management through delivery of timely and accessible training and extension. • Participate in initiatives outlined in the MFLNRO's Forest Stewardship Action Plan for Climate Change Adaptation.
Impacts:	See above.
Outcomes:	
Challenges:	
Lessons learned:	
Unknowns:	
References:	Provincial Forest Health Strategy 2013-2016

Performance reporting

The Forest Service Climate Change Performance Scorecard, 2011	
USA	
Goal:	The goal is to create a balanced approach to climate change that includes managing forests and grasslands to adapt to changing conditions, mitigating climate change, building partnerships across boundaries, and preparing US Forest employees to understand and apply emerging science.
Date implemented:	2011
Implementer(s):	US Forest Service
Key stakeholders:	National Forests and Grasslands
Description:	Since 2011, each National Forest and Grassland has used a 10-point scorecard to report accomplishments and plans for improvement on ten questions in four dimensions – organizational capacity, engagement, adaptation, and mitigation. By 2015, each is expected to answer yes to at least seven of the scorecard questions, with at least one yes in each dimension. The scorecard appears to be a way to encourage behavioural change and action within the National Forest and Grasslands.
Impacts:	See above
Outcomes:	
Challenges:	
Lessons learned:	"Furthermore, the Roadmap and Scorecard are designed to encourage innovation, experimentation, and adaptive management and improve our capabilities based on realistic assessments of our strengths and weaknesses. We already have many of the tools we need to respond to climate change, but we may need to develop new approaches to deal with new challenges by experimenting with our tried and true techniques. The Scorecard provides a way to share lessons learned so that we don't repeat mistakes or reinvent what's already out there." (Thomas Tidwell, Chief. 2011 Scorecard Guidelines)
Unknowns:	
References:	Website: http://www.fs.fed.us/climatechange/advisor/products.html Scorecard Guideline: http://www.fs.fed.us/climatechange/advisor/scorecard/scorecard-guidance-08-2011.pdf

Regulatory instruments

Regulatory instruments, or "command and control" approaches, employ policies, laws, regulations and standards to directly manage the activities of firms and individuals (Stavins 1997). These can influence either technology (e.g. equipment, processes, procedures) or performance (e.g. outcome-based).

We identified the following six types of regulatory instruments during the literature review:

Building codes: provide a set of rules that specify the minimum acceptable level of safety for constructed objects such as buildings and accessory structures. Building codes are intended to protect public health, safety and general welfare and are enshrined into law when formally enacted by a government or other authority.

Legislation: enacts a law or body of laws to mandate or prohibit activities.

Subsidy reform: alters the ways in which benefits are allocated by the government to groups or individuals, often in the form of cash payments or tax reductions.

Regulatory incentives: use rewards and penalties to encourage desired performance, where the regulated body is afforded some discretion in achieving goals (Lewis and Garmon 1997).

Research & Development (R&D) incentives: policy instruments offered by governments, often in the form of tax credits, to encourage firms to invest in R&D.

Voluntary certification: establishes a set of standards for practices which are adopted by groups or individuals and are not mandated by government.

Building codes

NFPA wildland fire building codes	
USA	
Goal:	NFPA 1143: the goal is to reduce wildland fire loss through the establishment, maintenance and coordination of policies and programs addressing fire prevention, risk assessment and mitigation, planning, incident management, personnel, infrastructure, training, communications and safety. NFPA 1144: the purpose is to assess fuel sources in the structure ignition zone for their potential to ignite structures and to identify possible mitigation measures to reduce the possibility of structure ignition.
Date implemented:	NFPA 1143: re-written in 2003 and amended in 2009 and 2013. NFPA 1144: re-written in 2002 and amended in 2008 and 2012.
Implementer(s):	Developed by the American National Standards Institute
Key stakeholders:	Governments, fire departments, private property owners
Description:	NFPA 1143, Standard for Wildland Fire Management: provides minimum requirements to fire protection organizations on the management of wildland fire, including prevention, mitigation, preparation and suppression. Requirements include developing a written risk and hazard assessment and mitigation plan, evaluating the capabilities and limitations of existing fire-fighting resources, establishing contractual agreements to provide for all required services, establishing roles and responsibilities of responders, etc. NFPA 1144, Standard for Reducing Structure Ignition Hazards from Wildland Fire: provides a methodology for assessing wildland fire ignition hazards around existing structures, residential developments and subdivisions and improved property or planned property improvement that will be located in a wildland-urban interface area and provides minimum requirements for new construction to reduce the potential for structure ignition from wildfires. NFPA also produces tip sheets to help homeowners take steps to reduce fuel hazards around their homes.
Impacts:	
Outcomes:	
Challenges:	
Lessons learned:	A 2002 report from the B.C. Auditor General called for wildland/urban interface standards such as those produced by the NFPA.
Unknowns:	
References:	NFPA Codes and Standards, Wildfire Technical Committee Managing Interface Fire Risks, Office of the Auditor General of BC (2002)

California Building Code Chapter 7A: Wildland-Urban Interface Code	
CAL FIRE	
Goal:	"…to establish minimum standards for the protection of life and property by increasing the ability of a building located in any Fire Hazard Severity Zone within State Responsibility Areas or any Wildland-Urban Interface Fire Area to resist the intrusion of flames or burning embers projected by a vegetation fire and contributes to a systematic reduction in conflagration losses."
Date implemented:	2007
Implementer(s):	State of California
Key stakeholders:	Private property owners
Description:	"Protecting a building from wildfire takes a two-pronged approach: • Remove flammable materials from around the building • Construct the building of fire resistant material The law requires that homeowners do fuel modification to 100 feet (or the property line) around their buildings to create a defensible space for firefighters and to protect their homes from wildfires. New building codes will protect buildings from being ignited by flying embers which can travel as much as a mile away from the wildfire." The Office of the State Fire Marshal's (SFM) Building Materials Listing Program (BML) mandates that all fire alarm systems, fire alarm devices, roof coverings, fire resistive wall and ceiling-floor assemblies, wall finish materials, fire and non-fire related hardware, insulating products, fire doors, fire dampers, electrical appliances and devices be approved and listed by the State Fire Marshal prior to sale or marketing within the state. New buildings located in any Fire Hazard Severity Zone within State Responsibility Areas, any Local Agency Very-High Fire Hazard Severity Zone, or any Wildland-Urban Interface Fire Area designated by the enforcing agency for which an application for a building permit is submitted on or after January 1, 2008, shall comply with all sections of this chapter. The code is supported by a hazard assessment and rating syste. The CAL FIRE and Resource Assessment Program (FRAP) Fire Hazard Severity Zone is used to determine fire hazard on a 9 m (30 ft) grid. This information is applied in areas under state jurisdiction. FRAP is one of the few programs in the United States that links fire severity (exposure) and building codes (construction attributes).
Impacts:	
Outcomes:	

CAL FIRE (continued)	
Challenges:	While FRAP links expected exposure to specific building code requirements, its classification system focuses primarily on proximity to wildland fuels and does not address the likelihood that buildings could be destroyed due to other sources of fire and ember exposures, such as from an adjacent burning structure. Other similar programs with less complex WUI hazard rating systems exist and are implemented across the United States. The Home Ignition Zone (HIZ) concept represents another WUI hazard severity assessment framework designed to be implemented at a parcel or structure level. HIZ includes the home and surrounding area within 30 to 60 m (100 to 200 feet). The method has been successfully used to educate homeowners on the different parameters that affect structure survivability.
Lessons learned:	Topography should be considered in conjunction with weather, specifically local wind.
Unknowns:	
References:	California's Wildland-Urban Interface Code Information CA Building Code Chapter 7A (January 2009 Supplement) Framework for Addressing the National Wildland Urban Interface Fire Problem, by Alexander Maranghides and William Mell

Legislation

Supporting sustainable forest management	
Finland	
Goal:	"…to safeguard the continuity and profitability of wood production while taking into account the biological diversity of forests as well as other forest products and services."
Date implemented:	• The Act on the Financing of Sustainable Forestry (1996) • The Act on energy support for low-grade timber (2011)
Implementer(s):	Ministry of Agriculture and Forestry
Key stakeholders:	
Description:	Private forest owners are eligible for public funding for some silvicultural and forest improvement measures. A new Act on energy support for low-grade timber offers support for harvesting energy wood from seedling stands, young stands or first thinning sites. Forest owners pay taxes on the basis of their stumpage revenues. Taxation is calculated on the basis of real income and expenses. The difference between earnings and expenses is treated as capital income, and is taxed at the general rate for capital income, 29% (2012).
Impacts:	Typical measures supported within the framework of the Act include supplementary regeneration after different types of forest damages or reforestation, prescribed burnings and road improvements. Forest owners may be supported in measures that are financially unprofitable but important from wood production or nature management point of view, like juvenile forest management or habitat protection measures.
Outcomes:	
Challenges:	
Lessons learned:	
Unknowns:	
References:	State of Finland's Forests 2012: Criterion 3 Productive functions Comparison report on the changes in the revised PEFC FI 1002 Standard and their impact on forest management, 2010.

Subsidy reform

Rural Development Regulation- Amendment 2009	
European Union	
Goal:	The Rural Development mechanism provides a framework to deliver adaptation measures in agriculture and forestry.
Date implemented:	2008 'health check' on policy implemented
Implementer(s):	EU Agriculture Ministers
Key stakeholders:	EU States
Description:	There is a limited budget available for this mechanism – in a recent policy change, all farmers that had been receiving direct aid will now have their payments reduced by 5 percent, with that money being shifted into the Rural Development budget. By 2012, that rate goes up to 10 percent, while payments in excess of €300,000 a year will receive an additional 4 percent cut. The funding obtained through this shift may be used by Member States towards programs addressing climate change, renewable energy, water management, biodiversity and innovation linked to these areas (EC 2009).
Impacts:	In the text of the regulation, types of operational activities to be funded by this mechanism are detailed. For example, 1) Training and use of farm advisory services in relation to climate change; 2) Conversion to more resistant forest stand types; 3)Prevention actions against forest fires and climate-related natural disasters.
Outcomes:	Potential effects of operation activities listed above include: 1)Provision of training and advice to farmers to reduce greenhouse gases and to adapt to climate change; 2) Reduction of negative effects of climate change on forests; 3) Carbon sequestration in forests and avoidance of carbon dioxide (CO_2) emissions, reduction of negative effects of climate change on forests
Challenges:	
Lessons learned:	
Unknowns:	
References:	European Commission (2009). "Health Check" of the Common Agricultural Policy. COUNCIL REGULATION (EC) No 74/2009 of 19 January 2009 amending Regulation (EC) No 1698/2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:030:0100:0111:EN:PDF Review of Key National and Regional Policies and Incentives to Support Adaptation and Adaptive Capacity in the Agricultural Sector by Livia Bizikova and Erica Crawford Boettcher

Regulatory incentives

Innovative Forest Practices Agreements	
British Columbia	
Goal:	Through IFPAs the Ministry of Forests, Lands and Natural Resource Operations will conduct several pilots to test new and innovative forestry practices. Designated licensees will be given an opportunity to increase their allocated harvest levels and maintain and enhance employment.
Date implemented:	The IFPA initiative is governed by Section 59.1 of the Forest Act, introduced in 1996, which contains the provisions under which the Minister of Forests will enter into an IFPA, the length of the agreement, the contents of the forestry plan, and other key requirements.
Implementer(s):	Province of British Columbia, Forest Renewal BC (Note: From 1994 to 2002 the Crown corporation, Forest Renewal BC, delivered a variety of programs, including IFPAs, aimed at supporting the forests and forest industry of British Columbia. From 2002 Victoria - B.C. Forests Minister Mike de Jong says Forest Renewal B.C. will be replaced by a forest investment account, with most of the work done by private contractors.)
Key stakeholders:	Forest licensees
Description:	IFPAs are one of the initiatives identified in the Jobs and Timber Accord. The Accord stated: "The Government will enter into innovative forest practices agreements and other enhanced forestry practices agreements to test new and innovative forestry practices. The Government will, as a matter of policy, and subject to the evaluation of pilot projects now under way, make available such agreements and expand such programs on a broad and fair basis. Participating licensees will have the opportunity to increase their allocated harvest levels and to enhance and maintain employment in the forest industry." Although no innovative practices to date have been directly linked to climate change adaptation, perhaps they could be? As well, many practices have been related to forest health, growth and yield, and long-term resilience – which have strong ties to climate change adaptation practices.
Impacts:	"Five companies in an innovative forestry practices agreement have had a combined increase of 373,000 cubic metres per year for their allowable annual cut, effective from Jan. 1, 2013, to Dec. 31, 2015" (2013 InfoTel News Release)
Outcomes:	Six IFPA Pilot projects were conducted in the interior of British Columbia, with millions of dollars spent by Forest Renewal BC
Challenges:	Criticism includes disagreement that innovative forest practices should lead to increased AAC because improvements are long-term and over-harvesting is occurring.
Lessons learned:	
Unknowns:	
References:	Innovative Forest Practices Agreements Handbook IFPA website http://www.for.gov.bc.ca/hth/timber-tenures/ifpa.htm Merritt innovative forestry harvest levels increased. 2013. InfoTel News release.

R&D incentives

Climate Based Seed Transfer Program	
British Columbia	
Goal:	The aim of this climate change adaptation initiative and project is to transition British Columbia's seed transfer system from a geographically-based science, policy and decision support framework to one that is climate-based. In the interim, steps to support this transition over the next five to ten years are underway as part of BC's Ministry of Forests, Lands, and Natural Resource Operations Forest Stewardship Action Plan for Climate Change Adaptation (2012-2017).
Date implemented:	Since 2008 to present (interim measures and policy amendments)
Implementer(s):	BC's Ministry of Forests, Lands, and Natural Resource (2012-2017).
Key stakeholders:	MFLNRO, people involved in forest reforestation (forest companies, woodlot owners, tree-planting businesses, silviculture specialists, greenhouse operations, etc)
Description:	"Since 2008, a number of interim measures directly related to seed transfer statutory requirements and policy have been put in place to guide practitioners in adapting their seed use practices for climate change. Specifically, transfer limit standards have been amended to encourage the movement (transfer) of seed in the direction of a warming climate (e.g. upward in elevation) and, a provision for limited movement of seed beyond its contemporary (current) range (e.g. tree species range and population expansion). The intent is to implement a new policy framework to support CBST over the next five to ten years. In the meantime, interim measures as amendments to the transfer limits described in the Chief Forester's Standards for Seed Use (see References).
Impacts:	
Outcomes:	The purpose of the 2010 Amendments to the Chief Forester's Standards for Seed Use are to expand the seed transfer limits of Western larch (Lw) to increase species diversity, and address the potential forest health and productivity impacts associated with a changing climate. Specifically, this amendment provides for the range and population expansion of Lw beyond its contemporary range (historical and current climate envelope) in areas projected to be climatically suitable in the year 2030.
Challenges:	Uptake unknown
Lessons learned:	
Unknowns:	
References:	MFLNRO 2013. CBST Program website. Assisted Range and Population Expansion of Western Larch for Use as a Climate Change Adaptation Strategy in British Columbia - June 2010 Climate-Based Upward Elevation Change - November 2008 Announcement - August 2008 Maps and Spatial Data – 2010 supports the June 2010 amendment Maps and Spatial Data – 2008 supports the November 2008 amendment" (MFLNRO 2013)

Voluntary certification

Adaptation in Voluntary Certification Standards (e.g. SFI or FSC)	
Various	
Goal:	"While certification standards promote sustainable forest management, it is unclear to what extent they support or help develop adaptive capacity for climate change. In general they assume a relatively unchanging forest, and they tend to support the protection and maintenance of existing species and habitats. The standards indicate little about how forests may change or how practices may need to adapt to new conditions." (Page 27, Johnston et al. 2010)
Date implemented:	Proposals/Recommendations in 2010 and 2012 reports (see references)
Implementer(s):	
Key stakeholders:	
Description:	"There is no explicit climate change adaptation strategy promoted by the FSC, but it has initiated a climate change mitigation strategy" …. An analysis suggested "that the majority of the criteria in the current FSC Maritimes Standard support a Resistance and/or Resilience approach to climate change in sustainable forest management". Some steps have already been taken to include adaptation in forest certification. For instance the new version of the CSA standard for SFM (Z809-08, Sustainable Forest Management) has provision for exploring climate change impacts and adaptation (CSA 2008).
Impacts:	
Outcomes:	
Challenges:	It appears that some of the ecological ideas structuring the FSC Maritimes Standard (both the Maritimes and generic Standard) such as the emulation of natural disturbance, relying of historic ecological benchmarks and favoring natural regeneration may require some thought in the context of climate change.
Lessons learned:	
Unknowns:	
References:	Climate change and forest management in Canada: impacts, adaptive capacity and adaptation options. A State of Knowledge report. Sustainable Forest Management Network, Johnston, M., Williamson, T., Munson, A., Ogden, A., Moroni, M., Parsons, R., Price, D. and Stadt, J. 2010. (page 27) Climate change and the FSC Canadian Maritimes Standard

PEFC FI forest certification scheme	
Finland	
Goal:	Update forest certification scheme requirements and standards every five years in accordance with the requirements of the international PEFC forest certification system
Date implemented:	The Standard Setting Working Group approved the updated standards in April 2009.
Implementer(s):	Ministry of Agriculture and Forestry
Key stakeholders:	The forest certification standard update was composed by a Standard Setting Working Group comprising of 40 different stakeholders. Draft standards were published for public comments.
Description:	The requirements outline 29 criteria that define forest certification requirements for ecologically, socially, culturally and economically sustainable forest management and forest use. Legal compliance is the basic requirement; thus, compliance with the certification requirements automatically means that legal compliance is achieved. The state also gives financial support to certain measures promoting forest growth and forest biodiversity within the framework of the *Act on the Financing of Sustainable Forestry*. The 2009 Standards address seven thematic groups. Climate-related criteria are included under the theme of "Promoting wood production" as follows: 2. Forest stand shall be preserved as a healthy carbon sink 3. Health of the stand shall be attended 4. Finnish native tree species shall be used in forest regeneration 6. Forest management planning shall promote sustainable use and management of forests 7. Seedling stands shall be tended to safeguard wood production 8. First commercial thinnings and delivery sales shall be promoted in order to improve the growing conditions of forest stands in private forests 14 Gene modified seed and plant material shall not be used
Impacts:	"The standard defines regional target requirements for seedling and sapling stand tending (at least 60 % of the sapling stands needing tending shall be managed). The updated Criterion 14 concerning the use of gene modified seed and plant material is stricter than in the previous standard. The updated criterion strictly prohibits the use of such material in forest regeneration."
Outcomes:	
Challenges:	"Legislation guiding the adaptation to climate change is still under development, and the existing regulations do not impose direct requirements on forestry. The monitoring methods of greenhouse gas dynamics and related action plans are not yet applicable to practical forestry. This currently limits the possibilities to elaborate normative regulations for climate change adapted forest management. The Government, however, intends to subsidize energy wood growing and harvesting as a way to meet the state targets for bioenergy use."
Lessons learned:	
Unknowns:	
References:	Comparison report on the changes in the revised PEFC FI 1002 Standard and their impact on forest management, 2010.

Appendix I: Interview questions

(Policy Developers and Implementers)

I. Objectives and Values

Interviewee name:

Interviewee position and affiliation:

1. What is the role of your department? And, what are its goals and objectives?
2. What are your current forest management objectives in your own role? And, how are these prioritized (e.g. criteria)?
3. What decisions do you make with respect to these objectives?
4. How do you influence the decisions of others?
5. How do your own objectives relate to those of i) your department? ii) other departments?
6. Who are the other actors, both major and minor, that interact with your department with respect to your objectives?

II. Climate Change and Risks

7. Are the following issues seen as risks for your department/organization? And if so, how and to what degree?
   - Fire risk?
   - Forest health?
   - Forest resilience?
8. How are these risks mitigated, addressed or shared?

III. Policy and instruments

9. What policies and instruments (e.g. regulations, standards, approval processes, fees) do you currently use to manage for your objectives and how do they influence the behaviours of other direct actors (e.g. industry, private landowners, municipalities)?
10. What do you see happening "on the ground" as a result of these policies and instruments?
11. Where do you feel that these instruments fall short (i.e., fail to adequately achieve your objectives) or generate unintended consequences? And, how could they be improved?
12. What do you think are important qualities and characteristics of instruments for managing i) fire, ii) forest health and iii) forest resilience)?
13. Are you aware of any innovative instruments or ideas that may have potential applications to better achieving your objectives or addressing/mitigating risks?

(Associations)

I. Objectives and Values

Interviewee name:

Interviewee position and affiliation:

14. What do you understand to be the current objectives of licensees? And, how are these prioritized (e.g. criteria)?
15. What decisions do licensees make with respect to these objectives? And, how do they influence the decisions of others?
16. Who are the actors, both major and minor, that interact with respect to forest management objectives?

II. Climate Change and Risks

17. Are the following issues seen as risks for licensees? And if so, how and to what degree? Who else might bear the risk? (i.e. community watershed; local economic activity and impacts on community; impact on FN etc.)
    - Fire risk?
    - Forest health?
    - Forest resilience?
18. How are these risks mitigated, addressed or shared?

III. Policy and instruments

19. What policies and instruments (e.g. regulations, standards, approval processes, fees) affect the decisions licensees make with respect to their objectives?
20. How much discretion or flexibility exists within the instruments and policies in how they influence decision-making?
21. What do you see happening "on the ground" as a result of these policies and instruments?
22. How do these instruments influence the behaviours of other direct actors (e.g. industry, private landowners, municipalities)?
23. Where do you feel that these instruments fall short (i.e., fail to influence decisions) or generate unintended consequences? And, how could they be improved?
24. What do you think are important qualities and characteristics of instruments for managing for these objectives (i.e., fire, forest health, forest resilience)?
25. Are you aware of any innovative instruments or ideas that may have potential applications to better achieving your objectives or addressing/mitigating risks?

(Forestry Operators)

I. Objectives and Values

Interviewee name:

Interviewee position and affiliation:

26. What are your current forest management objectives in your role? And, how are these prioritized (e.g. criteria)?
27. What decisions do you make with respect to these objectives? And, how do you influence the decisions of others?
28. How do these objectives relate to the forest management objectives of your company?
29. Who are the other actors, both major and minor, that interact with your company with respect to your objectives?

II. Climate Change and Risks

30. Are the following issues seen as risks for your company? And if so, how and to what degree?
    - Fire risk?
    - Forest health?
    - Forest resilience?
31. How are these risks mitigated, addressed or shared?

III. Policy and instruments

32. What policies and instruments (e.g. regulations, standards, approval processes, fees) affect the decisions you make with respect to your forest management objectives?
33. How much discretion or flexibility exists within the instruments and policies in how they influence decision-making?
34. What do you see happening "on the ground" as a result of these policies and instruments?
35. How do these instruments influence the behaviours of other direct actors (e.g. industry, private landowners, municipalities)?
36. Where do you feel that these instruments fall short (i.e., fail to influence decisions) or generate unintended consequences? And, how could they be improved?
37. What do you think are important qualities and characteristics of instruments for managing for these objectives (i.e., fire, forest health, forest resilience)?
38. Are you aware of any innovative instruments or ideas that may have potential applications to better achieving your objectives or addressing/mitigating risks?

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Annex 2. Phase 2: Case studies

Economic instruments for adaptation to climate change in forestry

Phase 2: Case studies

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Natural Resources Canada | Ressources naturelles Canada

Canada

UBC Forestry
University of British Columbia

Executive summary

Climate change will have significant impacts on our forests including negative impacts such as increased frequency and severity of wildfire, pest and disease outbreaks and changes in ecosystem dynamics (tree regeneration, growth and mortality) that lead to maladaptation of tree species. These impacts will have economic, environmental and social consequences. Adaptation involves undertaking activities to better prepare for those impacts such as assessing the risks of those impacts, planning for them and identifying and implementing mitigative or preventive measures.

The nature of forest management in Canada, where many management decisions are delegated to the private sector that also carries out most of the operational activities, means that the private sector will play a significant role in adaptation. Moving forward on adaptation requires understanding how to best engage the private sector. Economic instruments offer an alternative to command and control approaches; where properly designed, previous experience has shown that they can provide more efficient and cost-effective ways of meeting environmental objectives (e.g. OECD 2008; Stavins 2001). However, there has been little work done in this area in regards to adaptation (Bräuninger et al. 2011). The goal of this research is to identify economic instruments that could support adaptation of Canadian forests to climate change by drawing on the experiences and efforts taken to date in BC and elsewhere.

The term “economic instruments” has traditionally referred to the range of tools and approaches that operate on a more decentralized basis by increasing the cost of more environmentally damaging activities while increasing the return from more sustainable activities (UNEP 2004). More recently, these financial and market-based approaches have expanded through the consideration of behavioural and informational mechanisms that can be used to improve decision-making (Ferraro et al. 2013; Shogren 2010; Wilson et al. 2012). The benefits of economic instruments relative to regulatory approaches are that they offer increased flexibility, may require less regulatory expenditure and, in some cases, can raise revenues that can be used to achieve policy objectives. However, there are challenges in moving from theory to practical application of economic instruments, including identifying the appropriate tools and ways that they can be integrated into existing regulatory structures (UNEP 2004). Other policy constraints, such as political factions, legal gaps and institutional weaknesses, may also affect which types of tools that can be used. Examination of economic instruments and the benefits that they can potentially provide therefore requires consideration of the broader policy and institutional context in which they will be applied.

The *Economic Instruments to Support Adaptation to Climate Change in Forestry* project is exploring how different types of economic instruments (e.g. financial, behavioural, informational and regulatory) could be adopted to forest management and encourage forest managers, licensees and communities to take a pro-active approach to addressing the risks of climate change to Canada’s forests.

Phase 1 of the project, undertaken from October to December 2013, included a review of the goals of policy makers and forest managers and the most important risks to those goals. Potential instruments (i.e. financial, behavioural, informational and regulatory) were then identified in the context of measures to be considered in mitigating those risks.

This document presents the results of **Phase 2** of the project, conducted from January to October 2014, which focused on three case studies of economic instruments to support adaptation to climate change in British Columbia's (B.C.'s) forests:

Case study 1 explores wildfire risks in the context of communities and the use of municipal development permits (informational and regulatory instruments). Development permits are planning tools that local governments can use to manage development, protect the environment and address local health and safety issues. The system can be used to combine management of zoning, site planning and minor variants into a single process. More than a dozen communities in British Columbia and Alberta have begun to use development permits to control the extent, nature and location of new residential development in the wildland-urban interface (WUI), establishing an emerging policy instrument for local governments to address the risk of loss from wildland fire and ensure that communities are safe places to live, work and play.

Case study 2 examines the economic implications of using climate-based seed transfer (CBST) to implement assisted migration of commercial tree species. One of the potentially most cost-effective approaches to climate change adaptation in forestry is ensuring that seedlings planted following harvest are adequately adapted to the future climate. CBST is the process of allocating seedlings to planting sites based on climatic attributes, in contrast to British Columbia's current geographical seed transfer system based on seed planning zones, latitude, longitude, and elevation. CBST provides the mechanism for assisted migration, i.e. to move beyond a "local is best" seed transfer policy and select non-local seed sources that are adapted to the range of projected future climates at the planting site. The economic analysis in this case study indicates that assisted migration is potentially very beneficial to both the provincial economy and to government revenues, even if an increase in short-term risk of regeneration failure is required to achieve a reduction in the long-term risk of plantation failure. However, as private-sector resource tenants on crown land, forest licensees are highly sensitive to real or perceived increases in regeneration risks. In the context of the nascent scientific basis for CBST, a conservative approach to assisted migration is warranted. Nevertheless, whether government pursues a conservative or aggressive assisted migration strategy, accounting for regeneration risk will be a central challenge in engaging licensees as partners in the implementation of CBST policy. Monitoring of the impacts of assisted migration on regeneration success is identified as a fundamental requirement to managing perceptions of risk and also to equitable risk-sharing between licensees and government. This case study also investigates opportunities and challenges to risk accounting and risk sharing within the appraisal system, the timber supply review, and the professional reliance framework.

Case study 3 identifies incentives to support collaborative wildfire planning and management (informational, financial and regulatory incentives). This case study focuses on wildfire risk across the forested landscape (i.e. was not limited to the WUI zone). A common issue across jurisdictions, regardless of whether they specifically focus on the WUI, is identifying wildfire risks and coordinating planning and funding suppression and mitigation activities. Allocating financial resources to support planning or to implement activities identified through the planning process is a common challenge. The case study describes different programs and approaches to coordinating and planning among different stakeholders by drawing on examples from British Columbia, Canada; Victoria, Australia; and the USA.

It also describes different financing mechanisms to support different adaptation activities (e.g. to support coordination or fund wildfire treatments where the costs might exceed the timber values) and explores the use of an additional levy on stumpage in British Columbia as a way to generate funds for adaptation. While this case study focuses specifically on identifying key characteristics of instruments to support adaptation and reduce the risk of wildfires through collaborative planning and management, it is expected that such processes can be amended to address other climate-related risks (e.g. pests, maladaptation) in the future, including finding ways to finance associated activities.

List of acronyms

ABCFP	Association of British Columbia Forestry Professionals
ACE	Allowable Cut Effect
AMAT	Assisted Mitigation Adaptation Trial
AAC	Annual Allowable Cut
BCTS	BC Timber Sales
BEC	Biogeoclimatic Ecosystem Classification
BLM	Bureau of Land Management
CBA	Cost-benefit analysis
CBST	Climate-Based Seed Transfer
DEPI	Department of Environment and Primary Industries
DFAM	Defined Forest Area Management
DSE	Department of Sustainability and Environment
ESRD	Environment and Sustainable Resource Development
FEMA	Federal Emergency Management Agency
FFEI	Future Forests Ecosystem Initiative
FFT	Forests for Tomorrow; also Forestry Futures Trust
FGC	Forest Genetics Council
FNFC	First Nations Forestry Council
FPPR	Forest Planning and Practices Regulation
FRBC	Forest Renewal BC
FREP	Forest and Range Evaluation Program
FRIAA	Forest Resources Improvement Association of Alberta
FRIP	Forest Resources Improvement Program
FRPA	*Forest and Range Practices Act*
FRT	Forest Renewal Trust
IFPA	Innovative Forest Practice Agreement
LBIP	Land-Base Investment Program
LBIS	Land-Base Investment System
MAI	Mean annual increment
MFLNRO	BC Ministry of Forests, Lands and Natural Resource Operations
MPB	Mountain Pine Beetle
MPBI	Mountain Pine Beetle Initiative
NFP	National Fire Plan
NFPA	National Fire Protection Association
NPV	Net present value
ROCE	Return on capital employed
RPF	Registered Professional Forester
TFL	Tree Farm License
TIIP	Tree Improvement Investment Priorities
TIPSY	Table Interpolation for Stand Yields
TSA	Timber Supply Area
TSR	Timber Supply Review
USDA	US Department of Agriculture
USFS	US Forest Service
WMB	Wildfire Management Branch
WUI	Wildland-urban interface

Project background

The *Economic Instruments to Support Adaptation to Climate Change in Forestry* project is supported by Natural Resources Canada under the program of the Economics Working Group of Canada's Adaptation Platform, in partnership with BC's Forests, Lands and Natural Resource Operations and expert advisors representing forestry stakeholders. The goal of the project is to identify promising economic instruments to adapt British Columbia's forests to climate change. The project objectives are to:

1. Reduce risks of wildfire and impacts on communities and infrastructure.
2. Ensure forest health (e.g. minimize forest pests and disease) and reduce maladaptation
3. Promote forest resiliency to impacts of climate change.

Phase 1 of the project (October-December 2013) included a review of existing economic instruments in Canada, the US and Scandinavia and a series of interviews with forest industry experts, the BC government, First Nations and industry. The research team then hosted a workshop with 25 experts to identify critical climate-change related risks to forests and economic instruments that may be of greatest interest in the context of BC. The results from the workshop, in consultation with the Advisory Team and with input from the expert advisors, were used to identify three specific case studies of potential instruments that could be used to encourage adaptation within those risk areas.

Phase 2 of the project (January-October 2014), focused on these three case studies of economic instruments (Table 1). A second workshop will be hosted in November 2014 to review the case study results with 40 experts and evaluate the feasibility of the proposed instruments, including identifying any information gaps, what concerns might arise and how those can be addressed, and possible implementation requirements.

Economic instruments

Economic instruments refer to the range of tools and approaches that operate on a more decentralized basis by increasing the cost of more environmentally damaging activities while increasing the return from more sustainable activities (UNEP 2004). Such approaches have been employed to address environmental issues, including the use of pollution taxes, emissions charges, cap and trade systems, and deposit-refund systems (among others) as ways to address pollution. More recently, these financial and market-based approaches have expanded through the consideration of behavioural and informational mechanisms that can be used to improve decision-making around achieving better outcomes. Examples of such approaches include presenting information in a particular context, allowing decision-makers to evaluate their choices in the context of social norms, or addressing well-known cognitive biases that can distort outcomes (i.e. underestimating the consequences of low probability but high-impact events, how people evaluate gains relative to losses and commitment issues) (Ferraro et al 2013; Shogren 2010; Wilson et al 2012). While economic instruments are often contrasted with more traditional command and control (or regulatory approaches), commonly the two work together and can support one another.

The benefits of economic instruments relative to regulatory approaches are that they offer increased flexibility, may require less regulatory expenditures, and in some cases can raise revenues that can be used to achieve policy objectives. However there are challenges in moving from theory to practical application, including identifying the appropriate tools and how they can be integrated into pre-existing regulatory structures (UNEP 2004). As well, other policy constraints, such as political factions, legal gaps, and institutional weakness may also affect which types of tools that can be used. Examination of economic instruments and the benefits they can potentially provide therefore requires a consideration of the broader policy and institutional context in which they will be used.

While in theory there is a broad range of economic instruments to achieve environmental objectives, their application remains relatively limited with regulatory approaches predominating for the reasons previously identified (Stavins 2001). This same issue, moving from theory to practice, also affects the adoption of economic instruments for adaptation, particularly where there are a limited number of practical examples from which we can draw. Proposals for instruments to be used in adaptation range from the use of tools already being employed to address existing environmental issues to more theoretical constructs such as markets for adaptation credits (Bräuninger et al 2011). Sectoral studies have been conducted to examine how economic instruments could be used (among other tools) to address adaptation for sea level rise (Agrawala et al 2008; Gramis 2011); agriculture (Agrawala et al 2008); and water supply (Bräuninger et al 2011).

Some of the difficulties in developing instruments for adaptation, beyond translating the environmental objective into a related adaptation objectives, include barriers around adopting policies specifically associated with climate change including: the uncertainty and ambiguity around climate change impacts; differences between the time frame of those impacts and decision-making; and models that can be used to identify and understand climate change impacts and evaluate solutions. Other issues reflect more generally the issues related to institutional or policy change, including the distribution of costs and benefits; financial resources; knowledge and the availability of information; social acceptance and technical capability among other factors (Biesbrock et al 2013).

Introduction

Climate change will have significant impacts on our forests, where those negative impacts, including increased fire, pest and disease outbreaks and changes in ecosystem dynamics (tree regeneration, growth and mortality) that lead to maladaptation of tree species, will have economic, environmental and social consequences. Adaptation involves undertaking activities to better prepare for those impacts such as assessing the risks of those impacts, planning for them and identifying and implementing mitigative or preventive measures.

The *Economic Instruments to Support Adaptation to Climate Change in Forestry* project is exploring how different types of economic instruments (e.g. financial, behavioural, informational and regulatory) can encourage forest managers, licensees and communities to take a pro-active approach to addressing the risks of climate change to Canada's forests.

Phase 1 of the project included a review of the goals of policy makers and forest managers and the most important risks to those goals. Potential instruments, including regulatory ones, were then identified in the context of measures to be considered in mitigating those risks.

This document presents the results of **Phase 2** of the project, conducted from January-October 2014, which focused on three case studies of economic instruments to support adaptation to climate change in British Columbia's (B.C.'s) forest industry:

Case study 1 explores wildfire risks in the context of communities and the use of municipal Development Permit Systems (informational and regulatory instruments).

Case study 2 examines a specific practice for climate change adaptation, called Climate-Based Seed Transfer, using economic analysis to identify where and how information and incentives can play a role in enhancing forest resilience (informational instrument).

Case study 3 identifies incentives to support collaborative wildfire planning and management (informational, financial and regulatory incentives).

Table 1 provides a brief overview of the case studies, including the objectives and instruments assessed within each study.

Table 1: Summary of Phase 2 case studies.

Case study 1: Development Permit System	
Risk Category	Wildland Urban Interface Fire
Objectives	• Identify an emerging regulatory tool available to local and regional governments to manage the risk of loss from wildland urban interface fire. • Identify mechanisms for local governments to control the extent and nature of residential development in zones of high fire risk.
Potential Instruments	• Incorporate development permit approvals within a comprehensive strategy for communities to manage the risk of loss in the interface. • Local planning authority can be used to influence the extent and location of new residential development in the community. • Permits can be used to require fire resilience construction and landscaping for new homes built in the interface.
Generalization	• Case study showcases an emerging planning tool introduced in several communities in British Columbia to manage the largely uncontrolled and rapid growth of unprotected residences in the wildland urban interface. • Focus is on the BC context, but applies to interface fire management across Canada.
Case study 2: Climate-Based Seed Transfer	
Risk Category	Maladaptation
Objectives	• Identify the economic incentives and disincentives for climate-based seed transfer, from the perspectives of government and licensees. • Identify mechanisms to encourage licensees to be actively involved in research and implementation of climate-based seed transfer.
Potential Instruments	• Incorporate climate maladaptation into TSR to facilitate allowable cut effects. • Prioritize CBST research to minimize short-term economic risks to licensees. • Stumpage transfers (e.g. FIA).
Generalization	• Case study exemplifies the divergent perspectives of government and licensees on silviculture investments in general, particularly in climate change adaptation. • Focus is on the BC context, but applies to crown forest land across Canada.

Table 1: Summary of Phase 2 case studies (continued).

Case study 3: Collaborative Planning and Management	
Risk Category	Landscape wildfire, with extension to pests and maladaptation
Objectives	• Encourage long-term, multi-stakeholder planning. • Offer management structure to coordinate and guide actions using incentives for collaborative planning/area-based planning and funding for adaptation actions.
Potential instruments	• Type 4 Silviculture Strategies (integrate cumulative effects and fire planning). • Landscape Fire Management Planning. • Innovative Forest Practices Agreements. • Forest Renewal BC and Super-Stumpage. • US Forest Service programs. • Victoria (Australia) Government Bushfire Management Program.
Generalization	• Case study focuses on key features of individual and integrated tools to support area-based planning for wildfire; with broader applications to other risks (i.e. pests, maladaptation) once the program is established and additional information about these risks is available. • Focus is on the BC, Western US and Australian context, but applies to fire management across Canada.

