

Appendix 1: Climate Change Task Team - Terms of Reference

Type: Advisory

Chair: Brian Barber, Technical Advisor, Tree Improvement Branch

Responsible/Reporting out through:

Executive Sponsor: Henry Benskin, A/Deputy Chief Forester, on behalf of Jim Snetsinger, Chief Forester, and Forest Stewardship Division Management Team.

Purpose:

To advise the chief forester on the how the MoFR should strategically position itself in response to the impacts of climate change (CC) on the province's forest and range resources. This advice will be based on assessments of the short- and long-term options for addressing the impacts of climate change (CC) and identification of opportunities for the MoFR to contribute to provincial and national climate change goals.

Scope:

1. Identify and summarize the existing knowledge of the potential impacts of climate change on BC's forest and range resources, and key vulnerabilities and opportunities for these sectors.
2. In consultation with other MoFR staff, other government agencies, industry and academia identify:
 - key knowledge gaps and climate change adaptation options that could be implemented in the near-term, and assess their related policy barriers & opportunities, and resource & funding requirements.
 - CC adaptation options that could be explored over the longer-term, key knowledge gaps with respect to these options, and opportunities for addressing these gaps.
3. Identify action items in *Weather, Climate and the Future; BC's Plan* of relevance to the MoFR, develop recommendations for addressing them and reporting progress.
4. Develop a communication and extension strategy for raising awareness of climate change impacts, mitigation measures, and adaptation options within the division, ministry, and our clientele.
5. Maintain a close working relationship with MoE's Climate Change Section, which is responsible for the provincial government's overall climate change policies.
6. Establish linkages within the ministry, the forest sector, organizations involved in climate change adaptation research (e.g. CFS, C-CAIRN), and with other provincial and national forest sector organizations with an interest in climate change adaptation policy.
7. Ensure that MoFR interests are represented, where appropriate, in provincial and national adaptation policy initiatives, and apprise the chief forester of matters of interest or concern to the ministry.
8. Identify potential mitigation measures that the MoFR could implement to reduce greenhouse gas emissions that contribute to CC.

Appendix 2: MoFR Linkages with Federal and Provincial Climate Change Committees and Initiatives

Level of Initiative	Topic/Organization	Description	MoFR Lead	Involvement	Collaborators
National	National Forests Sinks Committee	Examining Article 3.4 Kyoto Protocol on carbon sinks/credits. Part of Canada's National Implementation Strategy on Climate Change.	D. Draper (D. Spittlehouse)	BC Government Representative on Committee. Prepare recommendations for minister's decision.	Federal Govt, Provinces, Territories <i>Also see</i> Fed Action Plan , IPCC , and Kyoto
	C-CAIRN Canadian Impacts and Adaptation Research Network – Forest Sector	Organization to promote and facilitate the sustainable management of Canada's forests under a changing climate	D. Spittlehouse P. Tschaplinski also Connected to C-CAIRN fisheries.	Member, Advisory Committee	NRCan
	BIOCAP	Not-for-profit research foundation. Promoting development and use of bio-energy and bio-products.	D. Draper	Board of Directors	Federal and provincial governments and industry
	Canadian Centre for Climate Change Modelling and Analysis and Canadian Institute for Climate Studies	Global atmospheric general circulation model, and analysis. Located at UVic. Links to Regional climate change model network . Provincial climate change scenarios. Latter promoting research "consortium"	D. Spittlehouse		MoE, NRCan Currently
Provincial	Deputy Minister's Climate Change Committee See BC's Plan: Weather Climate and the Future .	High level government action plan to reduce vulnerability, reduce emissions and increase energy efficiency. Includes strategies for carbon, MPB, and fire mgmt.	H. Benskin (D. Draper)	Development of strategies, plans to achieve action	Thiessen, L (MoE) MSBED, MEM, MSRM
	Carbon Management Project	BC analysis of Canada's potential ratification of Article 3.4 Kyoto Protocol technical issues (FM definition, A/R, carbon sinks and credits).	D. Draper	BC Government Representative	Federal Gov't, CFS, Provinces, CCCma
	Interagency climate change committee	Lead by WAP to promote communication between policy staff within BC government.	B. Barber D. Spittlehouse	Participation	J. Fraser (MoE), with connections to feds and provinces.
	BC Biorefining Initiative		H. Benskin		Larson, J. (MEM) Langridge, J (RTEB)