The multidimensional nature of these risks and interrelated nature of forest ecosystems leads to natural overlaps between many of the case studies and possible interactions between different instruments. For example, given that wildfire can occur across the landscape, tools to address fire risk on the public land base can address the wildland urban interface (Case Study 3) while efforts to mitigate risk on private lands within communities (Case Study 1) can be strengthened through outside efforts. Elsewhere, efforts to provide incentives for efforts to address fire risk on the forest landscape (Case Study 3) can also be adapted to address other risks such as maladaptation (Case Study 2). There may also be cases where co-benefits exist: for example, efforts to reduce fire risk may enhance forest resilience by reducing susceptibility to pests and pathogens. Finally, the integrated nature of these objectives in conjunction with the forest management system means that these instruments do not exist in isolation; in many cases, they are used in conjunction with existing policy mechanisms or used to support other efforts, including planning, the adoption of complementary economic instruments and even regulatory measures. Therefore, policy coherence is important in evaluating instruments, including consistency with existing policies, and any possible synergies along with potential incompatibility or conflicts.

The intention of this document is to stimulate thinking about how existing or innovative economic instruments could be applied to the three climate-related forest risk areas upon which this project is focused: fire, pests and maladaptation. The contents of this document will provide a foundation for selection and investigation of three detailed case studies of potential economic instruments for analysis during the subsequent phase of this research project, from March-December 2014. This information, as well as information from the case studies, will be made available in a final project report, to be completed by the end of December 2014.

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Case study: Development permits

An emerging policy instrument for local governments to manage interface fire risk in a changing climate

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Executive summary

Development permits are planning tools that local governments can use to manage development, protect the environment and address local health and safety issues. The system can be used to combine management of zoning, site planning and minor variants into a single process. More than a dozen communities in British Columbia and Alberta have begun to use development permits to control the extent, nature and location of new residential development in the wildland-urban interface, establishing an emerging policy instrument for local governments to address the risk of loss from wildland fire and ensure that communities are safe places to live, work and play.

Several local governments now include covenants in the development permit system requiring fire-resilient building materials for new homes. Conditions for approving a development permit may include fire-retardant roofing, exterior walls sheathed with fire-resistive materials, windows with tempered or double-glazed glass, decks built with fire resistant materials, screens on all eaves, attics and roof vents and chimney spark arrestors. The provincial and territorial governments do not presently include provisions addressing the risk of damage from wildland fires through their building codes; fortunately, these public safety measures are now emerging in local government development permit requirements.

The development permit system can also address landscaping and site considerations to reduce the risk that wildland fire will enter and spread through a community. This may include a requirement for defensible space of at least 10 metres around each home free of combustible materials, thinned plantings and reduced combustibles in a zone extending at least 30 metres around each home, underground servicing for hydro, considerations to address the additional risk to structures on a slope, fire breaks and other community safety measures. The overall objective is to ensure that new residential developments are designed with measures to defend against the risk of wildland fire blowing or burning into the community.

Most significantly, development permits provide local governments with the authority to control and even prohibit residential development in zones of high fire risk. There has been rapid growth in the number of people that live in or near the wildlands across Canada. This includes more permanent residences and seasonal homes. Evidence from the United States, Australia and emerging in Canada shows that growth in the number of people living in areas at risk is a critical factor that has been increasing loss and damage in the wildland-urban interface. Development permits give local governments the authority and responsibility to control residential development in interface zones with high risk of fire.

Land use planning is a tool that local governments around the world use to reduce the risk of flood damage. In Canada, several communities have begun to use planning tools, like development permits, within a comprehensive community wildland fire management strategy. The growing population living in the interface and projections of an increasing area burned by wildfire due to climate change suggests that these tools are likely to spread in the years ahead to be used by local governments across the country. Local planning decisions can provide an important contribution within a comprehensive community wildland-urban interface fire management strategy.

Contents

Introduction

Fire is an essential agent for ecological renewal and health in Canada's forests and grasslands. However, fire also has the potential to destroy homes, disrupt communities and threaten the health and safety of Canadians. Loss and damage from fire in the wildland-urban interface has been growing and is expected to increase significantly over the coming decades unless current practices adapt. In particular, the rising number of people that live in the interface and the impact of climate change to increase the expected area burned are two factors that will drive fire losses higher unless action is taken.

For almost one hundred years, fire specialists have managed the risk of loss and damage from wildfire in Canada with little involvement from individual property owners and communities located in or near the wildlands. Most fires were identified soon after they began and suppressed quickly. For many decades, there were few wildfire fatalities and relatively little damage to property.

Since the 1990s, however, there has been a trend of rising costs of fighting wildland fire and fire damage. These costs have been growing in Canada and have increased at an unsustainable rate in some other countries, like the United States and Australia. The most damaging wildfires in Canadian history, in terms of the value of property destroyed, were relatively recent events in 2003 and 2011. There is widespread agreement that the current approach to fire management needs to evolve (Canadian Council of Forest Ministers 2005; Hirsch and Fuglem 2006).

Emerging fire management best practices are complex and seek to involve many stakeholders. Fire specialists continue to address fires when they ignite. There are also efforts to reduce the risk of large, uncontrolled fire through prescribed burning, thinning of forests and creation of fire breaks. Beyond the forests, efforts are underway to involve property owners in managing the risk of fire damage. National programs like FireSmart seek to educate property owners and community leaders about the role of fire in the ecosystem and actions Canadians can take to reduce the risk that fire enters a community.

New wildfire management tools are frequently identified and tested in this changing environment. Of interest in this report is the emerging role of local government planning officials. Over many decades, planners have provided important tools to address other hazards, like the risk of loss from flooding. Some progressive communities have begun using established tools, like development permits, to address the risk of damage from wildfire.

The development permit system is a planning tool that local governments can use to manage development, protect the environment and address health and safety issues. The system can be used to combine management of zoning, site planning and minor variants into a single process. Some communities have begun to use development permits to control the extent, nature and location of new residential development in the wildland-urban interface, establishing a new policy instrument to address the risk of loss from wildland fire and ensure that our communities are safe places to live, work and play. These tools may spread in the years ahead to be used by local governments across the country, recognizing the important contribution that local planning decisions can make within a comprehensive wildland-urban interface fire management strategy.

Background

More than 93 percent of Canada's 402 million hectares of forests are located on public lands, so wildfire management has traditionally been viewed as the responsibility of the provincial, territorial and federal governments (Canadian Wildland Fire Strategy Vision 2005). Other stakeholders, like forestry companies, are aware of the importance of fire for their business operations. Communities located in the wildlands may have experienced multiple evacuation orders due to wildfire and are aware of the risks to health and property. Nevertheless, it is widely held that that the provincial, territorial and federal governments have lead responsibility for wildland fire management in Canada.

Provincial and territorial governments also have legislation in place that sets out the powers and authorities of local governments to address community issues. In British Columbia, this is the *Local Governments Act*; in Alberta, it is the *Municipal Governments Act*. The Government of Canada has legislation in place setting out the powers and authorities for a specified group of First Nations to manage their lands through the *First Nations Land Management Act*. The purpose of the provincial, territorial and federal legislation is to provide the legal framework for local action by establishing the powers, duties and functions necessary for local decision makers to respond to the needs of their communities.

Some of the functions assigned to local governments include policing and public safety, planning and land use management, enforcement of building regulations, urban fire protection, public health, storm and waste water management, waste and recycling management, heritage conservation and animal control (Tindall et al 2012). There is some variation across the country in the specific policy areas assigned to local governments. There is also variation in the role for local and regional governments. Nevertheless, the specific functions and authority of local governments are determined by the provincial and territorial governments and have considerable similarity across the country. In particular, land use development and community planning is a function provided by local governments across the country. The development permit system is one dimension of the planning authority assigned to local governments.

Building codes and the regulation of construction is also an essential element of managing the risk of loss and damage as a result of hazards. The provincial and territorial governments have primary responsibility for regulating construction practices in Canada, but aspects are shared with the federal and local governments. The Government of Canada produces a model building code in partnership with the provincial and territorial governments. The model code applies to federal lands and is a guide that provincial and territorial governments use to create their building code legislation. The provincial and territorial governments, in turn, assign responsibility for enforcing compliance with the codes to local and regional governments. The City of Vancouver has authority to manage a building code for the city. Other local governments across Canada can use land use planning powers to introduce requirements for their communities to address environmental or health and safety issues.

Partners in Protection and NFPA Canada made a joint submission requesting that the Canadian model building code introduce requirements to address the risk of loss and damage from wildland fire. The Canadian Commission of Building and Fire Codes, noting that there was not a consensus to go forward at the time, rejected this request in 2012 (Canadian Press 2012). Code officials indicated that local land use planning bylaws might be a better mechanism than building codes to address the hazard of wildland fire.

A brief history of wildland fire management

Fire has been present on the North American landscape for thousands of years. Wildfire is a natural phenomenon that is essential for the health of forests and grasslands. Many ecosystems have evolved to depend on fire to bring renewal and regrowth. This includes prairie, savanna and coniferous forests. Many plants and trees require fire to germinate and reproduce, while animals, in turn, are dependent on these grasslands and forests.

Fire is also a longstanding threat: lives have been lost and property destroyed by fire. This hazard has increased with more people living in the wildland-urban interface and active in the wildlands. Change in the climate is expected to significantly increase the area burned by wildfire and the risk of loss unless current fire practices adapt and evolve.

Prior to European settlement

Aboriginal groups across North America actively managed wildland fire for many generations prior to European settlement, resulting in profound changes to the landscape. Lightning brought natural fires that occasionally burned grasslands and forests, while intentional burning was conducted with greater frequency over smaller areas. Depending on need and circumstances, controlled burns may take place every one to three years. Moreover, intentional fires were at a different time of the season than natural fires that typically peak during the summer. In moist climates, intentional fire was used in the spring to control new growth, while in dry regions it was more common to set fires in the fall. The cycle of burning would be suspended during periods of prolonged drought due to the increased risk of fires burning out of control (Lewis 1982).

There were many reasons why aboriginal peoples actively managed fire, including hunting and protection of settlements. Fire could be used to divert deer, elk and bison into specific locations for easier hunting. Fire also increased the grasslands available to support larger herds of grazing animals and the food available to support the community. Regular burning near settlements reduced the threat to lives and property from catastrophic uncontrolled fire. Fire could also increase berry yields, reduce the cover that predators like wolves and bears may use to hide in, and ease movement through the wildlands.

Despite active efforts to manage the hazard, fire likely resulted in occasional periods of catastrophic loss of life and property. Natural periods of extended drought would leave grasslands and forests vulnerable to lightning or accidental ignition from a cooking fire, a peril beyond the capacity for management. Fire could destroy property accumulated over a lifetime, ruin crops and scare away prey. The largest loss of life may come from starvation and illness following the fire.

The wildlands in North America prior to European settlement had been shaped by many generations of natural and managed fire. In particular, fire management by aboriginal peoples had transformed some forests into grasslands and savanna, and where forests remain, fire was used to increase the open space between trees and remove underbrush.

European settlement

Fire management changed with European settlement. Available documentation indicates that settlers were largely unaware that the aboriginal community had actively managed the landscape. The objective in villages and towns was to suppress all urban fires. Lightning, campfires, sparks from a locomotive and other sources lead to an increased frequency of fires in the wildland. During very dry summers, large fire events destroyed settlements across North America. Hundreds of people were killed in emerging towns and villages, while the fate is unknown for thousands of men working in the forests (Pyne 1982).

Large fires sometimes burned through villages and towns across the continent. There was a tragic loss of life and distressing destruction of property. Some of largest fire losses ever experienced in Canada include the Miramichi Fire in 1825, the Saguenay Fire in 1870, Cochrane Fire in 1911, Matheson Fires in 1916, the Great Saskatchewan Fire in 1919, and the Haileybury Fire in 1922 (McIntyre 2003). Hundreds of people lost their lives, and many villages and towns were destroyed.

Several communities in the United States were destroyed by the Great Fire of 1910, prompting the U.S. Forest Service to commit to a strategy of suppressing all forest and grass fires in the wildland. Governments across Canada soon adopted a suppression strategy for much of the country. Success for firefighters was measured in how soon a fire was identified and put out.

European settlement brought a new era for fire management, with a focus on fire exclusion in the wildlands. The result, at considerable cost, was a significant reduction of fatalities and property damage across Canada and the United States due to wildfire. This approach was sustained for several decades.

Toward a modern approach

In the 1980s and 1990s, a number of large loss events began to re-emerge in Canada and on a larger scale in the United States. Decades of fire exclusion had transformed the wildland. There was a significant accumulation of shrubs, bushes and undergrowth that was described by firefighters as “fuel”. Moreover, the extended period of safety was one of the factors that encouraged more people to pursue recreation activities in the wildland and to live in the wildland-urban interface.

There has been a remarkable increase in the number of people in the United States who live in the wildland-urban interface, with the largest increases over the last few years. Data are not available for Canada but there is clear evidence that more Canadians are spending time in the wildlands and living in the interface, and these totals are expected to grow.

The Forest Service in the United States has withdrawn its commitment to suppress all fires in the wildland; nevertheless, firefighting efforts in Canada and the United States continue to focus on the early identification and suppression of fires in the wildland. The cost of fire exclusion has increased significantly over the past few decades, driven by the growing number of homes located in areas of risk and increased area burned. Some are questioning if this rising public cost can be sustained.

In 2005, a joint federal, provincial and territorial vision statement was released setting out a plan for managing fire risks through the *Canadian Wildland Fire Strategy*. This national vision seeks to establish a balance between actions to respond to wildfire, promote healthy forests, and build resilient communities. The vision statement has enjoyed strong support over the past decade from a broad range of stakeholders, although lack of funding continues to delay implementation.

One of the three core elements of the *Canadian Wildland Fire Strategy* involves the establishment of resilient communities and an empowered public. FireSmart Canada is the leading organization supporting community action in Canada to address wildfire.

In the 1990s, Partners in Protection created FireSmart with support from the Alberta Forest Services and a number of other partners. FireSmart Canada provides information about actions that should be taken by communities and individuals to protect themselves from the risk of wildland fire.

Partners in Protection continues to operate FireSmart as the national program seeking to protect lives and property across the country from wildfire damage despite the meagre financial support from the federal, provincial and territorial governments. One of the first documents produced by FireSmart was *Protecting Your Community from Wildfire*. This report sets out specific actions that can be taken at the community level by local governments and other stakeholders. This includes advice on planning tools available to local governments.

In the United States, there are many organizations pressing for greater local participation in wildfire management. For example, the American Planning Association has been providing wildfire advice to local planning officials since 2004, with reports like *Planning for Wildfire* (Schwab, Meck and Simone 2004). In Canada FireSmart has virtually been alone in the provision of local advice and support.

Development of a national vision for wildland fire management, provincial and territorial governments spending billions of dollars on fire suppression, and the welcome leadership by FireSmart Canada to promote community preparedness, are welcome advances in Canada's management of wildland fire. Nevertheless, wildland fire loss and damage is rising. In particular, Canada experienced its largest wildland fire damage events in 2003 and 2011, including hundreds of homes destroyed in Kelowna and Slave Lake. Moreover, the number of Canadians living in the interface and visiting the wildland continues to grow and evidence is mounting that change in the climate will significantly increase the expected area burned. Increased loss and damage is expected unless further change occurs.

As a result of recent major wildfire events in Canada, property owners and their communities are taking on more significant roles in protecting themselves. In addition to the FireSmart initiative, community planning and development permits, many communities have also begun to expand their abilities a deal with wildfires. This includes cross-training community firefighters in wildfire control techniques and coordination with wildland fire firefighters. Some communities have purchased wildland compatible fire engines and wildfire sprinkler systems for local deployment.

Drivers increasing the risk of loss and damage

Many factors affect the risk of wildland fire. Two drivers that are expected to push the risk higher over the coming decades are the number of people living in the urban-wildland interface and climate change.

A growing population living at risk

Since 1980, there have been millions of acres burned across Canada with little loss and damage. Fire management and suppression has been successful in preventing loss of life, injuries and damage to property. Beverly and Bothwell 2011 found that only one Canadian was killed by wildland fire in the period between 1980 and 2007, while three others died as a result of the stress associated with evacuations.

The number of Canadians living in the interface is unknown. On average, 7,500 Canadians are ordered to evacuate each year because of the risk of wildfire (Beverly and Bothwell 2011). Hundreds of homes were destroyed by fire in Slave Lake, Kelowna and a number of other communities. The population at risk includes people living in the urban-wildland interface and people that visit the wildlands. There is widespread agreement that the number of Canadians that live, work and play in the wildlands is growing.

The number of people living in the interface in the United States increased from 25 million in 1960 to now exceed 140 million (Bailey 2007). The number of homes in the interface has grown rapidly over several decades, including permanent residences and seasonal dwellings. The number of homes destroyed each year by wildfire in the United States increased ten-fold from 400 in the 1970s to more than 4,000 recently (Bailey 2007). A larger population at risk contributed to the increase in fire loss and damage.

Available data for Canada shows that the four provinces with the most homes destroyed by wildfire over the period since 1980 are Alberta, British Columbia, Manitoba and Saskatchewan (Beverly and Bothwell 2011). The largest loss of homes from wildland fire has been concentrated in Alberta and British Columbia, including several hundred homes lost in Slave Lake and Kelowna in fires during 2011 and 2003. More than 95 percent of the homes destroyed by wildfire in Alberta and British Columbia since 1980 were permanent homes while less than five percent were seasonal dwellings. The experience of permanent homes destroyed in Alberta and British Columbia has shaped the focus of public and policy maker attention.

In contrast, very few homes were destroyed by fire in the other provinces and territories since 1980, and more than half of these were cabins, cottages and other seasonal homes. There have been evacuations in communities at risk across Canada, but in most of the country the experience with buildings destroyed by fire has largely involved a relatively small number of seasonal dwellings.

Less than four percent of Canadians self-identify as aboriginals yet one third of the people evacuated since 1980 lived in First Nation communities (Beverly and Bothwell 2011). Most of these (88 percent) were located in Ontario, Manitoba, Saskatchewan, or Quebec. There are more than 750 aboriginal communities across Canada and most are located in zones of high wildland fire risk. Aboriginal communities are much more vulnerable to wildland fire than other communities across Canada, largely due to location. These communities face a wide range of socio-economic issues, including concerns about access to quality housing. The risk of loss from wildland fire is one of the many issues that need to be addressed.

Change in the climate

Fire frequency and intensity has long been highly correlated with climate conditions. Indeed, three critical factors that determine the area burned by wildfire include the frequency of ignitions, fire control activities and weather. Some weather factors that affect wildfire include temperature, precipitation, humidity, wind speed and the frequency of lightning (Flannigan 1990).

Evidence over several decades shows a high correlation between area burned and temperature (Gillett et al 2004). Projections of rising summer temperatures warn that the area burned each year in Canada is expected to double by the end of this century with warming of the climate (Flannigan et al 2009). Summer temperature is the most important long-term weather variable that predicts the expected area burned by wildfire.

Area burned is also highly correlated with periods of drought and long sequences without rainfall. A sequence of rain events, for example, makes a greater contribution to reduce the risk of wildfire than the same volume of precipitation falling in a single large rain event. Climate change is projected to increase the frequency of summer days with no rainfall across Canada.

Fire data also shows correlation between relative humidity and area burned. The impact of climate change on relatively humidity is projected to further affect the area burned by wildfire. Wind conditions are important determinants of the speed that fire spreads in the wildland. At this point, it is unclear from the climate research what the impact of climate change will be on wind speeds.

Forest and climate research consistently finds that much of the recent fluctuation in area burned is a result of variation in the climate. While the relationships are complex, there is widespread agreement that temperature is the most important predictor of area burned, with the expected warming associated with climate change expected to significantly increase the area burned in Canada unless actions are taken to reduce ignitions and increase suppression.

Climate models have been used to anticipate the change in the climate and expected area burned across Canada. These studies consistently show large increases in the area over time, with one recent study projecting that the area burned by wildfire will increase by 74 to 118 percent by the end of the century (Flannigan et al 2009). All studies project a significant increase in wildland fire as a result of hotter, drier summers across most of Canada.

Studies anticipate an earlier start to the fire season and the length of the fire season is expected to increase. A much larger area is expected to experience high to extreme fire risk with change in the climate. Indeed, fire may move beyond our forests and grasslands to include peatlands. Nevertheless, most of the increasing wildland fire risk is expected to remain concentrated in Canada's Boreal forest, Taiga and Montane Cordillera.

Elements of a comprehensive fire management strategy

In 2005, the Canadian Council of Forest Ministers issued the *Canadian Wildland Fire Strategy* setting out a shared national vision for managing the risk of fire. The elements of the desired future state set out in the vision included resilient communities and an empowered public, healthy and productive forest ecosystems and modern business practices for responding to wildfires. These critical elements would provide the foundation for a modern, national fire management strategy.

As Canada continues to work toward implementing a national strategy, several local governments have begun providing leadership at the community level. For example, a comprehensive community fire management plan is essential to build resilient and empowered communities. The national vision has strong support from a broad range of stakeholders, and awaits a clear commitment to ensure implementation. The vision can provide a guide for stakeholders, including local governments, to take action now even if it is unclear when the federal, provincial and territorial governments will fully commit to implement the agreed upon national wildland fire strategy.

Healthy forests and grassland ecosystems

Our forests and grasslands are not in the best health. Decades of population growth, urbanization, fire exclusion, infestations and poor forest management practices have disrupted our wildlands. A sustainable and vibrant future for Canadians should include long-term actions to establish and maintain healthy forests and grasslands. Fire should be embraced as essential for healthy and diverse ecosystems. Fire exclusion policies in the wildlands must give way for most of our forests. There is a national consensus that policy emphasis in the wildlands should shift to increasingly protect point values like homes, key watersheds and critical stands of lumber rather than exclusion (Canadian Wildland Fire Strategy Vision 2005).

Adaptive forest management should maintain or enhance the ecological integrity and productivity of the forest ecosystems while protecting the material values of society. Fire suppression is more effective when it is used in combination with prescribed burns, thinning and other proactive fuels management strategies. Aggressive, national efforts to confront infestations, like the Mountain and Western Pine Beetles, are also essential to ensure healthy forests.

Landscape fire planning and management is an important approach to reduce the risk of loss from interface fire. Fuel reduction, modified response fires, modified stocking standards and other harvest treatments can be used to create a more fire resilient landscape in the wildlands and the interface (Osbourne et al 2013). Qualified professionals can best plan for where fire is beneficial or detrimental, and critical areas can be targeted for ecological restoration or prescribed burns to create a more fire-resilient landscape.

Capacity to fight wildland fires

Wildland fire management professionals have successfully defended Canadians from loss of life and destruction of property for many decades. These brave individuals and their successors are a critical part of a modern wildland fire strategy. They need and deserve the appropriate training, equipment and other resources to continue to succeed in protecting Canadians at risk.

Climate change is expected to significantly increase the area burned, while the population living in the wildland-urban interface continues to grow. Provincial and territorial governments should plan for a material increase in the cost of fire monitoring and suppression. Increased costs will likely be sustained over several decades.

Canadians who choose to spend time in the wildlands and live in the wildland-urban interface need to increasingly accept responsibility for their safety and that of others. More aggressive actions should be taken to confront the increase in accidental fires and arson. Moreover, there should be greater clarity about the importance of firefighter safety and the circumstances when it is acceptable to permit structures to be lost to fire.

Resilient and empowered communities

Perhaps the greatest scope to re-establish control over the risk of loss from wildland fire involves the opportunity to educate and involve Canadians in fire management. The public needs to learn about the importance of fire for the health of ecosystems. Moreover, Canadians need to understand the actions they can and should take to minimize the risk that they create when they choose to live near wildland areas.

An empowered public can strengthen the fire resilience of communities through investments in fire resistant homes and participation in actions to make their community FireSmart. Through the informed actions of many people, Canadians can pursue a comprehensive set of risk management actions that enhance society's capacity to live successfully with the growing hazard of fire in the wildlands.

All three elements are essential to a national wildland fire strategy. A particular challenge involves securing participation of the public in recognizing and addressing this hazard. Exclusion of fire from urban areas is an approach that should not continue throughout the wildlands, despite several decades with few fatalities and relatively little property damage. For several generations, success in wildland fire management has been measured in the speed of detection of ignitions and minimizing the time required to suppress the fire. Public understanding and expectations need to change in the coming decades, ideas that may be difficult to explain to an increasingly urban population.

The emerging role of Development Permits

A growing number of communities located in the wildland or at the wildland-urban interface have developed a community wildland fire management plan. Most communities in Canada with a wildfire management plan identify the FireSmart Canada report *Protecting Your Community from Wildfire* as the template used to develop a plan. The planning guide was published in the 1990s and revised in 2003.

FireSmart Canada has also launched a community recognition program. They provide local training and a manual for homeowners. FireSmart is the national program championing actions by property owners and communities to address wildland fire. Importantly, the program was founded through a partnership model that enhances the capacity of the effort to serve the interests of a broad range of public and private sector stakeholders despite a very modest budget. The federal, provincial and territorial governments should provide increased funds to FireSmart Canada to support this important work.

Many community management plans in Canada also reference documents from the National Fire Protection Association (NFPA) in the United States. This includes NFPA 1144, the *Standard for Reducing Structure Ignitions Hazards from Wildland Fire*, a document that has evolved over the past 80 years from the 1935 NFPA 224 standard, *Fire Protection and Prevention for Summer Homes in Forest Areas*. NFPA is recognized as the international leader in wildland fire management best practices.

Some community plans make direct or indirect reference the FireWise program in the United States, state actions in California and Colorado, fire management practices in Australia and other international efforts. The forest management practices in Canada, the United States and Australia have many similarities and provide useful opportunities for shared learning about practices that can be applied in Canada.

The insurance industry is an emerging stakeholder supporting community actions to address wildland fire risk. The Institute for Catastrophic Loss Reduction has supported FireSmart for more than a decade, including and annual workshop to inform the insurance industry about wildfire, has conducted a showcase home retrofit with FireSmart, and published several research papers on aspects of wildfire risk reduction.

Communities that have developed a comprehensive wildland fire management plan consistently identify opportunities for many stakeholders to contribute, including a role for planning actions by local governments. The plans often include specific recommendations for local bylaws to control the nature, location and site features of new construction. Several communities in Canada have enacted or modified land use planning bylaws, while changes are under consideration in other communities.

The preparation of a comprehensive community wildland fire plan can provide a foundation for enacting local wildland fire management bylaws. Communities that have completed wildfire plans acknowledge the importance of financial support to complete this work. In British Columbia, the *Community Wildfire Protection Program* was launched in 2004 and administered by the Union of British Columbia Municipalities with funding from the Ministry of Forests, Land and Natural Resources. This popular program helps local governments to prepare community wildfire protection plans, develop fuel management prescriptions, implement fuel management demonstration projects and operate fuel management activities.

Local government Development Permits

Several communities have enacted wildfire bylaws regulating construction of new residential development. Some of these include Swan Hills, Alberta and Campbell River, Nelson, the District of North Vancouver, Prince George, Radium Hot Springs, Rural Saanich, Summerland, Rural Vernon and Williams Lake in British Columbia. A number of other communities have developed detailed regulations and are moving toward implementation including Greater Bragg Creek and Hinton in Alberta; and Kamloops, Kelowna, Langford and Maple Ridge in British Columbia.

Development permit regulations must be specified in the Official Community Plan, and as such require public consultation before they are enacted. There is often resistance to proposals to change development permit requirements owing to concern about increased cost imposed on developers and property owners.

There is large variation in the specific wording of the wildfire bylaws and the regulatory expectations across these communities. Moreover, bylaw requirements are one element of a range of wildfire safety activities pursued by these governments such as outreach programs using FireSmart, and operational activities by local governments to remove fuel and reduce the risk of wildland fire in the community.

The local wildfire bylaws consistently address three issues – acceptable building materials, landscape and site considerations, and the identification of zones where the high risk of wildland fire will result in the prohibition of new residential development unless construction and site considerations are met. Community planning regulations from more than a dozen communities in British Columbia and Alberta dealing with acceptable building materials are summarized in Appendix I, and landscape considerations in Appendix II.

Regulating the design and construction of homes

Wind can blow embers from a wildfire forward and they may land in the community. This risk is greatest for the homes located near the wildland, but embers can land on homes some distance into the community. If an ember lands on a structure with a roof that is not fire resilient, then the building may ignite and threaten to spread to neighboring homes. The risk of fire entering a community from embers carried in the wind can be addressed through the installation of fire resistant roofing, and wire screens on eaves and roof vents.

Wildfires can also burn into a community, initially threatening buildings on the immediate wildland-urban interface, but ultimately spreading through the community. This risk can be reduced through the installation of fire-resistive exterior walls, decks coated with fire-resistive materials, and windows fitted with tempered glass or double-glazed windows to protect against windblown debris that can break windows and allow fire to enter the home.

All of the communities identified in Appendix I include or are planning for a bylaw requiring fire-resistive roofing for new residential development in zones of high wildland fire risk. FireSmart, the Institute for Catastrophic Loss Reduction and others, consistently report that the single greatest risk of bringing fire into the community comes from homes with a untreated wood shake roof or other roofing not classified as fire resilient. The details of acceptable roofing materials vary across the communities, but consistent and appropriate attention is focused on the importance of fire-resilient roofing.

There is considerable variation with respect to additional regulation of the building materials that are required for new residential development in areas with a high risk of wildland fire. Some communities have no building materials requirements beyond roofing, like Swan Hills, while many have a comprehensive list of requirements, such as Nelson, North Vancouver, and Williams Lake. Some communities, like Nelson, are very specific in the identification of acceptable and unacceptable building materials, while others identify the public safety objective but are unclear about the specific building materials required. Swan Hills and Greater Bragg Creek seek to regulate roofing for all structures throughout the town, while the remaining communities focus on new home construction in zones with high fire risk.

Landscape regulations to keep fire out of the community

FireSmart has identified three zones of protection for structures in the wildland-urban interface. They advise the elimination of fuels to provide a defensible space of at least 10 metres around a home. For homes on a slope, this zone should be larger. The zone extending up to 30 metres around a home should have reduced fuels and the zone beyond 30 metres should be managed, where possible, to provide fire breaks and other protective actions for the community. All of the communities identified in Appendix II have embraced the concepts of defensible space around the home and have enacted or are working on implementing bylaws to achieve these objectives. Some communities, like North Vancouver and Campbell River focus primarily on the first 10 metres around the home. Others, like Swan Hills, use the three zones as identified by FireSmart.

Many communities specifically recognize FireSmart in the wildfire landscape regulations and bylaws they have enacted or are developing, and all have adopted actions that are consistent with the practices set out by FireSmart. The bylaws across the various communities are more consistent for landscape considerations than for building materials.

Some communities, like North Vancouver, introduced additional elements to reduce the risk that new developments would increase the risk of fire spreading from buildings into the forest. North Vancouver also can demand a retention/restoration plan from a professional arborist and replanting of trees lost during development. Summerland requires, and Kelowna encourages, lawns irrigated by an underground sprinkler system as a means of suppressing the risk of wildfire destroying the home. Langford has proposed a $1,000 a year “rent charge” for homes that fail to maintain reduced fuels within 10 metres of their homes.

Prohibiting new residential development

All of the communities in British Columbia and Alberta identified in the Appendices have established or are establishing the authority through their land use planning regulations to prohibit new residential development in zones with high risk of wildland fire unless specific covenants are met. For many decades, local governments have been using land use planning as a critical tool for managing the risk of flood damage by prohibiting development in areas where there is a known risk of flooding. These communities are now also using their planning authority to manage the risk of wildland fire.

Regulations to require that property owners establish and maintain a defensible zone surrounding buildings are not consistent with provincial and territorial building codes and can best be implemented through local government bylaws, as has begun to emerge in some communities in British Columbia and Alberta. Swan Hills and Greater Bragg Creel are seeking to regulate the establishment and maintenance of defensible space around all structures in the community -- not just homes in new developments.

Regulation to require fire-resilient building materials for new homes could be enacted through provincial and territorial building codes, or through local bylaws. Provincial and territorial governments have chosen not to address this issue yet so local government action is required. A result to date is inconsistent action across British Columbia and Alberta. Important differences between communities in terms of building regulations introduces additional cost for home builders, insurance companies and some other stakeholders that operate on a regional or national level but now need to ensure compliance with local requirements.

There are hundreds of communities across Canada located in the wildland-urban interface. At least 10 communities in British Columbia and Alberta have established bylaws to regulate new residential development to take into account the risks of wildland fire. Half a dozen other communities are advanced in their efforts to revise their bylaws and practices. Most communities, however, have yet to take action and can learn from these leaders. The growing number of Canadians that spend time in the wildlands and live in the wildland-urban interface, combined with growth in the expected area burned by wildfire due to change in the climate is expected to increase the risk of loss and damage from wildland fire over the next few decades. Nevertheless, most fire losses are preventable. Several communities are showing that local government planning actions, like development permits, can be part of a comprehensive community plan to manage the risk of wildland fire.

Three communities taking action

Several communities have chosen to use planning tools within their local bylaw to address the risk of wildfire in the wildland-urban interface. There are large variations in the specific actions adopted but the common overall objective is to ensure that new development brings homes designed for the risk of fire and that development does not increase the hazard for the rest of the community. The actions taken in Nelson, British Columbia, Swan Hills, Alberta and the District of North Vancouver, British Columbia provide an overview of the range of planning actions that have been taken by local governments.

Nelson, British Columbia

Nelson is a community of 10,000 people living in the Southern Interior of British Columbia. Known as the "Queen's City", the Nelson is located in the Selkirk Mountains. Nelson experiences hot, dry summers and is located in a region that regularly experiences wildfire.

The official community plan bylaw for Nelson includes four pages of wildfire interface design guidelines in its development permit area regulations. The first page is a map of the community identifying the specific locations in the wildland-urban interface on the southern side of Nelson where the wildfire development regulations apply. A subdivision application and building permits within the designated "Wildfire Interface Zone" are subject to special approval.

The second page sets out the landscaping requirements for site approvals. Referencing the three priority zones identified by FireSmart, Nelson requires no combustible material within 10 metres of a new home, reduced combustible materials within 10 to 30 metres with trees spaces at least 3 to 6 metres apart and no evergreens, and specific requirements for reduced combustibles 30 to 100 metres from each new home.

The third page identifies allowed, encouraged and not permitted building materials for new homes. Nelson requires a roof and siding that is fire resilient, and requires screened soffits. The use of double paned or tempered glass windows is encouraged. The bylaw identifies the specific building materials that satisfy or would fail to satisfy these requirements. Allowed siding, for example, identified in the bylaw includes stone, brick, stucco, fibre-cement boards, concrete block and pre-finished metal sheeting. Siding that is not permitted includes wood siding, shingles or shakes. Allowed roof materials include metal, asphalt, fire retardant wood shingles and shakes, fire rated recycled composite shingles, concrete tiles, ceramic tiles, and flat bitumen based roofing. Not permitted roofing is untreated wood shingles or shakes.

The fourth page reprints a graphic from the FireSmart homeowners manual describing 18 actions homeowners should take to protect their property from wildland fire.

Communities across Canada could readily adopt the approach used by Nelson in seeking to apply local planning authority to address the hazard of fire for new homes in the wildland-urban interface. The items addressed represent the major risks of damage from wildfire. Nelson is specific in the building materials required to secure approval, in contrast to the ambiguity found in some other jurisdictions.

Swan Hills, Alberta

Swan Hills is a town with about 1,500 citizens in Northern Alberta. In 1967, Swan Hills was incorporated as Canada's first centennial town. The town is located near the geographic centre of the province. Swan Hills supported growth in the oil and gas industry in the 1950s and 1960s, and is a local hub supporting hunting, fishing and a broad range of other recreation activities that take place in the surrounding wildlands. The town is located in the Northern Boreal forest in a region subject to recurring wildfires.

The town's land use bylaw is 107 pages in length. The bylaw includes a section setting out FireSmart Regulations for Dwellings and Structures and a three-page appendix identifying fire-resistant plants.

> "Every residence is required to have its house number clearly displayed near the front door entrance and easily visible from the street."

> "The Town requires all property owners to undertake vegetation management within 10 metres of a building. This is intended to create a fuel modified area in which flammable vegetation surrounding a building is eliminated or converted to less flammable species. The fuel-free zone is immediately adjacent to a given building and extends outwards in all directions for a minimum of 10 metres, and includes the following practices: Flammable forest vegetation shall be removed; all conifer limbs shall be removed to a minimum height of 2 m from the ground on residual overstory trees; annual grasses shall be mowed to 10 cm or less; and, no combustible material piles (firewood, lumber, etc.) shall be allowed."

> "The Town requires that roofing on all structures be ULC (Underwriter Laboratory of Canada) fire-rated."

Swan Hills chose to include these regulations in the Part 6 General Regulations section of the Town's land use bylaw rather than Part 3 dealing with development permits. Accordingly, the bylaw for Swan Hills appears to apply to new and existing homes in the town. Most other communities assessed in this study chose to focus on regulating new residential development, often combined with public outreach to existing homeowners. Swan Hills has used its planning bylaws to address the risk for all properties. Installation of fire-rated roofing and vegetation removal adjacent to all structures will significantly reduce the risk of fire entering Swan Hills. Moreover, the wording of the bylaw implies that the regulations apply to permanent homes and also to commercial buildings, seasonal dwellings and all other structures in the town, perhaps including garages and sheds. Dealing with all structures in a general regulation bylaw is a powerful way to use planning tools to contribute to a comprehensive community wildland fire plan.

A further research opportunity would involve assessing the powers and capacity of the town of Swan Hills for enforcement of these FireSmart regulations on existing homes. Also, has the town considered allowances, if any, for compliance by existing homeowners with low incomes or other special circumstances? A lesson from Swan Hills is that local regulations can be used to address the risk of wildland fire in the community not only for new residential development but also for existing buildings and structures.

District of North Vancouver, British Columbia

The District of North Vancouver is a community of about 85,000 people surrounding the 50,000 people living in the City of North Vancouver. It is located on the slopes of the Coast Mountains across the Burrard Inlet from Vancouver. Most of the growth in the community has taken place since 1950.

The District won the Sasakawa Award from the United Nations for leadership in disaster risk reduction, and has been recognized as a Role Model City for the United Nations' Resilient Cities campaign. In particular, the community is pioneering the efforts by local governments to apply risk management best practices to the risk of loss from natural hazards including landslides, debris flow, earthquake and wildfire.

The District issued a 25-page document setting out requirements for new development permits in natural hazards zones. One section sets out the objectives of the District when it considers an application. Another section identifies the fire-resistive materials and construction practices required. Another section sets out landscaping requirements. And there are requirements that vegetation and construction debris should be removed within three months of permit issuance, or immediately during high fire seasons. And the District may require that a tree assessment and restoration plan be completed by a professional arborist.

North Vancouver requires that new homes in wildfire areas use fire-retardant roofing, and asphalt or metal roofing should be given a preference. Decks, porches and balconies should be sheathed with fire-resistive materials; all eaves, attics, roof vents and openings under floors should be screened to prevent the accumulation of combustible material, using 3 mm, non-combustible wire mesh, and vent assemblies should use fire shutters or baffles; exterior walls should be sheathed with fire-resistive materials; fire-resistive decking materials, such as solid composite decking materials or fire-resistive treated wood; all windows should be tempered or double-glazed to reduce heat and protect against wind and debris that can break windows and allow fire to enter the home; all chimneys and wood burning appliances should have approved spark arrestors; and building design and construction should be consistent with NFPA 299.

A number of regulations have also been set out concerning the siting of new development if it is to be allowed in wildfire hazard zones. New building construction should include the use of firebreaks, which may be in the form of cleared parkland, roads, or utility right of ways; all new hydro servicing should be underground; wildfire mitigation and landscaping techniques should ensure that natural features of the site and adjacent ecosystems are protected, preserved and enhanced in accordance with District bylaws; if removal of trees or vegetation is deemed necessary to reduce risk, District approval is required and replacement trees or vegetation may be required by the District; and a defensible space of at least 10 metres should be managed around structures with the goal of eliminating fuel and debris, reducing risks from approaching wildfire and reducing the potential for building fires to spread to the forest, and the required defensible space may be larger over sloping ground where fire behaviour creates greater risk.

The commitment throughout the hazard work of the District of North Vancouver is to proactively manage the risk of loss and damage from landslide, debris flow, earthquake and wildfire for the benefit of present and future generations. The risk-based natural hazard development permit regulations in the District of North Vancouver provide a model that local governments across Canada should consider for the regulation of wildland fire and other natural hazards.

Conclusions

Fire has been present in our forests and grasslands for thousands of years, and is essential for the health of our ecosystems. Fire is also a threat to the life and safety of Canadians, with a risk of loss and damage that is projected to increase over the next few decades due to growth of the number of people who live in the wildland-urban interface and to change in the climate. For the past century, we sought to exclude fire from urban centres and the wildlands. The policy of exclusion is now evolving into a more complex, multi-stakeholder approach to fire management in the wildland.

In 2005, the Canadian Council of Forest Ministers established a shared national vision for managing wildland fire. The federal, provincial and territorial governments have yet to implement that national strategy, nevertheless several local governments have begun to take action to address wildfire risk in their communities. Local action includes developing a community wildland fire management plan. Within these plans, more than a dozen local governments in British Columbia and Alberta are using or preparing to use their land use planning authority to increase safety in their communities through bylaws and regulations dealing with wildland fire.

Development permits are a local planning tool that some local governments have begun using to require that new homes are built using materials that reduce the risk of fire entering the community, and that residential development includes defensive space surrounding new structures with reduced fuels. Most importantly, local governments are using their planning authority to prohibit and control new development in areas with high risk of wildland fire unless specific actions are taken to mitigate the risk.

The use of local government planning tools to address wildfire emerging in British Columbia and Alberta is likely to spread across Canada. For example, in June 2014, a revised Provincial Policy Statement by the Government of Ontario introduced new requirements for local governments under the *Planning Act*. Local governments in Ontario are now required to use their planning powers to address flood and wildfire. “Development shall generally be directed to areas outside of lands that are unsafe for development use due to presence of hazardous forest types for wildland fire. Development may however be permitted in lands with hazardous forest types for wildland fire where the risk is mitigated” (Ontario 2014).

Local governments have been leaders in reducing the risk of flood loss and damage through land use planning and are emerging as leaders in community wildland fire management. Nelson, Swan Hills and the District of North Vancouver are three communities that provide specific examples of planning regulations that can and should be followed by other communities across Canada in seeking to address the public safety concerns from the growing risk of loss from wildland-urban interface fire.

The focus of this paper has been on the leadership that is being provided by local governments. Provincial and territorial governments could also seek to encourage or compel local action. One option could be to circulate to local governments draft development permit regulations, perhaps using the District of North Vancouver or Nelson as models. Alternatively, draft development permit regulations could focus on site and landscaping issues, as set out in the FireSmart community planning guide, and the province or territory could modify its building code to address fire-resilient construction, perhaps as set out in NFPA 1144. Finally, local governments could be encouraged to address the risk of wildfire for all buildings, new and existing, through draft general bylaws. Swan Hills and Greater Bragg Creek are communities seeking to use planning regulations to reduce the wildfire risk for all structures. Additional research into actions underway in Colorado, California and Victoria, Australia, may provide additional guidance.

Unless current approaches change, loss and damage from wildland fire is expected to increase in Canada over the next several decades due to factors that include growth in the number of people living in the wildland-urban interface and change in the climate. Change is needed from many stakeholders. Local governments are emerging as important participants in wildland fire management. Development permits and other local government planning tools should be elements of a comprehensive community wildland fire strategy in a changing climate.

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Appendix I: Local building design and construction regulations

	Roofing	Exterior Walls	Other
Campbell River B.C. *Bylaw No. 3475, 2012*	See "Other"	See "Other"	For new development in high risk interface fire hazard areas, applications must be accompanied by a wildfire assessment and interface mitigation plan prepared by a qualified professional that minimizes the risk associated with the proposed development/building concept
Greater Bragg Creek Alberta *Proposed: Jan 2012*	See "Other"	See "Other"	Establish and implement FireSmart standards for exterior building materials for all new developments and retrofits of existing structures. Establish a powerline tree-freeing program with the distribution power provider to reduce the threat of wildfire ignition from downed powerlines.
Hinton Alberta *Proposed: Jan 2011*	See "Other"	See "Other"	Where appropriate, new subdivision and development applications deemed to be in High or Extreme FireSmart hazard areas, as per Map 3, shall submit a Wildfire Risk Assessment, prepared by a qualified FireSmart professional, in accordance with the requirements of the Town of Hinton. Wildfire Risk Assessments will be the landowner's responsibility and will include an evaluation of current and proposed FireSmart hazard and recommended FireSmart mitigative measures to be completed by the developer in conjunction with subdivision construction.
Kamloops B.C. *Proposed: Jan 2008*	All roofing materials and installation requirements meet the Class "B" fire rating requirements contained within the current B.C. Building Code (currently enforced)	See "Other"	All eaves, attics, decks and openings under floors are screened to prevent the accumulation of flammable material (currently enforced) All wood burning appliances are to be installed with approved spark arrestors. (currently enforced) As a minimum, be consistent with the current FireSmart guidelines. Be based on a completed site specific wildfire hazard assessment. Address building construction standards

	Roofing	Exterior Walls	Other
Kelowna B.C. *Proposed:* *May 2011*	Use only fire retardant material (Class A materials) on roofs.	Siding should be predominantly fire-resistant material Siding should extend from the ground level to the roofline.	*Wood Chimneys* • All chimneys should have approved spark arrestors (securely attached and made of 12-gauge welded or woven wire mess screen with mesh opening of less than 12 mm); • Chimney outlets should have at least 3 meters clearance from all vegetation and obstructions; and • Chimney outlets should be 0.6 m higher than any part of the roof within 3 meters. *Windows and Door Glazing; Eaves, Vents and Openings* • Remove vegetation from within 10 meters of glazed openings unless there are solid shutters to cover the glazing; • All eaves, attics, and underfloor openings need solid, non-flammable protective covers; and • Laminated glass and 20 minute rated door assembles should be used on building surfaces facing the forest interface. *Balcony, Decks and Porches* • Deck surface material should be made of predominantly non-combustible or fire-resistant materials such as wood composite products; • Slotted deck surface allow needle litter to accumulate beneath the deck. Provide access to this space to allow for removal of this debris. *Guidelines during Construction* • During construction of houses, all waste construction materials including brush and land clearing debris needs to be cleaned up on a regular basis to minimize the potential risk. no combustible materials should be left at the completion of construction; • Prior to construction of any wood frame buildings, there must be fire hydrants within operating range. When planning new developments, underground power line systems should be considered. Where such a system is not feasible, overhead utility lines should have a clearance of at least 3m from vegetation.

	Roofing	Exterior Walls	Other
Langford B.C. Proposed: 2002	All roofing material and insulation requirements meet the Class "B" fire rating requirements contained within the current B.C. Building Code.	May include recommendations for relaxations to restrictions on exterior building materials and roof sprinklers if resulting development changes the actual level of the risk from extreme or high to moderate or low. All buildings within 30m of a high or extreme wildfire risk area as identified by the Registered Professional Engineer must include fire resistant construction materials for exterior siding and roofing.	All eaves, attics, decks, and openings under floors are screened to prevent the accumulation of combustible material All wood burning appliances are to be installed with spark arresters For developments that only have one access route, exterior sprinkler systems on dwellings for protection against exposure fires are encouraged. Because of the potential for interface wildfires to interfere with hydro service to developments, and thus interfere with residential sprinkler systems, all hydro servicing in new developments within high and extreme interface fire hazard areas is encouraged to be underground and is required for developments of four (4) or more lots of urban density (i.e., lots less than 1,000 sq. m.). Building design and construction shall generally be consistent with the standards in the National Fire Protection Association Standard 299 (Standard for Protection of Life and Property from Wildfire).

Maple Ridge B.C. Proposed: July 2007	In new subdivisions within identified high risk areas of the District, roofing materials that are fire-retardant with a Class A and Class B rating should be a requirement of the development permit. It is recognized that wholesale changes to existing roofing materials within high risk areas of the District are not practical, therefore a long-term replacement standard that is phased in over the roof rotation period would significantly reduce the vulnerability of the community.	See "Other"	The District should begin a process to review and revise existing bylaws and building codes to be consistent with the development of a FireSmart Community. For areas that have been identified as high risk, consideration should be given to the creation of a Wildfire Bylaw that mandates fire resistant building materials, provides for good access for emergency response, and specifies fuel management on both public and private property in areas of identified high wildfire risk.

	Roofing	Exterior Walls	Other
Nelson B.C. *Bylaw No. 4247, 2013*	ALLOWED • Metal Roofing • Asphalt Shingles • Fire Retardant Wood Shingles & Shakes • Fire Rated Re-Cycled Composite Shingles • Concrete or Ceramic Roof Tiles • Flat Bitumen Based Roofing w/ Aggregate Finish • Screened Soffits NOT PERMITED • Untreated Wood Shingles or Shakes • Open Soffits	ALLOWED • Masonry: Stone & Brick • Stucco • Fibre-Cement Boards (Hardi-Plank®) - Concrete Block • Pre-finished Metal sheeting NOT PERMITED • Wood Siding • Shingles or Shakes	**WINDOWS** ENCOURAGED • Double Pane Glass & Tempered Glass DISCOURAGED • Single Pane Glass

	Roofing	Exterior Walls	Other
North Vancouver B.C. *Bylaw No. 6300, 2011*	Fire retardant roofing materials should be used, and asphalt or metal roofing should be given preference	Exterior walls should be sheathed with fire resistive materials	Decks, porches and balconies should be sheathed with fire resistive materials. All eaves, attics, roof vents and openings under floors should be screened to prevent the accumulation of combustible material, using 3mm, non combustible wire mesh, and vent assemblies should use fire shutters or baffles. Fire-resistive decking materials, such as solid composite decking materials or fire-resistive treated wood, should be used. All windows should be tempered or double-glazed to reduce heat and protect against wind and debris that can break windows All chimneys and wood-burning appliances should have approved spark arrestors. Building design and construction should generally be consistent with the highest current wildfire protection standards published by the National Fire Protection Association or any similar, successor or replacement body that may exist from time to time. All new hydro servicing that is in, or within 10 metres of, a wildfire risk area should be underground, or where this is not feasible, poles of non-combustible materials should be used.

	Roofing	Exterior Walls	Other
Prince George B.C. *Bylaw No. 7850, 2007*	Fire resistant roofing materials (Class A or B) such as metal, clay tile, asphalt shingles and treated wooden shingles should be used on all buildings and structures.	Fire resistant exterior walls materials such as stucco, metal, brick, rock, and concrete should be used on all buildings and structures. Logs and heavy timbers, although less effective, are also permitted.	Roof vents should be closed in and screened. Decks, porches and balconies should be sheathed with fire-resistant materials. Chimneys should have approved spark arrestors.
Radium Hot Springs B.C. *Bylaw No. 396, 2013*	Prohibit the use of wood shakes as a roofing material and limit the use of fire-retardant treated wood shingles.	See "Other"	Use recognized standards in the assessment of wildfire hazards (currently 'FireSmart' standards based on NFPA documentation).
Rural Saanich B.C. *Bylaw No. 8940, 2008*	All roofing material and insulation requirements must meet the Class B fire rating requirements contained within the current B.C. Building Code.	See "Other"	Building design and construction shall generally be consistent with the standards in the National Fire Protection Association (NFPA) Standard 1144 - Standard for Protection of Life and Property from Wildfire. All eaves and attic vents shall be screened using 3 mm non-combustible wire mesh at a minimum to prevent the entry and accumulation of combustible materials and windblown embers.
Rural Vernon B.C. *Bylaw No. 3387, 2007*	Roof coverings on every building must have a Class C fire resistance classification, determined in accordance with the B.C. Building Code.	Absent	Each development permit issued to authorize the construction of a building in the development permit area shall bear a notation indicating that additional information on the protection of development from wildfire hazard conditions is available in the "Home Owners Fire Smart Manual" provided by the Forest Protection Branch of the BC Forest Service.

	Roofing	Exterior Walls	Other
Summerland B.C. *Bylaw No. 2000-310*	All exterior roofs must be constructed of fire-resistant materials that meet a Class A, B, or C rating, excluding wood, wooden shake and shingle products, as defined in the Building Code and FireSmart.	All exposed, combustible structural elements on the exterior of any building must be of a heavy timber construction as defined by the Building Code. Any exposed surfaces, including walls and decks, that are not of heavy timber construction or which are not of non-combustible materials must use fire resistant materials.	All soffits must be of non-combustible materials. Window panes should be of thermal, tempered glass. All chimney outlets shall be 0.6 meters higher than any part of the roof that is within 3.0 meters. All wood-burning appliances shall require the installation of a spark arrestor. All screening for attic and basement vents for all buildings must be metal and of small enough openings to prevent sparks from passing into the building. Shutters, awnings and exterior walls must be made or constructed from fire resistant materials. All crawl spaces, the underside of porches and decks, and any sheds must be sealed. Balconies, patios and decks must be constructed from fire resistant or non-combustive materials. All buildings must contain an automatic fire-sprinkling system that is approved by a registered professional with a specialty in fire suppression design.
Swan Hills Alberta *Bylaw No. 15, 2012*	The Town requires that roofing on all structures be ULC (Underwriter Laboratory of Canada) fire-rated	Absent	Every residence is required to have its house number clearly displayed near the front door entrance and easily visible from the street.

	Roofing	Exterior Walls	Other
Williams Lake B.C. *Bylaw No. 2140, 2011*	The roof covering shall conform to Class A, B or C fire resistance as defined in the B.C. Building Code.	Any material used for exterior wall finishes should be fire resistant such as stucco, metal siding, brick, cement shingles, concrete block, poured concrete, rock and logs or heavy timbers as defined in the B.C. Building Code.	Chimneys should have spark arrestors made of 12 gauge (or better) welded or woven wire mesh with mesh openings of less than 12 millimetres. All eaves, attic and under floor openings should be screened with corrosion-resistant, minimum 3-millimetre non-combustible wire mesh. All windows must be double paned or tempered. Decks should be constructed of heavy timber as defined in the B.C. Building Code, or, with 1-hour fire resistant rated assemblies or non-combustible construction as defined by the B.C. Building Code. Manufactured homes should be skirted with a fire resistant material as outlined in the previous guideline for exterior wall finishes.

Appendix II: Local building siting and landscape regulations

	Priority Zones	Other
Campbell River B.C. *Bylaw No. 3475, 2012*	A report, prepared by a Registered Professional Biologist is required with recommendations for minimizing interface fire hazard in a manner that seeks to preserve, where possible, sensitive ecosystems that may occur in close proximity to development. Registration of a restrictive covenant that prohibits any outdoor burning may be required.	The development of a trail system is encouraged around developments that can accommodate fire vehicle access for fighting wildfire in interface areas Development shall incorporate fire breaks adjacent to residential areas. These may be in the form of cleared parkland, roads or trails.
Greater Bragg Creek Alberta *Proposed: Jan 2012*	Zone 1-2 vegetation management is necessary for a large proportion of the structures in the project area and is the responsibility of residents, business owners, and facility operators. Vegetation management required includes: • Removal of flammable forest vegetation within 10 metres of structures. • Removal of all coniferous ladder fuels (limbs) to a minimum height of 2 metres from ground level on residual overstory trees. • Removal of all dead and down forest vegetation from the forest floor. • Increased maintenance to ensure that all combustible needles, leaves, and native grass are removed from on and around structures. • Establishment and maintenance of a non-combustible surface cover around the structure including the use of FireSmart landscaping species. • Removal of all combustible material piles (firewood, lumber, etc.) within 10 metres of the structure. Zone 2-3 vegetation management is the responsibility of municipal and provincial governments, residents and landowners, and business owners/facility operators. All stakeholders should implement fuels reduction based on the priorities identified in this plan.	Ensure that all fuel modification projects are inspected on a regular basis and maintained as necessary. Detailed fuel modification prescriptions must be developed for each proposed vegetation management project prior to implementation. Rocky View County, along with other municipal governments, and Sustainable Resource Development should investigate the possibility of amending Section 664(3)(b) of the *Municipal Government Act* to permit fire hazard reduction on environmental reserve lands. Establish and legislate FireSmart access road standards for all new developments to ensure safe ingress and egress routes for residents/public and emergency responders. Ensure that adequate fire suppression water supply is provided for the Hamlet of Bragg Creek and all new developments within Rocky View County. Consideration should be given by RVC to the integration of the existing Elkana Ranch Elbow River water gallery and pumphouse as a water tender fill station.

	Zone 3 containment areas should be planned with collaboration of all parties in the West Bragg Creek Land Users Group. The responsibility for approval lies with Sustainable Resource Development and the strategy will be implemented jointly by Sustainable Resource Development and Spray Lake Sawmills (1980) Ltd.	

	Priority Zones	Other
Hinton Alberta *Proposed: Jan 2011*	FireSmart Zone 1 vegetation management options include: • Removal of flammable forest vegetation within 10 metres of structures. • Removal of all coniferous ladder fuels (limbs) to a minimum height of 2 metres from ground level on residual overstory trees. • Removal of all dead and down forest vegetation from the forest floor. • Increased maintenance to ensure that all combustible needles, leaves, and native grass are removed from on and around structures. • Establishment and maintenance of a non-combustible surface cover around the structure including the use of FireSmart landscaping species. • Removal of all combustible material piles (firewood, lumber, etc) within 10 metres of the structure. Zone 2-3 vegetation management is the responsibility of the Town of Hinton on MR and ER lands, the Provincial Government (SRD) on Crown lands, and landowners and developers on deeded lands. The goal is to reduce the wildfire intensity and rate of spread as it approaches developed areas. FireSmart Zone 2-3 fuel modification methods can vary from hand-crew to full mechanical operations or prescribed burning and may include a combination of complete fuel removal or fuel reduction including spacing of overstory and/or understory, removal of dead standing and/or laying material, and/or removal of ladder fuels (limbs). Debris disposal methods may include mechanical or hand piling and burning onsite, hauling and disposal offsite, chipping and spreading onsite, chipping and hauling offsite, or mechanical mulching onsite. Although there are presently no studies to indicate the acceptable depth of chips onsite, it is recommended that if this method of debris disposal is used the chips are spread sufficiently to avoid a continuous layer of chip material that may support surface fire or smoldering ground-fire during dry periods.	absent

	Priority Zones	Other
Kamloops B.C. *Proposed:* *Jan 2008*	Address building construction standards and vegetation management in Priority Zones 1, 2, and 3 where these areas fall within the ownership boundaries. Fuel reduced buffers around individual homes from the house to the property boundary, or 10 m in distance, whichever is the lesser, are maintained. In this respect, fuel reduced shall mean the area may contain natural tree cover in locations approved by the City of Kamloops, but the owner must landscape and maintain the area with the intent of eliminating the accumulation of combustible debris (currently enforced)	Be based on a completed site specific wildfire hazard assessment. Achieve the objective of reducing the Wildland Head Fire Intensity to Intensity Class 3 or less. Incorporate emergency vehicle wildfire access and egress into the lot or community design; in the case of communities, a minimum of two egress and access routes per community. Compliment vegetation management efforts on adjacent public or private lands wherever possible. Include risk reduction mitigations for fire risk to adjacent lands. Maximize healthy tree retention or replacement, while meeting the fire hazard reduction objective. Homeowners will continue to maintain FireSmart standards on their individual lots.

	Priority Zones	Other
Kelowna B.C. *Proposed: May 2011*	*Priority Zone 1-Fuel Free Zone (10 m from buildings)* A fuel free zone should be created around all homes and outbuildings. The fuel free zone should extend 10 m from the structure, or further if the terrain is sloped. the following guidelines should be considered: • There should be enough defensible space to protect buildings from approaching wildfire and to reduce the potential for a building fire spreading to the wildland. • Annual grasses within 10 m of buildings should be mowed to a height of 10 cm or less and watered regularly during the summer months. • Surface litter and downed trees should be removed regularly. • Dead, and dying trees should be removed. • Structures at the top of a slope will need a minimum of 30 m of defensible space. • Vegetation within this zone should be of a fire-resistant species • Trees within this zone should be pruned to a height of 2 to 3 m and not overhang the house or porch. • Remove all piled debris (firewood, building materials, and other combustible material) outside of the fuel free zone. • Defensible space should be provided by the developer and maintained by the property owner. • Community Strata rules should enforce the maintenance of this zone. *Priority Zone 2-Fuel Reduction Zone (10 to 30 m from buildings)* Fuel modification in this zone should include thinning and pruning to create an environment that will not support a high intensity crown fire. A surface fire may occur in this zone but it will be of low intensity and easily suppressed. Guidelines for this zone are as follows:	Keep roofs clean of all combustible material. All flammable trees and shrubs growing within 20 meters of any structures should be removed and replaced with fire resistant species. the most flammable species include those that accumulate dead foliage and branches and have a high content of oils and resin. Characteristics of fire resistant species to be replanted include the following: • Deciduous species; • Low growing plants; • Plants with thick woody stems; • Plants that accumulate low amounts of dead vegetation; • Plants with low resin content (deciduous species); • Plants that retain high moisture content. Propane tanks surrounded by vegetation are potential hazards. Combustion adjacent to these tanks could increase the internal pressure causing the tank to vent through a relief valve. The resulting fire can be one of a high-intensity and with the potential to destroy adjacent buildings. Hence, when positioning tanks, the relief valves should point away from buildings. Faulty relief valves will not allow pressure to discharge resulting in a boiling liquid explosion dangerous to those within 300 m. When designing new developments, particularly those in remote locations some distance from emergency services, some consideration should be given to the installation of underground sprinkler systems. These systems can serve as both a method of irrigation as well as an interface suppression tool. Sprinklers can be located on the rooftops of homes and

	• Actions in this zone should be oriented towards fuel reduction rather than removal. • Deciduous composition in the overstory should be promoted (i.e. Deciduous species should not be thinned out). • This zone should be extended as slope increases. The 20 m concentric distance from the boundary with priority zone 1 should be corrected for slope. • Thin trees for two tree lengths from buildings. • Treatments within this zone will include thinning of the canopy, thinning the understory and pruning lower branches • Leave trees should be the largest on site and canopy heights should be pruned to a height of 2 to 3 m. • Remove all dead and dying trees. • Dispose of all slash created by treatments through pile and burning or removal from the site. • This zone should be constructed by the developer and maintained by the property owner. • Community strata rules should enforce the maintenance of this zone. *Priority Zone 3-Fuel Reduction and Conversion (30 to 100 m from buildings)* The strategies for this zone are similar to those of priority zone 2 with the distance being slope dependent. this environment should be one that does not support a high-intensity crown fire. A surface fire may occur, but it will be of low intensity and easily extinguished. vegetation management should concentrate on vegetation conversion and reduction rather than removal. the following are guidelines for this zone: • Fuel management in this zone should only be undertaken if there are high hazard levels from heavy continuous fuels and steep topography. • Deciduous species should be promoted. • On sloped terrain, the width of this zone	outbuildings. In the event of a wildfire, the sprinklers would be engaged and would increase the relative humidity around the house as well as increase the fuel moisture content of any fuel adjacent to the home resulting in lower flammability and fire behaviour potential. Rooftop sprinklers are also recommended for homes in the interface that do not have fire-resistant roofing or siding.

	will need to be corrected for slope distance. • Thinning and pruning • This zone should be constructed by the developer and maintained by the property owner. • Community Strata rules should enforce the maintenance of this zone.	

	Priority Zones	Other
Langford B.C. *Proposed:* *2002*	Fuel reduced buffers around individual homes from the house to the property boundary or 10m in distance, whichever is lesser. The area may contain natural tree cover in locations approved by the District of Langford, but the owner must landscape and maintain the area with intent of eliminating the accumulation of combustible debris.	For new developments in high or extreme interface fire hazard areas, council and the approving officer may consider requiring the development of a trail system around developments, which would accommodate fire vehicle access for fighting wildfire in interface areas. In order to ensure the ongoing restriction on wood fuel adjacent to residences (excluding enclosed, covered firewood piles), the approving officer may require a Section 219 covenant requiring property owners to ensure the 10m fuel restriction zone around houses and buildings is maintained and that if they are not maintained, they may be required to pay a rent charge of $1,000 per year. In designing new subdivisions and neighbourhoods within the high to extreme fire hazard development permit areas, proponents shall consider the incorporation of fire breaks adjacent to residential areas. These may be in the form of cleared parkland, roads, or trails.
Maple Ridge *B.C.* *Proposed:* *July 2007*	Many homes and businesses are built immediately adjacent to the forest edge. In these neighbourhoods, trees and vegetation are often in direct contact with homes. The District should create building set backs with a minimum distance of 10 m when buildings border the forest interface.	Given the wildfire risk profile of the community, an emergency sprinkler kit capable of protecting 30 to 50 homes should be purchased and maintained in the community. Fire rescue personnel, or a designate of the department, should be trained to mobilize and set up the equipment efficiently and effectively during a fire event.

	Priority Zones	Other
Rural Vernon B.C. *Bylaw No. 3387, 2007*	The area of the development parcel within 10 metres of any building under construction should be kept free of flammable construction materials and debris. The area of the development parcel within 10 metres of any building should be cleared and kept free of all fallen timber and other dead vegetation, and dead standing timber should be removed from that area. Trees on the development parcel within 10 metres of any building should be limbed to a height of 2 metres above ground level. Vegetation on the development parcel within 30 metres of any building should be thinned to reduce the overall tree crown cover to approximately 3 to 6 metres between crowns if the existing crown cover exceeds that amount.	absent

	Priority Zones	Other
Summerland B.C. *Bylaw No. 2000-310*	Buffers shall be established in the Wildland/ Urban Interface Zone. Buffer requirements for wildfire hazard mitigation will be determined by Priority Zone, as identified by the Wildfire Hazard Assessment. Fuel loads shall be managed in each Priority Zone as prescribed by the Wildfire Hazard Assessment. Branches of coniferous trees shall be pruned to remove ladder fuels. The Wildfire Hazard assessment and associated mitigation requirements shall extend to a minimum of 50.0 meters beyond the boundary of the proposed phase of development under consideration. Only fire-resistant plants (including broad-leaf deciduous trees, low shrubs, ground covers and annuals) shall be planted within 5 meters of a building.	All development areas shall have at least two access routes, one that may include a dedicated emergency route, ensuring access for fire and other emergency equipment, as well as evacuation of residents. All non-decayed tree trunks and branches with a diameter greater than ten centimeters that originated from coniferous trees shall be removed from the ground. Accumulations on the ground of small branches and pine needles from coniferous trees shall be removed to prevent the spreading of fire on the ground or up trees. Where retained trees downslope from a building may pose a fire hazard, an increased buffer size or other mitigation measure is required. Where retained trees downslope from a building may pose a fire hazard, an increased buffer size or other mitigation measures are required. Landscape rock, top soil and other such non-flammable material shall be required in place of flammable wood-based chip or mulch for ground cover in flower beds, borders, decorative areas and such other areas that are not lawn, shrub or covered by a hard surface. All lawns shall be irrigated by an underground sprinkling system whose operation is controlled by a timer. Areas that are not lawn or covered by a hard surface shall be predominantly xeriscaped gardens. The ground elevation in the immediate proximity of existing coniferous trees or deciduous trees shall not be altered.

	Priority Zones	Other
Swan Hills Alberta *Bylaw No. 15, 2012*	The Town requires all property owners to undertake vegetation management within 10 metres of a building. This is intended to create a fuel modified area in which flammable vegetation surrounding a building is eliminated or converted to less flammable species. The fuel-free zone is immediately adjacent to a given building and extends outwards in all directions for a minimum of 10 metres, and includes the following practices: Flammable forest vegetation shall be removed; all conifer limbs shall be removed to a minimum height of 2 m from the ground on residual overstory trees; annual grasses shall be mowed to 10 cm or less; and, no combustible material piles (firewood, lumber, etc.) shall be allowed.	absent
Williams Lake B.C. *Bylaw No. 2140, 2012*	Landscaping on the property within 10 metres (Priority 1 zone) of a building shall not include coniferous evergreen shrubs such as junipers, mugo pines, or coniferous evergreen hedges. No additional or new coniferous evergreen trees are to be planted within 10 metres of the building. It is not advisable to retain previously existing mature coniferous evergreen trees within 10 metres (Priority 1 zone) of the building. Any coniferous evergreen trees that are to be retained on the property that lie within 10 metres (Priority 1 zone) of the building must: • Have limbs pruned such that they are at least 2 metres above the ground. • Be spaced so that they have 3 metres between crowns. (In other words, the tips of the branches of a tree are no closer than 3 metres to the tips of the branches of another). • No limbs should be within 3 metres of the building or attachments such as balconies. Landscaping on the property within 10 metres of a building (Priority 1 zone) shall use only non-combustible landscape mulches.	absent

Case study: Using cost benefit analysis to analyze assisted migration strategies

Colin Mahony RPF

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With support from GenomeBC and SelectSeed

Executive summary

One of the potentially most cost-effective approaches to climate change adaptation in forestry is ensuring that seedlings planted following harvest are genetically adapted to the future climate. To pursue this objective, the BC MFLNRO Tree Improvement Branch is in the process of transitioning from the current geographically-based seed transfer system to a climate-based seed transfer (CBST) system. This new system will attempt to match locally-adapted seed to new locations with appropriate future climates—a process called assisted migration. The purpose of this study is to investigate the economic benefits and risks of assisted migration from the different perspectives of government and forest licensees, and to evaluate economic instruments for engaging licensees as partners in implementation.

The cost-benefit analyses in this study indicate that assisted migration using CBST could provide very large returns to the provincial economy and stumpage revenues. These returns are robust to uncertainties in markets, site productivity and regeneration risks. The analysis suggests that even a large increase in regeneration risk is strongly preferred from the government perspective if it can reduce risks of mid-rotation plantation failure. Assisted migration via CBST is essentially cost-neutral for licensees if it is not associated with increased regeneration risk. However, an increase in regeneration risk is strongly economically unviable for licensees, in part because of higher discount rates and low exposure to harvest benefits, but in particular because licensees are liable for regeneration risk under the current policy framework.

Whether government pursues a conservative or aggressive assisted migration strategy, addressing regeneration risk will be a central challenge in engaging licensees as partners in the implementation of CBST policy. Ecosystem-based data on regeneration risks of assisted migration is fundamental to managing perceptions of risk and also to equitable risk-sharing between licensees and government. The stumpage appraisal system presents opportunities for risk sharing, but also has some important limitations. Tolerance of short-term risks may also be improved by creating awareness of climate change impacts on the forest resource, particularly through the Timber Supply Review and through supporting forest professionals in their role as mediators between the public and industry perspectives.

Assisted migration is one of several regeneration practices for climate change adaption, including higher planting densities, composite provenancing, and mixed species planting. All of these practices involve a trade-off between short-term costs and long-term benefits. Consequently, many aspects of this case study apply to this broader group of reforestation decisions currently implemented by licensees.

Contents

Introduction

One of the potentially most cost-effective approaches to climate change adaptation in forestry is ensuring that seedlings planted following harvest are genetically adapted to the future climate. The process of allocating seedlings to planting sites based on climatic attributes is called climate-based seed transfer (CBST), in contrast to the current geographical seed transfer system based on fixed boundaries, latitude, longitude, and elevation. CBST provides the mechanism for assisted migration, i.e. to move beyond a “local is best” seed transfer policy and match seed sources to the current or future climates that they are best adapted to. Given that there is already an extensive reforestation industry in BC representing hundreds of millions of dollars of economic activity annually, the operational implementation of assisted migration using CBST is likely to carry few additional direct costs. However, the science foundation, policy and decision support knowledge base for assisted migration is incomplete, and this is a primary barrier to its adoption by policy makers and practitioners. It is possible that developing the necessary genecological knowledge could facilitate low-cost adjustments to seed transfer practices with large impacts on forest productivity and climate change impact mitigation. Assisted migration appears to be an exceptional case study for the utility of information as an economic instrument for climate change adaptation.

The purpose of this case study is to investigate the potential for assisted migration to mitigate climate change impacts on the forest sector of BC’s economy. The Adaptree project[7] and the FLNRO CBST program[8] are already conducting extensive research on public opinion and the policy environment associated with this topic. This case study aims to complement these efforts with a quantitative cost-benefit analysis. The analysis assesses the economic return of long-term genecology research (including both genomics and traditional field trials) required to support both CBST and assisted migration. Given substantial uncertainties about timber markets, timber supply, climate change impacts, and the ability of assisted migration to mitigate these impacts, this assessment focuses on sensitivity analysis and threshold analysis.

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[7] http://adaptree.sites.olt.ubc.ca/

[8] http://www.for.gov.bc.ca/hti/climate_based_seed_transfer/2cbst_project.htm

CBST and assisted migration

CBST and assisted migration are related but distinct concepts. Seed transfer refers to the process of defining locations in which a specific seed source of a given species can be planted. The long-established premise of seed transfer is that populations are locally adapted to some degree and that moving seed to a different climate than its geographic origin (aka its "provenance"), even within the species range, can result in maladaptation and thus reduced productivity. Since their inception, seed transfer policies in BC have been geographically-based, i.e. they have limited seed transfer to mapped zones or to specified distances (latitude/longitude and elevation) from the seed source (Ying and Yanchuk 2006). In contrast, climate-based seed transfer systems use climatic information to define acceptable seed transfer limits for any given seed source. This climatic information can be qualitative, e.g. a seed source can be limited to specified biogeoclimatic subzone-variants). It can also be quantitative; the seed transfer limits can be mapped using thresholds in a set of climate variables such as mean annual temperature and mean annual precipitation.

Climate-based seed transfer would be a viable alternative to geographic seed transfer even in the absence of climate change, because it more directly and precisely identifies the climatic limits of for safe seed transfer. However, climate-based seed transfer is especially useful when climate change is expected to result in populations being maladapted to their own local environments. In this case, climate-based seed transfer can be used to match seed sources with potentially distant locations that are forecasted to have favourable climates in the future, a process called assisted migration (Aitken et al. 2008). Hence CBST is a system by which assisted migration can be accomplished. In this report, some amount of assisted migration is implicit in the use of the term CBST. Nevertheless, the concept of CBST should not be conflated with specific assisted migration strategies.

Approaches to CBST in BC

The BC MFLNRO Tree Improvement Branch is currently in the process of transitioning from the current geographically-based seed transfer system to a CBST system (BCMFLNRO 2012a). This process is guided by the Forest Genetics Council of BC, and is scheduled for the period of 2012-2017. The Ministry has implemented CBST interim policy that notably includes an assisted range expansion strategy for western larch. However, the form of the CBST policy being developed by the Ministry has not yet been released.

The elements of a viable approach to assisted migration via CBST for British Columbia are described in Ukrainetz et al. (2011). A key premise of this approach is that tree provenances are already somewhat maladapted to their local climates due to climate change over the past century; climate normals (30-year averages) of mean annual temperature have increased by approximately 1^{o}C since 1900. Assisted migration can compensate for this shift, likely resulting in increased productivity. In addition, provenances could be matched to projected climates about one-third of a rotation (20-25 years) into the future, which roughly corresponds to another 1^{o}C of climate change. In other words, about half of the assisted migration contemplated by this approach would be catching up to climate changes that have already occurred. The other half would target the anticipated climate at just beyond the free-growing age, when licensees transfer stand risks to the government. This conservative approach can be expected to result in improved productivity without increasing regeneration risks (Greg O'Neill, personal communication, July 28, 2014).

A conservative approach to assisted migration is currently appropriate, given the incomplete state of genecological knowledge and the large uncertainties with future climatic conditions. However, the conservative approach described above may fall short of the degree of assisted migration required to adequately mitigate the risks of climate change. As sufficient information becomes available, it may be preferable to accept an increase in regeneration failures to achieve an equal or greater decrease in mid-rotation stand failures and productivity declines. In addition to exploring the economic implications of a conservative assisted migration approach that will likely be applied in the near future, this study aims to explore the economic trade-offs between the short-term and long-term risks of climate-related genetic maladaptation associated with a more aggressive assisted migration policy. This can help inform policy as the information base for CBST becomes available. It can also point to economic and policy instruments for engaging licensees as partners in CBST implementation.

Research requirements of assisted migration via CBST

The core information for CBST is an understanding of how populations across the range of any given species respond to a broad range of specific climatic conditions. The most direct source of this information is provenance trials, in which seedlings from a climatically diverse sample of seed source locations (provenances) are planted together in several common gardens that collectively represent a broad range of climatic conditions. Over a period of decades, the data from these trials can be used to understand the optimal climates for tree populations in terms of measured traits such as height or volume growth. Importantly, provenance trials also indicate the range of climatic conditions to which populations can be transferred without unduly compromising productivity. With the exception of lodgepole pine, sufficient provenance trial data for most species in BC is not yet available. For example, the best provenance trials of interior spruce, the second most economically important species in BC, are only ten years old. Even the Illingworth lodgepole pine trial, an extensive installation established in 1974, has a limited temperature range relative to forecasted climate changes over the next century, and therefore is not sufficient for some assisted migration applications. The Assisted Migration Adaptation Trial (AMAT), installed by the MFLNRO Tree Improvement Branch between 2009 and 2012, is designed to provide the necessary data for BC tree species but will take many more years to yield sufficient data to inform CBST policy (Greg O'Neill, personal communication, July 28, 2014).