Preparing for Climate Change – Ministry of Forests and Range

Level of Initiative	Topic/Organization	Description	MoFR Lead	Involvement	Collaborators
	BC Bioproducts	Gov't-industry group promoting use of bioproducts – feedstocks, fuel and industrial products. Linked to BioProducts Canada , (sponsored by Industry Canada)	H. Benskin J. Langridge	Participate as required.	Hallman, R, (MAFF) BioProducts Canada Industry Canada,
	Royal Provincial Museum	Climate Change Display Richard Hebda	D. Spittlehouse M. Eng	Input/advice	

Appendix 3: Current MoFR Climate Change Related Projects, Research and Initiatives

Branch/Office	Topic	Description	MoFR Lead	Deliverables	Initiate	Complete	Collaborators
MoFR	Mtn Pine Beetle 2005 Action Plan	Provincial response to the MPB infestation.	R. Schultz, R. Deboise	Several objectives. See: http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/#action	On-going		Feds, Industry, Communities, FNs, Others
Forest Stewardship Division	Future Forests Ecosystem of BC Initiative	Exploration of opportunities to adjust approaches to forest management in response to rapidly changing conditions in our forest ecosystems	J. Snetsinger K. Weese	Report on options, recommendations http://www.for.gov.bc.ca/hts/Future_Forests/	Dec 05	May 06	Various
Forest Practices Branch	Species Selection	Committee reviewing species selection in MPB impacted areas	P. Martin	Recommendations on policy options http://www.for.gov.bc.ca/hfp/ft/species/index.htm	May 2005	Nov 7, 05	TIB, Res.Br, Ops Div
Research	Forest genetics and seed transfer	Impacts of climate change on pine productivity using transfer curves	G. O'Neill	Using transfer curves, estimate and map changes to pine productivity for three future decades			Hamann, U of Alberta
		Impacts of climate change on pine productivity using population response functions	T. Wang, UBC	a) Using population response functions, estimate and map changes to pine productivity for three future decades; b) estimate how facilitated migration of seed may mitigate some of the negative impacts to productivity.			Greg O'Neill, Alvin Yanchuk, Sally Aitken and Andreas Hamann
		Seed Transfer Systems	G. O'Neill	Explore alternative seed transfer systems and examine their advantages and disadvantages in terms of productivity, accuracy, risk, ability to accommodate a changing climate, and ease of implementation and use.			
		Climate-based Seed Transfer Impact Calculator (STIC)	G. O'Neill	Objective: to make the STICs more accurate and sensitive to transfers involving precipitation, and to allow productivity of any seedlot to be predicted for future climates, the current STICs will be converted from a geographic-base to a climate-base			Tongli Wang, UBC

Preparing for Climate Change – Ministry of Forests and Range

Branch/Office	Topic	Description	MoFR Lead	Deliverables	Initiate	Complete	Collaborators
		Sx genecology/climate change trials	O'Neill	Objective: to establish long-term genetic field trials of wide-ranging Sx provenances tested at wide-ranging sites. Data from these trials is fundamental for all seed transfer/climate change studies			Alvin Yanchuk, Barry Jaquish
		The role of climate change in Dothistroma infections	A. Woods	Objective: Using data from 25 Pli provenance test in northern BC, assess the role of site climate, provenance, seed transfer and climate change in recent Dothistroma infections			Greg O'Neill
		Pli provenance test remeasurement	G. O'Neill	Objective: to measure growth and wood quality traits in the 32-year-old Pli provenance tests			Michael Carlson, John Murphy, Alvin Yanchuk
		Role of seed transfer and climate change on Pli value	G. O'Neill	Objective: to use recent provenance data to develop transfer curves that will assist in estimating the effect of seed transfer and climate change on both volume and value of Pli			
	Biogeoclimatic zones	Modeling climate envelopes and BGC changes	D. Meidinger D. Spittlehouse	Updating BEC Zones	TBD		A. Hamann , T Wang - UBC
	Climate and air quality	General research and extension	D. Spittlehouse		On-going		MoE
	Adaptation and Forest Management	Adapting forest management to the impacts of climate change in Canada	D. Spittlehouse	Recent article in Forestry Chronicle Sept/Oct 2005 – also involved in BioCap funded project in collaboration lead by Mark Johnson, Sask. Res. Council.	Sept 05		Tim Williamson,(CFS) David Price(CFS), Adam Wellstead (CFS), Paul Gray (MNR), an Dan Scott (U. Waterloo)
	Growth and Yield	Climate change impacts on conifer productivity	G. Nigh		On-going		
Tree Improvement	Reforestation – policy	MA thesis on reforestation strategies for adapting BC's forests to climate change: Policy barriers and opportunities.	B. Barber	MA thesis & recommendations to MoFR	May 05	Aug 06	RRU
Forest Analysis	Timber supply analysis and risk assessment	Assessment of potential impact of climate change on forest resources, both timber and non-timber.	C. Fletcher, G. Lawrence	Inform policies and strategies	TBD		
Region	Forest Health	Dothistroma and climate change	A. Woods	Article in Bioscience, 2005.	2005		D. Coates, A. Hamann