Other research approaches are necessary to complement the provenance trials and to provide genecological information on a shorter time scale. For example, the Adaptree Project at the UBC Faculty of Forestry is using short-term seedling trials involving laboratory, nursery, and field experiments to study climate-related traits such as hardiness to cold and drought, and timing of growth and dormancy. Genomic tools are then used to investigate the genetic basis for the within- and between-population variation in these traits. Although the use of genomics to understand population-level adaptation to climate is in its infancy, it may become an important source of guidance for assisted migration (Sally Aitken, personal communication, May 8, 2014).

CBST also requires accurate information on the climate at any given seed source or planting site. To meet this need, ClimateWNA has been developed by the UBC Centre for Forest Conservation Genetics over the past 10 years in partnership with the BCMFLNRO, BC Forest Genetics Council, and Pacific Climate Impacts Consortium (Wang et al. 2012). This program uses weather station data to estimate historical values of biologically relevant climate variables at any specified location in western North America. It also provides downscaled climate change projections produced by all major global and regional climate models. Validating, maintaining, and updating ClimateWNA is an ongoing effort that requires stable funding.

Climate change impacts on forest productivity

Climate change puts both upward and downward pressures on forest productivity. There is evidence that CO2 fertilization, longer growing seasons, and higher temperatures could support increases in tree productivity: for example, Boisvenue and Running (2006) estimated that climate change over the past 50 years resulted in increases in forest productivity at a global scale in areas where water is not limiting. At the scale of British Columbia, Wang et al. (2006, 2010) used provenance trial data to project that 20-yr height of local lodgepole pine seed sources would increase in large areas of the province by 2050, while decreasing in moisture-limited areas of the southern interior. However, a crucial qualification on this projection is that provenance trials are located in landscapes that aren't affected by the climate change being simulated. Since many insect and disease outbreaks, as well as fire, occur at the landscape level (Raffa et al. 2008), projections based on provenance trials do not account for the effects of climate change on landscape-level biotic and abiotic disturbance regimes. As suggested by the recent mountain pine beetle and *Dothistroma* outbreaks, increases in productive potential in warmer and wetter climates are likely to be substantially counteracted, perhaps many times over, by increased disturbances (Dale et al. 2001, Woods 2011). For this reason, it is reasonable to assume that climate change will result in a net reduction in forest productivity (NRTEE 2011).

There are many different ways in which genetic maladaptation due to climate change can impact the productivity of the forest land base, each with distinct implications for cost-benefit analysis. It is essential to consider the costs and timing associated with each of these types of impacts.

- Growth reduction: as demonstrated by provenance trials, climatic maladaptation can directly affect the growth rates and/or mortality rates of individual trees. Assisted migration attempts to directly mitigate these stand level productivity losses by matching future climates with appropriate seed sources. Growth reductions are not associated with additional silvicultural costs.
- Regeneration failure: climate-related regeneration failures can occur due to frost, drought, snow press, and disease. Regeneration failures induce a delay in subsequent harvest, and also introduce incremental costs associated with replanting and brushing (in the range of $500 - $1500/ha[9]). Assisted migration can reduce regeneration failures if local seed is substantially maladapted to the climate due to historical climate change. Conversely, there is a risk that an aggressive assisted migration approach could increase regeneration failure if the seed is suitable for the projected future climate but maladapted to the present climate.
- Mid-rotation plantation failure: if the majority of an immature stand (20-60 years old) is killed by insects, disease, or drought, the productive potential of the stand may be reduced to the point where it is unlikely that the stand can be profitably harvested at any point in the future. In this case, it may be necessary to conduct a wholesale stand rehabilitation, involving knocking the stand down (at a cost of $1000-1500/ha) and replanting (at a cost of $500-1000/ha)[1].
- Catastrophic losses: catastrophic disturbances such as fire and insect outbreaks are influenced by the collective condition of forest stands at the landscape level (Carroll 2012). If deployed at the landscape level, assisted migration has some potential to partially and indirectly mitigate catastrophic disturbances by fostering healthier, more resilient stands. Nevertheless, all stands are susceptible to catastrophic disturbance to some degree, no matter how well they are climatically adapted (Haughian et al. 2012).

Sources of uncertainty

Beyond the reasonable assumption that climate change will negatively impact forest productivity, the magnitude of these impacts is extremely uncertain. Even if the magnitudes of climate change were known, the complexity of ecosystem responses to the altered climate confounds prediction, especially over the length of a forest rotation in BC. However, the trajectories of climate change are not known, because the international success at mitigating emissions is unknown and because the climate itself is a complex system for which prediction can only be very approximate. Given these compounding uncertainties, assumptions made in this study about the magnitude of climate change reductions to forest productivity should be understood to be essentially arbitrary. The purpose of this study is to examine the economic implications of a range of climate change impacts, rather than provide an estimate of the impacts themselves.

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[9] These ball-park silviculture cost estimates are based on a compilation of activity costs by region provided by Nigel Fletcher, MFLNRO Forest Investments Analysis Specialist, July 18th, 2014.

Despite the uncertainties in climate change impacts on forest productivity, it is reasonable to assume that a conservative and adequately researched assisted migration strategy will have a mitigating effect. The rationale for this assumption is that the conservative approach to assisted migration can operate on known climate changes over the past century, and on projected climate changes for the near future for which there are fewer uncertainties. Although the degree of mitigation is limited by the conservative approach, the potential for unintended consequences is low (Greg O'Neill, personal communication, July 28, 2014). Of course, a poorly researched and/or implemented CBST regime could negatively impact productivity through maladaptation, regeneration delays, and plantation failures. It is assumed throughout this analysis that CBST is appropriately implemented. Indeed, the purpose of a long-term sustained CBST research program is to ensure that seed transfer policy and practices are adequately supported by evidence.

Economic perspectives of Government vs. Licensees

When evaluating the incentives to implement assisted migration, it is essential to recognize the fundamentally different economic perspectives of government and licensees. There are three key factors that differentiate the perspectives of these two parties on silviculture investments and risk:

1. Harvest benefits: In addition to direct harvest revenues via stumpage and taxes, the government will generally consider increased economic activity associated with improved timber supply as a benefit of public silviculture investments. In contrast, the benefits of a silviculture investment to the licensee are restricted to profits over and above conversion costs and stumpage. Further, volume-based licenses carry no mechanisms to ensure that licensees will harvest the stands on which they pay the costs of regeneration. These factors mean that the benefits of a silviculture investment are larger and more certain for the government than for licensees.
2. Discount rate: social discount rates used by government for public forestry investments are 2% in BC. In contrast, silviculture investments must compete for licensee capital with other opportunities such as equipment upgrades, and thus are evaluated at private sector discount rates of greater than 6%. This difference in the time value of money gives the government a much longer-term outlook on the realization of benefits.
3. Liability: Under the current regulatory framework, licensees carry the liability for stand establishment. The liability for stand maintenance is returned to the government when the stand reaches a free-to-grow state, which occurs at stand ages between 10-20 years. Therefore, licensees are incented to minimize establishment risk, an objective that only indirectly and incompletely achieves the government objective of maximizing stand productivity.

It is well known that, as a tenant to the forest resource, licensees have little incentive to invest in silviculture at the regeneration stage. However, the different economic perspectives of government and licensees also affect how these two parties balance risk in both the short and long term. A major theme of this case study is how these two perspectives influence the willingness of the parties to participate in assisted migration under various risk scenarios.

Methods

Cost-benefit analysis framework

Cost-benefit analysis (CBA) evaluates a project, decision, or policy in terms of the present value of its total costs and benefits. CBA has emerged as a prominent tool for assessing the benefits of investing in adaptation to climate change (UNFCC 2011). Incremental CBA evaluates a project against the *status quo*, i.e. the costs and benefits expected to occur if the project was not undertaken. In this case, the costs and benefits of assisted migration are evaluated in comparison to the assumed costs and benefits of the current "local is best" seed transfer policies in place in British Columbia. Any avoided costs of the *status quo* are counted as benefits of the project. Any forgone benefits of the *status quo* are "opportunity costs" of the project. In this study, two values are reported as results of the incremental CBA: the net present return (NPV), the difference between the present value of benefits and costs; and the benefit-cost ratio (BCR), the ratio of benefits and costs.

Assessment of climate change adaptation projects requires a modification of standard CBA conventions. Typically, CBA assesses a project against an established and well-understood *status quo*. However, the impacts of climate change are not incorporated into forest growth estimates in widespread use throughout British Columbia and Canada. The analysis of climate change adaptation therefore first requires establishing estimates of climate change impacts associated with *status quo* management, and then estimating the degree to which the project under evaluation will mitigate those impacts. In this case study, project benefits must be understood to be a mitigation of expected losses. This approach to CBA is common in economic analyses of climate change adaptation (e.g. NRTEE 2011).

This analysis performs cost-benefit analysis from two alternative perspectives that could be held by the provincial government. The first is a narrower financial perspective that only considers stumpage and other direct revenues as benefits of harvest. The second is a broader economic perspective that also considers increases in economic activity as a benefit of improved timber supply. The methods in this study use conversion costs of additional harvestable volume as a proxy for the contribution of assisted migration to GDP. While this approach provides only a coarse approximation of economic impact, it is sufficient for the purpose of identifying the broad economic implications of assisted migration and its associated risks and uncertainties.

Stand-level economic modeling

The detailed method for economic modeling is provided in Appendix A. The following is a brief summary:

- Stand-level modeling was performed in an MS Excel spreadsheet referencing TIPSY v4.3 (BC MFLNRO 2013) yield tables for lodgepole pine at a range of site index from 11 – 23m. Climate change impacts on productivity were modeled in the spreadsheet by netting down merchantable volume.
- Harvest is assumed to occur at the culmination of the mean annual increment of the stand, i.e. "physical culmination."
- Net revenues were calculated using the FAN$IER (Enfor 2013) default conversion costs and wood product prices.
- Licensee profit was assumed to be 6% of conversion costs. Stumpage was calculated as a residual of licensee profit and conversion costs.
- Analysis was based on NPV instead of site value, i.e. only one rotation was considered.
- CBST costs were assumed to be $10/ha for research and $5/ha for implementation.

Stand-level Scenarios

There are three scenarios in the stand-level analysis (Table 3). These scenarios reflect different ways in which climate change could impact forest productivity. Scenario 1 reflects the simplest understanding of climate change impacts and mitigation by assisted migration. Climate change impacts are modeled as a 20% reduction in growth rate. Mitigation by assisted migration is a proportional reduction in the climate change impacts. To be clear, a 40% mitigation rate means that the climate change impacts are reduced from 20% to 12%. There are no costs associated with this scenario except for the $15/ha CBST research and implementation costs.

Scenario 2 is designed to investigate the trade-off between long-term risk associated with status quo management and short-term risk associated with assisted migration. Instead of causing a reduction in growth, the *status quo* (local) seed source is assumed to undergo plantation failure at 25 years, requiring a $2000 stand rehabilitation treatment. Assisted migration is assumed to prevent this event, but induce a regeneration failure at 5 years, requiring a $1000 fill plant. This of course is an idealized scenario, but it is intended to illustrate the dynamics of the trade-offs associated with allocating seed sources in a dynamic climate. The 25-year regeneration delay associated with the plantation failure is equivalent to a 26% reduction in mean annual increment at culmination age (MAIc). The 5-year regeneration delay associated with the regeneration failure is a substantial mitigation of this impact, and amounts to a 7% reduction in (MAIc).

Scenario 3 is a hybrid of the previous two scenarios: productivity reductions and stand failure risks are applied in approximately equal proportions. Productivity losses and mitigation rates are half of those applied in Scenario 1. Status quo plantation failures and assisted migration regeneration failures are both modeled as a 25% risk, and their associated rehabilitation costs are prorated according to this risk level. The overall climate change impacts on productivity (MAIc) are approximately the same as for Scenario 1.

Table 3: Summary of assumptions for scenarios of the stand-level analysis. Assisted migration mitigation rates are a percentage of the assumed productivity losses.

	Scenario base assumptions		
Assumptions	S1: Productivity losses only	S2: Stand risk trade-offs	S3: Hybrid impacts
Climate change impacts on stand growth			
Productivity losses	20%	0%	10%
CBST mitigation (% of losses)	40%	0%	20%
Regeneration failure at year 5 caused by assisted migration			
Probability of occurrence	0%	100%	25%
Brushing & fill plant cost ($/ha)	*n/a*	$1,000	$1,000
Plantation failure at year 25 averted by assisted migration			
Probability of occurrence	0%	100%	25%
Stand rehabilitation cost ($/ha)	*n/a*	$2,000	$2,000
Equivalent effects on productivity (% reduction in MAIc under base assumptions)			
Unmitigated climate change impacts	20%	26%	19%
AM-Mitigated climate change impacts	12%	7%	10%

The ownership of risks, costs, and benefits under current free-to-grow legislation predetermines Scenarios 2 and 3 to be highly unfavourable to licensees, who carry many of the costs of regeneration failure but would not benefit directly from the averted mid-rotation plantation failure assumed in these scenarios. For the purposes of these scenarios it is assumed that any substantial increase in regeneration risk associated with government CBST policy would be accompanied by risk-sharing measures to absorb this increase in risk. As a result, regeneration costs associated with assisted migration are assumed to be paid the government in this scenario.

Scenarios 2 and 3 assume that the stand established following regeneration/plantation failure grows at full productivity, with no climate change impacts. This is a simplification of the risks posed by a progressively changing climate. The risks to the rehabilitated stands would be the same or greater than to the original stand, and would therefore compound over time. An investigation of these compounding risks is left for future studies.

Province-level analysis

The stand-level cost-benefit analysis is rolled up to the province as a whole to obtain estimates of the total return on CBST investments. Species-specific rotation age, total volume increment, lumber value, and seedling deployment assumptions were obtained directly from the Tree Improvement Investment Priorities (TIIP) spreadsheet maintained by the Forest Genetics Council of BC (Table 4). Other assumptions are consistent with the stand level analysis.

Table 4: species-specific assumptions for the provincial-level cost-benefit analysis.[10]

Spp.	Average rotation age (years)	Total potential volume growth (million m^3/yr)	Lumber value $/$m^3$	Species-specific research costs ($/yr)*	Annual planting (millions of seedlings)	Annual planting (ha)**
Pli	60	20.6	$100	$100,000	100	90,731
Sx	75	14.7	$105	$100,000	62	56,427
Fdi	70	3	$105	$100,000	12	10,856
Lw	70	1.2	$105	$100,000	4	4,061
Pwi	70	0.2	$100	$100,000	1	482
Fdc	55	6.9	$110	$100,000	15	13,300
Cw	60	3.7	$115	$100,000	8	7,585
Hw	60	0.8	$100	$100,000	1	1,300
Ss	55	0.6	$100	$100,000	1	618
Pwc	50	0.1	$100	$100,000	0	118
Total		51.7		$1,000,000	204	185,478

*Research costs are applied to each species because genecology research is species-specific for the most part.

**Annual area planted is derived from annual seedlings planted, assuming a planting density of 1100 sph.

[10] Unless noted otherwise, assumptions are consistent with the Tree Improvement Investment Priorities (TIIP) spreadsheet maintained by the Forest Genetics Council of BC. Note that the TIIP analysis only includes planting for species and areas where tree improvement investments are considered worthwhile and is, therefore, a subset of areas where CBST is considered.

Results

Stand-level scenario analysis

Scenario 1 “Productivity losses only”

In this scenario, the base assumption is that volume production in the *status quo* seed transfer stand is reduced by 20% due to climate change, and assisted migration provides a 40% mitigation of this impact. This produces a modest (15 m^3/ha) gain in harvest volume relative to *status quo* seed transfer.

From the broader economic perspective of government, the benefits to the provincial economy far exceed the initial research and implementation costs (Table 5). Since assisted migration is assumed to cost only $15 per hectare, the financial return of the incremental volume gain is very large: $418/ha in net present value, or a benefit-cost ratio of 29:1. This result is robust to the assumptions of the analysis, in that the break-even assumptions are individually outside of a reasonable range. The break-even discount rate indicates that the internal rate of return of the implementation of assisted migration is 7%. It is also worth noting that the break-even cost of assisted migration is $433/ha, which indicates considerable room to incorporate risk associated with assisted migration (e.g. elevated regeneration risks).

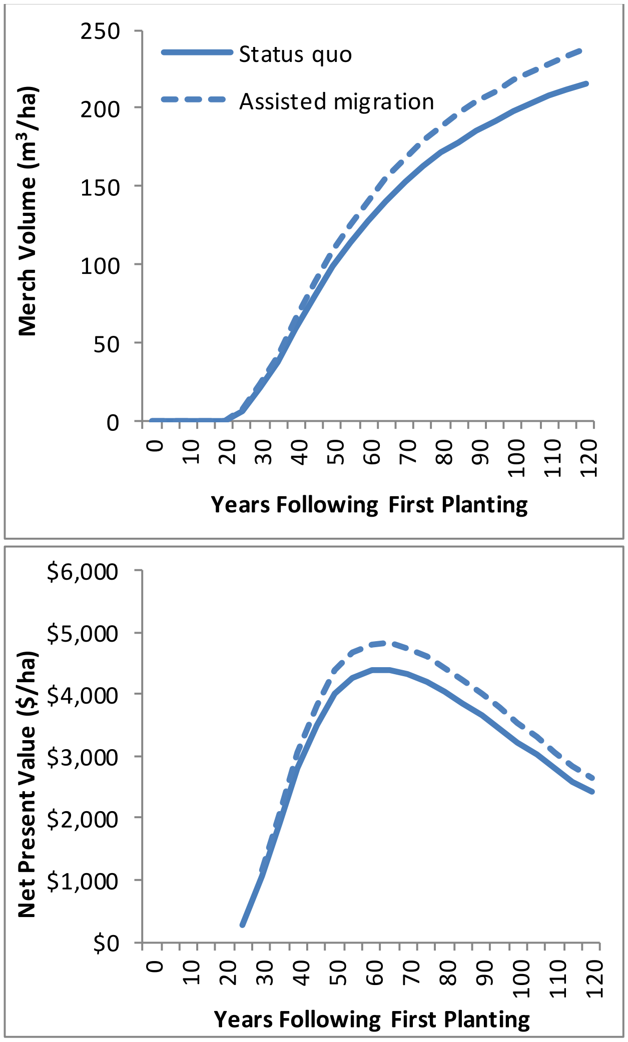
In this scenario, assisted migration is also economically viable from the narrower perspective of government revenues alone, though this viability is somewhat less robust to some variables (Table 6). The break-even discount rate is 4.5%, which is at the upper range of social discount rates applied to public projects in Canada (Boardman et al. 2010). Low productivity sites (site index <13m) do not carry sufficient volume to provide positive returns in stumpage. Despite these sensitivities, the government revenue perspective is robust to climate change impacts/mitigation and product value assumptions.

In contrast to the government perspectives, assisted migration is a cost-neutral activity for licensees under the assumptions of this scenario. Since government carries all research and implementation costs, the NPV is inevitably positive from the licensee perspective. However, even if the licensees were guaranteed a stake in the harvest of the reforested stand, which is not the case in current volume-based licenses, discounting at private sector discount rates would reduce the harvest profit on incremental volume ($6/$m^3$ in this scenario) to a negligible NPV. Hence any incremental costs to licensees would make this scenario economically unviable from the licensee perspective.

Table 5: Summary of the cost-benefit analysis of Scenario #1 from the perspective of the provincial economy.

Assumption	Base	Break-even*
Site Index (SI50)	17	13
Discount rate	2.0%	7.0%
CBST Costs ($/ha)	$15	$433
Economic benefits of harvest		
Gross product value ($/m^3)	$ 119	$ 93
Conversion cost ($/m^3)	-$ 93	-$ 93
Licensee profit ($/m^3)	-$ 6	$ 0
Stumpage ($/m^3)	$ 21	$ 0
Climate-change impacts		
Productivity losses	20%	1%
CBST mitigation (% of losses)	40%	2%
Induced regeneration failure		
Probability of occurrence	0%	n/a
Brushing & fill plant cost	$0	n/a
Avoided plantation failure		
Probability of occurrence	0%	n/a
Stand rehabilitation cost	$0	n/a

Results	**Status quo**	**AM**
Harvest year	70	70
Harvest Volume	152	167
Harvest Benefit ($/m^3)	$114	$114
NPV at Harvest ($/ha)	$4,325	$4,743
Incremental Net Present Value ($/ha)		$418
Incremental Benefit/Cost Ratio		28.8

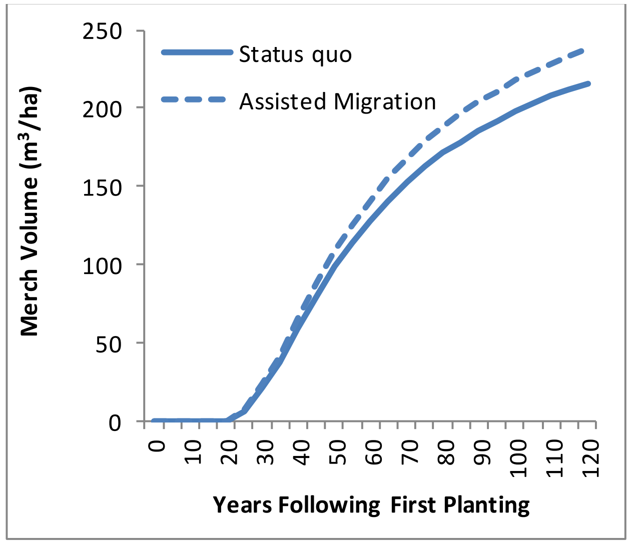


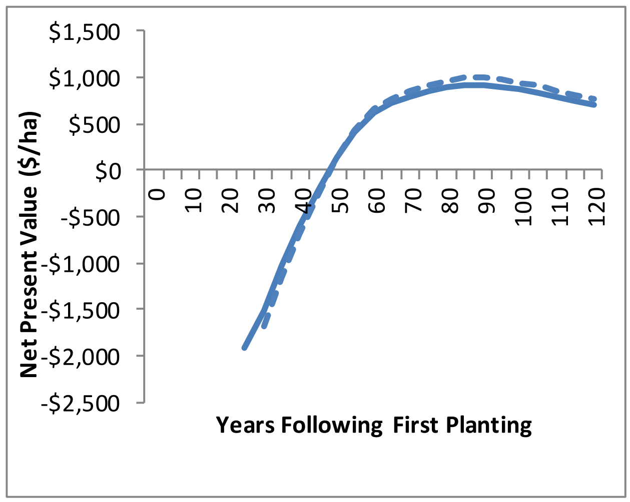
*The "Break-even" value is the value of the assumption that will provide a positive incremental NPV for CBST. Break-even values are determined individually as a threshold analysis; all other assumptions are held constant at the values listed in the "Base" column. The value "None" indicates there are no available values of the assumption that create a break-even NPV. "All" indicates that all possible values provide a break-even condition.

Table 6: Summary of the cost-benefit analysis of Scenario #1 from the perspective of government revenue only.

Assumption	Base	Break-even*
Site Index (SI50)	17	13
Discount rate	2.0%	4.5%
CBST Costs ($/ha)	$15	$79
Economic benefits of harvest		
Gross product value ($/m³)	$ 119	$ 102
Conversion cost ($/m³)	-$ 93	-$ 93
Licensee profit ($/m³)	-$ 6	$ 6
Stumpage ($/m³)	$ 21	$ 4
Climate-change impacts		
Productivity losses	20%	3%
CBST mitigation (% of losses)	40%	8%
Induced regeneration failure		
Probability of occurrence	0%	n/a
Brushing & fill plant cost	$0	n/a
Avoided plantation failure		
Probability of occurrence	0%	n/a
Stand rehabilitation cost	$0	n/a

Results	Status quo	AM
Harvest year	70	70
Harvest Volume	152	167
Harvest Benefit ($/m³)	$21	$21
NPV at Harvest ($/ha)	$786	$849
Incremental Net Present Value ($/ha)		$64
Incremental Benefit/Cost Ratio		5.2





*The "Break-even" value is the value of the assumption that will provide a positive incremental NPV for CBST. Break-even values are determined individually as a threshold analysis; all other assumptions are held constant at the values listed in the "Base" column. The value "None" indicates there are no available values of the assumption that create a break-even NPV. "All" indicates that all possible values provide a break-even condition.

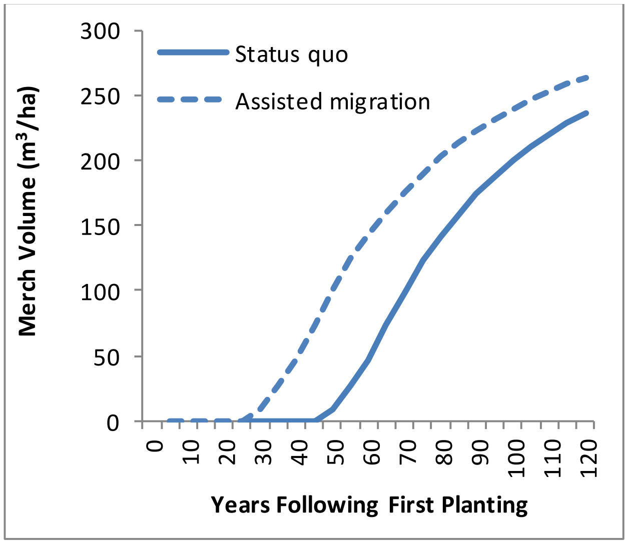
Scenario 2 “Stand risk trade-offs”

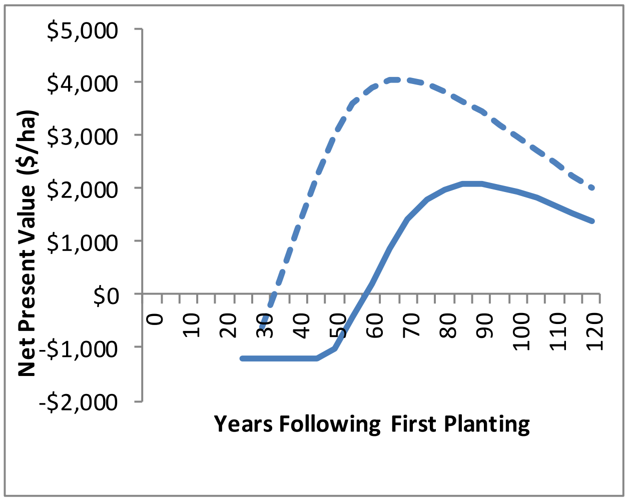
This scenario investigates the trade-off between adaptation to the current vs. the future climate at the planting site. The *status quo* seed source is assumed to undergo plantation failure at 25 years, requiring a $2000 stand rehabilitation treatment. Assisted migration is assumed to induce a regeneration failure at 5 years, requiring a $1000 fill plant. From the broader economic perspective of government, a regeneration failure is strongly preferred over a mid-rotation plantation failure, even in the absence of any other productivity losses (Table 5). The primary reason for this preference is that the delayed costs of the plantation failure remain higher than the more immediate costs of regeneration failure at the discount rate of 2%. The longer regeneration delay induced by plantation failure is also an important factor, but its effect is underestimated because future rotations are not incorporated into the analysis. The preference for a regeneration failure is highly robust to the assumptions of the analysis.

Table 7: Summary of the cost-benefit analysis of Scenario #2 from the perspective of the provincial economy.

Assumption	Base	Break-even*
Site Index (SI50)	17	all
Discount rate	2.0%	5.5%
CBST Costs ($/ha)	$15	$1,945
Economic benefits of harvest		
Gross product value ($/m^3)	$ 120	$ 93
Conversion cost ($/m^3)	-$ 93	-$ 93
Licensee profit ($/m^3)	-$ 6	$ 0
Stumpage ($/m^3)	$ 21	$ 0
Climate-change impacts		
Productivity losses	0%	n/a
CBST mitigation (% of losses)	0%	n/a
Regeneration failure at year 5 caused by AM		
Probability of occurrence	100%	all
Brushing & fill plant cost	$1,000	$3,100
Plantation failure at year 25 averted by AM		
Probability of occurrence	100%	35%
Stand rehabilitation cost	$2,000	All

Results	Status quo	AM
Harvest year	95	75
Harvest Volume	188	190
Harvest Benefit ($/m^3)	$114	$114
NPV at Harvest ($/ha)	$2,034	$3,964
Incremental Net Present Value ($/ha)		$1,930
Incremental Benefit/Cost Ratio		3.1





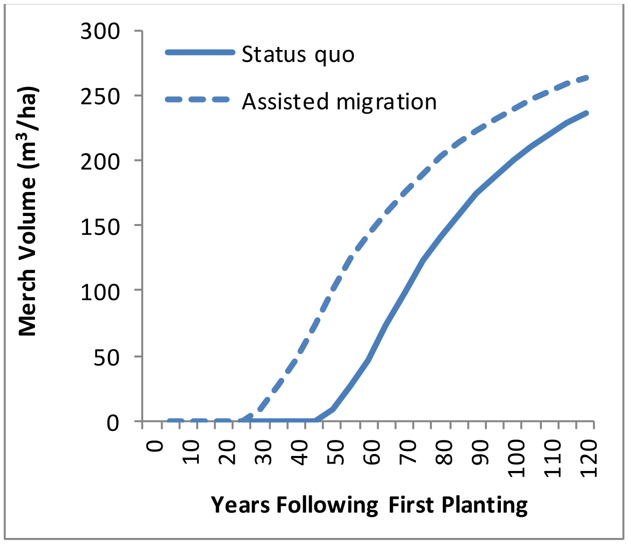
*The "Break-even" value is the value of the assumption that will provide a positive incremental NPV for CBST. Break-even values are determined individually as a threshold analysis; all other assumptions are held constant at the values listed in the "Base" column. The value "None" indicates there are no available values of the assumption that create a break-even NPV. "All" indicates that all possible values provide a break-even condition.

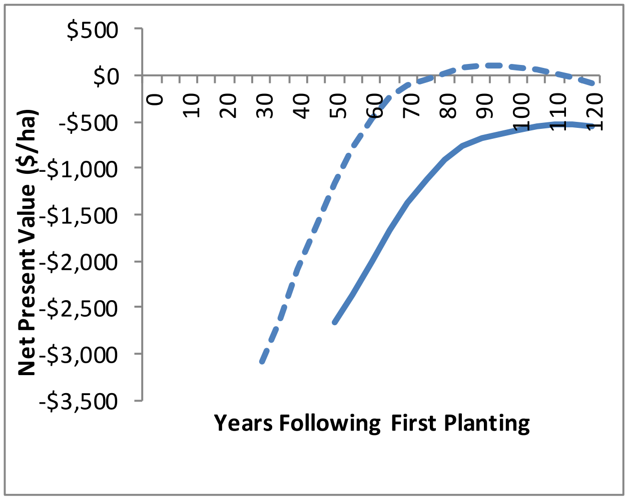
A regeneration failure is also strongly preferred from the narrower perspective of stumpage revenues alone (Table 6). However, the absolute NPV of both treatments is negative because the stumpage revenue is not sufficient by itself to cover the rehabilitation costs of the either type of stand failure under the base assumptions. This suggests that stand rehabilitation could be economically unviable at the stand level, though at the forest level it may be an important measure in maintaining timber supply. However, the break-even assumptions are very close to the base assumptions. This indicates that rehabilitation would be viable on some portions of the land base with higher productivity, higher product value, lower regeneration failure risks, and/or lower rehabilitation costs.

Table 8: Summary of the cost-benefit analysis of Scenario #2 from the perspective of government revenue only.

Assumption	Base	Break-even*
Site Index (SI50)	17	all
Discount rate	2.0%	4.0%
CBST Costs ($/ha)	$15	$104
Economic benefits of harvest		
Gross product value ($/m^3)	$ 120	$ 99
Conversion cost ($/m^3)	-$ 93	-$ 93
Licensee profit ($/m^3)	-$ 6	-$ 6
Stumpage ($/m^3)	$ 21	$ 0
Climate-change impacts		
Productivity losses	0%	n/a
CBST mitigation (% of losses)	0%	n/a
Regeneration failure at year 5 caused by AM		
Probability of occurrence	100%	All
Brushing & fill plant cost	$1,000	$1,600
Plantation failure at year 25 averted by AM		
Probability of occurrence	100%	65%
Stand rehabilitation cost	$2,000	$1,000

Results	**Status quo**	**AM**
Harvest year	95	75
Harvest Volume	188	190
Harvest Benefit ($/m^3)	$21	$21
NPV at Harvest ($/ha)	-$628	-$34
Incremental Net Present Value ($/ha)		$595
Incremental Benefit/Cost Ratio		1.6





*The "Break-even" value is the value of the assumption that will provide a positive incremental NPV for CBST. Break-even values are determined individually as a threshold analysis; all other assumptions are held constant at the values listed in the "Base" column. The value "None" indicates there are no available values of the assumption that create a break-even NPV. "All" indicates that all possible values provide a break-even condition.

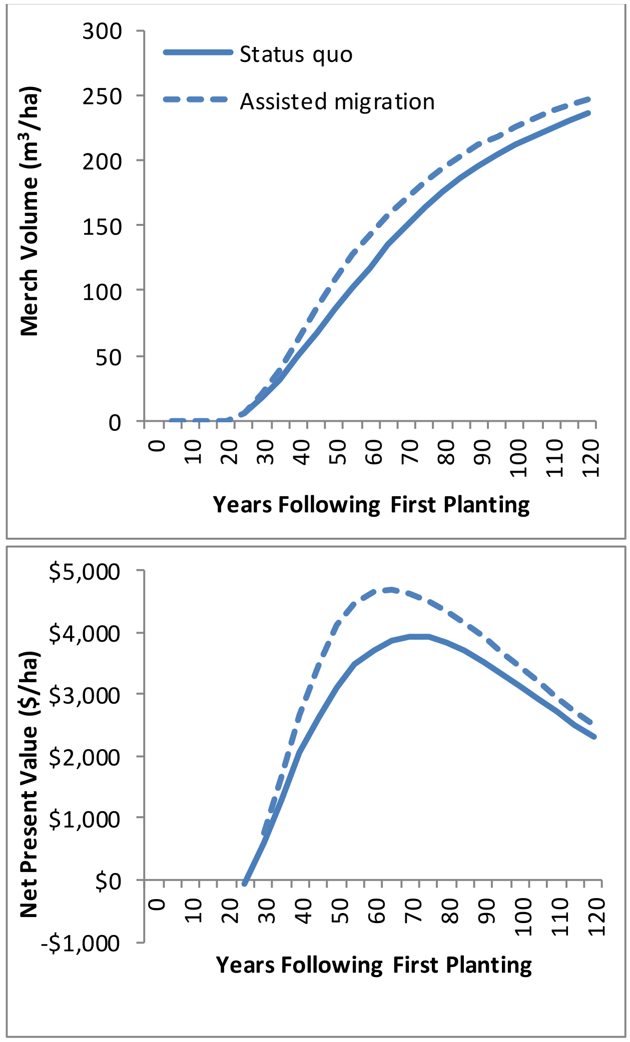
Scenario 3 "Hybrid impacts"

Scenario 3 integrates productivity impacts (Scenario 1) and stand risks (Scenario 2). Similar to Scenario 2, regeneration risk is strongly preferred over longer-term risk to plantations from the perspective of provincial economic activity. For example, the risk (probability of occurrence) of regeneration failure can be three to five times the risk of plantation failures, and the costs of rehabilitation are essentially irrelevant to this preference for short term risk (Table 5). This preference is less robust from the perspective of government revenues alone, but is nevertheless evident across all assumption thresholds (Table 6). It is notable that even though the volume impacts of productivity losses and regeneration delays are weighted equally, the assumptions for productivity losses and mitigation rates do not affect the economic preference for short term risk. This insensitivity is due to the overwhelming role of the stand rehabilitation costs in the cost-benefit analysis.

Table 9: Summary of the cost-benefit analysis of Scenario #3 from the perspective of the provincial economy.

Assumption	Base	Break-even*
Site Index (SI50)	17	all
Discount rate	2.0%	6.5%
CBST Costs ($/ha)	$15	$811
Economic benefits of harvest		
Gross product value ($/m³)	$ 119	$ 93
Conversion cost ($/m³)	-$ 93	-$ 93
Licensee profit ($/m³)	-$ 6	$ 0
Stumpage ($/m³)	$ 20	$ 0
Climate-change impacts		
Productivity losses	10%	all
CBST mitigation (% of losses)	20%	all
Regeneration failure at year 5 caused by AM		
Probability of occurrence	25%	80%
Brushing & fill plant cost	$1,000	all
Plantation failure at year 25 averted by AM		
Probability of occurrence	25%	5%
Stand rehabilitation cost	$2,000	all

Results	Status quo	AM
Harvest year	80	70
Harvest Volume	176	172
Harvest Benefit ($/m³)	$114	$114
NPV at Harvest ($/ha)	$3,835	$4,631
Incremental Net Present Value ($/ha)		$796
Incremental Benefit/Cost Ratio		4.3

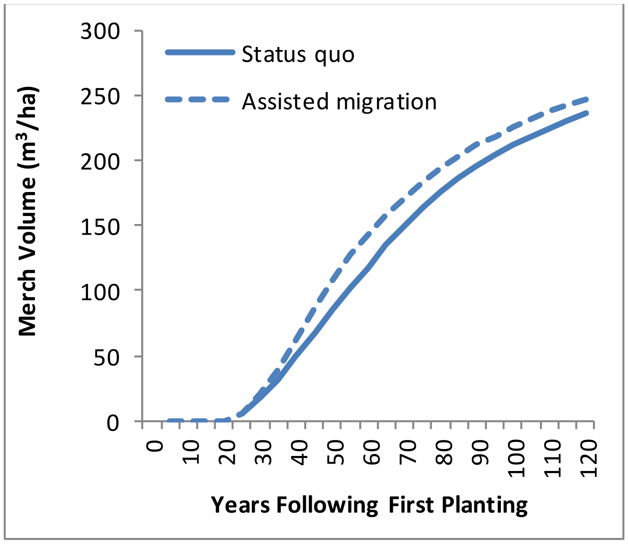


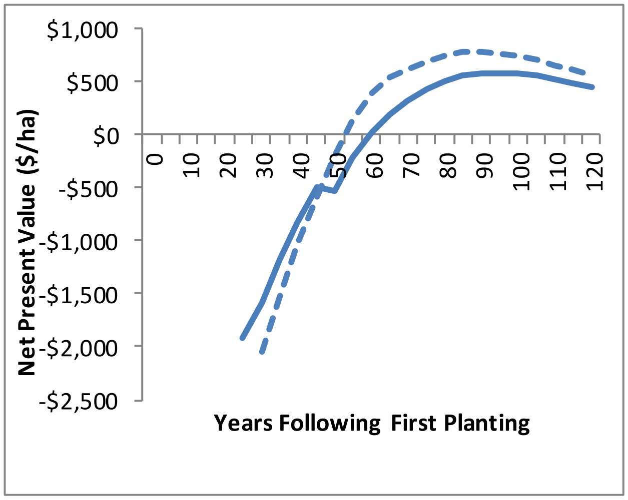
*The "Break-even" value is the value of the assumption that will provide a positive incremental NPV for CBST. Break-even values are determined individually as a threshold analysis; all other assumptions are held constant at the values listed in the "Base" column. The value "None" indicates there are no available values of the assumption that create a break-even NPV. "All" indicates that all possible values provide a break-even condition.

Table 10: Summary of the cost-benefit analysis of Scenario #3 from the perspective of government revenue only.

Assumption	Base	Break-even*
Site Index (SI50)	17	all
Discount rate	2.0%	4.5%
CBST Costs ($/ha)	$15	$120
Economic benefits of harvest		
Gross product value ($/m³)	$ 119	$ 102
Conversion cost ($/m³)	-$ 93	-$ 93
Licensee profit ($/m³)	-$ 6	$ 6
Stumpage ($/m³)	$ 20	$ 3
Climate-change impacts		
Productivity losses	10%	all
CBST mitigation (% of losses)	20%	all
Regeneration failure at year 5 caused by AM		
Probability of occurrence	25%	35%
Brushing & fill plant cost	$1,000	$1,500
Plantation failure at year 25 averted by AM		
Probability of occurrence	25%	15%
Stand rehabilitation cost	$2,000	$1,300

Results	Status quo	AM
Harvest year	80	70
Harvest Volume	176	172
Harvest Benefit ($/m³)	$22	$20
NPV at Harvest ($/ha)	$516	$621
Incremental Net Present Value ($/ha)		$105
Incremental Benefit/Cost Ratio		1.4





*The "Break-even" value is the value of the assumption that will provide a positive incremental NPV for CBST. Break-even values are determined individually as a threshold analysis; all other assumptions are held constant at the values listed in the "Base" column. The value "None" indicates there are no available values of the assumption that create a break-even NPV. "All" indicates that all possible values provide a break-even condition.

Province-level analysis

Table 9 provides a summary of the province-level cost-benefit sensitivity analysis from the government perspectives of the whole economy and stumpage revenues alone. This analysis assumes a range of 5-20% productivity losses due to climate change and that assisted migration will be able to mitigate 20-60% of these losses. CBST research is assumed to cost $1 million/year for 30 years and administrative implementation is modeled as a one-time cost of $15 million at year zero, for a total present value of $37 million for research and implementation. Results are presented for various trade-offs between risk of regeneration failures induced by AM and risk of plantation failures that would occur in the absence of AM. These trade-offs include bold-text threshold risk levels for one risk type, holding the other constant. For example, the second row of results indicates that low-range NPV is negative for regeneration risks greater than 3%, if the risk of plantation failure is held constant at zero.

Under the simplified assumptions of this analysis, the present value of assisted migration to the provincial economy as a whole is between $0.4 billion and $5 billion, which represents a range of benefit/cost ratios of 10 to 130. At a basic stumpage rate of $19/m^3, this translates to $43 million to $1 billion present value of stumpage (BCR of 2 to 25). These returns on investment are somewhat robust to trade-offs between regeneration failure and mid-rotation plantation failure. Assisted migration remains economically beneficial to the provincial economy under the assumptions of the analysis even if regeneration failures are approximately 10% more frequent than avoided plantation failures. However, if no plantation failures would occur under the status quo, the economic viability of assisted migration is not robust to induced regeneration failures. The larger costs associated with rehabilitating regeneration and plantation failures reduce the benefit-cost ratios to a range of 2 to 10.

This province-level analysis is extremely simplified, and should not be interpreted as anything more than a first-pass estimation of the general scale of the potential economic returns of assisted migration. Since assisted migration leverages existing reforestation expenditures to achieve climate change impact mitigation, it has potential to provide very large returns on the incremental investment in research and policy development, as demonstrated in this analysis. The scale of benefit-cost ratios returned from this study is consistent with the results of a previous cost-effectiveness analysis of adaptation policies in the forest sector measured through their impacts on timber supply (NRTEE 2011).

Table 11: Province level sensitivity analysis of a CBST research investment of $1 million/year for 30 years, plus a one-time policy implementation cost of $15 million.[11]

				Productivity loss due to climate change	5%	20%
				Assisted migration mitigation rate	20%	60%
Perspective	**Discount rate**	**Harvest Benefit ($/m³)**	**Induced Regen Failure Risk**	**Avoided Plantation Failure Risk**	**Low Range NPV (million $)**	**High Range NPV (million $)**
Government (whole economy)	2%	$114	0%	0%	$365	$4,791
			3%	0%	$11	$4,437
			10%	10%	$501	$4,927
			23%	10%	-$10	$4,416
			10%	**1%**	$25	$4,451
Government (stumpage only)	2%	$19	0%	0%	$43	$919
			1%	0%	$4	$1,278
			10%	10%	$179	$1,055
			14%	10%	$21	$897
			10%	**7%**	$20	$896

Timber supply impacts

The range of unmitigated climate change impacts used in the forest level analysis translates to 5-18% of provincial timber supply and the range of mitigated impacts is 4-14%. Because impacts on existing stands are not modeled in this analysis, the modeled impacts would not take place until the first cohort of stands planted today reach harvestable age, which is approximately 55 years on the coast and 65 years in the interior. As a point of reference, the current mid-term timber supply level is 15% lower than the long-term harvest level, which is attained at in the year 2070 (see Appendix A, Figure 10). Hence the climate change impacts modeled in this analysis correspond to a long-term harvest level as low as the current TSR mid-term harvest level.

The degree to which near-term timber supply would be affected by can only be explicitly assessed with a timber supply analysis, which is not within the scope of this study. Nevertheless, the most recent timber supply reviews for 14 of the 37 timber supply areas included a sensitivity analysis that reduce managed stand yields by 10% (Figure 2), which can be used as a proxy sensitivity analysis for the mitigated climate change impacts of 4-14%. Collectively, these sensitivity analyses suggest that short term harvest levels are not highly sensitive to simple productivity reductions in regenerated stands. Presumably this lack of sensitivity is due to mid-term timber supply shortages and falldown effects.

[11] The timber supply horizon for realization of benefits is 100 years. Risk thresholds are shown in bold text.

As a result of these considerations, this preliminary analysis suggests that reductions in future managed stand productivity could begin to impact harvests levels in the early part of the mid-term (year 2030+), if they were to be recognized in the timber supply review. However, there appears to be little opportunity for climate change mitigation to translate into short-term harvest levels as an allowable cut effect, primarily because this mitigation would occur in the context of a declining timber supply.

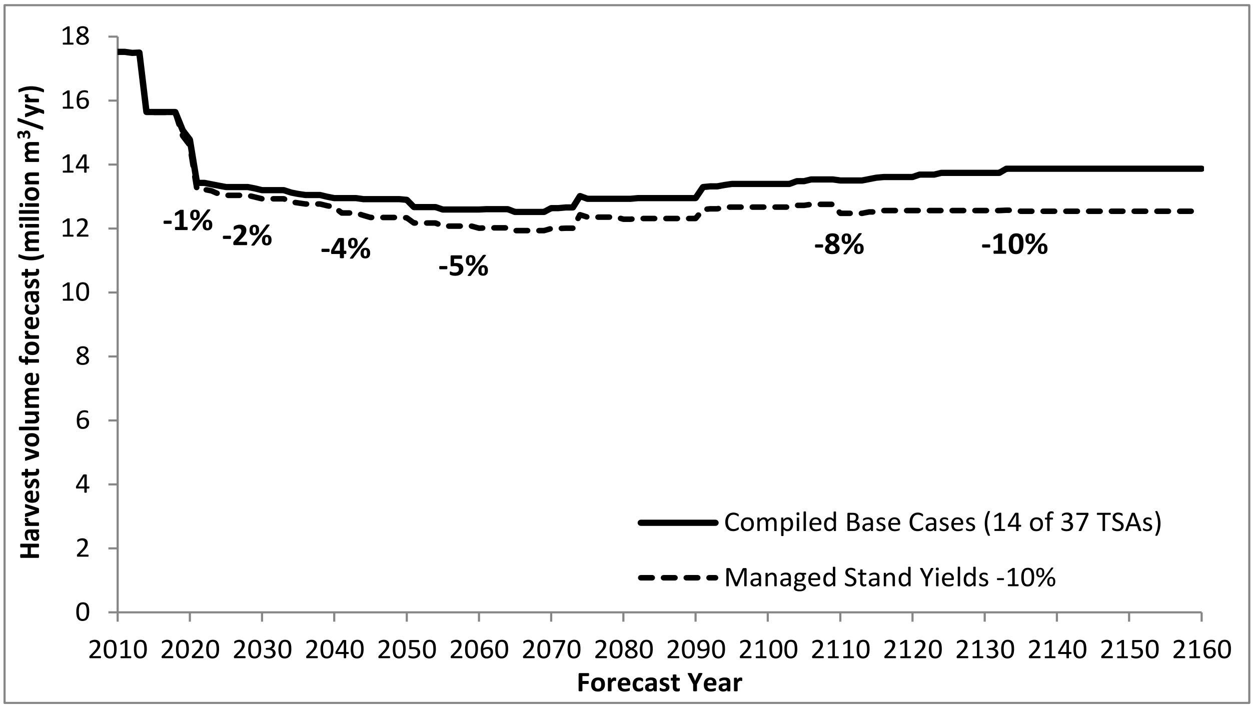


Figure 2: Compiled sensitivity analysis testing the timber supply impact of a 10% reduction in managed stand yields.[12]

[12] Harvest flows were compiled from the 14 of 37 timber supply areas[12] (21% of BC timber supply) for which this sensitivity analysis was performed in the most recent timber supply review (2004 – 2014).

Discussion: Instruments for adaptation

This analysis suggests that assisted migration using CBST is a robust public investment. A conservative approach to assisted migration is likely to be cost-neutral to licensees because it is not expected to increase regeneration risks. However, as more information on climate change and biotic responses becomes available, a more aggressive assisted migration strategy could be deemed necessary to adequately account for the magnitude of climate change expected for the next rotation of planted seedlings. If this were to be the case, this analysis has shown that even a large increase in regeneration risk is strongly preferred from the government perspective if it can reduce risks of mid-rotation plantation failure. In contrast, an increase in regeneration risk is strongly economically unviable for licensees, in part because of higher discount rates and lower harvest benefits, but in particular because licensees carry all regeneration risk under the current policy framework. As a result, licensees' aversion to real or perceived regeneration risks could be an important limitation on the feasibility of assisted migration. This section considers some economic instruments for engaging the support of licensees.

There are several potential mechanisms for engaging the support of licensees in trading off increases in short term risk to achieve substantial long term benefits to the economy. The first is as simple as providing adequate information on regeneration risks to allow licensees to make informed decisions about their economic interests. Second, the risk-sharing within the appraisal system is briefly discussed as a way of balancing licensees' exposure to the costs and benefits of new government policy. Third, instruments related to timber supply are evaluated; specifically, allowable cut effects and the timber supply review. Finally, the role of forest professionals in mediating public and private interests is briefly discussed.

Several of the options considered in this section are informational instruments, so the concept deserves some explanation. Information plays an essential role in behaviour change. Beyond pointing to the best available option, information is the basis on which people can justify their actions. In the absence of information on the risks, costs, and benefits of a course of action, individuals and organizations will typically default to accepted norms (Sunstein 2002). In the BC forestry context, this behaviour is evident in the frequency of adoption of default practice requirements in Forest Stewardship Plans and Site Plans. With respect to climate change adaptation, government is in a position to provide otherwise unavailable information on risks, costs, and benefits that practitioners and licensees require to act in their own professional and economic interests. Information therefore is potentially an efficient economic instrument.

Quantifying regeneration risk

This study has identified that the impacts of real or perceived regeneration risks on licensee's economic interests are likely a substantial limitation on implementation of assisted migration. The political feasibility of implementing optimal assisted migration strategies can be improved by providing licensees with information on these risks, and any benefits that offset them.

Provenance trials are the most direct source of information on regeneration risk. In addition to measurement of tree and stand growth attributes such as height and volume, survival data can be collected to generate "survival response functions". These functions indicate seedling survival rates for a range of tree provenances in a range of climatic conditions. Useful survival data from the assisted migration adaptation trial will soon be available. However, provenance trials, including AMAT, are almost exclusively established on zonal or otherwise favourable sites, while regeneration risks are most likely to be manifested on unfavourable (dry or wet) sites. As a result, provenance trials will not provide all of the information required to assess regeneration risks of assisted migration.

Operational controls could be a complementary source of information on regeneration risks. This approach would involve establishing a control unit composed of a local seed source to accompany treatment units planted with non-local seed. While this would not necessarily establish causality of regeneration problems on individual openings, a large number of such operational trials could be used to determine whether assisted migration was increasing regeneration risks in a larger aggregate of species, site, or biogeoclimatic unit. The incremental cost of these controls could be minimal, since they would be established to satisfy free-growing obligations, monitored through standard silviculture surveys, and compiled in the RESULTS database. The RESULTS database itself is a potentially useful means of monitoring regeneration risks. Given the vast scale of seed transfer in British Columbia, a data mining approach could be used in conjunction with provenance trials and operational controls to establish a site-specific survival response curve for major commercial tree species.

The sources of information on regeneration risk mentioned above all involve leveraging of existing initiatives at low cost. However, given the potential economic benefits of assisted migration suggested in this study, it may be worthwhile for the provincial government to evaluate the returns on investing in a dedicated research program around regeneration risk. In the absence of reliable information on regeneration risks, it will likely be difficult to achieve equitable risk-sharing mechanisms required to gain the support and participation of licensees.

Risk-sharing via the appraisal system

The current regulatory framework gives licensees responsibility for regeneration to a free-growing condition. Although licensees bear the risk of regeneration on each harvest opening, the average costs of regeneration are returned to licensees via the stumpage appraisal system. In many ways this is an efficient way of achieving basic regeneration results, since regeneration is directly incorporated into harvest planning and licensees have a strong incentive to achieve regeneration with minimum cost and delay. However, collective compensation for regeneration costs via the stumpage appraisal system is widely recognized as creating a "race to the bottom", in which licensees profit from keeping their regeneration costs below the average regeneration costs used to determine stumpage rates. Conversely, licensees are not compensated for activities that result in above-average regeneration costs. Under this framework, licensee practitioners are under intense pressure to avoid any costs and risks over those that are essential to achieving free-growing condition. Since climate change adaptation intrinsically requires taking on short-term risks to mitigate larger long-term risks, the "race to the bottom" is a major impediment to making these necessary trade-offs. Risk-sharing between licensees and government is an important component of adaptation measures such as assisted migration.

In theory, the appraisal system is a risk-sharing instrument since it will compensate licensees collectively for an increase in average regeneration costs. However, there are two problems with risk-sharing via the stumpage appraisal system, over and above the "race to the bottom". First, there may be delays of many years between when the risk associated with a new practice is taken, when the associated costs are incurred, and when the appraisal system accounts for these additional costs. Second, there may be substantial variability in risk exposure amongst licensees depending on the ecological attributes of their chart or license area and the current BEC variant-based silviculture costs may not sufficiently capture this variation. Due to the current scarcity of site-specific data on regeneration risks of assisted migration, an equitable appraisal of incremental regeneration costs is unlikely. These problems do not disqualify the appraisal system as a risk-sharing mechanism, but they would need to be addressed if licensees are to willingly participate in climate change adaptation measures.

Timber supply

Timber supply affects the business viability of licensees because it affects their access to timber via the allowable annual cut (AAC). It also affects their medium term (5-20 year) infrastructure investment decisions. Timber supply therefore is an important context for developing economic instruments for adaptation. Two potential instruments are considered here with respect to timber supply: (1) allowable cut effects and (2) information on mid-term timber supply impacts of climate change and assisted migration.

Current integration of climate change into timber supply

There is clear high-level direction to incorporate climate change impacts into TSR. Specifically, the Forest Stewardship Action Plan for Climate Change Adaptation (BC MFLNRO 2012c) lists "Develop approaches for incorporating climate change into inputs for timber supply analysis" as an action for achievement by 2015 to 2017. Based on this direction, MFLNRO is considering how to incorporate climate change into the timber supply review. MFLNRO commissioned a report on this topic in 2012 (Brown et al. 2013), which recommended (1) narrative discussion in AAC rationales, (2) development of relevant expertise and information within MFLNRO, (3) review of TSR assumptions in light of climate change, and (4) expansion of TSR beyond AAC determinations to inform forest policy in general. Consistent with the first recommendation, recent allowable cut determinations (e.g. Bulkley TSA: Peterson 2014) include a qualitative discussion of climate change as an area of general uncertainty. These discussions conclude that the information available on future climate change is insufficient to affect the AAC determination: "it is not clear if either increases or decreases to current harvest levels would be appropriate in addressing potential future increases in natural disturbance due to climate change." Instead, the specific timber supply implications of climate change impacts are accounted for as they occur, as has been the case with the mountain pine beetle epidemic and *Dothistroma* needle blight.

Timber supply review

There currently are very few quantitative assessments of the timber supply impacts of climate change in British Columbia. The current TSR methodology accounts for the massive timber supply perturbation associated with the mountain pine beetle, but assumes no similar stochastic events for the future. Similarly, it includes genetic gain associated with A-class seed, but it doesn't account for maladaptation effects strongly suggested by provenance trials. As noted in recent AAC rationales, this approach is justified within the narrow objective of making an AAC determination because it is unclear whether an increase or decrease in the cut would be appropriate in anticipation of unknown future disturbances (Peterson 2014). Nevertheless, the TSR and related analyses have an important broader role in the economic outlook of licensees, policy-makers, and communities.

Regardless of the short-term AAC response, there is no dispute that landscape-level disturbances reduce the overall timber supply. It is reasonable to conclude that the assumption of zero climate change within TSR almost certainly overestimates timber supply in the medium and long term. This absence of climate change impacts in TSR likely reduces political will within government and industry to make adaptive changes to forest management practices. Timber supply analysis, either TSR or a distinct process, is a potentially powerful informational instrument for adaptation to climate change that is underutilized at present.

Allowable cut effects

The productivity of stands planted in the short term can indirectly influence short term harvest levels (allowable annual cuts) by affecting the period over which existing growing stock must be rationed. This is the basis for "allowable cut effects" (Schweitzer et al. 1972), in which private investments in public forests are rewarded with increased harvest volume rights. The use of allowable cut effects as an economic instrument to incentivize private silviculture investments is controversial (Luckert and Haley 1995). Nevertheless, allowable cut effects have been applied across British Columbia during the past two decades to incentivize private investments in inventories and genetically improved planting stock (Weetman 2002). Allowable cut effects have incented very little investment in land-based investments aimed at increasing productivity.

Assisted migration via CBST is expected to increase stand productivity relative to the status quo, and therefore allowable cut effects superficially could be considered as an economic instrument. However, there are several important barriers to the potential for achievement of allowable cut effects related to assisted migration:

- Assisted migration produces a mitigation of productivity losses that are not currently incorporated into allowable cut determinations. In order for an ACE to apply, the TSR base case would first have to include reduced productivity due to climate change. This would require a fundamental rethinking of the TSR base case, which at present is based on current management and historical productivity/disturbance levels.
- Allowable cut effects are typically granted only in cases where the supporting evidence is of high precision and low uncertainty (Weetman 2002). Given the large level of uncertainty associated with timber supply impacts, it is unlikely that mitigation by assisted migration could meet the informational requirements for an ACE.
- Most timber supply units (TSAs and TFLs) currently have a declining harvest forecast in the short term, due to falldown effects or the mountain pine beetle epidemic. An ACE is very difficult to achieve when gaps in timber supply (aka pinch points) are expected to occur before the benefit of the silviculture investment is realized. This is often the case with MPB impacted units and other timber supply units with declining timber flows.

For these reasons, allowable cut effects appear to have limited potential as an economic instrument for implementation of assisted migration at the provincial scale in the near future.

Professional reliance

In addition to their responsibilities towards the management prerogative of their employers, forest professionals have a legislated responsibility to uphold the public interest in their practices. These dual responsibilities position forest professionals as mediators between the public and private interests in the forest resource. Forest professionals have an exclusive right to practice in the realm of forest regeneration decisions, and therefore they clearly have a unique role in the implementation of assisted migration. Professional reliance alone likely isn't sufficient: licensee foresters have a strong management prerogative to keep regeneration costs down and minimize short term risk. However, professionals' ethical responsibility towards the public interest undoubtedly puts some amount of pressure to consider long term regeneration success and risk tolerance.

The degree to which professional ethics affect reforestation decisions is influenced by (1) technical information available to the professional, (2) public pressure affecting the licensees' social license to operate, and (3) professional accountability, both formal and informal. The information necessary to support professional reliance includes better awareness of the rationale for assisted migration, clear guidance on how to effectively implement assisted migration at the prescription level, and good data on the risks of specific assisted migration prescriptions. Providing clear, balanced information to the interested members of the public will help to support professionals in balancing their ethical and management prerogatives. Finally, development of a professional culture supporting adaptation measures will modify norms of practice and generate informal accountability amongst practitioners.

Conclusion

The cost-benefit analyses in this study indicate that assisted migration using CBST could provide very large returns to the provincial economy and stumpage revenues if climate change causes reductions in tree growth but does not cause widespread plantation failure. If assisted migration is able to avert even a small percentage of plantation failures to due maladaptation of local seed, then returns would be even greater because stand rehabilitation costs and harvest delays would be avoided. Even if the benefits of assisted migration come at the cost of a substantially increased risk of regeneration failure, this trade-off is desirable from the perspective of government because regeneration failures are generally cheaper to rehabilitate than mid-rotation failures, and result in shorter harvest delays. The key factors that shape this perspective on risk are (1) that the large majority of benefits of harvest go to the provincial economy as costs of conversion (harvesting/milling) and stumpage, and (2) a low social discount rate of 2% conserves the importance of long-term benefits over short-term costs. Despite the current political barriers to an increase in regeneration risk that necessitate a conservative assisted migration policy in the short term, a more aggressive assisted migration policy appears to be an economically viable and robust strategy from the perspective of government.

From the perspective of licensees, a conservative assisted migration strategy is cost-neutral because there are no up-front research and implementation costs and because no plantation failures are modeled. However, the benefits of climate change mitigation on licensee profit are rendered miniscule by private discount rates. As a result, any substantial costs (>$1-2/ha NPV) cannot be supported by the harvest benefits. Adding stand rehabilitation costs associated with regeneration failure would result in an economic loss for the licensee at the stand level, despite partial and indirect compensation via the appraisal system. These factors suggest that licensees will be amenable to a conservative approach to assisted migration that minimizes regeneration risks, but likely would be opposed to the introduction of regeneration risks without a mechanism for transferring these liabilities to the government.

In light of licensees' rational aversion to increased regeneration risk, a conservative approach to assisted migration would be pragmatic under the current regulatory framework. However, this analysis has shown that, as more information on climate change and biotic responses becomes available, a more aggressive assisted migration strategy could be deemed to be highly beneficial for the provincial economy, even though it may cause an increase in regeneration risks. In that case, the licensee perspective on regeneration risk would need to be accommodated through policy, informational, and economic instruments. Better site- and provenance-specific information on regeneration risks of assisted migration, though not currently available, is fundamental to management of perceptions of risk and also to equitable risk-sharing between government and licensees. The stumpage appraisal system is the most likely instrument for risk-sharing, but several difficult problems need to be addressed: the lag time between the incurring of and compensation for regeneration costs would need to be reduced, and variations in regeneration risk would need to be equitably accounted for between licensees.

More fundamentally, the current appraisal system creates a “race to the bottom” that must be addressed before licensees can be incented to take on additional regeneration risk. The timber supply review represents a powerful but as-yet unused informational instrument for emphasizing the benefits of climate change mitigation to the public, practitioners, and licensees. However, allowable cut effects do not appear to be a promising instrument for incenting licensee participation in assisted migration. Finally, forest professionals clearly have an important role as mediators between the public and private perspectives on climate change adaptation. Government can support leadership amongst forest professionals by providing information on the necessity and mechanisms for assisted migration using CBST.

This economic analysis is focused specifically on assisted migration as a tool for climate change adaptation. However, assisted migration is only one of many regeneration practices that can be used for climate change adaption. These practices include higher planting densities, planting robust species rather than those that are fast to green-up, composite provenancing, and mixed species planting. All of these practices involve a trade-off between short-term regeneration cost and long-term economic benefits of a more robust and resilient forest. Consequently, many of the results and recommendations of this case study apply more generally to this broader group of reforestation decisions currently under the responsibility of licensees.

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Appendix A: Economic modeling methods

Growth and yield (TIPSY)

The stand-level analysis is based on yield tables produced by TIPSY v4.3 (BC MFLNRO 2013) using the assumptions listed in Table 12. There is one yield table for a range of site indices from 11-23m at 2m intervals. Net revenues are calculated using the FAN$IER (Enfor 2013) default conversion costs and wood product revenues. The yield tables are incorporated into a spreadsheet model for scenario and sensitivity analysis.

Table 12: Assumptions of the basic TIPSY yield tables.

Forest District	Okanagan-Shuswap
BEC zone	IDF
Slope	10%
Species	Pli
Regen delay	1
Regen method	Planted
Target density	1400
OAF1	15%
OAF2	5%

Cash flow assumptions

Harvest assumptions (financial vs physical rotations)

Harvest is assumed to occur at the culmination of the mean annual increment of the stand, i.e. "physical culmination." This is generally, though not always, later than the culmination of NPV, i.e. "financial culmination." There is some potential for this harvest assumption to confound CBA by underestimating incremental NPV, or even reversing the desirability of CBST vs. the *status quo*. To provide an opportunity to evaluate these effects, graphs of NPV across all potential harvest ages are shown.

NPV vs site value

This methodology compares cash flows of CBST and the *status quo* over a single rotation. However, the modeling methodology allows for the CBST and *status quo* cash flows to have different harvest ages. In such cases, it is theoretically preferable to include all future rotations in the comparison of cash flows, i.e. to calculate site value instead of NPV. For simplicity, future rotations are not considered in this analysis. This introduces a bias against cash flows that have a relatively early harvest age. However, this bias is not expected to be substantial enough to confound the exploratory objectives of the study.

Calculation of harvest revenues

Net revenues are calculated using the FAN$IER default conversion costs and wood product revenues. However, the spreadsheet model operates by netting down merchantable volume to simulate the effect of productivity losses due to climate change. FAN$IER harvest revenues are first converted to a $\$/m^3$ value, then multiplied by the netted down merchantable volume to calculate gross harvest revenue. The FAN$IER age-specific conversion cost is subtracted from gross revenue to calculate net harvest revenue. This net revenue is assumed to collectively account for crown stumpage and licensee profit.

Discount rate

The discount rate, the interest rate used to calculate the present value of future cash flows, is of central importance in CBA. Consistent with standard CBA methods, the real—as opposed to nominal—discount rate is used in this study. This convention is adopted because all costs and benefits in this study are expressed in real 2006 dollars, and thus are adjusted for inflation. 2006 is used as a reference year for calculation of real dollar value in this analysis because this is the reference year for FAN$IER outputs.

Private discount rates (licensee perspective)

From the financial perspective of private interests, the discount rate for investments is generally the opportunity cost of capital. The weighted average cost of capital for Canfor and West Fraser, the two largest licensees in the BC Interior, is 9%, implying an industry-wide average capital cost of >10% (Jon Muller, CIBC World Markets, personal communication, June 5th, 2014). This information is consistent with a long-term capital cost of 10-13% frequently cited for the BC forest industry (e.g. Roberts et al. 2005, Woodbridge Associates 2009). Over the past 20 years, the return on capital employed (ROCE) in the BC forest industry has averaged 3.5% (COFI 2004, 2013), i.e. much lower than the cost of capital. In this context, licensees must accept lower returns on investment in the short term in order to sustain their core operations. In contrast, long-term incremental silviculture investments beyond legislated silviculture obligations are discretionary spending, and therefore would be expected to be evaluated against the licensee cost of capital. In this analysis, an intermediate discount rate of 6% is assumed for the purposes of modeling the economic perspective of Licensees. However, this should be considered a lower limit of private discount rates for silviculture investments.

Social discount rates (government perspective)

It has long been recognized that the opportunity cost of capital is not an appropriate basis for discounting public sector investments, particularly in the case of silviculture where the costs and benefits are shared intergenerationally (e.g. Manning 1977, Heaps and Pratt 1989, Moore et al. 2013). Boardman et al. (2010) estimated the social discount rate for Canada at 3.5%, and argued that this rate should be time-declining for projects with intergenerational impacts beyond 50 years. Public silviculture investments in British Columbia are evaluated against a default social discount rate of 2%, as a matter of official policy. To reflect this precedent, the discount rate is set at 2% for the purposes of modeling the economic perspective of the BC government.

Incremental CBST costs

Research

The current investment in CBST research in British Columbia is approximately $700,000/year, and it is anticipated that an ongoing research programme of $1 million/year is required to develop the knowledge base for successful implementation of assisted migration using CBST (Jack Woods, forest genetics council of BC, personal communication, May 20th, 2014). For the purposes of stand-level CBA, this program cost is prorated to planted seedlings. Assuming that 230 million seedlings are planted on crown land in BC every year, and that 66% of these seedlings are allocated within an assisted migration strategy, the research programme would cost 0.6 cents per seedling. Assuming a planting density of 1400 stems per hectare, this cost equates to $9/ha. This research cost is rounded up to $10/ha for the purposes of the base assumptions of this analysis.

Implementation

The incremental costs of CBST implementation are limited, since adequate systems for tree breeding, seed and seedling production, genetic resource management and tree planting are already in place. However, administrative costs of transitioning to a CBST policy framework aren't negligible, and are incorporated into the analysis. CBST interim standards cost $2-3M over four years and program development for CBST is expected to cost $2M/year over 5 years (Lee Charleson, personal communication, July 25th, 2014). While most of the administrative costs will be incurred in the next 10 years, an average incremental cost of $500k/year over the next 30 years is assumed for simplicity.

Product value partitioning

Value partitioning is the process of dividing total product value (lumber and chips) into costs of conversion (logging and manufacturing), licensee profit, and stumpage. TIPSY provides a detailed and well-documented accounting of wood product values and conversion costs, via the economic extension FAN$IER (Enfor Consultants Ltd. 2013). For this reason, FAN$IER is a good basis for this economic analysis. However, some adjustments to FAN$IER defaults are warranted. First, the 1960 – 2006 reference period for lumber values is not justified, given fundamental restructuring of the global fibre markets since 1980; instead, lumber values are adjusted to a 1990 – 2012 reference period for this analysis. Second, conversion costs are specific to each district, so a representative district was selected. Finally, estimates of licensee profit and stumpage have been developed independently, since these assumptions are not provided by FAN$IER. Further rationale for the product value, conversion cost, profit, and stumpage assumptions are provided below. Figure 3 shows the outcome of these assumptions on product value partitioning.

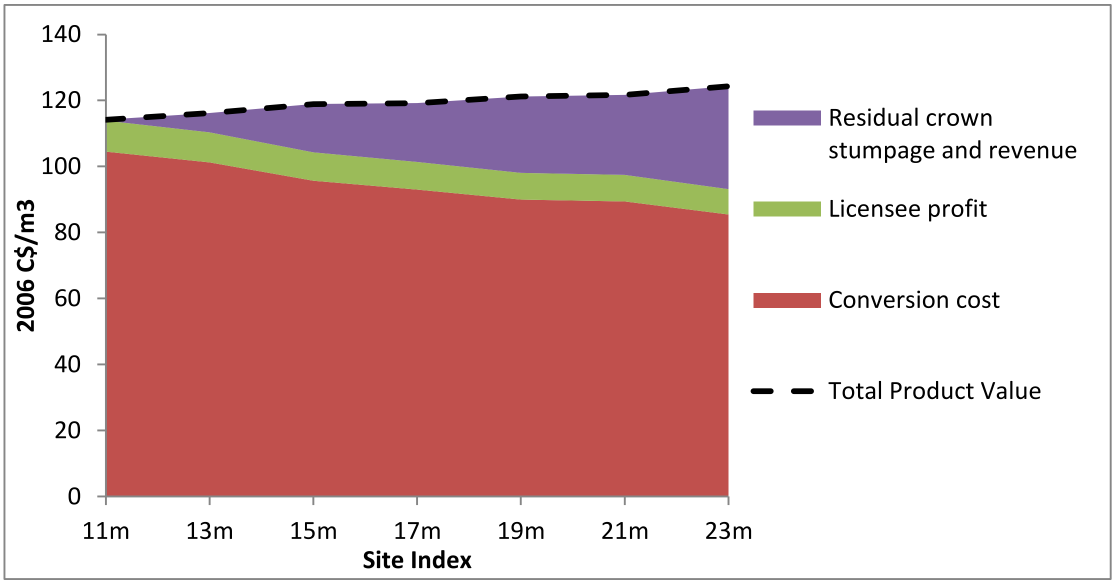

Figure 3: Assumed relationship between site index and value partitioning, showing the derivation of stumpage as a residual of product value minus conversion costs and profit.

Product values

FAN$IER product values include lumber, chips, and residues. Within the range of conditions modeled in this analysis, these products account for approximately 85%, 13% and 2% of the total harvested product value. FAN$IER default lumber values are strongly influenced by very strong markets of the 1970s (Figure 4). Given the restructuring of global wood product markets since the 1970s, it is doubtful that these product values will be replicated in the future (Toppinen et al. 2010). 1990 – 2012 provides a more conservative reference period for lumber values (Figure 5). The average value during this period is 84% of the 1960 – 2006 period ($396 vs. $470/Mfbm). To reflect this difference, default FAN$IER product values are multiplied by 85% for the base assumptions of this analysis.

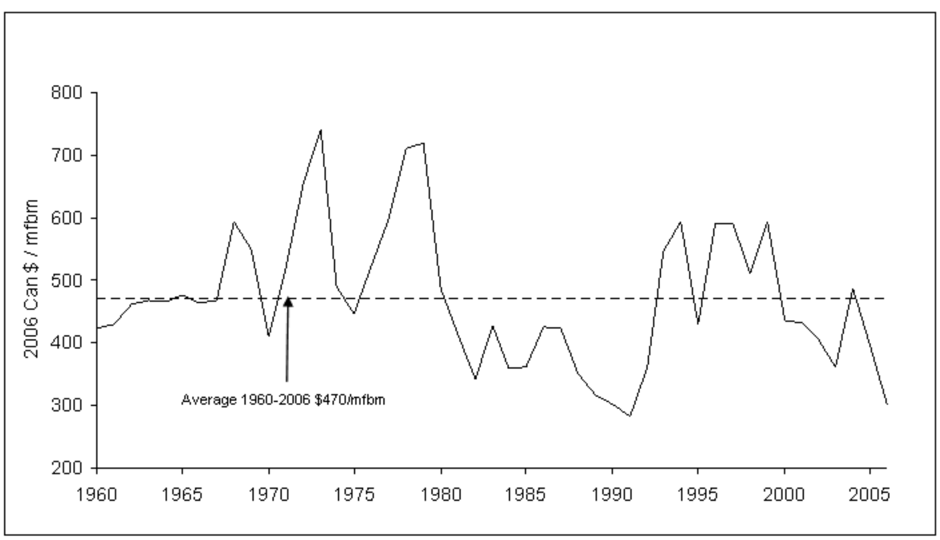

Figure 4: Trends in lumber prices in constant 2006 dollars (Western SPF Standard & Better 2x4 Random Length). Reproduced from the TIPSY v4.3 Help file (BC MFLNRO 2008).

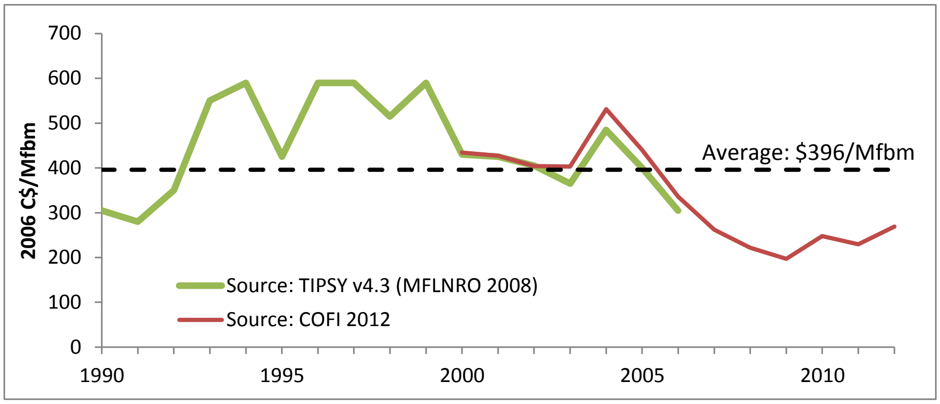

Figure 5: lumber prices for the 1990 – 2012 period, using supplemental prices for the 2000 – 2012 provided by COFI (2013).

Conversion costs

Default FAN$IER conversion costs are used in this analysis. The Okanagan Shuswap Forest District has average costs for the BC Interior and was selected as the basis for all TIPSY runs (Figure 6). Conversion costs decline with increasing harvest volume, and range from \$104/m^3 at site index 11m to \$85/m^3 at site index 23m.

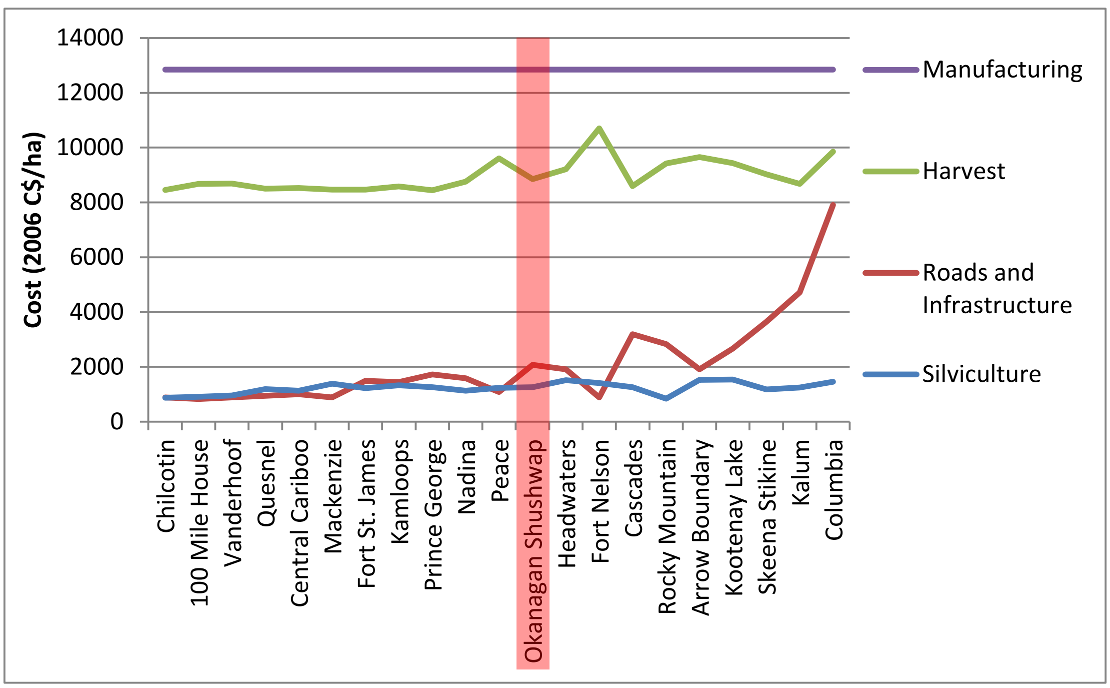

Figure 6: FAN$IER default conversion costs specific to each Forest District, showing the selection of the Okanagan Shuswap Forest District as the average-cost district for the BC interior. TIPSY stand assumptions are Pl planted at 1400 sph on a site index of 20m, with a ground-based harvest at MAI culmination.