Appendix 4: Possible Climate Change Impacts on Commercial Tree Species in British Columbia

The following predictions of tree species vulnerability to the indirect impacts of climate change on forest insect and diseases are based on the collective knowledge of the regional forest health staff of the Ministry of Forest and Range. This list is not complete. It is an attempt to address some of the more likely scenarios. In a few cases there is published scientific evidence that supports these predictions (e.g. Carroll et al. 2004, MacLachlan et al. 2006, Woods et al. 2005). For the majority of the relationships we must rely on educated guesses. All of these predictions follow the basic premise that short-lived insects and pests will likely be able to adapt more quickly to a rapidly changing environment than their long-lived hosts. Host tree species that are not as well adapted to sites as a result of a rapidly changing climate will be under greater stress and thus more susceptible to pests.

Lodgepole pine:

- Mountain pine beetle (MPB) is already attacking and killing trees as much as 60 years younger than what was previously thought possible,
- Warrens root collar weevil is already killing young lodgepole pine at significantly higher rates as a result of MPB killing most of the mature pine across the interior landscape,
- Changing pathosystems for western gall rust (DSG) and comandra blister rust (DSC) with possibility of increasing frequency of wave years with higher than normal spring and early summer precipitation. This phenomenon already appears to be happening in the central interior. Behaviour of pathogens that we thought we understood now changing, e.g., high risk period for rusts extending, so that pine stands are no longer safe after age 15,
- Atropellis canker benefiting from increased summer moisture higher incidence and severity of attack
- Dothistroma needle blight and other foliar diseases of lodgepole pine are on the increase in areas of the province that have been experiencing increased summer precipitation.

Douglas-fir:

- Growing season frosts in the Montaine Spruce (MS) and Sub Boreal Spruce (SBS) biogeoclimatic zones has historically been one of the range limiting factors for this species. Under climate change perhaps Douglas-fir will be able to replace or at least supplement lodgepole pine in SBS plantations as the latter species suffers increasingly from pests under climate change.
- Spruce budworm and other insect defoliators could be a bigger problem further north in the province if Douglas-fir was deployed to a greater extent.

- Spruce budworm incidence and severity of attack is already higher than the historical norm.
- Armillaria and Laminated root diseases could and probably will move north under CC. These pathogens will also cause greater damage in areas experiencing drought as trees will be stressed and more susceptible to disease.
- Foliar pathogens could be more of a concern in future under climate change in areas that experience increased summer precipitation.
- Douglas-fir will be drought stressed in drier ecosystems (summer drought), which can lead to bark beetle attack and mortality (stressed fir is both more attractive and less resistant to bark beetles) - this in turn will lead to ecosystem.

Western hemlock:

- Conditions for western hemlock should improve throughout current SBS under CC.
- Western hemlock is not drought-resistant but if mean summer precipitation will increase as most recent decade indicates in the northern SBS zone then this species could be deployed more extensively.
- Western hemlock within drier variants (and on shallow soils) within CWH have already shown effects of summer drought (die back and mortality)
- This species will likely suffer greater losses to insect defoliators under CC.