Licensee profit

Estimation of licensee profit is not straightforward, particularly as a function of stand-level growth and yield. Traditionally, licensee profit was incorporated into stand appraisal as a proportion of conversion costs or total stand value. However, under the current market pricing system operator profit is implicit in bid prices and is not specifically accounted for.

Return on capital employed (ROCE) is a widely published metric of industry profitability and provides a reasonable basis for estimating licensee profit. ROCE is also useful in that it is the benchmark for sustained investment in the industry over the long term. Over the 1990 – 2012 reference period, the BC forest sector had an average ROCE of 3.5%, compared to the Canadian Forest Sector average of 5.0% (Figure 7). This ROCE is well below the industry's cost of capital (10 – 13%) (Roberts et al. 2005), and is widely considered to be poor financial performance and insufficient to attract sufficient investment to sustain the industry over the long term (Woodbridge Associates 2009). As a result, the reference period ROCE is too low to be used as an assumption for long-term economic projections. Arguably, the minimum stand-level profitability assumption for long-term analysis should be the cost of capital. However, given that this level of profitability hasn't been demonstrated over the reference period or in any of the major regions of the global forest sector (Roberts et al. 2005), an intermediate assumption of 6% profit on conversion costs is more justifiable.

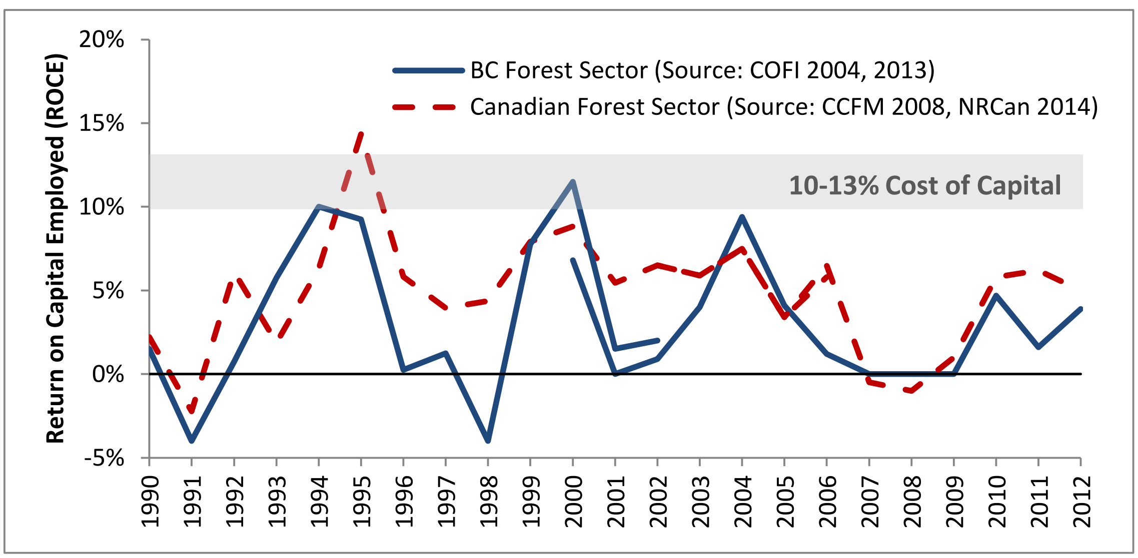

Figure 7: Return on Capital Employed of the BC and Canadian forest sectors over the 1990-2012 reference period.

Stumpage

As a form of resource rent, stumpage should in theory equal the total value of products derived from the stand, minus the costs of conversion and industry profit (Rothery 1945). The actual derivation of stumpage is of course much more complex than this simple equation. Nevertheless, this assumption of stumpage as residual standing value is a useful simplification for the generalized economic analysis being performed here.

Provincial forest revenues include several components (Figure 8), primarily stumpage on crown timber, BCTS timber sale revenues, and (since 2006) the softwood lumber export tax (Barnes and Niemann 2014). Since stumpage is essentially a residual of product values and conversion costs, it is highly sensitive to market fluctuations. Since 1995, annual average stumpage rates for interior lodgepole pine have varied from \$5 to \$35/m^3 (Figure 9). Combined with the complexities of stumpage appraisal relative to conversion costs, this market-based volatility is problematic for characterising "typical" stumpage rates. Nevertheless, the range of historical stumpage rates suggests that the base case assumptions of stumpage rates evident in Figure 3 (e.g. \$18/m^3 at site index 17m) are reasonable.

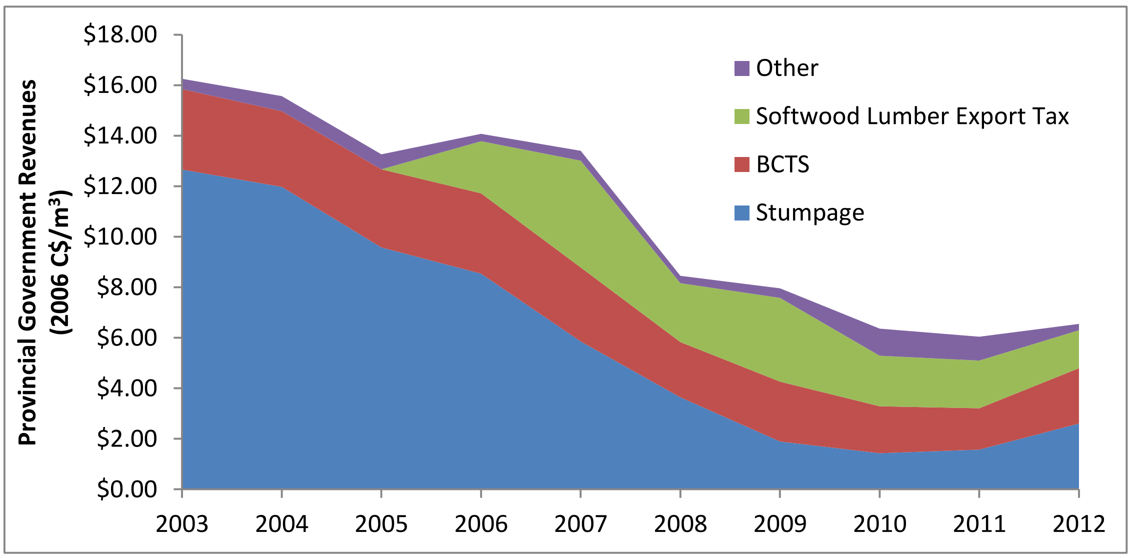

Figure 8: components of provincial government revenues from the forest sector over the 2003-2012 period. Adapted from Barnes and Niemann (2014).

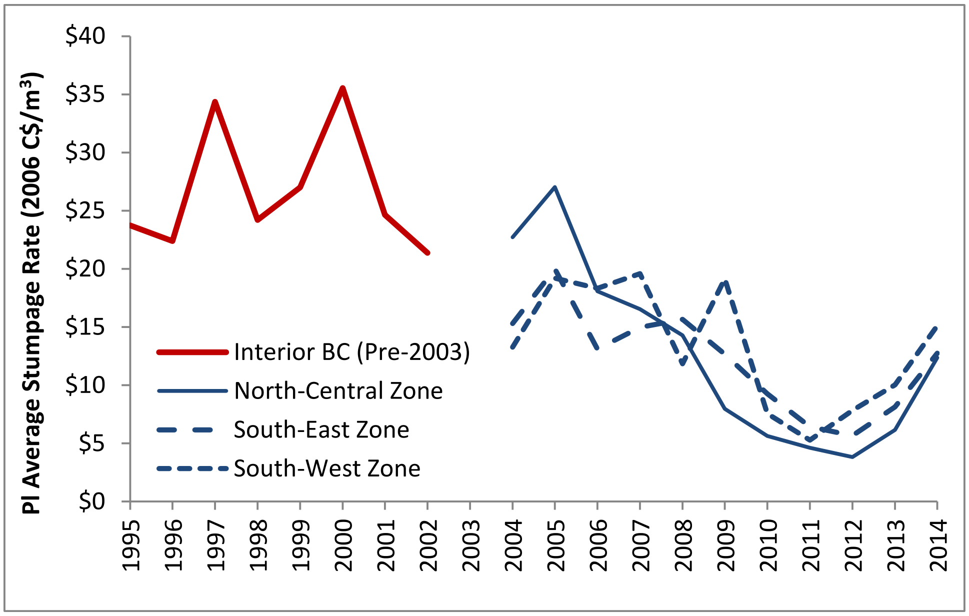

Figure 9: Average stumpage rates for Interior lodgepole pine, 1995-2014. Compiled from table 6-2 (pre-2003) and table 6-1 (post-2003) of the Interior Appraisal Manuals for the 1995-2014 period (BC MFLNRO 2014).

Verification of province-level assumptions

A compilation of the timber supply reviews for all BC crown land (Figure 10) indicates that an TIIP spreadsheet's estimated provincial productivity of 52 million m^3/year (Table 4) is only 80% of the TSR long-term harvest level of 65 million m^3/ year. The primary reason for this difference in total productivity is that the TIIP spreadsheet only includes species and areas where tree improvement investments are considered worthwhile and therefore doesn't capture the total productive potential of the province's timber harvesting land base. The 80% component of productive potential likely corresponds to an assisted migration implementation rate of 67% of seedlings, and thus the assumed productivity of 52 million m^3/year appears to be a reasonable, conservative estimate.

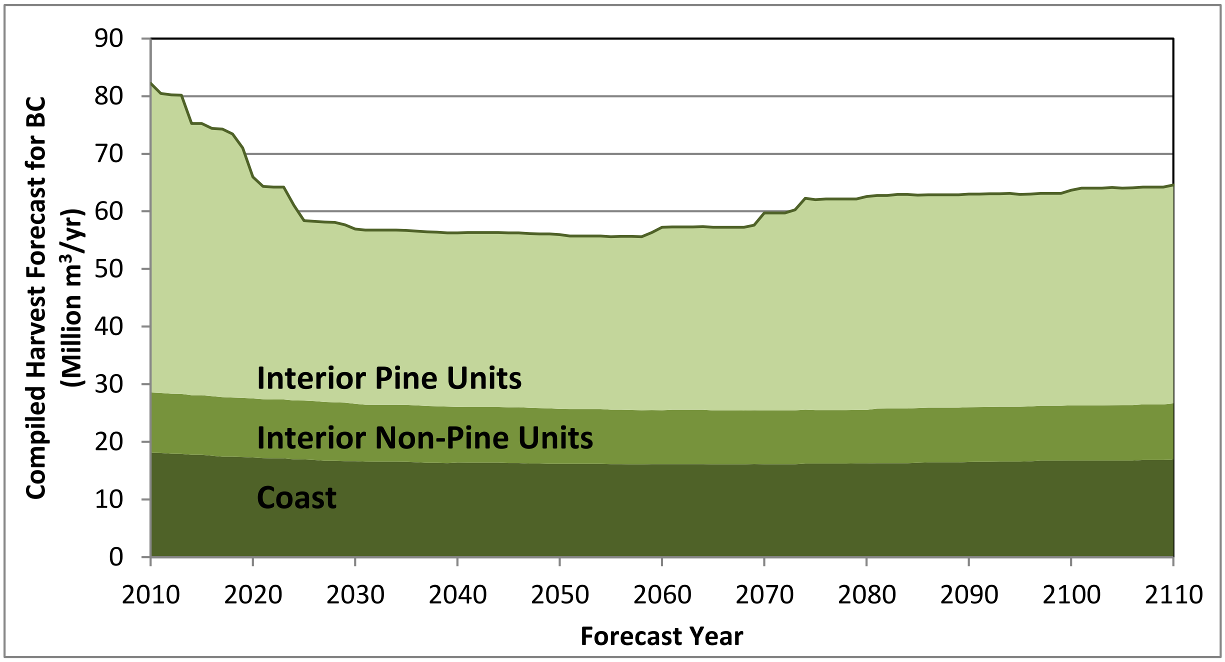

Figure 10: Compilation of TSR Base Case timber supply forecasts for all 37 timber supply areas and 34 tree farm licenses in British Columbia. Data includes the most recent data available for each unit to 2014 (provided by Atmo Prasad, BC MFLNRO).

The species-specific volume growth and harvest age assumptions stated in Table 4 were verified against TIPSY yield tables (Table 11). All of the implied site indices are reasonable averages for the province, and these site indices provided very close matches to harvest volume and harvest MAI. The only exception is coastal western white pine (Pwc), which constitutes only 0.2% of modelled provincial productivity. However, Pwc is modelled using an interior BC yield curve in TIPSY, and hence the TIPSY yield table is not a reliable benchmark for verification. These results indicate that the species specific growth assumptions reasonably reflect managed stand growth and yield assumptions used in TSR.

Table 13: verification of species-specific growth assumptions for the province-level analysis.[13]

Analysis Assumptions					Verification in TIPSY					
Spp.	Harvest Age	Assumed planting density	Implied harvest volume	Implied MAI_c	Implied approx. site index	TIPSY harvest volume	TIPSY MAI at harvest	TIPSY MAI_c age	TIPSY culm. volume	Harvest MAI as % of MAI_c
	(yrs)	sph	m^3/ha	m^3/ha/yr	m	m^3/ha	m^3/ha/yr	yrs	m^3/ha	
Pli	60	1400	289	4.8	20.5	287	4.8	55	264	100%
Sx	75	1100	260	3.5	17.5	270	3.6	95	379	90%
Fdc	55	900	423	7.7	29.0	416	7.6	75	599	95%
Fdi	70	1100	276	3.9	23.0	272	3.9	100	453	86%
Cw	60	1000	439	7.3	23.0	424	7.1	85	683	88%
Lw	70	1100	303	4.3	24.0	307	4.4	100	487	90%
Hw	60	1000	546	9.1	26.5	544	9.1	85	860	90%
Ss	55	900	756	13.7	31.0	765	13.9	75	1119	93%
Pwi	70	1000	305	4.4	23.5	309	4.4	100	508	87%
Pwc	50	900	567	11.3	35 (max)	412	8.2	70	642	90%

[13] Implied harvest volume was calculated from total potential volume growth and annual number of seedlings planted from Table 4. This and other derived information was used to derive a matching site index in TIPSYv4.3, from which summary statistics were derived for comparison with the original assumptions.

Case study: Enhancing collaborative approaches to managing wildfire risk

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October 27, 2014

Contents

Introduction

Across North America and around the world, recent wildfire trends have resulted in rising costs and damages associated with wildfires (MFLNRO 2014). Suppression costs were approximately $500 million in 2003, $400 million in 2009 and over $200 million in 2010. A record was set in 2009 for the most wildland urban interface fires (213 fires) and in 2010 for the most area burned in one fire season (330,000 ha) (WMB 2013). In addition to expenditures for suppression, wildfire costs also include economic losses associated with damaged or destroyed buildings and infrastructure; commercial timber losses; and indirect impacts through either increased costs or disruptions on associated economic activity. This does not include other losses associated with non-market values of forests, including impacts on habitat, recreation, carbon sequestration and other forest values.

A recent study published jointly by the Nature Conservancy, Sierra Nevada Conservancy and US Forest Service (Buckley et al. 2013) found that the economic benefits of investing in fuel treatments to prevent wildfire yielded benefits three or more times the costs. These benefits are distributed broadly among landowners, public and private entities, taxpayers and utility ratepayers, with federal and state/provincial governments collectively gaining at least half of the total benefits.

In western Canada, fire activity is already increasing and across Canada, the area burned each year could double by the end of the century (NRCan 2014a). The BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO 2014) estimates that the 2003 wildfire season cost $1.3 billion in direct fire suppression costs and indirect economic losses to affected infrastructure and business in the southern interior of British Columbia alone. Despite having a "world class wildfire response agency", the provincial Wildfire Branch recognizes that continuing to focus resources on fire suppression and response is no longer an option due to the increased risk of extreme wildfire events. Extreme events, or "mega fires," are predicted to increase as the climate changes and suppression will not be sufficient to protect communities or natural resource values. Consequently, proactive infrastructure, land and resource management are now being investigated to meet the challenges of climate change and the threats of wildfire to communities, critical infrastructure and natural values in BC.

However, during the February 2014 workshop, "Economic Instruments for Adaptation to Climate Change in Forestry," both provincial government representatives and licensees report that lack of coordinated planning and management across the landscape and insufficient funds to develop and implement plans continue to present barriers to effective adaptation. At present, licensees carry out their activities independently, without coordinated planning with respect to wildfire or other climate change impacts, particularly in management units where multiple licensees are accessing a common landbase. Government representatives are responsible for interacting with licensees and issuing approvals at the operational level and planning for and managing wildfire at the policy level. The provincial government is currently working toward increasing coordination and cooperation between government and licensees around wildfire on the landbase. Reductions in timber supply and overlapping tenures are diminishing any incentives for cooperation as licensees compete for timber, even as concerns about the impacts of climate change continue to grow.

Based on these concerns, government representatives and licensees identified the need for economic instruments to not only encourage collaborative planning and management among multiple stakeholders, but also to generate and allocate funding to support planning and adaptation projects on the landbase. Specifically, workshop participants wanted researchers to explore ways in which funding could be levied using an additional fee that licensees pay per cubic metre of timber harvested (i.e. stumpage).

To meet these research needs, this case study draws from examples of previous and existing instruments to encourage and fund collaborative planning and management within three jurisdictions that are pursuing collaborative planning and management approaches to wildfire: British Columbia, Canada; Victoria, Australia and the USA. These three jurisdictions share similarities including commercially and socially valuable forest resources, a mix of public and private ownership of forest lands, a history of large-scale wildfire events that have threatened human life and public infrastructure and resources, projected increases in the frequency and intensity of wildfires under climate change and growing risks to communities in the wildland-urban interface (WUI). As a result, they are testing innovative approaches to wildfire planning and management. These jurisdictions are also areas where public ownership of forestlands dominates although the level of government differs between countries. For example, in Canada, 90% of forest lands are controlled by the provinces (e.g. BC) and territories and only 2% are controlled by the federal government (NRCan 2014b). In Australia, states are responsible for management of approximately 75% of all lands; the national government's responsibility is to coordinate a national approach (McKinnell 1994). By comparison, 28% of all lands in the USA are owned and managed by federal agencies (Gorte et al. 2012).

This case study focuses on fire risk on the forested landscape. As such, it does not specifically focus on the WUI zone. Another case study does address community planning and the WUI. A common issue across jurisdictions, regardless of whether they specifically focus on the WUI, is identifying fire risks and coordinating planning across jurisdictions, and funding suppression and mitigation activities.

The case study information is presented in three sections:

- Emerging collaborative planning and management programs for wildfire;
- Financial instruments to support collaborative planning and management; and
- Financial instruments to support mitigation activities.

The first section describes programs that have been designed to encourage coordination among government, licensees and/or communities in pursuit of objectives with respect to wildfire. Examples are drawn from British Columbia, Canada; Victoria, Australia; and the USA.

The second and third sections describe the challenges of funding and financing these activities (e.g. to support coordination or fund wildfire treatments where the costs of activities might exceed the timber values). Examples are drawn from the Canadian Provinces of British Columbia, Alberta and Ontario and from the USA. Analysis of the potential funding that could be generated through an additional levy on stumpage in British Columbia is also included. This analysis is based on stumpage revenues reported through the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) Harvest Billing System for the year 2013. Two examples, one in British Columbia, and one in the US, are given of approaches to addressing mitigation activities where treatment costs exceed revenues but there are net public benefits.

While this case study focuses specifically on identifying key characteristics of instruments to support adaptation and reduce the risk of wildfires through collaborative planning and management, it is expected that such processes can be amended to address other climate-related risks (e.g. pests, maladaptation) in the future. The risks of wildfire incidence and actions necessary to reduce these risks are relatively well-understood compared to other climate-related risks; therefore, it may be practical to test and improve instruments to encourage and fund adaptation to wildfire first, then apply these instruments to other risks for which less information is currently available. This approach offers the opportunity to both test and develop a strong instrument and allow time to conduct additional research regarding other climate-related risks.

Emerging collaborative planning and management programs for wildfire

This section outlines the current policy context and an overview of the successes and challenges related to managing wildfire risks on publicly-owned lands in three jurisdictions: British Columbia, Canada; Victoria, Australia; and the USA.

British Columbia, Canada

Current approach to wildfire planning and management

The BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) is currently working to implement its new Landscape Fire Planning and Management program. Initial efforts have focused on stand-alone pilots; however, MFLNRO is also exploring ways to integrate the program into existing collaborative planning initiatives (i.e. Type 4 Silviculture Strategies). This reflects the need to create linkages between how plans influence and guide activities on the landbase, a key issue for much of the forestland in the Province.

Landscape Fire Planning and Management

Landscape Fire Planning and Management represents the current state of evolution of MFLNRO's fire management program. It was preceded by the Strategic Wildfire Prevention Initiative, a collaborative initiative between the Union of BC Municipalities, the First Nations Emergency Services Society and MFLNRO, which led to development of 302 Community Wildfire Protection Plans (189 with local governments, 113 with First Nation communities) for areas within two kilometers of a community (WMB 2013). These were subsequently used to prioritize management activities: over the course of the program more than 46,000 hectares in the high-risk community interface were treated. The Initiative relied on Provincial Strategic Threat Analysis (PSTA) datasets to identify interface areas that may be at risk of wildfire to support community wildfire protection planning.

MFLNRO's Wildfire Management Branch (WMB) has improved upon the previous process by implementing an integrated fire risk model, called "BURN-P3," that will use climate change forecasts to predict wildfire risk across the landscape several decades into the future. Starting in 2015, WMB anticipates having completed BURN-P3 modelling for all forest management units across the province. Incorporation of a climate change component will be supported by a *Climate Change Adaption Action Plan for Wildfire Management* (currently in draft).

Landscape Fire Planning and Management also establish human life and critical infrastructure as priorities for protection and offer a greater focus on stakeholder involvement to identify and incorporate community-level values into planning and action. Stakeholder involvement will occur through establishing a landscape planning committee in each District and/or a TSA and may be supported by existing collaborations between government and licensee through Type 4 Silviculture Strategies (see page 5). Fire modelling will be overlaid on maps of community values to establish priority areas for protection; these will form the foundation for development of five-year management or tactical plans that outline activities on the landbase to reduce wildfire risk.

Landscape Fire Planning and Management is funded through the Fire Preparedness Budget and the Land-Base Investment Program; between $85,000 and $240,000 have been allocated to the program each year since 2011 (Lyle Gawalko, pers. comm., August 20, 2014). WMB plans to engage communities (e.g. municipalities) in Landscape Fire Planning and Management (e.g. identifying community priorities and values), but recognizes that many communities do not have funding available to support fire planning and protection in the WUI; funding wildfire prevention in these areas will require Provincial support.

Other approaches to encouraging collaborative planning and management

Two of the challenges of implementing plans are the lack of an institutional mechanism that integrates higher-level objectives into operational activities within TSAs and insufficient funding for such activities. While many objectives exist at the landscape level, there is no strategic planning at that scale. Instead, licensees conduct operational planning that takes place mostly at the stand level. The disconnect between these geographic scales has been acknowledged by MFLNRO but remains unresolved. Addressing the problem would require funding for coordination (e.g. setting management priorities, developing plans) and for carrying out activities on the landbase. MFLNRO has recognized that these issues also impede other objectives and has implemented previous programs and initiatives in recent decades that have been designed to encourage cooperation and collaboration among licensees and with provincial, municipal and First Nations governments. This section offers an overview of some recent programs and initiatives, including:

- Type 4 Silviculture Strategies
- Innovative Forest Practices Agreements
- Mountain Pine Beetle Initiative
- Defined Forest Area Management

Type 4 Silviculture Strategies

MFLNRO (2013) anticipates that Landscape Fire Planning and Management will occur within the context of Type 4 Silviculture Strategies (WMB 2013), which encourage collective planning (e.g. forest management and silviculture investment) by government and licensees at the forest management unit level.[14] Silviculture Strategies integrate information (e.g. timber supply, habitat supply) with management objectives to guide the expenditure of public silviculture funds.

[14] FLNRO Silviculture Strategies website: http://www.for.gov.bc.ca/hfp/silstrat/index.htm

Silviculture Strategies have evolved through several Types since they were first introduced in 1998. Information about the various Types of Silviculture Strategies is available on the MFLNRO Silviculture Strategies website. In general, Type 1s support planning using stand level analysis and timber supply estimates that were similar to those from the Timber Supply Review. Type 2s expand on this approach by using in-depth forest modelling and analysis to generate a more detailed assessment of the forest at the management unit level. Type 3s incorporate habitat supply modelling and analysis to inform planning related to wildlife objectives. Type 4s, which were introduced in 2011, incorporate information about tree species selection and diversity targets by BEC subzone, socioeconomic considerations (e.g. revenue, employment) and other local non-timber objectives and climate change projections to develop spatially-explicit silviculture plans and address risks on the landscape.

Development of Type 4s enables MFLNRO to develop Land Base Investment Strategies that prioritize government investment in silviculture on Crown lands to account for impacts of climate change (e.g. pests like Mountain Pine Beetle, wildfires) and economic conditions. Information is provided to licenses with the intention to support broader, more comprehensive decision-making.

Type 4s are almost entirely focused on government investment on the land base and participation by licensees in development of Type 4 Silviculture Strategies is purely voluntary; any licensee commitments are not legally binding. While Type 4s have been developed in eight TSAs to date, MFLNRO has not yet begun the process of integrating Landscape Fire Planning and Management into these Silviculture Strategies. Completion of BURN-P3 modelling in 2015 will offer information to support integration; however, a shortfall of provincial government funding for silvicultural treatments (e.g. fertilization and rehabilitation in MPB-killed stands), research, modelling, strategic planning and management (e.g. District level) and periodic updating of Type 4s remains a barrier to effective, multi-stakeholder planning and management. Further, the cost associated with actions to reduce risk on the landscape (e.g. thinning or harvesting in uneconomic stands, which may include those surrounding communities, those impacted by Mountain Pine Beetle or those with low-value timber) can be a barrier to implementation, despite potential or proven long-term benefits.

Specific, cost-related constraints exist not only at the Provincial level, but also at the community and licensee level. The Wildfire Management Branch of MFLNRO acknowledges that funding of wildfire prevention in the WUI will depend on Provincial support due to limited community budgets. Where actions by licensees to reduce climate change-related risks on the land base require additional silviculture investments (e.g. denser planting, diverse species) in excess of allowances available from the provincial government through the Appraisal System, licensees are unlikely to make such investments.

Innovative Forest Practices Agreements

During its existence, Forest Renewal BC (FRBC), an arms-length Crown Corporation, introduced a tool to encourage licensees to develop and test innovative forestry practices with the potential to improve forest productivity. As an incentive, licensees were able to apply for an increase to their harvest level.

Many licensees used the initiative as an opportunity to invest in better inventory and growth and yield information that then supported increased harvest levels, rather than investment that increased the productivity of forests. Licensees contributed little beyond in-kind support for the program, partly due to uncertainty about the value of potential payoffs of participation.

Program equity was also a concern: only four IFPAs were awarded through a competitive process, while the remaining four were awarded directly. The Ministry of Forests did not receive any additional funding to support administration of the program and no provincial performance monitoring or reporting was completed.

The program was observed to contribute to improved TSA management and better working relationships among industry licensees and also with First Nations licensees; however, the longevity of these relationships is uncertain because, in some cases, AAC allocations that allowed First Nations to acquire volume were based on temporary uplifts in harvest levels that may not be sustainable.

Mountain Pine Beetle Initiative

The Mountain Pine Beetle Initiative (MPBI) was established through the First Nations Forestry Council (FNFC) and the then-BC Ministry of Forests and Range (now MFLNRO). MPBI was developed to assess, prioritize and address impacts of the MPB epidemic on First Nations communities, including aspects of fire protection, emergency preparedness and fuel management.

MPBI facilitated development of local responses with First Nations communities, including fire protection and emergency preparedness planning. Up to $42,500 was available to each community to support responses to priority MPB impacts, including identification of best practices for wildfire protection.

The Initiative led to development of the First Nations MPB Forest Fuel Management working group (FFMWG), which supports collaboration among First Nations, provincial and federal governments to implement fuel management activities with MPB impacted First Nations communities. By the end of 2010, 91 First Nations communities had begun to develop Community Wildfire Protection Plans, of which 59 had been completed, and 1,218 hectares of land was undergoing fuel treatment.

FNFC has reported that funding shortfalls have limited its ability to support community wildfire planning and protection. While some communities are familiar with fuel management, others require considerable technical and operational support; a shortage of qualified support staff and training resources has hampered the program’s effectiveness. Further, the lack of one designated body to oversee the program created some confusion for communities regarding where and when to apply for funds or seek advice.

Defined Forest Area Management

Another previous effort, called Defined Forest Area Management (DFAM), was initiated by then Ministry of Forests' Land-Base Investment Program (LBIP), funded through the Forest Investment Account, to encourage collaboration and cooperation between licensees for the purpose of collaborative planning across the landbase. A placeholder was included in the *Forest and Range Practices Act* that would require DFAM groups, consisting of licensees and holders of other forest agreements, to collect and analyze timber supply information within their operating area, make this information available to the public and First Nations for review and then submit it to the Chief Forester. It was proposed that funding for data collection and analysis would initially be provided to DFAM groups during a transition period.

The DFAM concept was unsuccessful because licensees and the provincial government were unable to reach agreement about who should bear the administrative and other costs of the new process (Tim Ebata, pers. comm., May 12, 2014). The current appraisal system does not begin to recognize new, ongoing costs for 18 months after they are incurred and licensees did not view expected future returns on their investment in inventories, analysis and planning as sufficient to justify the near-term expenditure. Licensees viewed DFAM as an effort by the then-Ministry of Forests to download provincial responsibilities and costs onto private companies and were therefore unsupportive of the concept. DFAM may have experienced stronger support if it was believed to result in only modest costs, if a transparent public-private cost-sharing formula was developed and if all licensees saw benefits from participating.

Victoria, Australia

The Victorian Government's Department of Environment and Primary Industries (DEPI) is responsible for fire planning and management on public lands within the State. The organization is moving toward an integrated approach and shared responsibility for bushfire management between government, agencies, communities and citizens. Released in 2012, the *State Bushfire Plan* outlines the responsibilities of various partners for bushfire management.

Current approach to wildfire planning and management

Strategic Bushfire Management Planning

British Columbia's Landscape Wildfire Planning and Management program was developed in parallel with the Victorian Government's Strategic Bushfire Management Planning program and both programs are currently being rolled out within their respective jurisdictions. Consequently, there are many similarities between the two programs. For example, both programs rely heavily on modelling of wildfire probability, behaviour and severity across the landscape (i.e. BURN-P3 in BC, Phoenix Rapidfire in Victoria).

Development of Strategic Bushfire Management Planning was motivated by the Black Saturday fires of 2009, which killed 173 people, and was an outcome of the subsequent Victorian Bushfires Royal Commission. The program is focused on fuel reduction on publicly-owned lands, with an annual reduction target of 5%, and uses an established ISO 31000-accredited risk management framework.

Strategic Bushfire Management Planning also integrates social values, discovered through community consultation and input, into wildfire planning. Local implementation teams in each of the seven catchments will begin working with communities in 2014 to understand how they would like to see public land managed for fire. Tenure-blind wildfire modelling (i.e. not influenced by administrative boundaries) will be integrated with community input during planning and operations. Fire management activities are implemented by local managers within the County Fire Authority in accordance with three-year state-wide Fire Operation Plans to achieve burn targets. The program is entirely funded by the Victorian government.

One foreseeable challenge is that program implementation is limited to publicly-owned lands; private lands are not within the jurisdiction of Department of Environment and Primary Industries (DEPI), which manages the program. DEPI plans to provide information to private landowners (e.g. forest plantation owners and operators) about wildfire risk to encourage adaptation; however, he decision to act remains at the discretion of the landowner. There are no economic or legal instruments in place to motivate adaptation to wildfire on private lands.

Since this program is currently being implemented, information about its successes, challenges and impacts is unavailable. Future monitoring and review will be necessary to gauge the program's effectiveness and form the basis for any modifications to program delivery.

USA

Following widespread and severe wildfires across the USA in 2000, the US federal government developed its National Fire Plan (NFP), which provides technical, financial and resource guidance and support for wildland fire management. Over $1.1 billion was provided to the US Forest Service (USFS) to implement the NFP (USDA 2001), including for development, improvement and application of wildfire modelling tools; completion of fuel treatments; and wildfire fighting. The US Department of Agriculture (USDA) and the Department of the Interior are jointly responsible for implementing five key activities outlined in the NFP: firefighting, rehabilitation, hazardous fuels reduction, community assistance and accountability. The NFP is delivered through federal, State and private forestry programs, with funding from federal and State agencies. For example, the Department of Homeland Security Federal Emergency Management Agency (FEMA) oversees several grant programs including Firefighters Grants and Fire Prevention and Safety Grants. Federal agencies tend to prioritize funding for activities in areas where other neighboring landowners (e.g. private, State) have indicated willingness to match funds (Keith Stockmann, pers. comm., Aug. 22, 2014).

Approximately 55 percent of the land across the western USA is federally owned and managed by one of several national land management agencies including the Department of the Interior Bureau of Land Management, the USDA Forest Service (USFS), the United States Fish and Wildlife Service and the National Park Service (Loomis 1993). In order to effectively manage these lands for wildfire, representatives from these agencies have the challenge of working with State land managers, local communities and private landowners to determine what fuel treatments to apply, where they should be applied and at what time of year; however, conflicting management objectives between these agencies can present challenges to collaborative planning. For example, federal managers emphasize multiple uses whereas States have a narrower mission on those portions of State holdings that are dedicated to revenue maximization to supplement school funding (Keith Stockmann, pers. comm., Aug. 22, 2014).

Federal and State governments have been working with communities since the early 2000s to reduce wildfire hazard in the WUI. These efforts have included development of Community Wildfire Protection Plans and the Fire Adapted Communities Learning Network in partnership with The Nature Conservancy, an environmental non-profit organization.

Current approach to wildfire planning and management

In 2009, US Congress mandated a more cohesive approach to land and wildfire management across all lands (i.e. federal and state) by enacting Title IV of the *Omnibus Public Land Management Act* and the *Federal Land Assistance, Management and Enhancement Act* (FLAME Act), which led to establishment of the Collaborative Forest Landscape Restoration Program and the National Cohesive Wildland Fire Management Strategy.

Collaborative Forest Landscape Restoration Program

The former led to establishment of the Collaborative Forest Landscape Restoration Program and Fund by the USFS. Its goals included leveraging local resources with those from national and private sources and facilitating the reduction of wildfire management costs, including through re-establishing natural fire regimes and reducing the risk of uncharacteristic wildfire. Up to $40 million annually was made available for projects on federal forest lands, with only 50 percent of total project costs being eligible.

National Cohesive Wildland Fire Management Strategy

The FLAME Act proposed creation of a bank of surplus wildfire fighting funds to be set aside during low wildfire years and accessed during bigger years; however, between 2011 and 2013, Congress withdrew $680 million of banked funds for other non-wildfire purposes. That same year, 500 fewer firefighters and 50 fewer fire engines were available at the start of the fire season and the US was struck by a severe wildfire season, with firefighting costs exceeded $1 billion dollars (EESI 2014).

The National Strategy (2014) and National Action Plan, The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy (2014), are also products of the FLAME Act. These documents establish three goals to extinguish, use and live with fire: restore and maintain landscapes, create fire-adapted communities and provide wildfire response. While it is too soon to observe the impacts of the National Strategy and National Action Plan, new information about priority areas for wildfire protection provided in the National Strategy could be used to prioritize funding to target high-risk areas. The funding question for this Strategy remains to be addressed.

Financial instruments to support collaborative planning and management

Securing sufficient and ongoing funding is a common challenge among existing and previous instruments to support collaborative planning and management. Funding is required to support activities such as coordinating among stakeholders, modelling impacts, planning and carrying out activities on the landbase (e.g. fuel treatments, harvesting marginal timber stands to create fire breaks). Financing is also required for treatments to mitigate risks; in the case of wildfire, possible treatments include harvesting activities to thin stands, create fire breaks, and reduce fuel loads. In some cases, this may align with existing harvesting opportunities such that there is minimal impact on costs; elsewhere, the type of treatment may either be significantly more costly or reach a point where the costs exceed the value of any timber removed as part of the treatment. In these cases, financing or some other kind of financial incentives are necessary to make such treatments economically viable. This is also a common issue in managing fire risk on the landscape.

In this section, we briefly review previous and existing funding mechanisms to support collaborative planning and management in British Columbia, Alberta, Ontario and the USA and analyze the potential to finance activities at the TSA level within British Columbia using a levy on stumpage. As noted in the Introduction, this was identified as an instrument of potential interest to participants (i.e. licensees and government and other representatives) during the first *Economic Instruments* workshop in February 2014. We also consider the application of one potential instrument to generate revenue to support collaborative planning and management activities on the landbase (e.g. to support coordination or fund wildfire treatments where the costs of activities might exceed the timber values).

British Columbia

Fire Preparedness Levy

Since 2008, the Fire Preparedness Levy has been used to collect a portion of Annual Rent received from licensees to support fire prevention programs in BC (BC Government 2011; MFLNRO 2012), including initial attack and fire suppression costs. The Levy rate varies with the type of tenure (Table 14) and accounts for between 17% and 100% of the total Annual Rent collected.

Table 14. Annual Rent and Fire Preparedness Levy by tenure type, British Columbia (2014).

Tenure type	*Annual Rent*	*Fire Preparedness Levy*	*Levy as % of Annual Rent*
Community forest agreement	$0.37/m^3$	$0.12/m3	32%
First nations woodland licence	$0.12/m^3$	$0.12/m3	100%
Forest licence	$0.37/m^3$	$0.12/m3	32%
Timber licence	$1.85/ha	$0.60/ha	32%
Tree farm licence	$0.57/m^3$	$0.12/m3	21%
Woodlot licence	$0.60/m^3$	$0.10/m3	17%

It is unclear on what basis this Levy was established, when they were established or if there is a process by which they are re-evaluated. They do not appear explicitly in the current *Forest Act*; in the previous version, they were recorded as a separate rental charge, but there was no reference as to how they were to be used or the intent of the charge.

WMB staff report that the Levy generated $1.8-$1.9 million annually between 2010 and 2014 (Table 2) and that Levy funds are directed into the Fire Preparedness budget (Lyle Gawalko, pers. comm., Oct. 14, 2014). While the Levy bolsters Fire Preparedness funding, it is also accompanied by the proviso that an accidental fire start by a licensee is not a cost recovery item (i.e. MFLNRO will not bill licensees for fire control costs).

Table 2. Annual Fire Preparedness Levy funds and Fire Preparedness Net Budget (2010-2014).[15]

Fiscal Year	*Fire Preparedness Levy Actuals*	*Fire Preparedness Net Budget*	*Levy as % of Fire Preparedness budget*
2010/11	$1,912,094	$36,323,977	5.3%
2011/12	$1,895,682	$24,340,182	7.8%
2012/13	$1,964,138	$25,705,029	7.6%
2013/14	$1,795,023	$25,087,639	7.2%
2014/15	$1,771,789	$24,776,100	7.2%

[15] Information provided by Lyle Gawalko, pers. comm., Oct. 14, 2014.

Super-stumpage

A past program that was also developed with the intention of funding investments on the landbase was super-stumpage, which was administered by a new, arms-length provincial government organization, Forest Renewal BC (FRBC) during the mid- to late-1990s. An additional levy was imposed on top of the existing stumpage rate (hence, super-stumpage) to create a pool of funds that would be available to licensees on a competitive basis for projects to bolster employment in the forest industry and improve timber productivity. These investments were expected to lead to an increase in economic activity while simultaneously meeting the government's environmental and conservation objectives.

The program was initially supported by the forest industry; however, administrative problems became apparent soon after its implementation. A legislative change was made to the *Forests Act* that meant project applications needed to be approved not by FRBC, but by the then-Ministry of Forests, which produced delays. FRBC also received fewer project applications because licensees were concerned that additional timber supply achieved in the mid-term may not be available for them to harvest through their forest tenures. Further, a decision was made by FRBC to reallocate program funding to pay down provincial debt. The overall outcome of these issues was anger and distrust on the part of licensees. Eventually, FRBC was replaced with the Forest Investment Account and then by the Forest Investment Account – Land-Base Investment Program, both of which were/are funded and controlled by MFLNRO (Tim Ebata, pers. comm., Sept. 26, 2014).

Yet, despite this experience, licensees and government representatives both appear to remain broadly supportive of the idea of increasing stumpage rates to create a fund for licensees to develop projects related to forest management and, in particular, adaptation. This support was observed during the recent workshop, *Economic Instruments for Climate Change Adaptation in Forestry*, held on February 26, 2014.

Innovative Timber Sale Licenses

Innovative Timber Sale Licenses (ITSLs) were developed and implemented by BC Timber Sales after the onset of the Mountain Pine Beetle epidemic to support short-term utilization of beetle-killed timber (i.e. where stands are economically marginal). ITSLs offer a one-time economic incentive to harvest MPB impacted timber by offering a lower upset stumpage rate for beetle-killed stands through the removal of post-harvest silviculture costs. Silviculture and reforestation obligations for these stands are assumed by MFLNRO through the Forests for Tomorrow (FFT) program, which was established to improve future timber supply and mitigate impacts on other forest values.

While assuming these obligations increases costs to government, it also allows MFLNRO to avoid shouldering the cost of fibre removal (site rehabilitation) prior to reforestation, reduces the fire risk of standing dead timber and grants MFLNRO the opportunity to test alternative and innovative silviculture and reforestation practices (e.g. those related to adaptation), which may not be explored independently by licensees. Unfortunately, funding shortfalls have created a situation where only a small proportion of the beetle-killed forest is harvested using ITSLs and there are also many stands that remain uneconomic even when the post-harvest silviculture costs are removed. BC Timber Sales has also been reluctant to offer ITSLs outside of their operating areas because of concerns that District Managers may be unwilling to issue them within the existing operating areas of tenure holders (e.g. in TSAs). This may reflect sensitivities around the perceived security of such operating areas. Where ITSLs are not an effective tool (i.e. harvesting remains uneconomic), there is the option to use a Forest License to Cut (FLTCs) to leverage value from any onsite fiber and reduce the cost of rehabilitation treatment to government (Al Powelson, pers. comm., May 12, 2014).

ITSLs are a politically attractive tool because they can support changes in forest structure without providing a subsidy: the BC government provides support to have stands logged by compensating for the difference in cost rather than reducing the cost of delivered fiber. Thus, ITSLs essentially maximize private investment in the logging and rehabilitation effort (Cam Brown, pers. comm., Sept. 29, 2014). ITSLs have the potential to support creation of fire breaks around communities where low-value stands cannot be harvested economically at current timber prices. In theory, it may be possible for MFLNRO to offer ITSLs in priority areas such as those with high-value community or infrastructure assets identified to be at risk during the Landscape Wildfire Planning process; however, this application has not yet been tested.

Alberta

In Alberta, the Minister of Environment and Sustainable Resource Development (ESRD) has delegated the responsibility to develop forest enhancement projects to an industry association, called the Forest Resources Improvement Association of Alberta (FRIAA), which manages the Province's Forest Resources Improvement Program (FRIP).

Forest Resources Improvement Program

FRIP was established in 1997 under the delegated authority of FRIAA and delivers operational activities, planning and inventory work, applied research projects, public education and forest protection initiatives through seven core programs including the Mountain Pine Beetle Program, Wildfire Reclamation Program, Mountain Pine Beetle Forest Rehabilitation Program and FireSmart Initiative Program.[16] The FRIAA Board of Directors is made up of seven industry representatives. Funding is generated through Reforestation Levies, Timber Dues and Crown Charges (i.e. Stumpage fees) and transferred by ESRD to FRIAA to support program development, administration and management.

Requests for project proposals are posted on the FRIAA website; funding is awarded through a competitive process. Project funding decisions are either made by FRIA or by a review committee, depending on the program (e.g. the FireSmart review committee includes representatives from ESRD, FRIAA, Alberta Municipal Affairs, Alberta Association of Municipal Districts and Councils, the Alberta Urban Municipalities Association and the Partners in Protection Association). Activity and financial reports must be submitted by the successful project proponents. Financial audits must be completed by approved contractors for projects awarded funding through FRIAA.

[16] See: FRIAA website: http://www.friaa.ab.ca/

Ontario

The Province of Ontario's *Crown Forest Sustainability Act* (1994) established two Trusts to support special forest projects on provincially-owned and -managed Crown lands to support long-term forest health. Both Trusts are held separately from general government revenues (i.e. the Consolidated Revenue Fund).

Forest Renewal Trust

The Forest Renewal Trust (FRT) provides dedicated funding to cover reimbursement of silvicultural expenses. Ontario Crown Timber Charges (i.e. stumpage rates) are paid into the FRT by licensees for timber harvest on provincial Crown lands based on rates per cubic metre that are established at the beginning of each fiscal year.

Forestry Futures Trust

Funding from the Forestry Futures Trust (FFT) is available to reimburse the cost of: projects to restore forest areas that have been damaged by fire or natural causes; silvicultural expenses where a licensee has become insolvent; intensive stand management and pest control; or other purposes as specified by the Minister. While FFT's funding scope does not currently encompass climate change adaptation-related projects, it would be possible to amend it for this purpose in the future (Laird Van Damme, pers. comm., Aug. 26, 2014).

Established in 1995, the FFT has distributed over $180 million through 38 rounds of competitive proposal processes.[17] Proposals are reviewed and approved by the five-member Forestry Futures Trust Committee, an arms-length committee of the Provincial Government. There is no formal field evaluation process for assessing the effectiveness of project expenditures; informal site visits are conducted by members of the Forestry Futures Trust Committee on an ad-hoc basis.

The FFT has received some criticism due to the influence of the Minister of Natural Resources on its funding allocations and its occasional use as a slush fund for the Forest Resources Inventory.

[17] See: FFT website: http://www.forestryfutures.ca/

USA

Stewardship Contracting

The US introduced stewardship contracts as a pilot twelve years ago. They consist of bundled contracts in which US Federal agencies (USFS and BLM) set desired objectives for a forest stand; the contracts are then put for bid with any resulting timber revenue offsetting the costs. Examples of objectives include road and trail maintenance or decommissioning to restore or maintain water quality, soil productivity, habitat for wildlife and fisheries, or other resource values; prescribed burning to improve stand composition, structure, condition and health or to improve wildlife habitat; removing vegetation or other activities to promote healthy forest stands, reduce fire hazards, or achieve other land management objectives; watershed restoration and maintenance; restoration and maintenance of wildlife and fish habitat; and control of noxious and exotic weeds and reestablishing native plant species (Pinchot 2011).

In 2007, 15% of timber harvested on Federal forest lands was through stewardship contracts; this increased to 23% in 2010 (Pinchot 2011). Fuels reduction and fire treatment was the most specific project outcome, reported by close to 90% of respondents involved in stewardship contracts (this was followed by habitat improvement and forest health) (Pinchot 2011: 26). Positive outcomes from the work included increased opportunities for collaboration, increased trust in land managers, and local economic benefits. In addition, through stewardship contracts land managers were able to leverage other resources and capacity to carry out activities, and it was seen as leading to improved efficiencies over traditional mechanisms. Barriers to be addressed included differences in perceptions about objectives and priorities between land managers and communities engaging in collaborative planning; lack of monitoring; willingness to engage by both agency personnel as well as county officials (who do not receive any receipts as they do from traditional timber sales); and lack of infrastructure to support economic values (where there is a lack of market for products such as thinnings). This can result in unwillingness of participants over how much they will do and affect what they can accomplish and can be matched by community frustration over how much can be achieved.

Analysis of potential revenue from a levy on stumpage in BC

This analysis explores the potential revenue that could be generated using an additional levy on stumpage rates paid by licensees on harvested timber. Such a levy could be used initially to fund specific, dedicated adaptation activities related to wildfire prevention and later broadened to combat threats related to pests and maladaptation. It has the potential to generate considerably more revenue than the existing Fire Preparedness Levy, which only collects $1.8-$1.9 million per year, and funds could be committed to pre-empting emerging risks under climate change.

Three scenarios for potential levies to support climate change adaptation were analyzed based on the Coast and Interior Appraisal Manuals (MFLNRO 2014a; 2014b) and Coast Market Pricing System Log Values (MFLNRO 2014c; 2014d). These scenarios represent the following three hypothetical levies on existing stumpage rates:

- Scenario A: Additional $0.25 per cubic metre ($m^3$) on the highest value grades of timber in both the Coast and Interior regions.
- Scenario B: Additional $1.00/$m^3$ on the highest value grades of timber and $0.25/$m^3$ on mid-value grades of timber in both the Coast and Interior regions.
- Scenario C: Additional $1.00/$m^3$ on all but the lowest value (i.e. high and mid-value) grades of timber in both the Coast and Interior regions.

Table 3 lists both the current (based on 2013) and hypothetical stumpage rates used in this analysis. These scenarios were designed to explore the sensitivity of how stand level stumpage would change as within stand stumpage rates were increased such that, everything else equal, the overall stumpage collected though the stumpage system would increase. The hypothetical stumpage levy scenarios recognize the need to maintain minimum stumpage rates on the lowest value stands (e.g. Grades X and Y). Only timber from Crown lands was included in the analysis.

Table 3. Current stumpage rates for the British Columbia Coast and Interior forest regions, 2014 (MFLNRO 2014a; 2014b; 2014c; 2014d).

Region	*Current*	*Scenario A*	*Scenario B*	*Scenario C*
Coast	All Grades (A-Z): Existing stumpage rates	Grades B-M: +$0.25/$m^3$ Grades U, X, Y: +$0/$m^3$	Grades B-G: +$1.00/$m^3$ Grades H through M: +$0.25/$m^3$ Grades U, X, Y: +$0/$m^3$	Grades B-M: +$1.00/$m^3$ Grades U, X, Y: +$0/$m^3$
Interior	All Grades (1-8): Existing stumpage rates	Grades 1-3: +$0.25/$m^3$ Grades 4 and 6: +$0/$m^3$	Grade 1: +$1.00/$m^3$ Grades 2 and 3: +$0.25/$m^3$ Grades 4 and 6: +$0/$m^3$	Grades 1-3: +$1.00/$m^3$ Grades 4 and 6: +$0/$m^3$

Current average stumpage rates were calculated at regional (i.e. Coast/Interior), management unit and cutting permit levels using data obtained from the Harvest Billing System for 2013. Average stumpage was calculated as the current total value of stumpage divided by the total volume of timber harvested in 2013.

Stumpage rates under each scenario were estimated by adding the associated levy to the current average stumpage rate. Total additional funding generated using the levy was calculated as the difference between the current total value of stumpage and the total value of stumpage plus the levy under each scenario.[18] In 2013, a total of $539 million in stumpage revenues were collected from licensees by the Province of British Columbia. Potential additional revenues that could be levied to support collaborative planning and management for wildfire range from $8.6 million under Scenario A to $34.7 million under Scenario C. By comparison, it is estimated that $12 million per year is the amount that would be required to fund wildfire prevention activities across the BC landbase (Lyle Gawalko, pers. comm., October 22, 2014). Total stumpage revenues in 2013 and the potential value of additional funding that could be generated in the Coast and Interior regions under each scenario are listed in Table 4. This information is also presented by forest management unit in Appendix I.

Table 4. Total estimated value of current stumpage and additional revenue under hypothetical scenarios, by forest region (million CAD).

Region	*Current*	*Scenario A*		*Scenario B*		*Scenario C*	
	Total stumpage	Total stumpage	Additional revenue	Total stumpage	Additional revenue	Total stumpage	Additional revenue
Coast	$96.6	$100.1	$3.5	$100.6	$4.1	$110.6	$14.1
Interior	$442.4	$447.6	$5.1	$449.2	$6.8	$463.0	$20.6
Total	*$539.0*	*$547.7*	*$8.6*	*$549.8*	*$10.9*	*$573.6*	*$34.7*

One potential consequence of imposing an additional levy on stumpage may be that low-value, economically marginal stands may become uneconomic to harvest. Theoretically, minimum stumpage would reflect the fact that the value of such stands is just sufficient to cover licensees' costs of

[18] Expert advisors from the BC forest sector have suggested that such a levy should only be applied to timber billed using scale-based methods and that Timber Sale Licenses (TSLs) should be excluded from the levy. Cruise-based billing was introduced in the wake of the Mountain Pine Beetle crisis to encourage salvage harvesting of standing dead timber by offering lower stumpage rates; the use of cruise-based billing is expected to diminish over time as the number of beetle-killed stands decreases. Since the Harvest Billing data did not indicate whether the timber was assessed using scale- or cruise-based billing, all scenarios assume that billing is entirely scale-based (i.e. the value of stumpage is assessed based on timber grades, rather than an average stumpage value applied at the Cutting Permit level). While the use of this assumption is expected to generate an overestimate of the total potential revenues from a levy in the near term, as stands are increasingly assessed using scale-based billing, this margin of error will narrow. For more information, see:
http://www.for.gov.bc.ca/ftp/hva/external/!publish/web/hbs/HBSCruiseBasedBillingProcedures.pdf
BCTS also uses TSLs for the timber auctioned through its program (approximately 15%-18% of the total timber harvested in BC). If BCTS was to be exempted from the levy, an alternative mechanism would need to be implemented to ensure that it contributed its share of adaptation funding.

harvesting and transportation; if stumpage rates were to increase, the increase in costs of those stands could then exceed the value of such stands.

Therefore, we simulated the economic impact of increasing stumpage through adding additional levies only on higher value timber. We examined at the current distribution of cutting permits, classified by level of stumpage, and how that distribution changed under the different scenarios. We developed histograms showing the shift in the distribution of cutting permits by average stumpage rate under the different scenarios. This shows both the average change in values and the incidence of those levies (i.e. which stands are most impacted and by how much).

This does not necessarily illustrate the viability of harvesting stands under each scenario; for example, whether or not a shift in stumpage for a Cutting Permit that was at $0.25/m^3 and is now at $0.50/m^3 remains economically viable to harvest. However, it does provide an upper bound on the revenue that can be raised, and the sensitivity of that revenue to the underlying distribution of stumpage values.

The following histograms (Figure 1) show how the different levies under each Scenario shift the average value of stumpage for Cutting Permits. For example on the Coast, under Scenario A, the biggest shift is between Cutting Permits currently assessed at $0.25/m^3 and those that are valued at $0.50/m^3, resulting in only a few Cutting Permits being valued at minimum stumpage. Most of the timber volume increases to a value of $0.50/m^3; there is little change among the remaining Cutting Permits at higher stumpage.

Scenario B produces an even greater shift, where some additional volume moves from $0.50/m^3 Cutting Permits to $0.75/m^3, but again there is expected to be limited impact on higher value Cutting Permits.

Under Scenario C, which represents the highest levy, the greatest shift is expected such that the highest number of Cutting Permits is at $1.25/m^3, and most of the volume is valued at $0.75/m^3 or more. There is also an impact on higher value stumpage (i.e. anything greater than $6/m^3). A detailed breakdown by management unit can be found in Appendix I. This more detailed breakdown reveals that the funds raised by management unit vary significantly and are not necessarily proportional to the level of harvesting activity; therefore, consideration will need to be paid about matching needs to resources and the appropriate level and scale to carry out such activities.

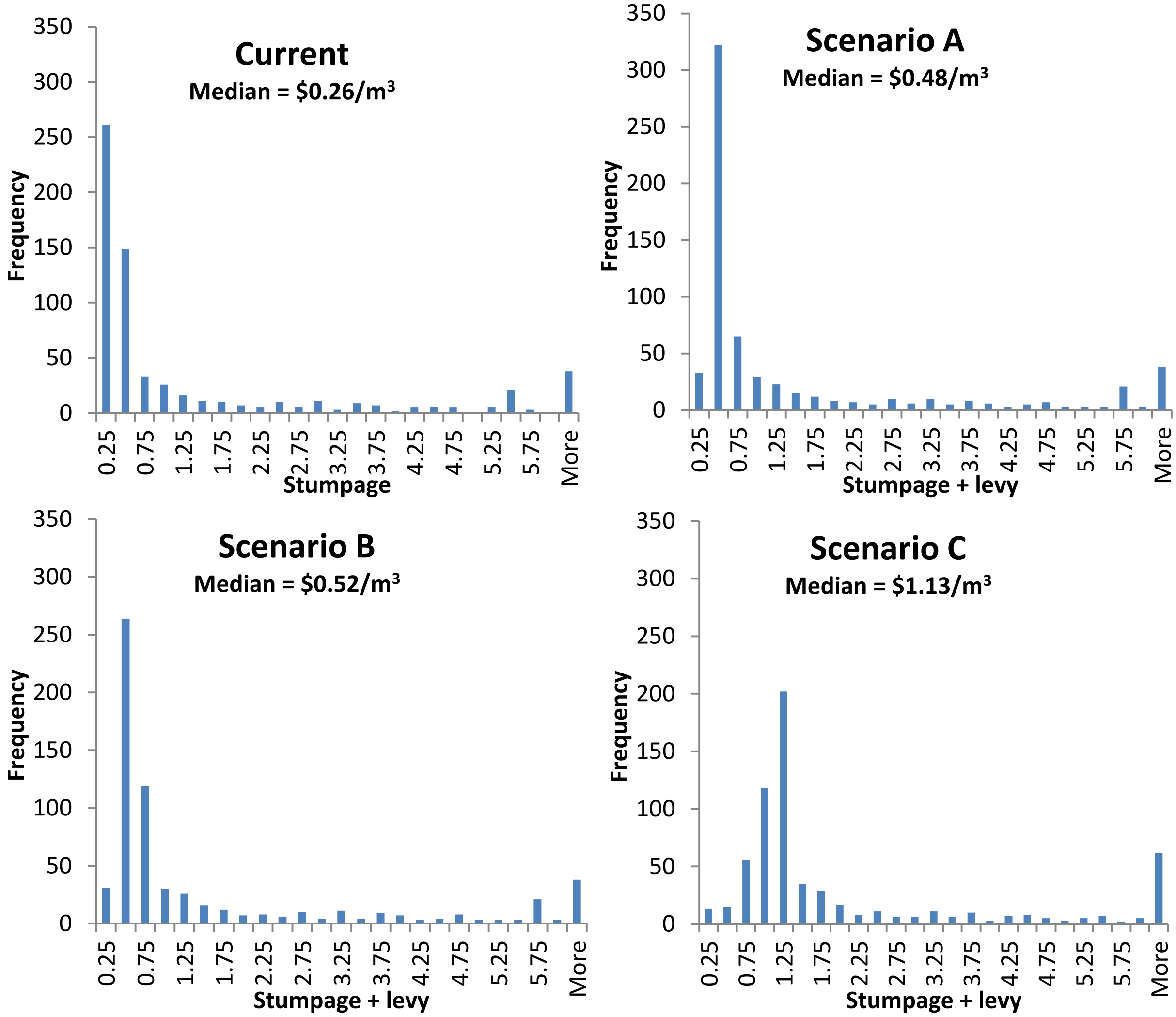

Figure 11. Frequency (i.e. number) of cutting permits at each stumpage and levy rate under current conditions and hypothetical scenarios, Coast Region.

The results for the Interior (Figure 2) are similar to those for the Coast, where the most frequently harvested Cutting Permits are also those with the lowest value (i.e. \$0.25/m^3). However, the distribution of stumpage is not as skewed toward minimum rates as in the Coast Region; there is relatively more volume in higher-valued Cutting Permits. As the stumpage levy increases from Scenario A to Scenarios B and C, most of the change in average stumpage value occurs in Cutting Permits that are currently valued below \$0.50/m^3 (Scenarios A& B) or below \$1.50/m^3 (Scenario C). Therefore, the main impact of the stumpage levies is seen on the lower value Cutting Permits, which shift to slightly higher average values. The greatest change is expected to occur under the highest levy; however, the value of the shift is less than the actual levy (i.e. a \$1 increase does not result in a direct \$1 increase for each Cutting Permit).

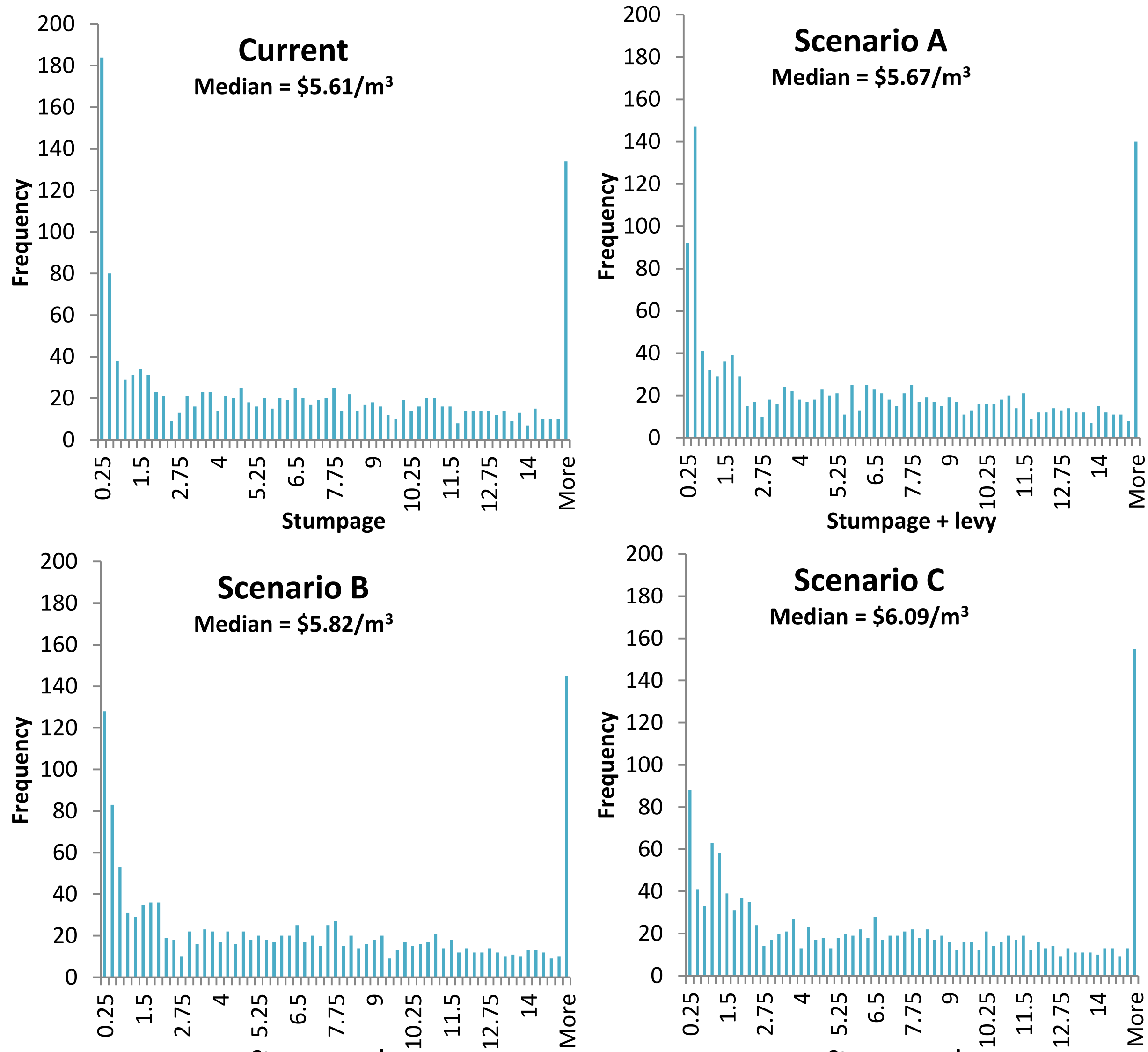

Figure 12. Frequency (i.e. number) of cutting permits at each stumpage and levy rate under current conditions and hypothetical scenarios, Interior Region.

Key aspects of instruments to support collaborative planning and management

Experiences with previous and existing instruments to support collaborative planning yield important information about planning, design and implementation of instruments. The following key aspects of instruments are drawn from the literature and interviews with practitioners with experience in the forest industry in BC.

All parties see the benefit of participating. Programs with direct, quantifiable economic benefits (e.g. structural cost, insurance, life and limb, cost of fire suppression) have been more widely accepted than programs where the benefits of participating are less clear. MFLNRO's Defined Forest Area Management (DFAM) program suffered because the return on investment to licensees resulting from cooperation was unclear. Where licensees, communities and governments all see the benefit of acting to reduce climate-related risk (e.g. wildfire), support will be granted more readily.

All affected levels and departments of government are involved. MFLNRO Wildfire Management Branch (WMB) staff have identified the need to have all relevant fire authorities (e.g. uniformed WMB officers, local fire chief and Emergency Management staff) working together to raise awareness about the risks and actions that communities and licensees can take to reduce the risk of wildfire. When communities are supportive of actions near their communities (e.g. harvesting for fire breaks), licensees are more willing to support fuel reduction efforts.

One issue that remains unaddressed is integration of management objectives of multiple government departments across the land base. In British Columbia, MFLNRO seeks to integrate habitat considerations into development Type 4 Silviculture Strategies, but does not always have representation from the Ministry of Environment, which manages wildlife, during Type 4 planning processes. BC's Innovative Forest Practices Agreements were reported to have demonstrated some successes in terms of building partnerships with First Nations and some Type 4s involve First Nations, but there remains room for improvement in terms of First Nations engagement in planning and management across the land base.

Engaging additional levels and departments of government can also help to address the public goods nature of preventing wildfire and adapting forested landscapes to climate change. Actions and investments by the forest sector to reduce wildfire risk to communities and infrastructure generate benefits not only to the forest industry, but also to the public as a whole. Thus, other parties can derive benefits from the actions of the forest sector without necessarily contributing to the cause. Where collective action (e.g. in partnership with communities and other industries) to reduce wildfire risk is possible, this should be encouraged to leverage resources and recognize the public benefits of wildfire reduction and other climate change adaptation activities.

Information about the level of risk is publicly available. Both the Victorian Government's Department of Sustainability and Environment (DSE) and BC MFLNRO's WMB now use wildfire modelling to characterize the risk of wildfire across the landscape and identify priority areas for protection based on critical infrastructure and other values. This information is available to communities, infrastructure owners and operators and licensees to help them understand risks on the landscape. DSE's tenure-blind modelling offers information to public and private landowners and managers to offer a complete picture of fire risk across the landscape.

Sufficient government resources dedicated to planning and management. Provincial and regional plans for wildfire and forest health are developed and implemented by MFLNRO. MFLNRO also conducts wildfire modelling and administers and coordinates Type 4 Silviculture Strategies. Where government is responsible for forest resources and community safety, it will be necessary to maintain sufficient resources (e.g. financial, human) for these activities, including contracting of independent experts to generate additional information to input into planning processes. Conversely, the failure of BC's DFAM program is attributed, in part, to lack of government resources to coordinate activities among licensees.

DSE's SBMP has reported positive outcomes from dedicating separate resources to strategy versus operations. By enabling staff to focus primarily on one of these issues, they have created capacity for long-term planning and management (e.g. preparedness) while continuing to meet the demands of urgent, short-term issues (e.g. response).

Policies, targets, objectives and strategies are clearly established. In BC, Landscape Fire Planning is supported by the WMB Climate Change Action Plan. This policy lends support for activities on the landbase by providing overarching direction and strategic focus.

Specific targets for the Strategic Bushfire Management Planning program are listed in the Victorian Government's DEPI 2014-2015 Service Delivery Plan. The DEPI Department of Sustainability and Environment Strategic Bushfire Management Planning program established a target for fuel reduction of 5% on public land and a Code of Practice for how these reductions would be achieved. The existence of a target helped to set a measurable goalpost for successful program implementation and to identify the resources (e.g. financial, human) to accomplish this goal. The Code of Practice prioritizes human life over other considerations and aims to minimize the ecological impact of bushfire management across the landscape and improve ecological resilience, thereby mitigating potential unintended consequences of management actions.

DEPI developed the planning framework for its Strategic Bushfire Management Planning program around a strategic risk management approach. This differed from previous approaches, which were focused on tactical efforts and delivery but lacked strategic direction. DSE acknowledges that this shift toward strategy has been difficult because of the urgency of fire issues and the pressing need for fast action. To facilitate the change, DSE separated Strategic Bushfire Management Planning into strategic and operational teams: while the strategic team continues to support tactical efforts as needed, their primary focus is on longer-term management issues. This creates dedicated resources for strategic initiatives but also presents a challenge in terms of ensuring that strategic plans are effectively implemented operationally. The two teams must work closely but independently.

Broadly, funding can be allocated to undertake targeted actions in priority areas identified by the relevant wildfire management authority. This can help to create incentives for specific actions that are known to reduce fire risk. Incentives must be integrated with a strategy that is specific to each management area (e.g. TSA); in BC, this strategy is expected to be developed through Type 4 Silviculture Strategies.

Actions are clearly defined. Wildfire Management Branch has identified specific actions and treatments (e.g. landscape fire breaks) that are required to reduce wildfire risk. Having a strong understanding of required actions can help wildfire experts to work with communities and licensees and direct activities to effectively reduce risk.

Funding is available to support licensee actions as required. As in the case of the BC Timber Sales Innovative Timber Sale License program, funding is available for treatments that cannot be undertaken economically by licensees (e.g. harvesting of low-value beetle-killed timber). This program could be expanded to support implementation of fire breaks on the landscape where harvesting is not economical for licensees. Where harvesting is economical, licensees could be engaged to prioritize critical areas identified by Wildfire Management Branch.

Type 4 Silviculture Strategies are currently focused on government investment on the landbase; not on licensee investments. The creation of a funding source and mechanism to encourage licensees to invest differently (e.g. to reduce fuel or create more fire resilient landscapes) could help to achieve government objectives related to adaptation.

A major challenge of MFLNRO's DFAM program was the absence of an appropriate funding formula or matrix to identify how costs related to investments in forest health would be covered. The existing appraisal system is not designed to address forest stewardship costs and cannot be relied upon to support investment in long-term climate-related expenditures. The existence of dedicated funds to support DFAM could have increased its chances of success.

The Innovative Timber Sale License (ITSL) program is currently used to achieve harvesting of uneconomic timber, specifically timber that has been impacted by Mountain Pine Beetle (MPB). Timber that is not of sufficient value to be harvested by licensees but that has been identified by MFLNRO as a priority for harvesting (e.g. to reduce fuel on the landscape) can be bid on by BCTS and then harvested by licensees without incurring responsibilities for replanting and regeneration. In the case of fire prevention, the focus of this program could be shifted to include harvesting of uneconomic stands in accordance with activities to reduce wildfire risk (e.g. fire breaks). A similar program could be implemented at the District level using a Forest License to Cut.

Clear and equitable funding formula. A clear funding matrix would need to be developed to outline who pays into the program, exactly what is eligible for payout and the value of funding available to licensees. This formula could be similar to the hypothetical levy on stumpage that is outlined in this report and could be supported by a risk-sharing framework that identifies the allocation of responsibilities for climate change-related risks among parties involved in forest management. To address some of the issues that arose during the super-stumpage program, it would be necessary for any stumpage revenues to be re-allocated back into the program at the regional (e.g. TSA) level. Eligible actions would also need to have a clear, apparent benefit to future forest condition and mid- to long-term timber supply in order to garner support from licensees.

Funds are administered by a third party. The issue of who controls and allocates funding for projects was important during the super-stumpage program, which was administered through Forest Renewal BC (FRBC). Because FRBC was not effectively independent from the provincial government, a portion of its finances were transferred to general revenues and used to help pay off the provincial deficit. This has been a perennial issue for governments, where despite previous commitments financial exigencies can lead governments to redirect funds towards general revenues or other purposes.

One way to address this is through having funding for adaptation projects held and administered by an independent, third party organization. In BC, such an organization could be governed by a board of directors (representatives from MFLNRO and licensees, including holders of First Nations Woodland Licenses and Community Forest Operations). The board of directors must have the ability to approve proposals and allocate funding to projects as it sees fit.

One option could be establishment of co-operatives at the management unit (e.g. TSA) level that would manage and allocate funding for adaptation projects. Funds levied through a program, such as the hypothetical stumpage levy described in this case study, could be collected and reside in the management unit from which they were collected and audited annually. Internalizing funding may help to address administrative issues that plagued previous programs (e.g. Super Stumpage) and promote continuity of adaptation programs.

Dedicated, long-term program. MFLNRO's Forests for Tomorrow (FFT) program is its longest-running program for investment in long-term forest productivity. While finances allocated by the provincial government, via the Treasury Board, are not sufficient to meet all needs for government investment across the land-base, the program does offer a model for investing in the long-term productivity of uneconomic stands that have suffered climate-related impacts due to Mountain Pine Beetle.

Conversely, the FRBC model was ineffective because it was discontinued due to funding cuts when the provincial government entered a deficit. In order to gain the support of licensees for a new program, it is necessary to provide assurance that the program will be supported by committed government funding for a minimum fixed period of time. This type of commitment is difficult for government to provide because of elections, changes in the political climate and external economic forces that influence government finances, but is necessary to generate significant, long-term results.

One point of government contact for the instrument. Licensees seeking innovative ways to invest in long-term forest productivity have expressed frustration at the difficulty of working with multiple branches of the provincial government (e.g. Timber Pricing, Stewardship, Wildfire Management) to navigate the appraisal system. For example, it is currently possible for licensees to apply for an engineered stumpage estimate to obtain a higher, short-term silviculture allowance for an 18-month period until the new silviculture cost begins to become recognized through the appraisal system. However, because the existing appraisal system was not designed as a tool to support forest stewardship, this type of exception would require input from multiple government branches prior to approval. The engineered estimate is intended to be applied to investments in road development, but is being tested for potential application to additional silviculture costs. The added transaction cost to licensees, in terms of time and effort to demonstrate the need for an engineered estimate, serves as a disincentive for innovative investments on the landbase. By providing one point of contact for licensees who can work internally with other government branches to coordinate effort, new instruments to support climate change adaptation can be implemented with greater ease.

Integration with existing programs and planning processes. Type 4 Silviculture Strategies represent the current stage of evolution of landscape (i.e. TSA) level planning in BC. MFLNRO's WMB is working to integrate its Landscape Fire Planning and Management program into existing forest management programs (e.g. Type 4s, FFT). Ensuring that new, climate-related instruments harmonize and integrate with existing forest management programs can increase their effectiveness. This can be accomplished by updating the funding criteria (e.g. FFT Silviculture Funding Criteria), decision-making tools (e.g. Return on Investment software) and guidance documents for existing programs to align with or encompass priorities of new programs.

Supported by action on private land (e.g. homeowners, municipalities). Provincial government action alone is not sufficient to reduce the risk of wildfires. Provincial efforts must be bolstered using incentives for fire prevention aimed at individuals and municipalities. In BC, this is occurring through the FireSmart program (individuals) and through Community Wildfire Protection Plans (municipal) in order to protect human lives and infrastructure and effectively deploy local resources in the event of a fire. The Strategic Wildfire Prevention Initiative, administered by the Union of BC Municipalities (UBCM), offers funding to local governments in the form of grants to implement proactive wildfire risk reduction (MFLNRO 2014e). The Provincial Fuels Management Working Group (PFMWG), which includes representatives from the UBCM, the MFLNRO Wildfire Management Branch and the First Nations Emergency Services Society, offers guidance for the program. The program has allocated $62 million in funding since 2004, which has supported development of 312 Community Wildfire Protection Plans, 443 prescriptions and 328 Operational Projects.

The Victorian Government has identified their lack of control over private land as a challenge to reducing wildfire across the landscape. Currently, their authority only encompasses activities on public lands, including timber harvesting activities undertaken by VicForests. The Victoria Government provides information about fire risk, based on modelling results, to communities and private land and infrastructure owners; however, there are no incentives or regulations in place to compel these private landowners to reduce their fire risk either individually or collectively. Since the Victorian Government only controls 33% of the total landbase (17% parks, 13% forest, 3% other lands; VicForests 2014), the actions and decisions of private landowners have serious consequences for risks to both private and public forests and lands.

Subject to periodic review. Following implementation, a new instrument for adaptation should be subject to regular, periodic (e.g. five-year) review to assess its effectiveness and identify and address unintended consequences. In BC, Type 4 Silviculture Strategies have been developed in partnership with licensees. Since all commitments made through the Type 4 process are voluntary, MFLNRO will need to monitor and audit impacts on the landbase to identify whether changes to management and silviculture practices have been implemented and their effects.