Larch, western and Siberian:

- These species tend to be better adapted for colder environments but possibly could cope with drought and possibly help supplement lodgepole pine in SBS under CC.
- Could suffer greater losses to foliar diseases in areas of increased summer precipitation.
- Insect defoliator damage to larch species will also likely increase.
- Research group in Kamloops has been cautioning about use of western larch in Lillooet area (very light demanding, have to watch species mixes)

Spruce:

- Increased losses due to leader weevils - increased range and hazard of spruce weevil
- Increased losses to foliar diseases (*Rhizosphaera kaukhoffii*) etc.
- spruce beetle lifecycle completed in one year = increased attack

Western redcedar:

- This species could be deployed to greater extent under climate change in Northern Interior Forest Region

- Western redcedar is less susceptible to Armillaria root disease and so is a valuable species for areas that are heavily infested with that pathogen.
- As Armillaria root disease spreads north over time under climate change need to move western redcedar as well.
- Increased foliar disease in current range of species under CC
- In Coastal Douglas Fir (CDF) biogeoclimatic zone this species is slowly dropping out of species mixes as a result of summer drought. This will likely occur in the Southern Interior ICH zone as well

True firs:

- Subalpine -fir range will shrink as tree line rises under influence of CC
- Foliar diseases and insect defoliators will increase under CC
- Increased risk of balsam woolly adelgid spreading into interior forests

Broadleaf species:

- Die-back issue for paper birch associated with drought in southern interior.
- Trembling aspen probably better adapted for drought than paper birch
- Foliar diseases have already been a concern in NW where increased summer precipitation has occurred.

Possible Climate Change Impacts on Pests

- Armillaria and Laminated root diseases will move N. Laminated root disease is particularly well adapted to take advantage of drought stressed trees.
- Budworms and other insect defoliators will flourish
- Leader weevils will flourish and spread
- Damage associated with rusts and foliar diseases will intensify if spring and fall moisture increases
- Pythiums and Phytophthoras in seedlings in spring will get worse in young stands
- Sudden Oak Death (SOD) *Phytophthorus ramorum* and other introduced diseases will become more prevalent
- Tomentosus root disease may be displaced by Armillaria and Laminated root rot, however, if we planted a greater component of spruce due to reductions in lodgepole pine deployment we could have more Tomentosus.
- General expansion of insect ranges northward and up in elevation
- BEC variant boundaries are probably already changing and will continue to change; trees within these margins will find that the conditions under which they established and grew are changing; these changing environmental conditions will stress them; stressed trees are generally more susceptible to pests.

Appendix 5 – Example of Decision-Focused Risk Assessment

A Decision-Focused Risk Assessment for Forest Health under Climate Change

(A.J. Woods, with input from A. Britneff, P. Hall, S. Hoyles, L. MacLauchlan, L. Rankin, K. White, D. Wilford, and S. Zeglen.)

“The overall risk varies...the primary determinants of risk are the potential for a high magnitude impact coupled with scientific uncertainties that prevent precise forecasting of the situations that will be highly risky.” Compass Resource Mangement Ltd. 2004

“Focus on the decision process.

Science serves decisions; it does not make them.

A better decision process will lead to more transparent and defensible decisions (withstand public, auditor, regulatory scrutiny).

Decision makers must commit to a more active role.” Compass Resource Mangement Ltd. 2004

“Risk assessment is the process of estimating the consequences of defined management options on defined management endpoints, with explicit expression of the uncertainties in these estimates.” Compass Resource Mangement Ltd. 2004

Introduction:

The scientific uncertainty surrounding the specific direction of climate change, particularly regarding precipitation, has significant consequences for forest pests, their hosts and forest management in BC. Climate change will directly affect the environment which will indirectly affect the host, the damaging agents (insects or fungi) and the resulting damage (Figure 1).



Figure 1. The disease triangle altered to account for both disease and insects.

Published scientific evidence of the unpredictability of the behaviour of forest pests under changing precipitation regimes (e.g. *Dothistroma* needle blight (Woods et al 2005)) illustrates this vulnerability. To date, other examples of the impacts of climate change on the forests of BC have been more predictable. One would expect trees in areas of the southern interior to eventually succumb to drought if the drought was severe and prolonged. Similarly, one would expect that mountain pine beetle populations could again reach epidemic levels in the absence of killing winter conditions given the

preponderance of over-mature lodgepole pine throughout much of the interior and the history of such occurrences (Safranyik 1988). That said, the extent and the duration of this epidemic are beyond almost everyone's expectations. In the case of *Dothistroma*, a relatively small increase in the frequency of warm-rain events coupled with a recent increase in mean summer precipitation tipped the scales in favour of the pest. That pest has in turn had devastating consequences for lodgepole pine dominated plantations in the ICH zone of northwest BC. This result was not so predictable. One would have expected that lodgepole pine would benefit from increased precipitation and warmth during the growing season (Rehfeldt et al. 1999). Our past experience with *Dothistroma* in BC would not have led us to predict the current situation.