The current, voluntary arrangement adheres to the prevailing provincial model of professional reliance, rather than strict regulation, which allows professional foresters the discretion to make decisions based on their professional knowledge. The current regulatory framework is built around the *Forest and Range Practices Act* (FRPA), which was implemented in 2004. If the voluntary approach to management agreements such as Type 4 Silviculture Strategies is found to be ineffective, the provincial government could decide to implement regulations under FRPA to mandate action.

Start with fire, move to other climate-related issues. The current status of information and awareness of wildfire issues, impacts and mitigative actions can be applied to other climate change issues (e.g. assisted migration) in the future as more concrete information becomes available. A model for planning and funding adaptation to wildfire can be developed, tested and refined and then applied to other forest-related risks.

In BC, for example, adaptation funds could initially be used to support activities such as creating fire breaks in uneconomic stands. Once the instrument has been tested, evaluated and improved, it could be made to be more broadly applicable to silviculture investments on the landbase that address issues related to pests and maladaptation. Licensees could submit a proposal for funding to the program to invest in actions such as denser plantings and fertilization for a period of 18 months, until such time that the appraisal system recognizes these additional costs.

Conclusions

While awareness of the potential risks of climate change to BC's forests and actions required to mitigate these risks continue to grow, Provincial government representatives and licensees are concerned that a lack of coordinated, multi-stakeholder planning across the land base and a shortfall of provincial government funding for development and implementation of plans will be barriers to action. Fortunately, willingness to explore instruments to support collaborative planning and management exists on the part of both licensees and government representatives. Learning from successes and challenges of previous and existing programs and initiatives offers the opportunity to test new programs to reduce the risk of wildfire under climate change. Wildfire risks present clear, quantifiable risks to both licensees and government, so the benefits of collaboration are more readily apparent to all parties than they may be for other, less well-understood risks associated with pests and maladaptation. Once a successful instrument is implemented, tested and improved, it can be used to encourage cooperation and collaboration to reduce other climate change-related risks to forests at the landscape level.

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Appendix I

Table A2-1. Total estimated value of current stumpage and additional revenue under hypothetical scenarios, by forest management unit (million CAD).[19]

	Current	*Scenario A*		*Scenario B*		*Scenario C*	
Management unit	Total stumpage	Total stumpage	Additional revenue	Total stumpage	Additional revenue	Total stumpage	Additional revenue
Coast	***$96.6***	***$100.1***	***$3.5***	***$100.6***	***$4.0***	***$110.6***	***$14.1***
TFL	**$13.3**	**$14.9**	**$1.7**	**$15.2**	**$1.9**	**$20.**	**$6.7**
Quatsino	$1.2	$1.5	$0.26	$1.6	$0.31	$2.3	$1.1
Tahsis	$1.5	$1.6	$0.15	$1.7	$0.18	$2.1	$0.61
Naka	$1.1	$1.1	$0.04	$1.1	$0.04	$1.2	$0.14
Mission	$0.07	$0.08	$0.01	$0.08	$0.01	$0.11	$0.04
Nimpkish	$0.50	$0.72	$0.21	$0.76	$0.25	$1.4	$0.85
Squamish	$0.08	$0.10	$0.01	$0.10	$0.01	$0.13	$0.04
Haida	$1.9	$2.4	$0.45	$2.4	$0.50	$3.7	$1.8
Fraser-Homathco-Kingcome	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Alberni	$3.7	$3.9	$0.20	$3.9	$0.24	$4.5	$0.80
Cordero-Knight	$0.04	$0.06	$0.02	$0.06	$0.02	$0.12	$0.08
West Coast	$0.70	$0.80	$0.09	$0.80	$0.10	$1.0	$0.35
Duncan Bay	$1.8	$1.9	$0.13	$1.9	$0.13	$2.3	$0.52
Maquinna	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Clayoquot	$0.07	$0.08	$0.01	$.08	$0.01	$0.10	$0.03
Morseby Island	$0.03	$0.06	$0.02	$.06	$0.02	$0.13	$0.10
Haida Gwaii	$0.25	$0.30	$0.05	$0.30	$0.06	$0.46	$0.22
Jordan River	$0.28	$0.30	$0.02	$0.30	$0.02	$0.36	$0.09
WL	**$0.14**	**$0.2**	**$0.08**	**$0.23**	**$0.09**	**$0.47**	**$0.33**
CFA	**$1.5**	**$1.6**	**$0.08**	**$1.6**	**$0.10**	**$1.8**	**$0.32**

[19] Note: Zeroes may appear due to rounding.

Table A2-1 (continued):

	Current	*Scenario A*		*Scenario B*		*Scenario C*	
Management unit	Total stumpage	Total stumpage	Additional revenue	Total stumpage	Additional revenue	Total stumpage	Additional revenue
Coast (continued)							
TSA	**$80.1**	**$81.7**	**$1.6**	**$81.9**	**$1.8**	**$86.5**	**$6.4**
Arrowsmith	$12.3	$12.4	$0.09	$12.4	$0.11	$12.6	$0.37
Fraser	$7.0	$7.3	$0.30	$7.3	$0.32	$8.2	$1.2
Kingcome	$9.7	$9.9	$0.22	$9.9	$0.24	$10.5	$0.89
Mid Coast	$3.6	$3.7	$0.11	$3.7	$0.13	$4.00	$0.46
North Coast	$0.50	$0.50	$0.01	$0.50	$0.02	$0.50	$0.05
Pacific Coast	$17.9	$18.1	$0.16	$18.1	$0.19	$18.6	$0.62
Queen Charlotte	$4.1	$4.2	$0.09	$4.2	$0.10	$4.4	$0.36
Soo	$2.3	$2.4	$0.09	$2.4	$0.10	$2.7	$0.34
Strathcona	$13.3	$13.6	$0.24	$13.6	$0.29	$14.3	$0.96
Sunshine Coast	$9.5	$9.8	$0.28	$9.8	$0.31	$10.6	$1.1
Other	**$1.6**	**$1.7**	**$0.08**	**$1.7**	**$0.10**	**$1.9**	**$0.33**

Table A2-1 (continued):

	Current	*Scenario A*		*Scenario B*		*Scenario C*	
Management unit	Total stumpage	Total stumpage	Additional revenue	Total stumpage	Additional revenue	Total stumpage	Additional revenue
Interior	***$442.4***	***$447.8***	***$5.4***	***$449.6***	***$7.1***	***$464.0***	***$21.5***
TFL	**$40.9**	**$41.8**	**$0.91**	**$42.1**	**$1.2**	**$44.5**	**$3.6**
Port Edward	$0.31	$0.39	$0.08	$0.4	$0.09	$0.62	$0.31
Little Slocan	$0.13	$0.13	$0.00	$0.14	$0.01	$0.14	$0.01
Boundary	$5.0	$5.1	$0.12	$5.1	$0.15	$5.4	$0.48
Spillimacheen	$1.5	$1.5	$0.05	$1.5	$0.05	$1.7	$0.22
Inkaneep	$0.75	$0.75	$0.00	$0.75	$0.00	$0.77	$0.02
Clearwater	$2.1	$2.2	$0.06	$2.2	$0.07	$2.4	$0.25
Arrow Lakes	$3.2	$3.2	$0.09	$3.3	$0.18	$3.5	$0.35
Sinclair	$4.7	$4.8	$0.08	$4.9	$0.15	$5.1	$0.33
Sicamous	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Jamieson Ck	$3.1	$3.2	$0.05	$3.2	$0.06	$3.3	$0.22
Kitimat	$0.39	$0.41	$0.02	$0.43	$0.04	$0.48	$0.09
Chetwynd	$3.1	$3.2	$0.05	$3.2	$0.03	$3.3	$0.22
Okanagan	$0.86	$0.87	$0.01	$0.88	$0.02	$0.91	$0.05
Bowron-Cottonwood	$7.4	$7.5	$0.13	$7.6	$0.19	$7.9	$0.53
Naver	$5.4	$5.5	$0.06	$5.5	$0.08	$5.7	$0.23
Selkirk	$0.60	$0.62	$0.02	$0.62	$0.02	$0.67	$0.07
Goldstream	$0.08	$0.09	$0.01	$.09	$0.01	$0.11	$0.03
Inkaneep	$2.3	$2.3	$0.06	$2.3	$0.04	$2.5	$0.23
WL	**$1.3**	**$1.5**	**$0.24**	**$1.7**	**$.36**	**$2.30**	**$0.94**
CFA	**$1.3**	**$1.5**	**$0.25**	**$1.5**	**$.26**	**$2.30**	**$0.98**

Table A2-1 (continued):

	Current	*Scenario A*		*Scenario B*		*Scenario C*	
Management unit	Total stumpage	Total stumpage	Additional revenue	Total stumpage	Additional revenue	Total stumpage	Additional revenue
Interior (continued)							
TSA	**$398.4**	**$402.4**	**$3.9**	**$403.6**	**$5.2**	**$414.2**	**$15.7**
100 Mile House	$15.9	$16.0	$0.07	$16.0	$0.07	$16.2	$0.29
Arrow	$6.4	$6.5	$0.09	$6.6	$0.20	$6.8	$0.37
Boundary	$10.7	$10.8	$0.14	$10.9	$0.19	$11.3	$0.58
Bulkley	$4.2	$4.4	$0.12	$4.3	$0.08	$4.7	$0.48
Cascadia	$3.2	$3.3	$0.03	$3.3	$0.05	$3.3	$0.12
Cassiar	$0.40	$0.49	$0.09	$0.49	$0.09	$0.77	$0.37
Cranbrook	$13.0	$13.3	$0.29	$13.3	$0.31	$14.1	$1.2
Dawson Creek	$3.8	$3.9	$0.08	$3.9	$0.06	$4.1	$0.31
Fort Nelson	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fort St. John	$5.5	$5.7	$0.21	$5.6	$0.09	$6.3	$0.86
Golden	$5.3	$5.4	$0.11	$5.6	$0.23	$5.8	$0.45
Invermere	$8.3	$8.5	$0.19	$8.6	$0.27	$9.1	$0.77
Kalum	$0.90	$0.95	$0.04	$1.0	$0.06	$1.1	$0.17
Kamloops	$34.7	$35.0	$0.37	$35.3	$0.62	$36.1	$1.5
Kispiox	$1.2	$1.3	$0.04	$1.3	$0.05	$1.4	$0.17
Kootenay Lake	$5.8	$5.9	$0.12	$6.0	$0.22	$6.3	$0.47
Lakes	$11.0	$11.0	$0.02	$11.0	$0.01	$11.0	$0.06
Lillooet	$0.86	$0.90	$0.04	$0.93	$0.07	$1.0	$0.16
MacKenzie	$17.1	$17.2	$0.08	$17.2	$0.10	$17.4	$0.32
Merritt	$34.1	$34.3	$0.26	$34.4	$0.32	$35.1	$1.0
Morice	$21.5	$21.8	$0.26	$21.8	$0.25	$22.5	$1.0
Nass	$0.37	$0.38	$0.01	$0.41	$0.04	$0.42	$0.05
Okanagan	$39.6	$40.2	$0.55	$40.5	$0.89	$41.8	$2.2
Prince George	$111.7	$112.1	$0.41	$112.2	$0.5	$113.3	$1.6
Quesnel	$22.6	$22.7	$0.04	$22.7	$0.05	$22.8	$0.18
Revelstoke	$1.1	$1.2	$0.05	$1.2	$0.10	$1.3	$0.21
Robson Valley	$0.26	$0.27	$0.01	$0.27	$0.01	$0.29	$0.03
Williams Lake	$18.8	$19.0	$0.20	$19.0	$0.22	$19.6	$0.78
Other	**$0.53**	**$0.60**	**$0.07**	**$0.65**	**$0.12**	**$0.79**	**$0.26**

Annex 3. Workshop summaries

Workshop 1 summary

Workshop Date: February 26, 2014, 8:30 am – 4:30 pm

Workshop Location: Arbutus/Queenswood Room, Cadboro Commons Building, University of Victoria

Introduction

We are currently conducting research, funded by Natural Resources Canada, to examine economic instruments for adaptation to climate change in forestry. Economic instruments offer an alternative to command and control approaches: where properly designed, they can provide more efficient and cost-effective ways of meeting environmental objectives. Examples of economic instruments range from financial incentives (e.g. taxes, subsidies), to risk-financing instruments (e.g. insurance), to the provision of information in order to create opportunities for changes in behavior (absent coercion). However, there has been little work done in this area with respect to climate change adaptation. The main purpose of this project is to identify economic instruments that could facilitate adaptation in Canadian forestry by drawing on challenges and opportunities within BC.

Through targeted interviews, workshops, and case studies, the research project will identify economic instruments with potential applications to managing three key risk areas: forest fire, forest health, and ecosystem resilience. The project began in October 2013 and will wrap up in December 2014. To obtain feedback from managers and practitioners in the field of forestry, particularly with respect to potential case studies, a one-day workshop was held at the University of Victoria on February 26th, 2014. The workshop included government representatives, forestry practitioners and climate change experts. Through small and large group discussion, participants provided feedback on the following issues: which instruments show the greatest potential for successful implementation to address issues of i) fire risk, ii) forest health and iii) forest resilience? What could cause these instruments to fail? What characteristics should an economic instrument have to increase its chances of successful implementation and outcomes? And, what issues need to be considered when selecting and designing instruments for adaptation?

The purpose of this document is to summarize the outcomes of the workshop. Bulleted points have been transcribed from the workshop in order to preserve the original language and terminology.

Discussion #1: What specific impacts are you concerned about?

The workshop opened with small group discussions among participants about the specific impacts of climate change that were of greatest concern. Participants were assigned to groups to ensure that a broad range of perspectives (e.g. risk areas, policy, operations, provincial government, licensees) were represented within each group. This discussion helped to frame the issue and set the stage for the subsequent discussions about specific actions that could be taken to mitigate impacts (Discussion #2) and economic instruments that could motivate action (Discussion #4). At the end of the discussion, all participants were asked to 'vote' for the impacts of greatest concern to them. It is important to note that the impacts identified were broad in scope; specific impacts to sub-regional landscapes and temporal variations in impacts were not the focus of this discussion.

Fire

Top Ranked Impacts

- Repeated, catastrophic wildfires and impacts to communities, GDP and timber.
- Impacts on community safety and infrastructure in interface areas.
- Increased severity of wildfires and resulting soil and watershed impacts.

Description of impacts

Public safety

- Regular, large interface fire losses
- Catastrophic impacts to communities
- Ability to conduct hazard reduction

Ecosystem services

- Higher severity and intensity of fire, soil sterilization, soil consumption
- Community watershed's drinking water losses
- Loss of soil productivity, increased erosion potential; roads
- Increased greenhouse gas emissions
- Damage to forests
- Watershed impacts-water quality, quantity, timing
- Air quality impacts (significant fire)
- Increased risk of fire in certain ecosystems
- Increased treatment costs
- Hydrology/natural flood control
- Loss of habitat/reserves
- Recreation/tourism impacts
- Potential for self-regulating landscapes in future (positive)

Private property

- Escalating protection and insurance costs

Timber supply

- Loss of timber
- Investment uncertainty
- Inability to predict future timber supply (i.e. unstable supply)
- Higher intensity and severity of wildfire impacts to production

Social displacement

- Loss of professionals (e.g. Slave Lake)
- Loss of infrastructure to support employment

Forest practices

- Higher risk leads to less silviculture investment
- Higher risk to using fire as a tool

Broader economic impacts (non-timber)

- Economic, Property, Infrastructure (including Hydro transmission, LNG)
- Upward spiraling of suppression costs
- Suppression costs displace budget for other programs
- Impacts to GDP (e.g. impact of wildfires in Northeast BC on LNG development)
- Loss of silviculture investment
- Cascading costs that accumulate, e.g. hydrologic event on top of burned area

Pests

Top Ranked Impacts

- Changes in productivity/susceptibility to pests and impacts to timber supply.
- Challenge of identifying the next big pest problems.

Description of impacts

Exotic species

- Trade barriers/restrictions
- ecological impact
- New pests emerge e.g. DF pole beetle
- Impact on urban forest

Social

- Viewscapes, tourism, recreation
- Public/Worker safety
- Less social license to control pests

Economic

- Pest-driven increases to costs of forest management
- Young stand plantation failure

Planning

- Challenge of identifying the next big pest

Ecosystem dynamics

- New conditions for currently innocuous species
- New range for old pests
- Asynchrony between hosts and insects
- Unknown natural controls, or lack thereof
- Genetic change in pests associated w new environmental conditions

Indirect impacts

- Slope stability
- Cumulative effects; more dead trees affect change to wildfire
- People and jobs (community health, economics, tied to forest health)

Maladaptation

Top Ranked Impacts

- Impacts on future harvesting and economic opportunities.
- Reduced resilience, reduced ecosystem services.

Description of impacts

Timber supply

- Assumptions or expectations about future growth/survival not met.
- Loss of productivity, reduced AAC Mortality due to extreme events, e.g. drought
- Decreased fibre quality (less saw logs)

Decision-making

- Decisions that work now don't work for future
- Choosing best response to single best guess of the future might be catastrophic (or will work)
- Young stands aren't growing as predicted based on historical models

Economic

- Loss of cone/flower production
- Loss of product value
- High discount rates favour investment with rapid payback; therefore we are maladapted
- Increased liability/NSR (Who pays?)

Ecological

- Loss of keystone species - ripples through ecosystem
- Invasives increase presence

Indirect impacts

- Greater impact and susceptibility to pests
- Reduction in tolerance
- Hot, dry forest range at edge; ecosystem change to grass

Discussion #2: What specific actions could be taken to reduce risks?

This discussion moved from impacts to actions: participants identified actions which could help to mitigate the top ranked impacts that had been previously identified. At the end of the discussion, once again, all participants voted for the impacts of greatest concern to them.

Fire

Top Ranked Actions

- Incorporate fuel and fire management into stocking standards.
- Increase the use of predictive tools, identify priorities; better climate and risk modelling.
- Design stand traits to address fire and hazard potential.
- Strategic harvest planning for fire breaks.
- Fuel management (e.g. reduction, hardwood introduction).
- Collaborative planning to identify high value and high risk areas.

Description of actions

Planning

- Wildfire resistant landscape planning with targets and monitoring requirements
- Identify highest risk priority areas for treatment
- Collaborative planning to ID high value and risk areas
- Better climate risk modeling
- Goal: self-regulating landscape
- Use CC lens in fire risk and consequence modeling
- Identify time frames for discounting in cost-benefit analysis

Insurance

- Tie fire risk assessment to insurance rate

Governance

- Coordinate levels of government
- Disaster response plan
- Community preparedness assessment
- Change the economics of fuel reduction

WUI practices

- Increase treatment funding for fuel break treatments
- Introduce hardwoods
- Develop/support biomass initiatives to use dead timber around communities
- FireSmart development by-laws
- Avoid development in at risk locations

Practices

- Appraisal system changes to encourage other harvest patterns
- Clearcut or partial cut "fireproofing"
- Manage pests to avoid creating more fuel

Hydrological

- Flood plain management and mapping risk areas

Education

- Encourage individuals and communities to deal with interface issues/risks
- Public education (penalties/fines)

Pests

Top Ranked Actions

- Monitoring to know what is coming.
- Early detection, early response.
- Research ecological amplitude of species based on possible ranges to predict pest responses to climate change.
- Scenario planning – prepare for what could occur and how to respond.
- Make the regulatory response system more flexible.
- Manage at the landscape level for a mosaic of species and age to reduce susceptibility.

Description of actions

Monitoring/Research

- Better inventory/planning
- Better monitoring post-Free Growing
- Partner with university/college
- Research species traits, genetics
- ID long term natural range of variability
- Want flexible response even to small outbreaks

Planning

- Recognize uncertainty- manage for ecosystem resilience/risk
- Better forecasting/prediction - risk analysis
- FH committees, improve communication
- Harvest highest risk first, prioritize: economic incentive for "low value" stands
- Volume incentive vs economic i.e. out of AAC, incentivise through extension of terms of license

Economic

- Opportunistic economy (flexible mills)
- Increase tools/tech to deal with dead wood

Regulations

- Change FRPA objectives to account for forest health risks
- Free-growing standards
- "Zero-based regeneration": didn't look at past, create new system
- Review OGMA and related requirements re: pest habitat
- TSA structure- collective: part of license operating budget for surveys, insurance policies?, Sec. 57 of IFPA- AAC up, carbon project if voluntary
- Make regulatory response system more flexible
- Higher utilization of waste

Treatments

- Promotion of forest health treatments to protect Midterm timber supply
- Biological control

Practices

- Use genetically resistant stock
- Prescribed fire
- Shorter rotation
- Surveillance re: invasives e.g. Control transport of pests

Maladaptation

Top Ranked Actions

- Conduct operational trials (e.g. seedlots, species).
- Share the risk between government and industry, allow for failure in a structured manner.
- Match genetics of planted forests to new climates.
- Look at landscape level threats.
- Ensure diversity at the stand and landscape level, acknowledge costs related to productivity and profit.

Description of actions

Planning

- Diversity (stand/landscape), acknowledge costs re: productivity and profit
- Determine which ecosystem services to manage for (e.g. water, timber, air, recreation)

Monitoring

- Monitor! Understand keystone species and "tipping point" for ecosystems, monitor and manage keystone
- Measure change in growth and yield (ecosystem change)

Research

- Match genetics of planted forest to new climate (and species)
- Industry and government operational trials: seedlots and species (take risks)
- Adaptive management: integrate research with operations (up research, up education/extension of information)
- Improve estimates of impacts

Economic

- ID markets for species that would be more productive
- Build more explicitly into 'certification' schemes

Practices

- "Manage" pest impacts through competitive exclusion, fungal competition, genetic resistance, cover crops
- Silviculture activities that increase resilience (e.g. Thinning to reduce moisture competition)
- Fund enhanced basic silviculture (increased density, species diversity). Fund with increase in stumpage)

Regulations

- Share the risk (government and industry), Allow failure in a structured manner
- Climate based stocking standards
- Climate-based seed transfer guidelines

Conservation

- Conservation measures for high risk populations and genetics

Communication

- Ensure latest information is communicated in Timber Supply Area Forest Health strategies
- Need social license, Educate/inform public/communities of importance of issues and actions

Discussion #3: What would make an instrument fail or succeed?

A brief presentation was made to introduce the concept of economic instruments in advance of this discussion. Participants then discussed potential economic instruments to motivate the actions identified in Discussion #2. Once each group had agreed on one economic instrument they felt could be suitable, participants were asked to consider and identify characteristics of economic instruments that could make them i) failures; or ii) successes.

Potential reasons for failure

- Under-funded
- Unequal application
- Overly complex, misunderstood
- Social pushback
- Political, industry pushback
- Not bold enough; too little, too late
- Unintended consequences
- Doesn't meet objectives
- No incentive for those who do the work
- Market saturation, transformation
- Not ground-truthed
- Lack of flexibility
- Poor cost-effectiveness (compared to alternative)
- Poor communication (e.g. Implementation of HST)

Potential reasons for success

- Endorsement by various parties
- Designed by everybody
- Fit within supply chain, not disruptive
- Majority acceptance
- Meet objectives; get desired results
- Communicate awareness
- Effect on core business
- Have a worse alternative
- Good timing for acceptance
- Intermediate steps to measure intermediate success
- Long-term commitment of leadership
- Easily understood
- Common understanding of costs + benefits and shared responsibility
- Clear rewards
- Consistency with other arrangements
- Takes advantage of existing frameworks

These characteristics were assessed and categorized after the workshop and compared to criteria for economic instruments that were previously identified during a literature review. This served to ground-truth the criteria; these criteria will be used to evaluate and compare the economic instruments selected for the case study during the forthcoming phase of the project.

Criteria

Adaptive	Incorporate planned and periodic evaluation and changes
Equitable	Consider and mitigate distributional impacts
Effective	Be able to meet objectives
Efficient	Achieve outputs optimally relative to resources allocated
Flexible	Address both incremental and transformative changes
Gradual	Include a transition period
Harmonized	Be consistent with other legislation, standards, policies and reporting requirements
Legitimate	Be politically, culturally and socially acceptable
Practical	Be plausible given technological, social and economic constraints and relevant timescales
Robust	Be applicable under a range of future climate projections
Risk-based	Be able to address uncertainty
Results-based	Have measurable outcomes, based on professional reliance
Science-based	Be based on high-quality scientific knowledge
Synergistic	Offer co-benefits, considers and addresses unintended consequences
Scalable	Operate at local, regional or provincial scales
Transformative	Forward looking, anticipates changes and scenarios
Transparent	Offer a clear set of rules and processes

Participants were then asked to turn their attention back to their small groups to further develop their concept for an economic instrument, bearing in mind these criteria.

Discussion #4: Candidate Case Study Instruments

During the final discussion of the workshop, each small group of participants presented a potential economic instrument that could motivate adaptation to climate change in forestry within B.C. Two potential economic instruments were identified for each risk area as follows.

Risk Area	Instrument	Details
Fire	New "fire break" tenures for the wildland urban interface	• Remove reforestation obligation • Maintain fire breaks in perpetuity • Support integrated resource mgmt • Offer wood off quota
Fire	Manage development interface through tiered insurance/development charges	• Landscape level fuel reduction within zones of high risk and consequence • Reduced reforestation obligations • Special cost allowances in appraisal system • If zones are not receiving attention required they are eliminated from the AAC
Pests	Link harvest opportunities to risk reduction	• Area-based planning • Clear timber objectives and provincial standards • Incentive to participate because you get to define the plan • Volume incentives • Dollars to implement plans or treatments
Pests	Trust fund for forest health monitoring network	• Minimum stumpage increase to $1/m^3$ • Recognition of funding requirements similar to the vote on fire suppression • Implement tax credit
Maladaptation	Long-term R&D for climate-based seed transfer	• Incentives for research • Cost-neutral • Establish operational trials • Build a silviculture cost estimate into the appraisal system followed up with free-growing relief • Alternative seed policy
Maladaptation	Climate change knowledge base to support practitioners	• Increase resilience and match genetics to ecosystems • Provide better information at two levels: TSR and operational levels • Offer map of changing ecosystems over time

Participants then voted for the instrument they felt was the most interesting to them and that they would like to learn more about. The concept of a trust fund for forest health monitoring network was a clear favourite. The idea of area-based planning and management among multiple stakeholders arose several times during the workshop.

These potential instruments, as well as those identified in the interview summary and literature review, will be reviewed by the project team as potential case studies during the subsequent phase of the research.

Thank you to all workshop participants for your time and commitment!

We will continue to keep you updated as the project progresses.

Workshop 2 summary

Workshop date: November 19, 2014, 8:30 am – 3:00 pm

Workshop location: Meeting Room, Pacific Forestry Centre, 506 Burnside Rd. W, Saanich, BC

Introduction

This project, funded by Natural Resources Canada, is focused on identifying the potential role of economic instruments to support adaptation to climate change in forestry. Economic instruments offer an alternative to command and control approaches: where properly designed, they can provide more efficient and cost-effective ways of meeting environmental objectives. Examples of economic instruments range from financial incentives (e.g. taxes, subsidies), to risk-financing instruments (e.g. insurance), to the provision of information in order to create opportunities for changes in behavior (absent coercion). However, there has been little work done in this area with respect to climate change adaptation. The main purpose of this project is to identify economic instruments that could facilitate adaptation in Canadian forestry by drawing on challenges and opportunities within BC.

Through targeted interviews, workshops, and case studies, the project has identified economic instruments with potential applications to managing three key risk areas: forest fire, forest health, and ecosystem resilience.

Phase 1 (October 2013-February 2014) included i) a review of existing economic instruments that are currently being used in forestry, agriculture and other land use; and ii) a interviews with forestry practitioners about their perspectives on climate change-related risks to forests in BC and existing instruments to support adaptation. A one-day workshop was organized at the University of Victoria on February 26th, 2014 to review the results of the Phase 1 research and identify case study instruments of interest for further investigation during Phase 2.

Phase 2 (March 2014-December 2014) focused on case studies of three types of economic instruments: Development Permit Systems, Cost-Benefit Analysis of Climate-Based Seed Transfer and instruments to support collaborative planning and management for wildfire. A second workshop was organized at the Pacific Forestry Centre on November 19, 2014 to review the case studies and identify potential challenges and solutions for implementation. More than 40 government representatives, forestry practitioners and climate change experts participated in small and large group discussions and provided feedback on the following issues: What are the challenges that you foresee if this instrument was to be implemented in BC? How could these challenges be addressed? What would be the key features of this instrument? What would need to happen next to implement this instrument? What are the steps required? Who could help us? Who could be affected? How do we get them on board?

The purpose of this document is to summarize the outcomes of the workshop. Bulleted points have been transcribed from the workshop in order to preserve the original language and terminology.

Discussion #1: What are the challenges that you foresee if this instrument was to be implemented in BC?

The workshop opened with a brief overview of the challenges presented by climate change for BC's forests and the role of economic instruments in addressing these challenges, followed by brief presentations highlighting the findings from each of the case studies. These presentations were offered to frame the small and large group discussions for the day ahead.

Following the presentations, participants were asked to self-organize into small groups (i.e. 5-6 people) to focus on one particular case study. One group focused on Development Permit Systems, three on Cost-Benefit Analysis for Climate-Based Seed Transfer and two on collaborative planning and management for wildfire. Participants were then asked to generate a list of all the challenges that they could foresee with implementing their instrument of interest. This discussion was intended to help the researchers identify barriers to implementation that they maybe not have anticipated, explore possible solutions (Discussion #2) and develop an action plan for implementation (Discussion #3). At the end of the discussion, each of the groups presented a summary of their discussion to the broader group in plenary.

Development Permit Systems

Challenges

Cost

- Only feasible for new developments.
- No funding for fuel treatments on private land or other incentives.
- Costly for a homeowner or developer to implement FireSmart; more acceptable in high-value areas than in rural areas.
- However, protecting private property is not the role of government.

Priority

- Local government has other issues such as flooding to deal with as well.

Scale

- Doesn't address landscape-level issues.

Relative impact

- Greater impact achieved through the Strategic Wildfire Prevention Program.

Mandatory vs. voluntary

- Promoting development permits as voluntary would be preferable.

Cost-Benefit Analysis for Climate-Based Seed Transfer

Challenges

Monitoring and information

- Lack of monitoring and information about plantation failures and provenance performance.
- Reporting requirements may be inadequate for monitoring.
- The RESULTS reporting system does not collect data about plantation failure.
- Young stand monitoring is province-level; not adequate for site-level monitoring.
- Would need regular monitoring and guidelines to identify what is acceptable.

Uncertainty

- Lack of understanding about probabilities of plantation failure and how plantation failure is measured and attributed to CBST versus other causes.
- Difficult to prove that failure is due to seed; however, plantation failure due solely to genetics is unlikely.

Risk

- Lack of a defined timeframe or framework for risk-sharing between licensees and government.
- Need to identify who bears the risk of plantation failure if licensees adopt CBST.
- How is risk quantified? When (e.g. # years) is risk transferred to government?
- Risk belongs with the government; how would licensees be compensated for losses associated with risks taken?
- Risk will be different based on species, climate, type, etc.
- Licensees would bear risk for potential public good; incentives are not well-aligned for uptake.

Consistency

- Need to align Stocking Standards, Forest Stewardship Plans and Seed Transfer Guidelines

Collaborative planning and management for wildfire

Challenges

Cost

- The forest sector is expected to pay for the full cost of adaptation, but there are beneficiaries outside the forest sector.
- Everyone benefits, so everyone should share the cost of reducing wildfire risk.
- Needs to be multi-party and multi-agency and across the landbase.
- Must be more comprehensive and inclusive than DFAM.
- Need to share expertise and knowledge and get different sectors to participate.
- Contributing funding to adaptation can help to build accountability, trust and assurance.

Scope

- This is much bigger than wildfire.
- Wildfire planning is one piece of landscape planning; the scope may need to be broader.
- Identify other planning opportunities to avoid creating another silo.

Incentive to adapt

- The levy itself would not provide an incentive to adapt; need both funding and an incentive to participate.

Scale

- What scale (e.g. provincial, TSA, stand) is appropriate for planning? The risk level may differ by scale, with implications for funding, planning, etc.
- Need to plan at all scales and ensure plans flow together.
- Make sure there are harmonized provincial and regional objectives.
- Must be regionally sensitive.

Priorities

- Who decides which projects are funded and on what basis?
- Actions need to have scientific basis.
- The longer this sits out there and the gap exists, the deeper it gets.

Discussion #2: How could these challenges be addressed?

This discussion moved from challenges to solutions: participants were asked to select one or two challenges from the list generated during Discussion #1 and identify potential solutions. At the end of the discussion, once again, all participants reported the highlights of their discussion back to the broader group in plenary.

Development Permit Systems

Challenge

Cost

- No funding for fuel treatments on private land or other incentives.
- Costly for a homeowner or developer to implement FireSmart; more acceptable in high-value areas than in rural areas.

Solutions

Cost reductions

- Offer reduced home insurance rates when FireSmart recommendations are implemented.
- Create free tipping days for free local collection of branches, leaves, etc.
- Focus communications to get new or existing materials into home building centres (e.g. brochure with techniques to reduce wildfire threat at each scale).
- Engage local governments in discussion.
- Stay connected, look for resources.
- Allocate a percentage of annual fire operations budget for fire prevention.

Cost-Benefit Analysis for Climate-Based Seed Transfer

Challenge

Monitoring and information

- Lack of monitoring and information about plantation failures and provenance performance.
- Reporting requirements may be inadequate for monitoring.
- The RESULTS reporting system does not collect data about plantation failure.
- Young stand monitoring is province-level; not adequate for site-level monitoring.
- Would need regular monitoring and guidelines to identify what is acceptable.

Uncertainty

- Lack of understanding about probabilities of plantation failure and how plantation failure is measured and attributed to CBST versus other causes.

Risk

- Lack of a defined timeframe or framework for risk-sharing between licensees and government.
- Need to identify who bears the risk of plantation failure if licensees adopt CBST.
- How is risk quantified? When (e.g. # years) is risk transferred to government?
- Risk belongs with the government; how would licensees be compensated for losses associated with risks taken?
- Existing framework impedes people from doing something different.

Solutions

Improve monitoring

- Update RESULTS reporting system to monitor plantation failure.
- Enhance young stand monitoring.
- Explore LIDAR and remote sensing to monitor plantation performance.
- Collect and share information about provenance trials.
- Conduct risk scenario planning.
- Clarify scope of innovation for Stand Development Monitoring.
- Develop a formal risk-sharing agreement between Decision Makers and licensees to ensure equal treatment.
- Waive free-growing obligations if a licensee follows government guidance.
- Show that risk belongs to government.

Champion within leadership

- Need high-level leadership within the provincial government.
- Define outcomes and conduct retrospective analysis to identify regeneration or plantation failure.

Risk-sharing

- If plantation failure increases, the Stumpage system will eventually recognize increased silviculture costs over time. Need a bridging mechanism to offset cost in the interim (e.g. specified operations or engineered estimate).
- Favour a regime-based costing approach.
- Implement standards and use professional reliance to create wholesale change. Require that licensees specify strategies to address climate change and offer guidance for preparers and approvers of those plans.
- Maintain long-term CBST field trials and check in with BCTS and licensees: create a feedback loop to provide greater certainty and adjust incrementally.

Collaborative planning and management for wildfire

Challenge

Cost

- The forest sector is expected to pay for the full cost of adaptation, but there are beneficiaries outside the forest sector.
- Everyone benefits, so everyone should share the cost of reducing wildfire risk.
- Needs to be multi-party and multi-agency and across the landbase.
- Must be more comprehensive and inclusive than DFAM.
- Need to share expertise and knowledge and get different sectors to participate.
- Contributing funding to adaptation can help to build accountability, trust and assurance.

Solutions

Broader funding using tax revenue

- Focus across the landbase and on all sectors (i.e. not just on forestry).
- The whole province benefits, so look at the potential to use tax revenue to fund.
- Could look at forest carbon opportunities to generate funding.
- Planning and action needs to occur at the local level, so funds should be controlled and disbursed locally.
- Make Land Use Plans more flexible.
- Work with Community Forests as implementers.
- Develop planning and implementation pilot projects at the TSA level.
- Gain government support for broader collaborative planning by using the potential cost of wildfire to build a business case based on pilots.
- Address collaboration by targeting the highest risk areas (e.g. those around communities) first to gain support.

Discussion #3: Next steps

- What would be the key features of this instrument?
- What would need to happen next to implement this instrument?
- What are the steps required?
- Who could help us?
- Who could be affected? How could we get them on board?

Development Permit Systems

- The existing Strategic Wildfire Prevention Initiative is the best tool for local government; this includes community wildfire management plans.
- Development Permits could be useful to contain community boundaries (e.g. prevent expansion into the interface). Contain the regional growth strategy to prevent development into the WUI. A good example lies with the work done on earthquakes for cost and damage.
- Science needs to inform best practices: have an independent body validate the FireSmart recommendations. Link this to localized climate change information and tie to cost-benefit analysis for treatment or construction options.
- Could extend information to decision-makers about risks included in FireSmart program.
- Existing tax on fire insurance should be separated from general revenue and used to address the fire risk issue.
- Need clear identification of who bears the costs and risks.
- The key feature is collaborative partnerships in developing the system.
- DPs must not be presented as downloading from the provincial government to local governments.
- Must be voluntary rather than mandatory to allow autonomy. Provide a sample of best practices to make it easy for governments to tailor them.

Cost-Benefit Analysis for Climate-Based Seed Transfer

- Need a common understanding of the uncertainties and the knowledge base.
- Need equitability to ensure that people who are taking on risks are benefitting.
- Need many elements that are safe to failure. Have several instruments at play to implement the plan.
- Shift silviculture obligations: licensees are responsible for late rotation, government is responsible for early rotation.
- Reduce silviculture obligation on licensees who implement CBST.
- Stand monitoring is a big gap: need to be able to pinpoint where plantation failures are occurring and what provenances are being affected.

Collaborative planning and management for wildfire

- Rather than looking for new funding, reallocate existing resources based on priority. We have all the resources and funding available in government to do this, we just need to reprioritize.
- Take small steps first (e.g. pilots for landscape level planning and implementation of actions).
- Initial scope needs to focus on wildfire.
- Need to identify a logical landscape planning unit that is not too big and not too small, then bring in relevant participants. District level seems to be most logical.
- Build a framework; it's not feasible to launch a broad landscape planning project. Use a phased approach. Phase 1 would be at the District level: get a position assigned for planning and coordinating stewardship with the relevant clients (e.g. forests, water, land, habitat, ecosystem restoration). Then scale it up to include broader communities and stakeholders.
- Ideally, the framework could adapt to include non-government people (e.g. community) who could take the lead.
- Could be some push-back from the District manager; would need to work with them to gain support.

Thank you to all workshop participants for your time and commitment!

We appreciate your effort and support with this research.