The *Dothistroma* example highlights the uncertainty regarding forest pests and their hosts throughout much of the province. The combinations of hosts and their suite of pests will of course be different depending on location but the scientific fact remains that short-lived insects and fungi will be able to adapt to new environmental conditions under climate change much more quickly than their long-lived hosts. We don't know how these relationships will play out but we predict they will occur. In some cases these new relationships could be positive for some forest resources. In others there is a high probability that these new relationships will be negative, particularly in terms of timber productivity. This reality coupled with the inherent uncertainties associated with global climate change places forest management under a significant cloud of uncertainty.

The indirect impacts of climate change on BC's forests orchestrated by forest pests will present varying opportunities for management intervention. In mature unmanaged forests our options for interventions will be confined to being reactive rather than proactive as the forests, their species mixes and genetic diversity, are set. We will have to wait and see what the next pest outbreak or environmental stressor will be, and then react. In contrast, the establishment of new forests can be managed proactively. We can increase diversity both in terms of genetics and species, we can also adjust establishment densities to increase the resiliency of managed stands and to reduce the risk associated with climate change and its indirect affects on pest/host interactions. For this reason in this example we have chosen to focus the Decision-Focused Risk Assessment for Forest Health on young managed stands.

The Forests For Tomorrow (FFT) initiative provides an opportunity to implement forest management recommendations with a longer term focus. The stands established under FFT are predicted to experience significant environmental changes over their rotation due to climate change, see Hamann and Wang (in press). The FFT program could demonstrate measures that could be used to improve the resiliency and adaptive capacity of forests throughout BC.

Decision-Focused Risk Assessment for Forest Health

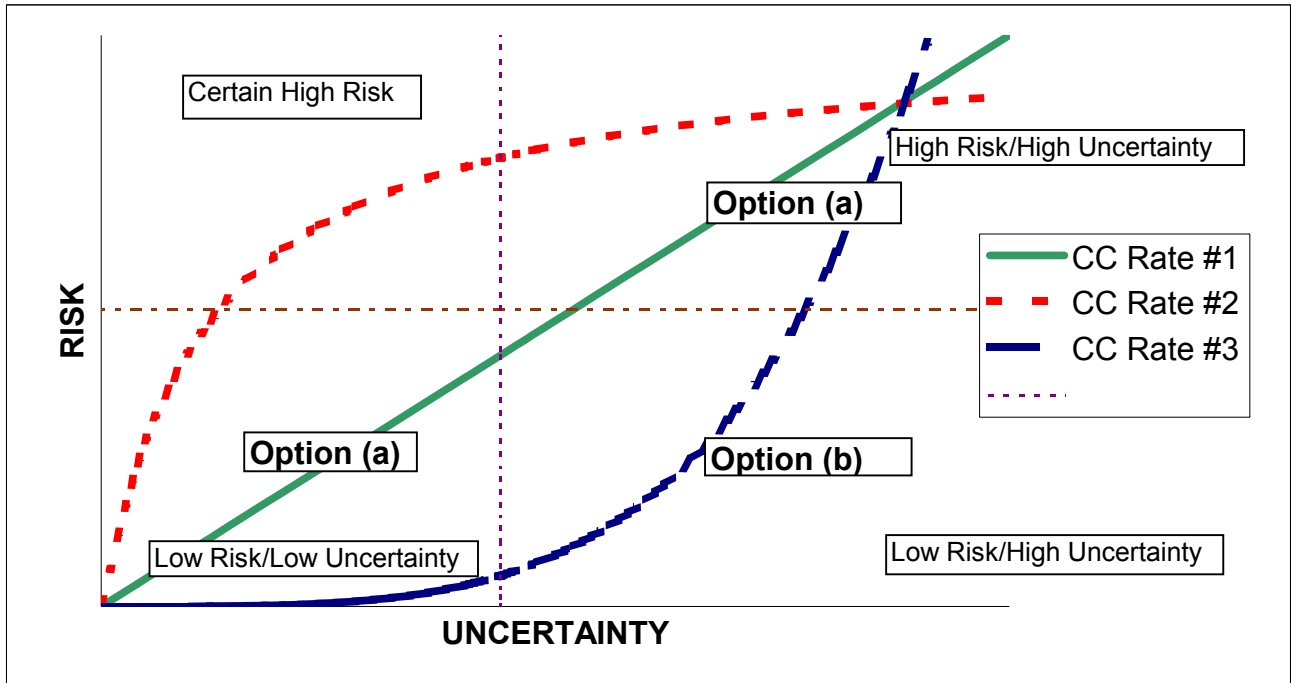
<p>Question:</p>	<p>What is the predicted impact of Climate Change on:</p> <ul style="list-style-type: none"> • managed stand resiliency, • forest management sustainability, • timber supply predictability, • managed stand productivity, • multiple use availability, and • community stability. <p>considering CC’s relationships with Forest Health agents if we:</p> <p>(a) follow current practices regarding species selection and stocking standards until direction of climate change is more clear, or</p> <p>(b) increase species and genetic diversity at the stand and landscape level by ensuring that all currently preferred and acceptable tree species are incorporated into intimately mixed plantations AND application of the projections of changes to BEC boundaries predicted by Hamann and Wang (in press) to incorporate a proportion (up to 20%) of the dominant commercial tree species from the 2025 projected BEC zone distribution?</p>	
<p>Objectives and Endpoints</p>	<ul style="list-style-type: none"> • Resilient managed forests capable of coping with uncertainty of CC, • Sustainable forest management, • Stable, predictable Timber Supply, • Productive managed stands, • Maintenance of diversity of uses for forest land, • Stable forestry dependent communities • Minimal disruption/cost to forest industry. 	
<p>Information on Impacts</p>	<p>(1) Likely impacts of alternative (a): follow current practices regarding species selection and stocking standards until direction of climate change is more clear:</p> <p>Resilient managed forests: Our current practice regarding species selection and stocking standards is based on the philosophy that there is a “best” species or combination of species which in turn is based on years of experience under relatively stable climatic conditions and the assumption that environmental conditions including host/pest relationships are stable. Given our current understanding of Climate Change and our experience with host/pest interactions thus far, following (a) could delay the creation of resilient managed stands because we may well continue to choose the wrong “best” species or the wrong “best” provenance of a species until it is clear we have made a mistake.</p>	

<p>Information on Impacts</p>	<p>Sustainable Forest Management: We have seen what can occur when a change in the climate favours a pest (Woods et al 2005). We also have published science (Hamann and Wang 2005) that predicts the climatic conditions that resulted in managed stand failures in the ICH could occur in large portions of the SBS by 2025. We do not know precisely what will happen under climate change but we do know that large-scale plantation failures are possible in the ICH because we have already seen it happen. Other areas of the province are predicted to become drier. It is possible that if we continue to follow option (a) in those areas, less drought resistant species may continue to be planted until it is obvious that moisture deficits will threaten their survival. Under option (a) we would wait until a predicted result becomes a reality and then change. This option may hamper our ability to achieve the objective of Sustainable Forest Management if the climate continues to change at current rates.</p> <p>Stable, predictable Timber Supply: If rotation periods for our commercial tree species were much shorter (25 years?) we could follow option (a) and achieve the objective of a predictable Timber Supply, adjusting species preferences to maintain stability as new evidence of CC/Forest Health impacts became apparent. In general we do not currently manage for short rotation species nor are most of our current commercial species suited to such management, with the exception of some deciduous species. If, however, the climate does not change as quickly as predicted we will have sufficient time to adapt to new conditions under option (a).</p> <p>Productive managed stands: Evidence that suggests that FH/climate change interactions are already leading to less productive managed stands is mounting. Lodgepole pine is no longer a preferred species in the NW ICH because of <i>Dothistroma</i> needle blight (Woods et al 2005). Young lodgepole pine mortality due to Warren’s root collar weevil has increased, to the point that stand rehabilitation is required in some stands (MPB epidemic is forcing the weevils out of mature forests into managed stands, MPB epidemic has been linked to climate change (Carroll et al. 2004)). The incidence of hard pine rusts in pine stands of central BC has increased significantly over the past two decades based on a review of published articles (van der Kamp and Spence 1987, Woods et al. 2000). Foliar diseases that historically have been so insignificant that identification guide books do not include them as pests in BC are frequently being reported in Free Growing surveys in central BC (e.g. <i>Phaeoseptoria contortae</i>, <i>Rhizoshaera kaukhoffii</i>). If we continue under option (a) until it is even more evident that climate change may be affecting our ability to maintain productive managed stands, we forego potential increases in productivity that we might have been able to obtain through the use of a mix of potentially pest and climate change resistant species.</p>
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<p>Information on Impacts</p>	<p>Maintenance of diversity of uses for forest land: Our ability to achieve this objective is likely similar under both option (a) and (b). If timber productivity is the priority for an area option (a) is the most vulnerable option to the indirect impacts of Climate Change on host/pest interactions. Other resource values such as range, recreation and biodiversity may benefit under option (a) or at least be neutral.</p> <p>Stable forestry dependent communities: Forest pests are just one of many factors influencing community stability. Following option (a) perpetuates the reactive management approach which can lead to boom-bust situations such as the current MPB epidemic. If we wait until there is another obvious problem before we adjust practices we inevitably experience greater instability in terms of timber supply which in turn affects community stability. If Climate Change does not occur as quickly as predicted the difference between option (a) and (b) diminishes as does the respective affect on community stability.</p> <p>Minimal disruption/cost to forest industry: Option (a) results in no disruptions to current practice and no increase in cost to industry in the short term. In the short term option (a) is lowest risk because current species selection guidelines are based on past experience regarding tree species and their favoured environmental conditions, conditions that are assumed to be relatively stable. If the trajectory of current climate change projections and indirect impacts on forest health agents become reality, costs to industry could rise sharply as efforts required to reforest areas increase due to plantation failures and poorly adapted provenances. The increased uncertainty associated with climate change could lead to an extension of the Free Growing obligation period, as high-risk species become less acceptable to grow. If climate change does not occur as quickly as predicted option (a) is least cost.</p> <p>(2) Likely impacts of option (b) increase species and genetic diversity at the stand and landscape level by ensuring that all currently preferred and acceptable tree species are incorporated into intimately mixed plantations AND application of the projections of changes to BEC boundaries predicted by Hamann and Wang (Ecology, in press) to incorporate a proportion (up to 20%) of the dominant commercial tree species from the 2025 projected BEC zone distribution</p> <p>Resilient managed forests: Increasing the diversity of species deployed in plantations through the use of intimately mixed plantations will inherently increase the resiliency of managed stands.</p>
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	<p>The probability of a single forest pest having the ability to severely impact the productivity of a stand is virtually zero if that stand is made up of intimate mixes of a variety of host and non-host species. Under option (b) managed stands would be more resilient and more capable of coping with the indirect affects of climate change whatever the next pest outbreak may be. Following option (b) also reduces the probability of creating non-productive areas.</p> <p>Sustainable Forest Management: Increasing diversity in plantations through the use of intimately mixed species and families within species (option b) will improve our chances of achieving the objective of sustainable forest management. The current MPB epidemic has emphasised the importance of diversity in the landscape and the role of diversity in the achievement of sustainability. A diversity of age classes within a single host species dominated landscape would have resulted in a forest that can be managed more sustainably. In the post MPB situation, under the cloud of uncertainty attached to Climate Change, a diversity of species, intimately mixed, and a diversity of stand structures offers a better chance of achieving sustainability.</p> <p>Stable, predictable Timber Supply: Experience thus far with the affects of Climate change on host/pest interactions suggests that the stability and predictability of timber supply will be challenged regardless of the option chosen. Though timber supply modelling may be more difficult under option (b), stability and predictability may improve under this option as the probability of plantation success improves despite the myriad combinations of host/ pest interactions under climate change. Some productivity loss is implied by including acceptable species as well as preferred in option (b).</p> <p>Productive managed stands: The speed at which the climate is predicted to change over the next rotation will compromise the productivity of managed stands regardless of the option chosen. Currently preferred species will be challenged by novel host/pest and climate interactions. Some species will cope better than others but we do not know how these new interactions will play out. If we follow option (b) we have a higher probability of having some trees that do cope better. As we see the new host/pest interactions develop we can adapt species mixes to maintain productivity of managed stands on the land-base. Having the variety of species already deployed in intimately mixed plantations buys time and provides an opportunity to have a scientific basis for management decisions (adaptive management).</p> <p>Maintenance of diversity of uses for forest land: Our ability to achieve this objective is likely similar under both option (a) and (b).</p>
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	<p>If timber productivity is the priority for an area option (b) is the least vulnerable option to the indirect impacts of Climate Change on host/pest interactions although there are some implications for timber supply due to increased use of alternate species.</p> <p>Stable forestry dependent communities: Following option (b) allows for greater adaptability and promotes a more proactive forest management approach which should lead to more stability in timber supply and related community stability over the mid to long term. Overall volume will most likely drop due to climate change under either option but option (b) may limit the extent of the drop.</p> <p>Minimal disruption/cost to forest industry: Option (b) would require change to current forest practices which would result in increased costs to industry in the short-term. It is likely that a new silviculture survey approach would be required - one that would consider the diversity of species and genetics within species as the primary goal rather than achieving a minimum height in a minimal period of time. The short-term increase in costs associated with option (b) would result in less disruption/cost to industry over the mid- long term provided climate change and the indirect impacts of climate change on forest health agents occur as predicted (Logan et al. 2003).</p>	
<p>Decision Guidance</p>	<p>There are inherent risks associated with both options due to the degree of uncertainty associated with climate change. The magnitude of the risks depends a great deal on the rate at which the climate changes (Figure 2). If the climate changes more quickly than predicted there is a high degree of certainty that forests will be at very high risk not only from forest health agents but from fire, floods and many other factors regardless of the option chosen. If the climate changes more slowly than predicted there should be sufficient time to alter species selection and stand management practices to adapt to the new environments under option (a). Hansen et al. (2005) suggest that the climate is already changing and that given the inertia within the system, this change will continue even if we were able to immediately cut greenhouse gas emissions entirely. The predicted changes to BEC zone boundaries of Hamann and Wang (in press) are based on several “middle of the road” projections of the rate of climate change. These predicted changes have significant implications for forest health and forestry management in general. Option (b) may not go far enough to provide sufficient managed stand resiliency if the climate changes too quickly but it does provide a less risky option than (a). The Forest Health group recommend option (b) be implemented through FFT.</p>	



(c) **Figure 2.** Conceptual framework for assessing risk associated with option (a) follow current practices regarding species selection and stocking standards until direction of climate change is more clear, or option (b) increase species and genetic diversity at the stand and landscape level by ensuring that all currently preferred and acceptable tree species are incorporated into intimately mixed plantations **AND** application of the projections of changes to BEC boundaries predicted by Hamann and Wang (in press) to incorporate a proportion (up to 20%) of the dominant commercial tree species from the 2025 projected BEC zone distribution. (graph by Stefan Zeglen and Erin Hall)

Appendix 6 – Options for Reducing Emissions from MoFR Operations

Procurement

- Work with partners inside and outside government to access GHG friendly products, achieve economies of scale, and benefit from their recommendations; This would include keeping informed of, and helping to guide central government's procurement policy and practices regarding environmentally responsible actions;
- Raise our familiarity with environmental performance of equipment such as photocopiers and printers;

Buildings

- Moving toward energy-efficiency in our buildings, and investigating opportunities to reduce energy costs,

Transportation

- Transportation: working with staff and partners to minimize greenhouse gas emissions from vehicles.

Other

- Working with MoE, other agencies, partners, clients and staff on mitigation strategies for the forest sector
- Developing and supporting planned activities that would lead to reduction of GHGs during the course of MoFR business;

Operations

- Explicitly considering climate change mitigation in planning and operations as part of the way we do business, for example, encouraging the paperless office or providing avenues for increased composting to reduce methane from landfill sites.

Awareness

Increasing staff awareness of mitigation opportunities, for example:

- encouraging staff and offices to take on Canada's One-Tonne Challenge, which aims to reduce per-capita GHG emissions by one tonne annually. This program aims to use less energy, save money, improve air quality, and protect our environment.

- developing a staff involvement program to raise awareness of mitigation opportunities. Some of this work could be through workshops, info materials, presentations to senior managers, staff, cross-sectoral partners, etc.;

Monitoring

- working with staff and partners to develop monitoring mechanisms to assess MoFR's progress in reducing greenhouse gas and increasing energy efficiency;
- initiating and supporting a sustained program that would encourage interested staff and offices to assess and improve upon their GHG output and energy efficiency over time.
- providing reports to forest managers to assist in environmentally responsible decision-making at the local level;

Appendix 7 - Glossary of Terms

Adaptation

The actions that people take in response to, or in anticipation of, projected or actual changes in climate, to reduce adverse impacts or take advantage of the opportunities posed by climate change (Tompkins and Adger 2003).

Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2001).

Mitigation

Actions to cut net emissions of greenhouse gases and so reduce climate change. Examples are using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings and expanding forests and other “sinks” to remove greater amounts of carbon dioxide from the atmosphere (UNFCCC 2005).

Resilience

The capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity and feedbacks (Resilience Alliance: <http://www.resalliance.org>).

Vulnerability

The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of “exposure” and “adaptive capacity” (IPCC 2001).